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Evaluation of Movement Programmes in the Treatment of Dyslexia

A dissertation submitted to the University of Dublin
for the degree of Doctor of Philosophy

Erika Doyle
Trinity College Dublin, March 2008

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Abstract

Evaluation of Movement Programmes in the Treatment of Dyslexia

Erika Doyle

Developmental dyslexia, or specific learning difficulty, is a prevalent condition, affecting up to 10% of the population, which can be severely disabling without early diagnosis and persistent and intensive remediation. This study evaluates claims that the condition is linked to the abnormal persistence of early motor reflexes in the child's profile or to a deficit in cerebellar function and that the condition can be remediated by either a programme of replicating primary reflex movements or a programme designed to enhance control of balance.

Two recent strands of research suggest that dyslexia is associated with the retention of primary motor reflexes, which normally disappear in a systematic fashion during the first year of motor development, and with difficulties in balance and automaticity linked to cerebellar functioning. Associated with this research are two innovative remedial programmes which aim to compensate for these developmental obstructions by reactivating suspended motor development (known as retained-reflex-replication) and by stimulating cerebellar functioning through balance activities. Along with improvements in motor functioning, it is argued, are parallel improvements in reading and spelling.

What is emerging at the present time is growing evidence for a fundamental association between disordered motor development and dyslexia, and for the remedial potential of motor reflex replication and balance training. Given the frustrations, anxieties and concerns for the future of their children, it is not surprising that parents of dyslexic children have flocked to these new treatments which have also elicited considerable media interest. However it is paramount that further evidence be obtained to evaluate the reliability and validity of these treatments. Apart from the studies by McPhillips et al. (2000) and Reynolds et al. (2003), there is a complete lack of published research designed to evaluate the efficacy of reflex replication or of balance training as treatments for dyslexic children. Those studies examined children of 8-11 years of age, whereas this study recruits younger children aged 3-7 years. In addition to investigating whether two generic movement programmes can help children with dyslexia overcome their difficulties, this study exploits the opportunity to evaluate an early indicator test battery.

Declaration

I hereby declare that this thesis has not been submitted as an exercise for a degree at this or any other University. The scale of this study necessitated two principal researchers, of which I was one, who shared all aspects of recruitment, testing, training and administration. However, the literature review, methodology, data-analysis and thesis write-up are entirely my own work.

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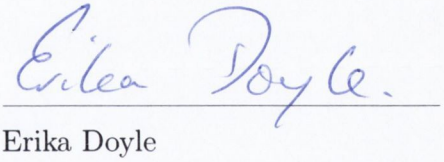

Erika Doyle

March 24, 2008.

Acknowledgments

This study was a huge undertaking and could not have been completed without the hard work and generous support of many people. Firstly, I wish to thank the children and parents who took part in this study, their patience, commitment and good humour were inspiring. Thanks to my supervisor Prof. Ray Fuller for his advice and patience with my big ambitions and little panics during the study.

Love and thanks to my children Neil and Aoife, who have grown up during this research, they acted as guinea pigs when younger and were very patient with their mother during the write-up. I could not have completed this work without the support of my mother who was constantly there to help me with the children during my studies. Thanks too to Denis for his encouragement to start a psychology degree in the first place and his support all the way through.

I wish also to thank, my colleague, Elaine Smith, for the chats, problem solving and laughs that took place in Rm. 1.15; Dr. Linda Doyle, for her never ending encouragement and advice when problems seemed insurmountable; my family and friends, particularly Lesley, Miriam and Niamh and the bookclub gang for all their support throughout the years.

The guys in the Sigmedia Group, Hugh, Andy, Laurent, were always patient and helpful when we worked on the development software to allow us to find and score the relevant video clips. We could not have managed all the data without them. Eight research assistants also worked on the project - Stephanie, Aisling, Nicola, Judy, Emma, Aileen, Evelyn and Cliona - thanks to them for their help and good humour.

I am most grateful to Enterprise Ireland and the Ireland Funds for funding this study. Finally, and most importantly, thanks to Prof. Anil Kokaram, Oscar winnner, friend and advisor, for his patience, kindness, and fabulous cooking, for keeping me going when things got tough. Thank you.

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Summary

This study is concerned with the impact motor control may have on the acquisition of reading. The theories behind retained reflex and cerebellar deficit hypotheses are explored alongside more traditional causal theories of developmental dyslexia. Two motor treatments that claim to remediate dyslexia are evaluated, and the opportunity is taken to evaluate motor performance as an early indicator of dyslexia in young children. A multi-factorial, longitudinal design was adopted in order to explore these three principal research questions.

The introduction briefly acquaints the reader with the debate surrounding dyslexia such as types of readers, definitions and prevalence of dyslexia. The current situation in Ireland is presented along with the prevalence of reading disabilities. The genetic predisposition for dyslexia is discussed in conjunction with environmental influences. Evidence of the co-morbidity of dyslexia with other disorders suggests an underlying neurological development disorder.

The co-existence of different causal theories of dyslexia based on visual and phonological deficits, noise or timing issues and cerebellar abnormalities, which interact at the environmental, biological, cognitive and behavioural levels are described in Chapter 2. Early movement and development, the emergence and inhibition of reflexes, cerebral and postural development in early childhood and the role of the cerebellum in cognition are then discussed in the following chapter.

The history of motor programmes in the treatment of dyslexia and their evolution from the field of physiotherapy is described in the next chapter. Reflex remediation and balance training programmes that claim to remediate dyslexia are described, and a model detailing the possible effect of motor programmes in reading acquisition is discussed.

Chapter 5 presents the design of three movement programmes, the reflex remediation

programme, balance training programme, and placebo-controlled 'pseudo programme' used in this study. A manual for each of these is available in Appendices L, K and M. A new test battery comprising balance, reflex, fine-motor, oculo-motor and phonological tests was designed for this study, and details are to be found in Chapter 6 and a full set of the battery is included in Appendix E.

The study used on a mixed factorial design with two main factors: type of treatment (4 levels) and time sample (3 levels) with repeated measures on the last factor. Video data and observer records were stored and managed using a new system, developed in conjunction with the Sigmedia Group, TCD. This provided video on demand as well as automated indexing to allow useful segments of the assessments to be viewed and scored. A user interface which allowed data entry into a web database compatible with a statistical analysis package was also included.

No evidence was found to support the claims that reflex remediation or balance training programmes can reduce the severity of dyslexia risk in children from dyslexic families in comparison to similar children in placebo-control or no-treatment control groups. Indeed the balance group tested significantly worse for dyslexia at the end of the study. Subsequent analysis on the efficacy of a motor test battery in predicting dyslexia in young children found that balance, reflex, motor and phonological tests proved to be predictors of dyslexia although at a low level. Balance and reflex initial 'at risk' indicators did not yield any significant associations for dyslexia risk when measured on the DEST/DST. However within the groups, significant associations were found between both balance and reflex scores as initial 'at risk' indicators and phonological scores when they were used as outcome measures. As expected ADHD proved to have a significant association with risk of dyslexia at both the mild and high criteria. The discussion chapter reviews these findings in the light of the proposed model of motor impact on reading. Finally, limitations of the research are presented along with suggestions for future work.

1

Introduction

The ability to read fluently and with comprehension is a unique achievement of the human species and not one to be taken lightly. Speech and written language represent the highest point of human evolutionary achievement. If speech is the characteristic that sets us apart from other animals, then reading is to a very large extent dependent upon speech mechanisms (Beaton, 2004).

Reading, writing and spelling are pre-requisite skills for functioning well in modern life. Most people will have fluent control of the written language by adulthood. Others work hard to achieve an acceptable level of competency while others will fail to achieve the basic skills of reading, writing and spelling. It is not known why so many people have difficulty in learning to read. There may have to be a trade-off between language and non-verbal skills such that at the level of the individual one develops at the expense of the other, however in the population as a whole both are maintained in balance by evolutionary pressure (Annett, 2002).

Reading is acquired culturally as we do not have genetic predisposition to reading as we would have to speech, and it is most likely that oral language and literacy operate in combination and develop together. Reading is a complex behaviour that depends on

cognitive skills which develop word recognition and reading comprehension. Phonemic awareness has been found to be associated with the early development of word recognition and reading, and factors strongly associated with comprehension include oral vocabulary and listening comprehension (Adams, 1990; Wagner, Torgeson, & Rashotte, 1994; Snow, Burns, & Griffin, 1998). Learning to read is a phenomenon that requires all these processes.

Historically children who unexpectedly failed to read were said to be suffering from 'word' or 'letter-blindness'. It is to Morgan that we owe the first description in the medical literature of what is now referred to as 'developmental dyslexia'. He wrote to The Lancet giving an account of a boy who had reading problems but had no apparent brain damage (Morgan, 1896). Around the same time, Hinshelwood published a series of articles describing cases of acquired word and letter blindness in the absence of speech difficulties (Hinshelwood, 1896, 1895, 1898) and a report of 'congenital word-blindness' (Hinshelwood, 1900). However he refers to Kussmaul as the person who coined the term to describe the reading difficulties of previously literate brain-damaged patients (Kussmaul, 1877). He is also the first person who described this difficulty in reading occurring in the presence of intact speech (Broadbent, 1896).

1.1 Reading Disorders or Dyslexia?

Children fail to read for various reasons, among them acquired brain injury, low IQ, inadequate schooling, or environmental factors. The term 'reading disorder' is a general description without any reference to the child's IQ levels. It is vague and encompasses terms such as 'backward readers' - those children with a low reading score in relation to their age (Yule, Rutter, Berger, & Thompson, 1974) and 'garden variety poor readers' (Stanovitch, 1991) - where the child's low level of reading might be a consequence of a generally low IQ, and developmental dyslexia. Dyslexia literally means 'difficulty with words' (Government Publications, 2002) and the term 'developmental' recognises the congenital and neurological nature of the disorder. It is an innate rather than acquired condition.

Initially dyslexia was considered a medical condition with terms such as 'minimal brain damage' and 'minimal brain malformation' being used in the 1940's (Szklut & Breath, 1985). After the British Medical Association advised its members that dyslexia was not a medical condition, educationalists approached the problem from a functional perspective,

using terms such as 'learning disabilities' in the 1960's and then 'specific learning difficulty' in the UK and 'specific learning disability' in the US. Recently 'learning disorder' is used in the US rather than 'dyslexia' and 'specific learning difficulty' in Ireland (Government Publications, 2002) - these act as umbrella terms under which dyslexia is listed with other conditions such as dyscalculia, dysgraphia and dyspraxia (BPS, 1999).

The search for the underlying cause of developmental dyslexia has not proved straightforward. Just as there are many factors involved in learning to read, there are many which prevent the individual child from reaching their full literacy potential. Debates about the labelling and definitions of dyslexia abound, but what we must keep in mind is that there is no simple cause of dyslexia. Many things may go wrong in a child's development which impacts on their physical maturation and academic performance. Part of the problem with defining the concept of dyslexia is that some researchers work from a tight discrepancy criterion while others work from a more holistic and inclusive baseline. Despite years of research and the debate in the field, children are continuing to fail to read. Understanding and remediating reading failure and treating the other symptoms and co-morbid conditions are important goals for research. The current study will hopefully contribute somewhat to those goals by testing early indicators of dyslexia and investigating programmes of reflex and balance remediation.

1.2 Dyslexia and the issue of IQ

The concept of a specific reading impairment has often been distinguished from that of a general weakness in reading. Vernon suggested three categories of poor readers: those whose difficulty was due to environmental factors, such as lack of support for reading in the home and inefficient schooling; those who suffered some form of emotional maladjustment and those who weakness is often severe and of an organic or constitutional nature (Vernon, 1962). The latter cases, he suggested, should be classified as specific dyslexics. Other researchers are of the same view that children with specific reading and writing difficulties constitute a different but small proportion of poor readers (Ingram & Mason, 1965).

Critchely supported the concept of dyslexia for the following reasons: '*persistence into adulthood; the peculiar and specific nature of the errors in reading and spelling; the familial incidence of the defect; the greater incidence in the male sex. To these criteria may be added: the absence of signs of serious brain damage or of perceptual defects; the absence of significant psychogenesis; the continued failure to read despite conventional techniques*

of instruction; and the association of normal if not high intelligence' (Critchley, 1970) p.11.

This leads us to the issue of the relationship between IQ and dyslexia. Vellutino advocated the abandonment of IQ in defining reading disability on the grounds that IQ did not predict response to remediation in a large scale longitudinal study of poor readers, while general language skills did (Vellutino, Scanlon, & Lyon, 2000; Vellutino et al., 1996). Unexpectedly the children who benefited least from intervention had significantly smaller discrepancies than those who benefited most. In other words those with a higher IQ may have been able to make the most of their ability to overcome their reading difficulty. Thus it may be premature to abandon the use of IQ in the field of reading disabilities. Wadsworth et al. found that individuals with high full scale IQ relative to their word recognition ability, tended to have higher heritability coefficients for reading than those with lower IQ relative to their word recognition ability (Wadsworth, Olson, Pennington, & DeFries, 2000b). It may be that environmental factors were more likely to be responsible for reading deficit where IQ was low, whereas genetic influences were stronger in readers of high IQ. Olson also found that there were fewer books in the home of low IQ disabled readers, and their mothers had fewer years of education than mothers of disabled readers with high IQ (Olson, 2002).

There is ongoing debate about whether dyslexia is part of a continuum of normal reading ability, with Stanovitch arguing that reading disability is not a discrete entity but a graded continuum (Stanovitch, 1989). However Snowling found that dyslexic children were not like normal readers at the lower end of the distribution curve as they did not perform similarly to a group of reading-age matched younger readers when decoding stimuli across modalities (Snowling, 1980). The use of grapheme-phoneme correspondences was observed when nonwords were presented in both visual and auditory modalities which had to be recognized immediately. The use of grapheme-phoneme correspondences increased with reading age in normal readers but dyslexics had a specific difficulty in this area. It is suggested that an increase in the size of sight vocabulary is the main factor in their increase in reading age.

Elsewhere dyslexia is regarded not just in terms of poor reading but as a distinct cluster of cognitive skills and Nicolson (1996, p3.) criticizes the Stanovitch view, stating that he considers '*that serious damage is done to the concept of dyslexia if dyslexia is viewed merely as one end of the poor reading continuum..*'. Unfortunately while it is almost universal practice to only include in a research sample participants who have an average or high IQ, often little else is known about whether they have other deficits other than in spelling and

reading (Beaton, 2004). This information would prove useful in discriminating between children who struggle just with reading and those who may have a neurological/genetic component to their difficulty and may also benefit from remediation for motor and reflex difficulties.

Parents often regard a speech versus reading comprehension discrepancy relevant when they are concerned that their child has dyslexia (Beaton, 2004). An alternative might be a discrepancy between listening comprehension and reading level, in conjunction with IQ (Stanovitch, 1991). Another possibility is that a discrepancy between performance on a test of reading comprehension and single or non-word reading ability could be informative as to the cognitive basis of any reading deficit (Siegel, 1999).

It is worth noting that the current trend in the United States is not to assess pupils for dyslexia but instead to treat all poor readers the same, regardless of the cause of their difficulty, and to administer intensive reading programmes (see www.wcer.wisc.edu/txutility).

1.2.1 Ethical Issues

The association of dyslexia with average or high IQ has given rise to some ethical questions. In effect it has proved a pragmatic though perhaps not reliable way for educational services to categorize which children should receive resources. It might be argued that the aim should be to ensure equal treatment of children with literacy difficulties, regardless of the causes. However it does not follow that a large discrepancy between intellectual ability and reading and spelling attainment is of no significance. In our increasingly knowledge-based society it is necessary that individuals acquire text-based information. It could be argued that the greater the person's intellect the more likely will be their need to acquire this knowledge and their need to express themselves in writing. Therefore the greater their discrepancy, the greater the difficulty that will be imposed on them in their academic or working lives.

In order to facilitate research and remediation, an agreed term which describes a neurological specific learning difficulty, and a way of specifying the other characteristics which the child may also present for remediation, is needed. At present 'dyslexia' is an umbrella term for difficulties predominantly, but not only, in reading. Children with dyslexia may also experience early speech and language problems. They often confuse directions such as left and right and have difficulty with short-term memory, for example, remembering days of the week, tables and the alphabet. Some dyslexic children have poor pencil control

and awkward handwriting. Many have difficulty with phonological discrimination and sequencing, often mixing up the sounds of words or order of numbers (see the Dyslexia Association of Ireland website: www.dyslexia.ie).

1.3 Definitions of Dyslexia

So a central unresolved issue in the literature concerns how developmental dyslexia should be conceptualized. The scientific literature refers to either poor readers or to dyslexics without distinguishing between the categories unless this is the central aim of the investigation. Beaton suggests that we should not expect to find a unique pattern of dyslexic behaviour, rather he would view it as a constitutional weakness that influences the way in which certain tasks are carried out (Beaton, 2004).

Many definitions of dyslexia have been suggested over the years. The most widely accepted definition by the World Federation of Neurology (1968) was one of the earliest to include the IQ-performance discrepancy criterion:

' *A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin*' (Critchley & Critchley, 1978).

The more recent inclusive definitions which recognise dyslexia as a constitutional disorder, incorporate a range of characteristics which are accounted for neurologically and so allow for the future development of theoretical and explanatory models. Both the British Dyslexia Association (BDA) and the Dyslexia Institute (now known as Dyslexia Action) have inclusive definitions:

'*Dyslexia is a combination of abilities and difficulties that affect the learning process in one or more of reading, spelling and writing. It is a persistent condition. Accompanying weaknesses may be identified in areas of speed of processing, short-term memory, organisation, sequencing, spoken language and motor skills. There may be difficulties with auditory and /or visual perception. It is particularly related to mastering and using written language, which may include alphabetic, numeric and musical notation.*

Dyslexia can occur despite normal intellectual ability and teaching. It is constitutional in origin, part of ones make-up and independent of socio-economic or language background',

(The Dyslexia Handbook, p.7 (Cooke & Owen Adams, 2007). See www.bdadyslexia.org.uk).

'*Organising or learning deficiencies which restrict the student's competencies in information processing, in motor skills and working memory, so causing limitations in some or all of the skills of speech, reading, writing and essay writing, numeracy and behaviour*' (The Dyslexia Institute (Doyle, 1996)).

Perhaps the most inclusive definition is that of the National Joint Committee on Learning Disabilities (NJCLD) [1] in the US. It acknowledges a central nervous system dysfunction and recognizes the possible co-occurrence with other disorders:

'*A heterogenous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual and are presumed to be due to central nervous system dysfunctions. Even though a learning disability may occur concomitantly with other disabling conditions (e.g. sensory impairment, mental retardation, social and emotional disturbance) or environmental influences (e.g. cultural differences or insufficient/inappropriate instruction), it is not the direct result of those conditions or influences*' (Szklut & Breath, 1985).

1.4 Dyslexia in Ireland

The term 'Specific Learning Disability' (SLD) was adopted by the Special Education Review Committee (SERC) of the Department of Education and Science in 1993. It is an exclusive rather than inclusive definition and states that:

'Impairments in specific areas such as reading, writing and arithmetical notation, the primary cause of which is not attributable to assessed ability being *below the average range, to defective sight or hearing, emotional factors, a physical condition or to any extrinsic adverse circumstances'* (Government Publications, 2002).

In the summer of 2000, the Minister for Education and Science announced the creation of a Task Force on Dyslexia. The Task Force, in its final report (see www.education.ie) proposed a broader use of the term dyslexia. It stated that:

[1]The NJCLD is a national committee of representatives of organisations in the United States committed to the education and welfare of individuals with learning difficulties. See www.ldonline.org/about/partners/njcld

'*dyslexia is manifested in a continuum of specific learning difficulties related to the acquisition of basic skills in reading, spelling and/or writing, such difficulties being unexpected in relation to an individual's other abilities and educational experiences. Dyslexia can be described at the neurological, cognitive and behavioural levels. It is typically characterised by inefficient information processing, including difficulties in phonological processing, working memory, rapid naming and automaticity of basic skills. Difficulties in organisation, sequencing, and motor skills may also be present*' (Government Publications, 2002).

The report also recognised that the learning difficulties arising from dyslexia

- occur across the lifespan, and may manifest themselves in different ways and at different ages;
- may co-exist with difficulties in the area of number (dyscalculia)
- may be associated with early spoken language difficulties
- may be alleviated by appropriate intervention
- increase or reduce in severity depending on environmental factors
- occur in all socio-economic circumstances
- co-exist with other learning difficulties such as Attention Deficit Disorder and may or may not represent a primary difficulty.

Currently the Irish Department of Education and Science (DES) guidelines state that in order for a student to be considered for language exemptions and spelling waivers, the term Specific Learning Disability should not include disabilities due to poor general intellectual functioning. Account must be taken of the following criteria in determining whether a Specific Learning Disability exists, viz

- assessed intellectual functioning at average level or above
- marked failure to achieve expected levels of attainment in basic skills such as reading and writing
- a history of such failure not related directly to factors such as poor attendance, poor motivation or problems in social interaction which may affect attainments. (DES, 1994)

In primary schools the Department advises that in determining eligibility for learning-support teaching, priority should be given to pupils whose achievement is at or below the 10th percentile on standardised tests of reading or mathematics (DES, 2005).

This policy of the Department of Education and Science does not take into account any of the other symptoms mentioned by the Taskforce on Dyslexia or the Dyslexia Association of Ireland. This may be because motor or organizational difficulties are not seen to have a direct impact on learning. However, one could argue that it would be more efficient to administer an early screening test to children as they enter school between the ages of 4 and 5 years. Those deemed at risk could then be given school readiness training which includes motor, social and attention skills (see Kohen-Raz in Chapter 4) and reading programmes before they fail to read. The current procedure for diagnosis and treatment of dyslexia varies among schools nationally and often results in children steadily falling behind their peers in literacy. Many enter secondary school at age 12 with a late diagnosis and little reading intervention or academic support.

Putting resources in place at the early primary school stage to remediate equally all those struggling with reading is sound policy. Those that continue to fail to read beyond the age of 7 would be already flagged by the school and a full assessment for dyslexia and/or co-morbid conditions could take place at this stage. Once the specific difficulty is identified, intensive programmes could be put in place for such children (see intensive reading programme (Hatcher, Hulme, & Ellis, 1994)).

For the purposes of this study (The Dyslexia Early Years Project (DEYP)) the author took the view that children with developmental dyslexia and children who are poor readers are not the same. This is not to say that they should not benefit from the same intensive reading programmes either individually or in the classroom. The genetic and neurological factors of dyslexia are not yet fully understood. A diagnosis of dyslexia is usually based on a discrepancy between ability and performance in reading and difficulty with some or all of the other literacy skills. However as the children sampled for the DEYP were all pre-readers, it was decided to recruit children only from families where there was a history of dyslexia because of the evidence relating to the heritability of dyslexia (Pennington, Gilger, Pauls, Smith, & deFries, 1991). Either a parent or a sibling had a positive diagnosis of dyslexia, or there was a strong suspicion that a parent had dyslexia, and often there was a diagnosis in the extended family also.

1.5 Prevalence

The media often exaggerate the prevalence of reading disabilities. In the technical literature estimates within the English-speaking world typically fall between 5% and 10% of the population (Critchley, 1970; Pennington, 1990). The prevalence of reading disability may be somewhat lower in countries where languages with sound(s) represented by a given letter have a more consistent correspondence than in English. Makita reported a figure for prevalence of dyslexia of less than 1% for Japanese school children (Makita, 1968). Adopting a discrepancy analysis definition of dyslexia with data from children born in the UK during a particular week in 1970, Miles tentatively suggested a prevalence of underachievement in reading of between 2% and 4% (Miles, 1993b). However he also included the presence of a number of 'signs' thought to be particularly frequent among dyslexics when he reported this figure. Among them were difficulty with directions, short-term memory, sequencing and familial incidence.

Many studies of incidence have produced varying figures because they have used different criteria. It is likely one child in every classroom will need ongoing appropriate specialist teaching throughout his/her time in school and support in further education, training and employment. In the US it has been suggested that up to 10% of the population (or even more) show some signs of dyslexia, particularly when it is present in other members of the family (Pennington, 1991). While no conclusive research has been carried out in Ireland to determine how prevalent dyslexia is, the incidence in Ireland is expected to be in line with English speaking countries.

A difference in the incidence of dyslexia between boys and girls has been regarded as one indication of a constitutional basis for the condition. A ratio of approximately three to four males to one female is reported in many studies (Hallgren, 1950; Miles, Haslum, & Wheeler, 2001; Wolff & Melngailis, 1994). The ratio appears to vary with the criteria used, such as the discrepancy between reading level and IQ and the severity of the condition (Lovell, Shapton, & Warren, 1964).

However in familial and genetic twin studies the sex ratio reported has been much lower than 4:1 (DeFries & Alarcon, 1996). In fact close to a 1:1 ratio has been found (Wadsworth, DeFries, Stevenson, Gilger, & Pennington, 1992). This is not to say that dyslexia might not be more severe in males than in females (Lubs et al., 1993), just that there is no evidence of differential heritability in boys and girls (Wadsworth, Knopic, & DeFries, 2000a).

It has been suggested that the reason why more boys than girls were found in a school-based samples was that teachers are more likely to perceive boys rather than girls as being disruptive (Shaywitz, Shaywitz, Fletcher, & Escobar, 1990). In an analysis of data from more than 11,000 subjects in Great Britain, Miles found that there was no gender bias (Miles, Haslum, & Wheeler, 1998). The reasons why larger proportions of males than females appear in research samples could be due both to teachers' perceptions, and a referral bias, and the selection criteria.

If clinical criteria were used that included poor spelling plus or minus poor reading, rather than poor reading alone, the ratio of boys to girls was 4.5:1 (Miles et al., 1998). However if the criterion was 'poor achiever' based on a discrepancy of reading comprehension in relation to IQ, then the sex ratio was closer to 1:1. Another explanation is that as word reading deficits become more severe in children with IQ scores above 100, the samples include more and more males (Olson, 2002).

1.6 Genetics

The familial clustering of reading and spelling difficulty was recognised early in the last century (Fisher, 1905; Stephenson, 1907). While dyslexia tends to run in families this does not necessarily implicate genetic factors since families share the same environment. However the strongest evidence of genetic influences on dyslexia has come from the Colorado Twin Study of Reading Disability (Stevenson, Graham, Fredman, & McLoughlin, 1987). This large scale twin study compared the concordance of the trait in monozygotic (identical) and dizygotic (non-identical) twin pairs. This found the heritability of dyslexia to be 50%. Working with data from the Colorado Family Reading Studies, both Gilger et al.(1991) and Pennington (1990) put the familial risk rate for dyslexia at the lower percentage of 35-45%. Although there are likely to be genetic factors involved in the predisposition towards dyslexia, it cannot be attributed to a single locus. Often there is a difference between the 'phenotype' (how severely an individual is affected with dyslexia) and the 'genotype' (the genetic make-up of that individual). This could be due to a number of factors such as:

- genetic heterogeneity - where different genes may be influencing the trait in different families
- reduced penetrance - where some individuals with a predisposing genotype may not

develop dyslexia (due to environmental or random interactions)

- phenocopy - where some individuals without a predisposing genotype may nevertheless be dyslexic (again this could be due to environmental or random factors)

- oligogenic inheritance - this is where the trait might result from the simultaneous presence of predisposing genotypes at several different genes, whose interaction results in elevated risk of developing dyslexia.

An additional complication is the difficulty of defining exactly what the phenotype of dyslexia is, given the ongoing debate about what constitutes the core deficit.

Recent genetic studies indicate that there is likely to be a gene influencing reading disability on the short arm of chromosome 6 (Fisher et al., 1999). In addition there have been some results suggesting regions on chromosomes 1, 2, 3, and 15, although these data are not as conclusive (Bisgaard, H. Eiberg, Niebuhr, & Mohr, 1987). A combined analysis of US and UK families found that chromosome 18 is likely to be involved in single word reading among other reading related processes (Fisher et al., 2002). This is the strongest linkage evidence to date. However the size of the human genome makes it difficult to investigate which chromosomes, and the location on them, are relevant to dyslexia. So far all attempts to map quantitative-trait loci influencing dyslexia susceptibility have targeted specific chromosomal regions, so that there has been limited information from which to make inferences regarding the genetic etiology of dyslexia.

It should be noted that the gene loci identified are unlikely to be concerned with reading itself (Ellis, 1985) as there has been insufficient time for reading-specific genes to have evolved since the appearance of written language over 5,000 years ago. It is thought that the relevant genes must be involved in the speech related (phonological) processes on which reading depends. Pennington states that: 'contrary to intuition, individual differences in reading skill have more to do with speech than with vision and at least as much to do with single-word processing as with the processing of connected text' (Pennington, 1997, p.14). It is not known how genes influence the acquisition of language and reading and it may be that they are associated with other types of developmental disorders.

In addition to this complex etiology it must be noted that inheritance is only half the story. It may be that the environment in the womb (encompassing toxins, immune deficiencies and nutrition) interacts with the genes and causes a problem with neural organization that results in inefficient lateralization, noise in the transmission between synapses, and

subsequently aberrant motor and ocular reflexes and interference in auditory discrimination. All or a mix of these may predispose the infant to a difficulty in perceiving the sounds and shapes of words, along with a co-morbidity with other conditions as described above.

In view of the importance of heritability and the debate around the sex ratio between boys and girls, it was decided to recruit primarily boys from families with a history of dyslexia for the Dyslexia Early Years Project (DEYP). It was assumed that appealing to families where parents or siblings had a diagnosis of dyslexia or were suffering from spelling and/or reading problems, that the study would be successful in recruiting a proportion of up to 50% of children with a genetic predisposition towards developing dyslexia.

1.7 Comorbidity with other Disorders

It is argued that people with dyslexia share a cluster of genes, which may account for the variations in the nature and extent of specific learning difficulties (Olson, 2002; Fisher et al., 2002). Portwood suggests that dyspraxia (Developmental Coordination Disorder) may be comorbid with autism, dyslexia and ADHD in 45% of cases (Portwood, 2000). In comparing ADHD children with controls, 25% of the children with ADHD presented with significant delays in the development of mathematics, reading or spelling and up to 30% showed problems with language (Barkley, Fischer, Edelbrock, & Smallish, 1990).

The overlap between various developmental disorders is evident from the American Psychiatric Association's Diagnostic and Statistical Manual (APA, 2000). Along with Developmental Co-ordination Disorder (DCD or Dyspraxia), Attention Deficit Hyperactive Disorder (ADHD), Autism Disorder, Aspergers Disorder, learning disorders including those in reading, mathematics and written expression are listed. The DSM also refers to several disorders of speech and language such as Developmental Articulation Disorder, Developmental Expressive Language Disorder, and Developmental Receptive Language Disorder indicating a comorbidity with Specific Language Impairment (SLI). Portwood states that delays in non-motor milestones such as phonological disorder and expressive language disorder are commonly associated with DCD (Portwood, 2000).

Practictioners and parents have long been aware of overlapping disorders, and this is now being supported by the growing evidence from genetic studies of co-morbidity with other disorders (Stevenson et al., 2005). A preschool twin study of the relationship between

attention/deficit and/hyperactivity disorder and reading skills found that reading difficulties and inattention symptoms (but not hyperactivity and impulsive symptoms) were attributable to common genetic influences (Willcutt et al., 2007). This may indicate perceptual stimulus overload and thus an inability to attend to detail in both ADHD and dyslexic children. Although there is a strong linkage for reading problems on chromosome 6, the same site is also linked to ADHD (Willcutt et al., 2002).

In relation to dyspraxia and speech and language difficulties, Iversen claims that up to 70% of dyslexics are at the borderline or clinical range for DCD (Iversen, Berg, Ellertsen, & Tonnessen, 2005). It has also been found that early speech and language skills predict later literacy outcome (Gallagher, Frith, & Snowling, 2000). A study in Australia highlighted the need for future studies to assess both the reading and oral language abilities of participants to determine how specifically impaired and homogeneous samples really are. It found that 50 % of children both with a specific language impairment (SLI) and dyslexia fulfilled the criteria of the other diagnostic category (McArthur, Hogben, Edwards, Heath, & Mengler, 2000). There are indications that children under the age of five who have one or two parents with dyslexia, are likely to score lower than control children on speech related tasks such as rhyme awareness and production (Locke et al., 1997). In a study to determine whether SLI and dyslexia are distinct developmental disorders the results supported the view that SLI and dyslexia are distinct but potentially comorbid developmental language disorders. A deficit in phonological processing was closely associated with dyslexia but not with SLI when it was present in the absence of dyslexia (Catts, Adlof, & Hogan, 2005).

This evidence suggests an underlying neurological developmental disorder with a range of severities and clusters of symptoms which vary from individual to individual. A child could be diagnosed with one or more of the above developmental disorders depending on the group of symptoms he presents.

In addition, chromosome 6 is also close to the site linked to autoimmune diseases. It is also suggested that this gene locus may also be responsible for sensory, cognitive and attentional skills which are all necessary for smooth day-to-day functioning (Stein, 2004).

Thus it is suggested that the idea of dyslexia as a categorical trait should be rejected in favour of the idea of a varying continuum of developmental disorders (Francks et al., 2001).

1.8 Summary

Tim Miles' (Miles & Miles, 1990) view is that dyslexia is a disorder with a neurological basis and a neuropsychological evaluation should be undertaken along with traditional diagnostic assessment. Following on from this, Frith argues that rather than being restricted by tight definitions of reading failure along with arbitrary cut-off points and discrepancies, dyslexia should instead be thought of as neurological disorder, with a complex causal chain from biology to behaviour, and not just a reading problem (Frith, 1990). The evidence from twin, familial and co-morbid genetic studies supports this view. If we accept a genetic link to dyslexia (rather than just random or environmental factors) the next step is to look at what arises in a child with a predisposing genotype when that genotype interacts with the environment in utero and after birth.

Rather than referring to the theories in the next chapter as causal theories of dyslexia, it may be more appropriate to view them as links in the chain from genotype to phenotype. This is not to diminish their importance or the worthwhile research undertaken in each strand, rather to place the theoretical arguments in context. Predominantly the theoretical debate falls into two camps, differing in where the emphasis of explanation lies, cognitive processes or physiological functioning. The cognitive processes emphasis encompasses the phonological deficit hypothesis, the temporal deficit hypothesis, automatization deficit and the cerebellar deficit hypothesis. Following on from the genetic predisposition outlined above, the physiological emphasis includes neuro-anatomic aspects, the magnocellular deficit hypothesis, and reflex theory. The cerebellar deficit hypothesis could be seen as related to both the physiological and cognitive domains, indeed Fawcett argues that it is a 'unifying theory' (Nicolson, Fawcett, & Dean, 2001a). Nevertheless, it is obvious that cognitive processes must have their physiological process substrate and that differences in physiological functioning may impact on cognitive processes. Thus the distinctions here may be largely artificial. It may be best to view both processes as interactive and part of a system whose deficits may impact on reading. Reflex theory, for example, is strongly related to cerebellar processes and motor control. It is this theory, along with the early development of movement, that will be discussed in detail in Chapter 3.

2

Causal Theories

Reading and writing are among the most difficult skills we have to master. Many processes contribute to the act of reading including the ability to recognise and decode words and phonemes, the ability to process stimuli rapidly, the use of short and long term memory, and the automatisation and metacognitive management of the whole process.

The traditional view of dyslexia as a reading problem is now challenged by the view of dyslexia as a broader condition. Dyslexia is widely accepted as a congenital and neurological disorder. Beaton calls for a theory of causation at either the cognitive or biological level (Beaton, 2004). However many of the disparate theories of dyslexia are not in fact causal but descriptive. While they have often been difficult to integrate there is a growing consensus that they are not discrete theories and may overlap in accounting for a multi-system deficit with a neurological basis (Habib, 2000). Frith proposes different causal models based on genetic brain abnormalities, visual and phonological deficits, and on cerebellar abnormality (Frith, 1997). This over-arching three-level framework allows for the co-existence of different causal theories, which interact at the Environmental, Biological, Cognitive and Behavioural levels (Frith, 2001). See Figure 2.1.

In describing dyslexia it is important to make a distinction between these different levels.

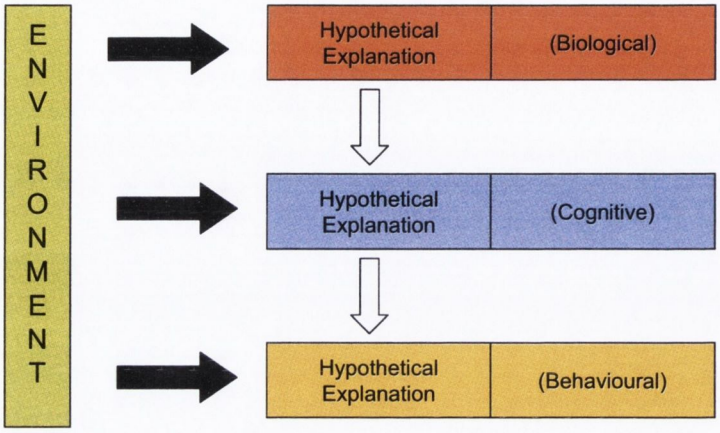

Figure 2.1: *Friths three-level framework adapted (Frith, 2001, p557).*

It is at the behavioural level where difficulties can be observed and assessments made. The biological level is where causes may be investigated. Thirdly, the cognitive level lies between these levels. At the cognitive level the disorder may potentially be characterised as a distinct and recognisable entity despite many varied symptoms (Frith, 1997).

The longest established and most widely accepted theory of dyslexia is that it arises from an impairment in phonological processing and/or phonological representation of words (Snowling & Hulme, 1994; Snowling, 2001). Other theories propose that dyslexia involves deficits in auditory temporal processing (Tallal, 1980, 1984); deficits in the automatisation of skills, including word recognition (Nicolson & Fawcett, 1994b) and in the visual and auditory magnocellular system (Stein & Walsh, 1997; Witton, Richardson, Griffiths, Rees, & Green, 1997).

It is obvious that cognitive processes must have origins in a physiological substrate. However the physiological underpinnings of dyslexia are largely unknown and most of the research to date confirms the correlation status of theories rather than any one or a combination of them having an unequivocal causal role. The main theories of dyslexia will be described briefly in this chapter followed by a proposed model of interaction (Figure 2.2) and an introduction to the aims of the current study, the Dyslexia Early Years Project.

2.1 Low Essential Fatty Acids

Starting at Frith's biological level and its interaction with the environment, it is worth mentioning research that suggests nutrition may have a part to play in the development of dyslexia. Essential fatty acids cannot be made by the body and so must be included in the diet. Research has found that deficiencies of certain Highly Unsaturated Fatty Acids (HUFAs), Omega-3 and Omega-6 can play a part in a range of behavioural and learning difficulties (Carroll, Mullaney, & Eustace, 1994) and visual acuity of infants (Makrides, Neumann, Simmer, Pater, & Gibson, 1995).

Stordy (1995) found that visual deficits in dyslexic adults were improved after supplementation with Omega-3 fatty acids. Furthermore brain imaging has shown abnormalities of membrane lipid turnover in dyslexic adults consistent with HUFA deficiency A later study found that dark adaptation was shown to be impaired in 10 dyslexic young adults when compared with a similar control group, dark adaptation improved in 5 dyslexia patients after supplementation with a docosahexaenoic acid (DHA)rich fish oil and movement skills in a group of 15 dyspraxic children improved after supplementation with a mixture of high-DHA fish oil, evening primrose oil, and thyme oil. However, since this study had no placebo control group and numbers were small, confidence in its results is undermined (Stordy, 2000). Double-blind, placebo-controlled studies, are needed to clarify the benefits of HUFAs in dyslexia and other closely related conditions.

Other results support the hypothesis that fatty acid metabolism is abnormal in dyslexic adults (Taylor et al., 2000) and that a high dietary intake of HUFAs may be beneficial in dyslexia. The associations found in controls between Fatty Acid Deficiency Signs (FADS) and visual symptoms suggest that HUFA supplementation might also help some non-dyslexic individuals. It is argued that some people may need higher levels in their diet because they have difficulty in converting simple Essential Fatty Acid (EFA) to the more complex HUFA, an unusually rapid breakdown and loss of HUFA, or a difficulty in recycling, transporting or incorporating HUFA into cell membranes

Among the male children, the correlation between fatty acid deficiency scores and reading and spelling ability was found to be significant (Richardson et al., 2000). However no non-dyslexic controls were used in this study and the measure of presumed fatty acid deficiency was not objective but based on a list of symptoms including excessive thirst, frequent urination, dry skin and hair. In both the adult and child studies, it was acknowledged that the effects reported may not be related to dyslexia but may be the result of the presence

of a confounding comorbid condition, attention deficit hyperactivity disorder (ADHD), which has also been linked to fatty acid deficiency (Stevens et al., 1995). While results at present are correlational and occurring in co-morbid neurodevelopmental disorders, further research into how fatty acid metabolism might relate to the functioning of the visual system is perhaps warranted.

2.2 Magnocellular Theory

One controversial theory of dyslexia is the magnocellular deficit theory. It is based on the idea that the magnocellular division of the visual system is responsible for carrying low spatial and high temporal frequency visual information and that there is some impairment of magno function in dyslexia (Lovegrove, 1996; Stein & Walsh, 1997; Stein, 2001).

The magnocellular stream (M-stream) is one of the two functionally separate visual pathways running from the retina of the eye, through the lateral geniculate nucleus (LGN) and culminates in the cerebellum which is involved in eye and limb movements. The M-stream consists of large cells and responds primarily to form and movement, depth, and small differences in brightness. It processes fast moving visual information which has high constrast sensitivity and low spatial sensitivity (Livingstone, Rosen, Drislane, & Galaburda, 1991). The second pathway, the parovcellular or P-stream feeds into the temporal cortex and and is responsible for the perception of fine detail, colour and high contrast. Its cells are smaller than the M-stream and it conducts information more slowly. Visual processing consists of sustained activity (fixations) and transient activity (rapid movements). Sustained activity is controlled by the parvocellular system and inhibited by the magnocellular system, whereas transient activity is controlled by the magnocellular system and inhibited by the parvocellular system.

Two partially independent systems are used in reading. The visual or orthographic system detects the visual form of the whole word and leads to direct understanding while at the same time triggering a parallel auditory representation. The auditory or phonological system decodes the sounds that make up letters, phonemes and syllables. These sounds are then combined to yield auditory representation of the whole word. Good visual and auditory function depends on the performance of the magnocellular neurones. Lovegrove et al. demonstrated that contrast and flicker sensitivity in dyslexics is impaired (Lovegrove, Bowling, Badcock, & Blackwood, 1980). The visual magnocellular system is responsible for timing visual events when reading and helps to keep the eyes fixated on their target.

This sensitivity to visual motion seems to help determine how orthographic skill develops. In dyslexics the development of the magnocellular layers of the lateral geniculate nucleus (LGN) is abnormal, thus motion sensitivity is reduced (Talcott et al., 1998; Eden, Van-Meter, Rumsey, Maisog, & Zeffiro, 1996) and many dyslexics show unsteady binocular vision (Stein, 2001). It is reported that some dyslexics find that letters appear to move around the page and cross over and thus monocular occlusion (blanking of one eye) may improve reading (Stein & Fowler, 1985).

The auditory magnocells in the brainstem signal changes in sound frequency and amplitude. Phonological ability (letter/sound rules) depends on auditory sensitivity to frequency and amplitude changes (FM & AM). In some cases dyslexics' auditory sensitivity is significantly lower than that of good readers and this may explain their phonological problems (Witton et al., 1997; Han, Saaskilahti, Helenius, & Uutela, 1999; Talcott et al., 2000a). Indeed it has been found that a deficit in extracting the suprasegmental attributes of the speech stream may contribute to the difficulties in phonological awareness in dyslexic children (Goswami et al., 2002).

The suggestion that dyslexics may have a specific impairment of their visual magnocellular system is disputed as the impairment is slight and not found in all dyslexics. A review of research (Skottun, 2000) found that studies supporting the magnocellular theory are far less prevalent than studies of spatial contrast sensitivity in dyslexics where no loss of sensitivity has been found or where contrast sensitivity reductions are inconsistent with a magnocellular deficit.

Pointing to a sensorimotor basis for dyslexia, Stein (2001) notes that the cerebellum receives a large magnocellular input and can be considered as the 'head' ganglion of the magnocellular system. While the cerebellum is known to be important for the acquisition of sensorimotor skills, its particular contribution to reading is mainly to control eye fixation and calibrate saccades as the eye moves from one word to the next and from the end of one line back to the beginning of the next. It is also argued that it may help to mediate the inner speech that is required for phonological analysis, for example when a child mentally sounds out the letters in a word.

Livingstone reported abnormalities in the magnocellular but not in the parvocellular layers of the LGN in dyslexic brain preparations. The brains examined were said to have been 'symmetrical' at the planum temporale (PT) and symmetry has been said to characterize phonological dyslexia (Larsen, Höien, Lundberg, & Ödegaard, 1990). However reviews of the literature have concluded that PT symmetry may not be indicative of dyslexia specif-

ically, but more likely to represent an oral rather than a written language deficit (Plante, Swisher, Vance, & Rapcsak, 1991). Beaton sounds a note of caution about the histological findings from dyslexic brains, stating that it is unlikely that there is any relationship between magno deficits and planum symmetry (Beaton, 2004). The same dyslexic brains have been used in previous studies of the planum temporale (Galaburda & Livingstone, 1985), lateral and medial geniculate nuclei (Livingstone et al., 1991; Galaburda & Livingstone, 1993) and the cerebellum (Finch, Nicolson, & Fawcett, 2002). However, Beaton has previously drawn attention to the uncertainties regarding the diagnosis of dyslexia with regard to these brains (Beaton, 1997).

It has been observed that compensated adult and child dyslexics show a deficit in matching speech sounds to the correct picture of corresponding articulatory movements (Griffiths & Frith, 2002). An alternative explanation may be that a subtle magno deficit in processing lip movements results in errors in perceiving the phonemes of speech in early childhood (Shankweiler, Crain, Brady, & Macaruso, 1992; Swan & Goswami, 1997a). The possibility of a weakness in registering the phonological representations of words is worth investigating (Snowling & Hulme, 1994) in the light of the co-morbidity of dyslexia and specific language impairment.

2.2.1 Noise exclusion in visual and other modalities

Research evaluating signal-noise discrimination in dyslexic and non-dyslexic children has found that deficits in visual noise exclusion, not magnocellular processing, contribute to the etiology of dyslexia (Sperling, Lu, Manis, & Seidenberg, 2005). Magnocellular and parvocellular visual stimuli were presented with and without high noise. The M stimulus consisted of wide bars that alternated between light and dark. The P stimulus consisted of thinner light and dark bars that did not alternate. In the no-noise condition the pattern appeared to one side of a central fixation mark, while the other side remained blank. In the high noise condition random bright or dark spots similar to tv static were presented on both sides of the fixation mark with the signal embedded in one patch. The children's task was to indicate the side of the screen that contained the pattern. It was found that dyslexic children had elevated contrast thresholds when stimuli of either type were presented in high noise. However they performed as well as non-dyslexic children when either stimulus was displayed without noise. It is important to tease out how such a deficit might affect reading acquisition. The authors propose that a noise exclusion deficit may affect reading through several causal pathways. One possibility is that noise hampers representations

of letters in the visual modality by interfering with the identification of word shape and boundaries between words, as well as recognition of sequential orthographic structure. Deficits at this level could have a negative effect on the development of phonological representations, as the child needs to be able to visually recognize the shape of a letter before associating it with a sound. He also needs to recognise the letter visually in a string of letters and blend the sound of the letter when it is used in conjunction with others.

Another possibility is that the visual deficit may be an indicator of a more basic underlying perceptual difficulty that interferes with the formation of perceptual categories in a variety of domains (Sperling, Lu, & Manis, 2004). It is the phonological category that is most relevant to reading but other modalities may be affected. This notion is consistent with evidence that speech perception is abnormal in infants at risk of dyslexia (Molfese, 2000). The fact that speech, attention and motor deficits co-occur in some children with dyslexia (Portwood, 1999; APA, 2000) lends some support for the hypothesis of an underlying perceptual difficulty affecting many modalities (Ramus, 2004).

2.3 Phonological Deficit Hypothesis

Despite differing views on the causes of dyslexia, the existence of a phonological difficulty is rarely disputed (Ramus, Pidgeon, & Frith, 2003). Described as a deficiency in the processing of linguistic units, or phonemes, that make up all spoken or written words (Shaywitz, Mody, & Shaywitz, 2006), it is the most widely held causal theory with up to two thirds of dyslexics presenting with a phonological deficit. According to the original proponents of the phonological deficit hypothesis, the deficit is a reduced sensitivity to the phonological structure of language (Snowling & Nation, 1997; Stanovitch, 1988b; Hagtvet, 1997). Phonological processing involves the analysis of spoken words into speech sounds and in particular the ability to link them to graphemes [1] [2].

Dyslexics often find it difficult to apply grapheme-phoneme or orthographic-phonological conversion rules. These enable the child to recognize a word that is unfamiliar in print but that is known to them in their spoken or hearing vocabulary (Stanovitch, 1986). There is still no universal consensus as to how phonological awareness influences reading ability. It

[1] grapheme: a unit of a writing system consisting of all the written symbols or sequences of written symbols that are used to represent a single phoneme

[2] phoneme: The smallest phonetic unit in a language that is capable of conveying a distinction in meaning

is argued that phonological recoding is the most common source of word reading difficulties in dyslexic children (Rack, Snowling, & Olson, 1992), accounting for the persistent but not universal occurrence of a non-word reading deficit in dyslexia (Snowling, 1980).

Research over the years has shown dyslexics to have impairments in phonological processing including delays in rapid and automatic naming (Denckla & Rudel, 1976), impaired verbal learning and memory (Nelson & Warrington, 1980), weak performance on non-word repetition and phoneme awareness (Snowling, Chiat, & Hulme, 1991; Bradley & Bryant, 1978), difficulty in segmenting phonemes (Kamhi & Catts, 1986), and difficulties in object naming (Snowling, Wagtendonk, & Stafford, 1988). Since the ability to read nonsense words is more predictive of the ability to read regular rather than irregular words (Baron, 1979), this may be a reflection of impaired phonological representation (Metsala, Stanovitch, & Brown, 1998; Brown, 1997) than specifically a spelling to sound translation.

Research suggests that phonological deficit cannot be accounted for by either a deficit in rapid or temporal processing (Ramus, 2003a, 2003b), or a lower-level auditory processing deficit (Amitay, Ben-Yehudah, Banai, & Ahissar, 2002), as a phonological deficit can appear in the absence of other sensory or motor disorders and is sufficient to cause literacy impairment.

However not all dyslexic adults and children have deficient phonological skills (Rack, 1997; Nicolson & Fawcett, 1995). This may indicate that there is a wide range of phonological ability among dyslexics and that not all dyslexic symptoms are caused by a problem with phonological awareness or recoding. Despite appearing to be a homogenous group, dyslexic children have different patterns of phonological skills and difficulties with different aspects of phonological processing, which may explain individual differences in reading and spelling performance (Snowling, 2000). One could conclude that some dyslexics have a specific phonological deficit while others have both phonological and sensorimotor impairments. However the evidence is inconclusive, and the association between the two is still to be explained (Ramus, 2006). Indeed very recent research (Ramus & Szenkovits, in press) suggests that phonological representations of dyslexic adults are basically intact and that a phonological deficit only surfaces under certain task requirements involving short-term memory, conscious awareness and time constraints. Instead it is proposed that some dyslexic adults have a deficit in *accessing* phonological representations. This point will be revisited in the Discussion chapter; next we will turn to the issue of timing.

2.4 Temporal Processing Deficit: A Timing Problem

Reduced capacity for processing rapid successive information may compromise oral and written development. For example, a child listening to a continuous speech stream must segment the acoustic signal into chunks that represent the phonemes of her language (Tallal, 2000). The working memory or short-term memory (STM) system holds information while it is being analysed. The STM is thought to be a limited capacity store capable of holding approximately seven 'items' or chunks. These items or chunks may contain a lot of information and are assumed to be held in the STM by rehearsal. If that is interrupted, the information has a half-life of 10-15 seconds. If the STM is deficient, the child is challenged and cannot hold the information for processing. There has been considerable discussion about the role of auditory temporal discrimination and perception in dyslexia and other developmental language disorders (Zurif, Gardner, & Brownell, 1970; Farmer & Klein, 1995). Tallal's work has mainly been with children with SLI and findings have been criticised for conceptual confusion (Studdert-Kennedy & Mody, 1995) in referring to a deficit affecting the rate of auditory information processing (rapid perception) and a deficit in 'auditory temporal analysis' (perception of temporal properties of stimuli) (Tallal & Piercy, 1978). Two issues that remain to be resolved are whether a temporal deficit exists (Mody, Studdert-Kennedy, & Brady, 1997) and whether it is specific to stimuli within the linguistic domain or whether it is a general auditory temporal deficit. Bishop et al. (1999a) found in a twin study that whereas phonological impairments were highly inheritable, auditory deficits were more tightly linked to experiential factors. They question whether non-verbal and speech processing deficits have a common origin.

Adding to the debate, a 'double deficit hypothesis' has been proposed which states that dyslexics have a general processing speed deficit in addition to phonological problems (Wolf & Bowers, 1999). In this conceptualisation children not only have trouble in distinguishing phonemes, but also perform poorly on tests of rapid naming which appear to measure something separate from phoneme awareness. These problems may occur together or be mutually exclusive. Children with both problems tend to be at the lowest end of the reading continuum suggesting a double deficit beyond what can be explained by the phonological deficit hypothesis above.

Poor performance on naming speed may indicate that in many people with dyslexia, brain circuits that connect visual information with the verbal system fail to operate efficiently. While this could indicate a problem specific to language or explain co-morbidity with SLI, it is argued that this suggests a difficulty with varying degrees of generality. In this

situation some people have difficulty rapidly processing just visual language and others having difficulties rapidly processing several types of information.

It is suggested that this 'temporal processing impairment' theory of dyslexia could also account for at least some of the perceptual, motor and cognitive symptoms very often associated with the learning disorder, a coincidence that has remained unexplained so far. Bridging the theories of Stein, Snowling and Wolf, (Stein & Walsh, 1997; Snowling, 1980; Wolf & Bowers, 1999) Habib proposes that there is a neurological mis-timing which results in streams of visual information decaying more slowly in dyslexics than non-dyslexics, and streams of auditory information being packaged in longer chunks of time in dyslexics than non-dyslexics (Habib, 2000). The end result is that the quality of information is poorer, which means that when visual and verbal information has to be matched up, such as when reading or spelling, the matching process is more complicated and takes longer. This theory places the difficulties that dyslexics encounter at quite a deep neurological level. However other research would argue that there is little evidence for a link between sensory deficits and phonology or reading (Ramus, 2001). In a study simultaneously looking at auditory, visual, motor and phonological skills in dyslexic children, the authors reported no significant group differences in any of the sensori-motor tasks, yet large differences in phonological skills (Kronbichler, Hutzler, & Wimmer, 2002).

2.5 Cerebellar Deficit/Automaticity Theory

Some definitions of developmental dyslexia imply that it is a pure disorder affecting literacy alone. However literacy problems are frequently accompanied by impairments in motor and perceptual functions. One theoretical framework, the cerebellar deficit hypothesis (CDH) (Nicolson et al., 2001a), predicts difficulties beyond literacy. Munhall (1994) noted that speech production lies at the junction between a symbolic linguistic system and the physiology of motor control. Speech and reading are serial activities extended in time. Other human behaviours are also organised according to temporal and spatial constraints, such as the ability to judge the speed of an object and adjust behaviour accordingly (Beaton, 2004). It is well known that dyslexics often have a history of difficulty with co-ordination and copying tasks (Miles, 1993; Denckla, 1985). However, this is not just apparent in gross motor movement: fine motor skills, which have an impact on handwriting, are also affected in some dyslexic children (Rudel, 1985). Children with SLI also perform poorly on uni-manual motor tasks and it is suggested that '*genes*

that put the child at risk for communication problems also affect motor development, with the association being the most evident when speech production is affected',((Bishop, 1991) p.56).

Fawcett and Nicolson (2004) propose an ontogenetic causal chain, where cerebellar abnormality from birth leads to slight speech output fluency, in turn leading to difficulty in hearing speech sounds and then to impaired phonological awareness. While cautioning that this causal chain awaits confirmation, they suggest that this theory demonstrates how an abnormality in the cerebellum can lead, via difficulties in cognitive processing such as poor automatization and phonological impairment, to deficits in reading.

Difficulty with balance and co-ordination in children with dyslexia has long been noted (Orton, 1925). Nicolson and Fawcett (1992) assert that demands on attentional resource allocation can cause dyslexics to fail to carry out tasks such as balancing automatically. They propose that dyslexia is a general learning deficit not specific to reading but affecting the final stage of any skill mastery - where the skill becomes fluent or automatic. Thus dyslexia is seen as an 'automatization' deficit where the extra resources necessary for coping only become apparent when a second task is performed simultaneously (as in the dual task of balancing and counting backwards (Nicolson & Fawcett, 1990)). Here the child's conscious compensation coping mechanism is tested to an unsustainable level, and performance on the first task deteriorates. However this work (Fawcett & Nicolson, 1992) has proven difficult to replicate except in children with high ratings for attentional difficulties (Yap & A. Van der Leij, 1994; Wimmer, Mayringer, & Raberger, 1999). Attentional problems therefore may cause the dual task balancing problems seen in these studies (Raeberger & Wimmer, 2003). Wimmer and Raebeger argue against Nicolson and Fawcett Cerebellar Deficit Hypothesis which proposes that balance problems are a sign of a cerebellar deficit and were found to be associated with dyslexia. Their work found that poor balance skills were found to be associated with ADHD, whereas poor performance on rapid naming was found be be associated with reading disability (Raeberger & Wimmer, 2003). Difficulties learning to read are due to a phonological deficit and not to a general skill-automatization deficit (Wimmer, Mayringer, & Landeri, 1998).

The automatization deficit hypothesis does not dismiss the importance of phonological deficits in the aetiology of dyslexia in that phonological skill is one of the earlier skills to be automatised (Fawcett & Nicolson, 1992). Further work comparing motor and cognitive tasks in dyslexic children found that the motor deficit shown by dyslexics occurred in addition to '*weak or transient deficits for non-word repetition and speech rate; small but persistent impairments for phonological discrimination and digit span; and a marked and*

persistent impairment in rhyme and segmentation' (Nicolson and Fawcett, 1994a, p.159).

Further evidence for a connection between dyslexia and motor control shows that poor readers performed significantly weaker on tasks of manual dexterity (on eye-hand coordination and two hand coordination) and on tests of balance (Iversen et al., 2005). Not all the children were dyslexic, however 63% of the dyslexic group and 53% of the 'poor reader' group scored at or below the 5th percentile compared to only 13% of the control group.

However the extent of comorbidity with other disorders also raises the issue of whether, if cerebellar abnormalities are found, are they correlates of dyslexia or are they merely associated problems or linked to another deficit? Bishop recommends that the presence or absence of two other disorders, SLI and ADHD are documented as, if a cerebellar abnormality is found in a dyslexic subject it is tempting to assume it is instrumental in producing reading difficulties, however the opposite could be true. The cerebellum has considerable plasticity, and can be influenced by, as well as influence cognitive and behavioural deficits (Bishop, 2002).

An alternative view to the one that the cerebellum plays a role in language and other tasks is that cerebellar activation may reflect the preparation for all possible responses, not just in articulation or reading (Ivry, 1997).

Another aspect of the cerebellum's influence on learning via timing, balance, motor and ocular control is explored in recent research into the retention of primitive reflexes (McPhillips, Hepper, & Mulhern, 2000; Jordan-Black, 2005; Blythe, 2001). The chronology of primitive reflex development is well established (Gesell, 1938) however research into this area in relation to dyslexia is more recent and ongoing. The role of primitive reflexes in early development and research highlighting the possibility that the cerebellum is involved in cognition will be explored in the next chapter.

It may be most fruitful to view dyslexia as a multi-system deficit that is most apparent when there is a failure to read but can often have other symptoms. Physiological, cognitive and behavioural levels of dyslexia are interdependent and may be influenced by both genes and the environment. Environmental stresses on the developing fetus include inadequate nutrition, abnormal metabolism of fatty acids, or high levels of toxins in the womb environment (Stordy, 1995; Chaudhuri, 2000). If a certain genotype is present and the development of the fetus is compromised by an inadequate environment, neural connections may be impaired (McCartney & Hepper, 1999). Reduced fetal reflex movement

in the womb could have an impact on the emergence of reflexes and the development of cerebral dominance in the infant (Gazzaniga, 1973) and on vestibular dysfunction (Ayres, 1979).

To conclude, the evidence so far shows that the cerebellum is responsible for motor control in the developing child and primitive reflexes emerge and should be inhibited at certain developmental stages (Holt, 1991). Fetal movement is necessary for development of muscle tone (McCartney & Hepper, 1999) and increased myelination aids the transmission of nerve impulses (Kolb & Whishaw, 1996). A phonological deficit impairs the discrimination and phonological representation of words (Snowling, 2001). ADHD, a co-morbid condition, impedes concentration and thus short-term memory that is necessary to hold words or letters before committing them to long term memory for later recall is compromised. Poor visual tracking and motor control can affect fluent reading (Stein, 2001) and poor hand-eye coordination affects handwriting (Portwood, 1999). Whether all these deficits link together to affect the dyslexic child's academic performance is still unclear, and some would argue that it is in only a subset of dyslexic children that a sensori-motor deficit may exist alongside, rather than cause, reading impairment (Ramus, 2003a).

In order to explain the theory Figure 2.2 proposes a developmental pathway along which visual, auditory and motor deficits may appear and have knock-on effects on automatization and the development of phonological skills, thus compromising reading acquisition at school for some children. If a genetic predisposition to dyslexia impairs neural connections in the womb, the transmission of stimuli necessary for healthy fetal movement may be low. Laterality and reflex inhibition could be affected along with the VOR and motor development after birth. If neural connections are not efficient this may result in noise in the system which could help explain the co-morbidity of speech, attention and sensori-motor problems in dyslexic children where tasks have not become automatised and access is haphazard. The cerebellum aids reading via the Vestibular Ocular Reflex, ensuring accurate eye movements. Thus aberrant reflex activity may affect oculo-motor functioning which impacts on children's readiness for school. Where perception of both auditory and visual detail is impaired, phonological representations and decoding take longer, working memory is slower, and motor outputs are not smooth. In real terms these deficits affect the child's visual pursuit, hand-eye coordination and recall of words ultimately impacting on their reading and writing performance.

The work reported in this dissertation attempts to answer some of the questions raised above about the contributions of the cerebellar deficit and the retained reflex hypotheses to a developmental theory of dyslexia. To do so, the Dyslexia Early Years Project aimed

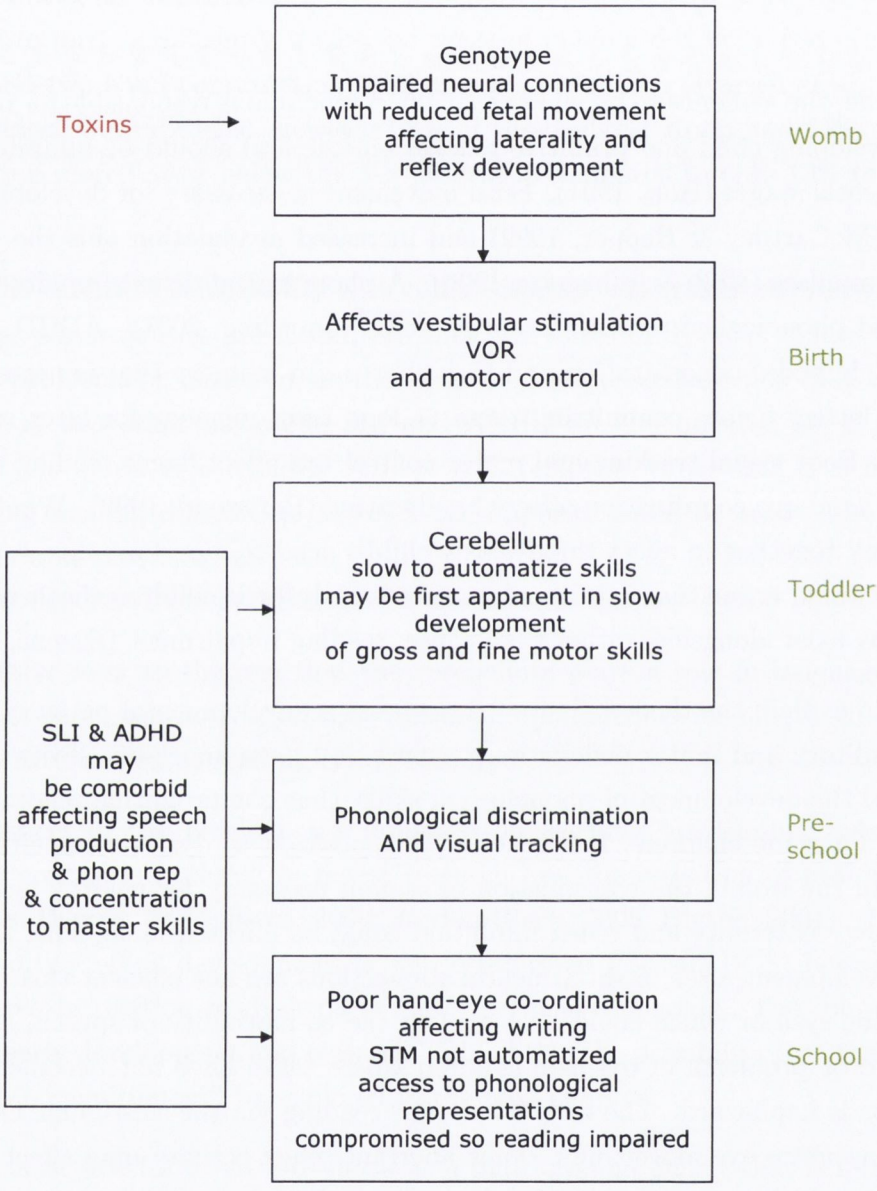

Figure 2.2: *A speculative causal model for learning difficulties.*

to ascertain whether the risk of dyslexia in young children who had completed one of two movement intervention programmes decreased over one year of treatment. It also set out to look at early indicators of dyslexia from a battery of balance, motor and retained reflex tests.

It is estimated that of those children diagnosed with dyslexia before 8 years of age, 82% can be brought up to their class level within 2 years. This percentage steadily drops and by age 14 just 6% achieve such gains, (cited in Goldberg & Schiffman, 1972). Thus it is imperative to predict which children may develop dyslexia and put remediation programmes in place. To-date, intensive reading instruction is deemed most efficient and incorporates phonemic decoding, fluency in word recognition and text processing, construction of meaning, vocabulary, spelling and writing (Foorman & Torgesen, 2001). Recent research has opened up the debate around the efficacy of motor programme interventions. A study by Reynolds et al. (2003) and a recent follow-up (Reynolds & Nicolson, 2007) showed that children who followed a programme of balance and cerebellar stimulation improved on balance and reading scores and a study in the Lancet in 2000 claimed that retained reflex replication had reduced the persistence of retained reflexes and improved children's reading scores (McPhillips et al., 2000). See Chapter 4 for a critique of this work.

After reviewing this work, it was decided to evaluate the role of motor and balance development in the ontogenisis of dyslexia. The main aims of the Dyslexia Early Years Project were to evaluate the efficacy of two motor interventions in remediating dyslexia as follows:

Aim 1: To investigate whether a movement programme designed to reduce the persistence of retained reflexes reduces the risk of dyslexia as measured by the Dyslexia Screening Test/Dyslexia Early Screening Test (DST/DEST) and phonological measures of pre-reading skill.

Aim 2: To investigate whether a movement programme designed to stimulate the vestibular system and improve balance skills reduces the risk of dyslexia as measured by the DST/DEST and phonological measures of pre-reading skill.

In the event of no treatment effects, it was also proposed to test the efficacy of a motor test battery in predicting dyslexia in young children as follows: [3].

1. Whether the balance test battery as a whole was a predictor of risk of dyslexia as

[3]Note that in principle, this can be done looking exclusively at the control group. However, since neither intervention worked, the entire sample of four groups could be used in the end

per the DEST/DST.

2. Whether the reflex battery as a whole was a predictor of risk of dyslexia as per the DEST/DST.

3. Whether the oculo-motor functioning tests were a predictor of dyslexia as per the DEST/DST.

4. Whether the motor/adiadochokinesia tests were a predictor of dyslexia as per the DEST/DST.

5. Whether the phonological tests were a predictor of dyslexia as per the DEST/DST.

The next chapter describes early movement, the development of reflexes and the role of the cerebellum in motor control. A review of the reflex and balance movement programmes that are used to treat dyslexia follows that chapter.

3

Early Movement and the Development of Reflex and Postural Control

The previous chapter has considered the main causal theories of dyslexia. In order to understand how the test battery and treatment programmes for the current study were developed, this chapter describes early movement from the emergence of reflexes in utero to the acquisition of postural control as the child prepares for learning in school. The influence of the Central Nervous System on the development of early movement is described. This leads to a discussion of the difficulties that arise when primitive reflexes are not inhibited fully. The Cerebellum's role in this is also discussed. The chapter concludes by proposing a model of the stages in the developmental pathway that may be adversely affected and result in a Specific Learning Difficulty.

3.1 Central Nervous System

The Central Nervous System (CNS) is the largest part of the nervous system and includes the brain and the spinal cord. Together with the peripheral nervous system, it has the fundamental role of controlling behaviour. One aspect of the CNS is to act as a system in which appropriate motor output is computed as a response to sensory input. However research suggests that motor activity exists well before the maturation of the sensory systems, and that the senses only influence behaviour without dictating it. There is mounting evidence that the rich repertoire of fetal movement patterns plays a significant role in the development of the nervous system and the muscles. It seems that not only are they important for the regulation of natural cell death in the brain and spinal cord but also modulate the fine tuning of the connectivity of the central nervous system (Prechtl, 1997).

3.1.1 Neural Connections, Facilition and Inhibition

The neuron is the basic unit of the nervous system. Neurons are electrically excitable cells in the nervous system that process and transmit information. They are the core components of the brain, spinal cord and peripheral nerves. Neurons are typically composed of a soma, or cell body, a dendritic tree and an axon. They receive input on the cell body and dendritic tree, and transmit output via the axon.

Neurons communicate via chemical and electrical synapses, in a process known as synaptic transmission. Synapses can be both excitatory and inhibitory. The fundamental process that triggers synaptic transmission is the action potential, a propagating electrical signal that is generated by exploiting the electrically excitable membrane of the neuron. Excitation is the activity produced in an organ, tissue, or cell of the body that is caused by stimulation, especially by a nerve or neuron. Excitatory neurons excite their target neurons. Inhibitory neurons inhibit their target neurons. Inhibitory neurons are responsible for locally regulating the activation of excitatory neurons which carry the information flow. Neurons are classified as follows: afferent neurons convey information from tissues and organs into the central nervous system. Efferent neurons transmit signals from the central nervous system to the effector cells and are sometimes called motor neurons. Interneurons connect neurons within specific regions of the central nervous system. Afferent and efferent neurons can also refer generally to neurons which, respectively, bring information to or send information from brain region.

The combination of excitatory and inhibitory messages produces modulation which is the process by which the nervous system organizes itself (Ayres, 1979). For example, messages from the vestibular nuclei facilitate motor messages throughout the spinal cord to maintain our muscle tone and body posture. Meanwhile the activity of the vestibular nuclei is inhibited by messages from the cerebellum. This inhibition prevents vestibular activity from becoming excessive. Every sensory and motor process involves a complex arrangement of facilitory and inhibitory forces. Without sufficient inhibition, sensory impulses would spread like wildfire through the nervous system and the body would be overwhelmed. The ability to modulate sensation is one process that the young child must learn in order to be able to deal with sensory stimulation later on in life.

While the newborn infant has most of his neurons at birth, he has very few interconnections or synapses between the neurons. Neurons must be stimulated to grow and develop interconnections. As the infant interacts with his body and the world, the sensory and motor impulses transmitted along the neurons cause the fibres to grow and reach out to other neurons. Sensory stimulation and motor activity during early childhood will mould the neurons and interconnections to form sensory and motor processes that will remain relatively stable for life. The sensory and motor parts of the nervous system continue to be somewhat flexible during childhood, however by the age of 10, growth of connections is practically complete in most parts of the brain (Ayres, 1979).

3.2 Myelination

Myelination is the development of a fatty sheath of myelin around the axons of the emerging neurons in the central nervous system. This promotes nerve impulse conduction in the fetus and newborn. The process of myelination is a clear marker of CNS maturity allowing efficient communication both within and between emerging neural structures. Myelination begins at about 22 weeks in the spinal cord roots. By birth there is some evidence of myelination in almost all parts of the CNS (Holt, 1991). Myelin is laid down by the glial cells as insulation for the nerve fibres but the rate and pattern of myelination varies for different parts of the CNS. The functions of the CNS depends upon synaptic connections between the axons and dendrites of cells.

The brain stem is the first area of the brain to myelinate and it is largely myelinated at birth. The first reflexes of the newborn (primary reflexes) such as sucking are controlled by the brain stem (Jean, 2001). The pattern of myelination within the spinal cord is from

head to tail.

The earliest movements generated by the embryo and fetus would seem to begin before sufficient myelin is laid down in the spinal cord for these to originate in the brain stem. It is suggested that movement is initially generated at the periphery of the system and that this has an effect on the later development of higher centres within the CNS (McCartney & Hepper, 1999). Although the spinal cord may not be myelinated in the early months of gestation, it may still be possible for a degree of conduction to take place as nerves become functional before myelination (Kolb & Wishaw, 1996). The distances involved at this stage are very small (about 5cm long at 12 weeks gestation) and it may be possible that the emerging brainstem is directly involved in the generation of the earliest movements. It would follow therefore that these reflexive movements would in turn impact on the development of the brainstem and closely associated structures such as the cerebellum.

The emergence of lip and oral sensitivity at eight weeks gestation further suggests the early involvement of the brainstem in sensory movement via the cranial nerves. Further research is needed to determine if the brainstem is the location for the 'independent modules' that control early movement (Prechtl, 1992) or if the onset of movement is generated at a local level coming under brainstem control as myelination proceeds.

At birth, movement is controlled by lower brain structures including the brain stem and cerebellum. Although the primary sensory and motor areas of the neocortex show some myelination before birth, the pyramidal tract, a large collection of axons that travel between the cerebral cortex and the spinal cord, is still not myelinated. Its role is to send information from the motor cortex to the motor neurons but at birth it is not able to conduct impulses efficiently. The pyramidal tract becomes increasingly myelinated during early development and this allows the development of voluntary, conscious movement and the inhibition of brainstem mediated reflexes that characterise fetal and newborn life.

3.3 The Vestibular System

The vestibular or balance system is the sensory system that provides the dominant input about the body's movement and orientation in space. Together with the cochlea, the auditory organ, it is situated in the vestibulum in the inner ear. The vestibular system comprises two components: the semicircular canals, which indicate rotational movements; and the Otoliths, which indicate linear translations. Information from the vestibular

apparatus is used primarily to influence the muscles that contribute to the equilibrium and to the eye movements that ensure that the retinal image is kept stationary when the head moves.

The sense of equilibrium [1] depends on signals from sense organs that record the position and movements of the head. Such receptors are found in the *vestibular apparatus* in the inner ear. Together with the cochlea they form the *labyrinth.* Signals from vestibular receptors contribute to our conscious awareness of the position of the body in space, although the main tasks of the vestibular apparatus are automatic or reflex control of equilibrium and eye movements. The vestibular apparatus is not the only source of sensory information for maintaining equilibrium however, and neither does it provide all necessary information. Visual information and signals from somatosensory receptors (found in the skin muscles and joints of the body) also contribute. To control the upright, bipedal position of the human body, the brain needs information not only of the position of the head in space (provided by the vestibular receptors) but also the position of the head in relation to the body and the mutual positions of the major body parts (Brodal, 2004).

The vestibular apparatus emerges in utero. It is mature in shape and is partially innervated by eight weeks gestation and by six months it is also mature in size and completely innervated. It is the only organ in the body to become 'adult' in size during gestation (Balashavo, 1963). It projects to the four vestibular nuclei in the brain stem and to the cerebellum.

The vestibular nuclei provide a complex integrative function connecting with the thalamus and sensory cortex, the visual system via the oculomotor nuclei, the reticular information, the spinal cord and the cerebellum. They are directly involved in postural control through the vestibular-ocular-motor pathways and the vestibular-spinal tracts (Magnus 1926 cited in McPhillips 2003).

3.4 The Visual System

The visual system has the complex task of (re)constructing a three dimensional world from a two dimensional projection of that world. The psychological manifestation of visual information is known as visual perception. The visual cortex is responsible for

[1] a state of rest or balance due to the equal action of opposing forces of gravity and skeletal muscles

higher-level processing of the visual image. It lies at the rear of the brain above the cerebellum.

Convergence is the simultaneous inward movement of both eyes toward each other, usually in an effort to maintain single binocular vision when viewing an object. Saccades are quick, simultaneous movements of both eyes in the same direction. Initiated by the frontal lobe of the brain, saccades serve as a mechanism for fixation, refixation, rapid eye movements and the fast phase of optokinetic nystagmus (Cassin & Solomon, 1990). These must be fully developed to allow the eyes to scan along a line of letters and send a clear image to the brain when reading as only the fovea on the retina of the eye has sufficient visual acuity to discriminate the fine detail of written text. Saccades take the eyes to a new fixation point although not all saccades are 'progressive', about 15% of saccades involve 'regressive' or backward movements of the eyes.

Pursuit movement is the ability of the eyes to smoothly follow a moving object. It is one of two ways that visual animals can voluntarily shift gaze, the other being saccadic eye movements. Pursuit differs from the vestibulo-ocular reflex, which only occurs during movements of the head and serves to stabilize gaze on a stationary object.

3.4.1 Vestibulo-ocular Reflex

The Vestibulo-ocular Reflex or VOR is a reflex eye movement that stabilizes images on the retina during head movement. It produces an eye movement in the direction opposite to the head movement, thus preserving the image on the centre of the visual field (Ito, 1989). For example, when the head turn to the right, the eyes move to the left, and vice versa. Since slight head movements are present all the time, the VOR is very important for stabilizing vision. The 'gain' of the VOR is defined as the change in the eye angle divided by the change in the head angle during the head turn. If the gain of the VOR is wrong - for example if eye muscles are weak or if a person puts on a new pair of eyeglasses - then the head movements result in image motion on the retina which produces blurred vision. In such conditions, motor learning adjusts the gain of the VOR to produce more accurate eye motion, this is referred to as VOR adaptation. The cerebellum is essential for motor learning to correct the VOR in order to ensure accurate eye movements.

Aberrant reflex activity affects oculomotor functioning. The asymmetrical tonic neck reflex (ATNR) has an adverse effect on tracking while the tonic labyrinthine reflex (TLR) affects convergence. The Moro reflex affects fixation and the symmetrical tonic neck reflex

(STNR) impacts on the readjustment of binocular vision from one distance to another. These reflexes and how they mediate effects on oculo-motor functioning will be described in 3.16.

3.5 Proprioceptive System

Proprioception is the mechanism involved in the self-regulation of posture and movement through stimuli originating in the receptors embedded in the joints, tendons, muscles and the labyrinth. This sensory information caused by contraction and stretching of muscles and compression of joints informs the brain of body position. Unlike the six exteroceptive senses (sight, taste, smell, touch, hearing, and balance) by which we perceive the outside world, proprioception is an interoceptive sense that provides feedback solely on the status of the body internally. It indicates whether the body is moving with required effort, as well as where the various parts of the body are located in relation to each other.

Kinesthesia is a term that is often used interchangeably with proprioception. However kinesthesia refers only to the sensations involved in active muscle movement and is the conscious awareness of joint position and movement.

3.6 Sensory Integration

Sensory integration is the ability to take in information through all the senses to combine the resulting perceptions with prior information, memories, and knowledge already stored in the brain, in order to derive coherent meaning from processing the stimuli. The mid-brain and brainstem regions of the central nervous system are early centres in the processing pathway for sensory integration. These brain regions are involved in processes including coordination, attention, arousal, and autonomic function. After sensory information passes through these centres, it is then routed to brain regions responsible for emotions, memory, and higher level cognitive functions.

Sensory Integration Dysfunction is a neurological disorder causing difficulties with processing information from the five classic senses (vision, auditory, touch, olfaction, and taste), the sense of movement (vestibular system), and/or the positional sense (proprioception) (Case-Smith, 2005). Sensory information is sensed normally, but perceived abnormally. This is not the same as blindness or deafness because sensory information is sensed but

tends to be analyzed by the brain in an unusual way that may cause pain or confusion (Biel & Peske, 2005).

Sensory integration dysfunction can be a disorder on its own, but it can also be a characteristic of other neurological conditions, including autism spectrum disorders, dyslexia, dyspraxia, pervasive developmental disorder, Tourette's Syndrome, multiple sclerosis, and speech delays (Schaaf & Miller, 2005). Unlike many other neurological problems that require validation by a licensed psychiatrist or physician, this condition can only be properly diagnosed by an occupational therapist. There is no known cure, however there are many treatments available (see www.enableireland.ie, www.dyspraxiaireland).

Brain damage is one condition that usually leads to poor sensory processing, however in most cases of sensory integrative dysfunction there may not be actual damage to the structure of the brain. The problem may be mild and be at least partially corrected by therapy (Ayres, 1979). Reading, writing and arithmetic require a great deal of sensory integration. Sensory integration dysfunction may interfere directly with the learning process in the brain. It may also cause poor behaviour or concentration that may interfere with school work even though the child has a normal capacity for learning.

3.7 Developing a Sense of Balance

The first of all the senses to develop, is the sense of balance. It is vital for posture, movement, and a sense of 'centre' in space, time, motion, depth and self. Stimulation of the balance mechanism is an integral part of the embryo's growth. Every movement that the mother makes is felt in the cushioned environment of the womb. After birth the movements continue to be sensed through a vast repertoire of movement patterns from lying, kicking, rolling and sitting, to crawling and creeping on hands and knees, walking and running, hopping, skipping, swinging, rolling and tumbling. Through these movements further connections are made between the vestibular system and higher centres in the brain. It is not until the age of 7-8 years that the balance mechanism, cerebellum and corpus callosum are myelinated and it is in these early years that vestibular stimulation is the natural ingredient of every normal child's play.

The infant begins with constant repetition of arm and leg movements, practising extension and flexion of the muscles and training hand-eye coordination (Goddard, 1996). At 6 months the child will roll back and forth across the floor preparing the balance system

for sitting, standing, and eventually walking. Crawling on hands and knees allows the combination of vestibular, proprioceptive and visual systems for the first time. Walking increases mobility and allows the independent use of the hands. These are the early building blocks for learning which must be practised and integrated.

3.8 Fetal Movement

Fetal movement is generated from within although it may be affected by environmental agents such as alcohol, toxins and hormones (Chaudhuri, 2000; Jones & Smith, 1973). Fetal Alcohol Syndrome (FAS) is an irreversible condition occurring in some children of mothers who have consumed alcohol during pregnancy. It is characterized mainly by craniofacial malformations, physical and mental retardation, cardiac septal defects and minor joint abnormalities. A lesser degree of these deformities sometimes unnoticeable is described as Fetal Alcohol Effect (FAE), the main characteristic of which is varying degrees of mental retardation (Behrman, Kleigman, & Jenson, 2000). Fetal movements are random but are fully patterned and co-ordinated from the outset (Prechtl, 1992). Despite the complete change of physical environment at birth from the fluid-filled intrauterine world of the fetus to the 'dry' air breathing world of the newborn, the movements of the newborn remain essentially the same. Furthermore, these movements survive despite the major structural changes in the central nervous system which occur during fetal and newborn life. Prechtl (1992) likens this process to 'pattern-generation' where movements are released by independent modules within neural development.

This is consistent with recent findings that show neural activity is not haphazard but consists of co-ordinated waves of neuronal signalling from the moment inter-neuronal connections are made (Katz & Katz, 1996). These waves of excitation and inhibition shape the very structure of the developing neural system and the rhythmic firing of neurons is not viewed as a by-product of underlying development but as an essential part of the process, see Figure 3.1. From the moment one neuron connects with another the development of the CNS becomes an interactive process. This allows the genetic code, which is finite, to extend its influence beyond a simple mapping process.

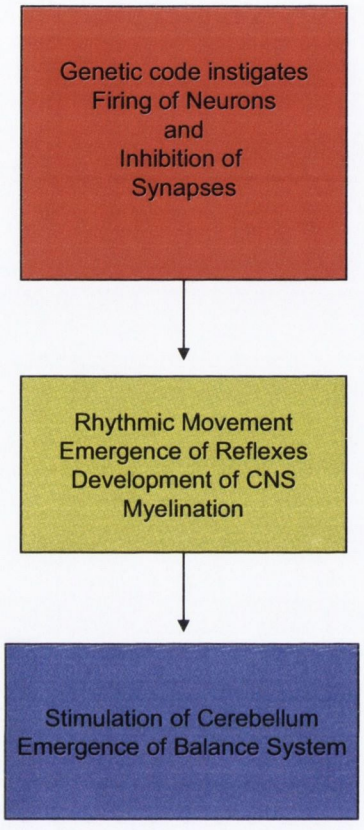

Figure 3.1: *The progress of early development in the foetus.*

3.9 Early Development

The sequential development of muscular tone and reflexes is a feature of early development in the fetus. A caudocephalad pattern (lower to upper extremity) and a centripetal (distal to proximal) pattern guides the development of tone and reflexes. However the sequence of motor development in the newborn during the process of myelination of the central nervous is in the opposite direction. Arnold Gesell, founder of the Child Development Center at Yale University, described the features of child development as occurring in several channels or pathways: gross and fine motor, adaptive, language and personal-social pathways (Gesell, Amatruda, Castner, & Thompson, 1930; Gesell & Amatruda, 1947). On the basis of these observations Gesell considered the pattern of development to be so uniform that he felt that it must follow the priniciples below:

- development occurs in a definite sequence
- development shows a cephalocaudal progression (head to toe)
- development proceeds from gross undifferentiated skills to precise and refined ones.

3.10 Reflex Theory

A reflex theory of motor control was first proposed in 1906 by the neurophysiologist Sir Charles Sherrington. This theory views movement as a combination or sequence of reflexes. Complex movements are described in terms of compound reflexes and their successive chaining. A stimulus is required at a receptor, and is conducted via a neural pathway to a effector (muscle) which produces a motor response. This structure is known as the reflex arc, and through feedback may produce the next stimulus for the next response (chaining). Over the years, therapists have referred to this concept as a sensory-motor, cause-effect system.

Gesell proposed the 'neuro-maturational' theory of human motor control, arguing that increased 'corticalisation' of the brain eventually resulted in higher-order movement patterns, free from the control of retained reflexes (Gesell, 1988). This hierarchical theory of motor development, where complex reflexes are controlled by higher levels of the Central Nervous System was popular during the 20th century (Boabth, 1965; Fiorentino, 1972).

Primary or primitive reflexes are movement patterns which emerge during fetal life and are critical for the survival of the newborn. Primitive reflexes emerge in utero and their emergence at this early stage of development suggests that they may play a critical role in determining CNS functioning (Illingworth, 1987). Many of these reflexes involve large stereotypical movement patterns. They may assist the birth process and they provide strong survival responses for the newborn.

More than 70 primitive reflexes have been identified (Illingworth, 1987) and they may be classified according to function, time of appearance or the type of stimulus that elicits them. As they are inhibited or transformed during the first year of postnatal life, a secondary or postural reflex system emerges that provides reflexive support for movement and balance as the child moves to the upright world of the toddler. Reflexes are said to 'persist' or to be 'retained' if they have not been inhibited. The postural reflex system is closely linked to the cerebellum (Kohen-Raz, 1996) and it becomes pre-eminent as the

central nervous system matures. It is should remain active throughout adult life.

It appears that neurological reflexes may operate within a hierarchical system starting with the reflex mechanisms of the brainstem, through the medulla and the pons, the reticular activating system, the hindbrain and the basal ganglia. They operate via the vestibular nuclei under the influence of the vestibular apparatus, up to the primary limbic system of the cerebral cortex, with the cerebellum playing an important role in integrating each stage of development (McGlown, 1990). If any of the primitive reflexes are retained longer than they should be, or fail to be transformed, the developing central nervous system will have a functional, and perhaps even a structural weakness and the inhibitory activities of the cerebral cortex will fail to develop. The hidden mechanisms of a hierarchy of reflexes are at the very heart of the development which depends on a programmed and smooth transition from primitive infantile and postural reactions to higher modified and transformed reflexes which form the automatic content of voluntary actions.

3.11 Development of Reflexes

Primitive reflexes are automatic, stereotyped movements, directed from the brain stem and executed without cortical involvement. Primitive reflexes emerge in utero, and are present at birth. They should be inhibited by 6-12 months and are essential for the survival of the infant in the first few weeks of life. They have a limited life-span and after helping the infant survive the first few months of life, they are usually inhibited and controlled by higher centres of the brain allowing more sophisticated neural structures to develop, which then allow the infant control of voluntary response.

During the first year of life, as connections to higher centres in the brain are established, the increased involvement of higher brain centres is reflected in the transformation of primitive to postural reflexes. This marks the successful passage of the baby through basic postural abilities and motor skills in the early years. These skills underpin later automatic control of balance, posture, coordination and centres involved in the control of eye movements. The increased involvement of higher brain centres also reflects increased maturity in the functioning of the central nervous system (Blythe, 2005).

3.12 Emergence of Reflexes

Each reflex has a vital part to play in setting the stage for later functioning. Five weeks after conception the embryo starts to show signs of response to external stimuli. Gentle touch to the upper lip will cause the embryo to withdraw immediately from the stimulus. A few days later, this area of sensitivity will spread to include the palms of the hands and soles of the feet until eventually the whole body surface is responsive to touch. At this stage the response is always one of withdrawal from the source of contact and is a total body reaction. As tactile awareness develops, withdrawal upon contact gradually lessens.

It is when the withdrawal reflexes are gradually lessening at about 9 weeks gestation that the first of the primitive reflexes emerge. The presence of a cluster of such reflexes may be indicative of neuro-developmental delay (Goddard, 1996).

3.12.1 Emergence of Primary Reflexes

The Moro reflex appears between 9 and 12 weeks after conception and is followed by the Palmer reflex at around 11 weeks in utero. This is gradually transformed from an involuntary grasp to fine finger control. The palmar reflex is seen when a finger is placed in the palm of the infant and the fingers flex. A tight grip is maintained as long as the stimulus is present. Similarly, the planter grasp may be stimulated by a light touch across the sole of the the foot resulting in a downward curl of the toes. It may be that these grasp reflexes reflect our evolutionary history when clinging to the mother's fur was an important response. It is thought that the palmar grasp is replaced by the pincer grip when the infant is about six months old. A retained palmer reflex beyond 5 months after birth impedes the development of both manual dexterity and manipulation of objects (Holt, 1991). Handwriting will be affected later as the child will be unable to form a mature pencil grip. This is often seen in dyslexic children. As both the hands and mouth are major sources of exploration and expression during the neonate period, continued reflex activity in the area may have an adverse effect upon fine muscle coordination, speech and articulation. This points to co-morbidity of specific learning difficulties and speech and language problems (Portwood, 1999).

The Babinski or Plantar reflex should not be confused with the Babkin reflex described below. The Babinski reflex is one of the fundamental signs of a lesion of the pyramidal tract and is most useful diagnostically in neurological examinations (Holt, 1991). It is

elicited by a sharp stroke along the lateral border of the sole of the foot of the infant from heel to toe. The response consists of movement (either flexion or extension) of the big toe and sometimes fanning of the other toes. The reflex is present throughout life but after 2 years of age the motor response should become more controlled and restricted.

The rooting reflex emerges 24-28 weeks in utero, is fully present at birth and should be inhibited at 4 months. A light touch on the cheek or edge of the mouth will cause the infant to turn the head towards the stimulus, and open the mouth with extended tongue in preparation for sucking. The persistence of rooting and infant suck reflexes beyond the first six months after birth may disturb the emergence of voluntary muscular control around the mouth and jaws. This may lead to disturbances in speech production and articulation as it is thought that the muscular action involved in feeding is an essential preparation for babbling and speech (Shepherd, 1990).

The Babkin reflex begins to emerge in fetal life at thirteen weeks and demonstrates an early hand-mouth neurological link. Deep pressure applied to both palms of the infant simultaneously leads to head flexion and opening of the mouth. This reflex should disappear by 4 months and persistence is usually thought to indicate a cerebral lesion. The Babkin response may be used to stimulate the suck reflex during early feeding.

The asymmetrical tonic neck reflex (ATNR) emerges at 18 weeks in utero and is fully present at birth. It will be described in detail below. It is followed by the spinal Galant reflex which emerges at 20 weeks in utero, is actively present at birth and should be inhibited when the infant is between 3 and 9 months of age. Little is known about the functions of the spinal Galant reflex. It may take an active role in the birth process as contractions in the womb stimulate the lumbar region of the infant. The reflex causes the infant to wriggle or squirm. Persistence of this reflex in childhood could lead to difficulty in sitting still. If stimulation is applied along both sides of the spine of the infant, a simultaneous bladder contraction may occur and the baby may urinate. See Figure 3.2 [2]. It is difficult to know if Galant's reflex is the initial trigger of bladder emptying in humans, however if the reflex persists into childhood it may play a part in enuresis or bedwetting (McPhillips, 2003).

The tonic labyrinthine reflex forwards (TLR) emerges in utero, is present at birth and should be inhibited by approximately 4 months of life. However the backwards TLR only emerges at birth and is gradually inhibited. Both of these are described in more detail in

[2]I wish to acknowledge the use of line drawings from Sally Goddard's book 'A Teachers Window into a Child's Mind'(1996).



Figure 3.2: *An infant exhibiting the Galant Reflex.*

the following sections.

The Landau reflex and symmetrical tonic neck reflex are neither true primitive or postural reflexes. They are not present at birth and do not remain present throughout life. They seem to act as a bridge between the primitive reflex stage and the development of postural reflexes, muscle tone and vestibulo-ocular motor skills. The Landau reflex emerges between 3 and 10 weeks of age and should disappear when the child is around 3 years old. It helps to increase muscle tone when the infant is prone and simultaneously acts as an inhibitory influence upon the TLR (forwards) increasing headrighting and muscle tone in the torso. It enables the child to lift the head and chest and is an important prerequisite for more advanced movements involving the arms and hands later on. The symmetrical tonic neck reflex (STNR) then emerges between 6 and 9 months of age and should be inhibited when the baby is between 9 and 11 months. It helps to raise the baby up from the prone position on to its hands and knees and is described below.

The emergence of reflexes in utero and after birth are presented in Table 3.3.

A more detailed description of the four reflexes used in this study follows:

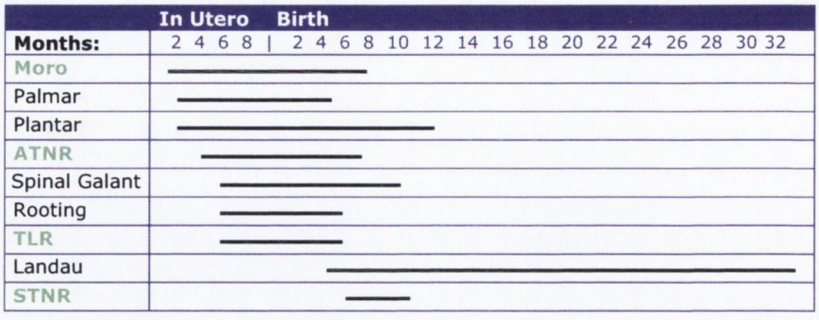

Figure 3.3: *The timeline for emergence of reflexes.*

3.13 Moro Reflex

The Moro reflex emerges at 9 weeks in utero, is fully present at birth and is inhibited between 2-4 months of age. The Moro reflex is a composite series of rapid movements made in response to sudden stimuli. Figure 3.4 illustrates the action. It consists of a sudden symmetrical movement of the arms upwards and away from the body, accompanied by the opening of the hands, a momentary freeze and then a gradual return of the arms across the body into a clasping posture. Abduction (opening of the arms and legs outward) is accompanied by a sudden intake of breath. Adduction facilitates the release of that breath.

This reflex may also be elicited by a sudden sound (such as a loud noise, a different voice) or a change of light (such as the lights being switched on in a dimmed bedroom). Care must be taken, however, not to confuse this response with the startle reflex where the elbow is flexed and extended as in the Moro response and where the hands remain closed. The Moro reflex may be elicited in, at least three different modalities: vestibular, auditory and visual. As the Moro is the earliest primitive reflex to emerge it is essential for the survival of the neonate. The Moro reflex is an involuntary reaction to threat. The baby cannot yet analyze incoming sensations to assess whether the threat is real or not. The brain stem releases an immediate Moro response as if an emergency trip-switch were triggered automatically. It acts as the earliest form of 'fight or flight' response and may be triggered occasionally in later life in situations for extreme danger. The major effect of the Moro reflex is to alert the baby to a change of environment. In turn, if the stimulus is significantly strong, the baby may alert others to intervene by crying. This has obvious survival value but as this reflex is inhibited the young child is able to filter



Figure 3.4: *The Moro Reflex elicited in an infant.*

sudden changes in stimuli very quickly without triggering a deep survival response. It is also thought to play a major part in developing the baby's breathing mechanism in utero, coinciding with the earliest breathing-like movements observed in the womb. It facilitates the first 'breath of life' at birth.

The persistent absence or asymmetry of response in the newborn is of great concern and the Moro should not be elicitable after about six months of age while the startle pattern remains into adulthood. If the Moro reflex fails to be inhibited at 2-4 months of life, the child will be hypersensitive in one or several sensory channels, causing him to over-react to certain stimuli such as sudden noise, light, movement or alteration of position or balance. Any of these may elicit the reflex at unexpected moments, so that the child is constantly 'on alert' and in a heightened state of awareness. The Moro reflex may lead to the young child being over-reactive to new stimuli as he/she struggles to ignore or filter out non-threatening events. The child may appear anxious and easily distracted as the immediate environment presents a range of diverse stimuli that are difficult to ignore. The child may also have difficulty selectively attending to specific visual and/or auditory stimuli as background events constantly impinge on the child's awareness. Further work is required to examine whether the persistence of a Moro reflex has specific physiological, perceptual and cognitive effects.

3.14 Asymmetrical Tonic Neck Reflex (ATNR)



Figure 3.5: *An infant exhibiting the ATNR Reflex.*

The Asymmetrical Tonic Neck Reflex (ATNR) was first discovered by Magnus and DeKleijn (1912) but believed only to be found in experimental preparations of decerebrate animals. Much later, while analysing motion picture films of neonates, Gesell and Ames discovered that the reflex was present in all newborn children . The characteristic 'fencer' posture is seen in the infant when the limbs towards the side to which the head is turned are extended with flexion of the limbs on the occipital side (see Figure 3.5). This caused Gesell to note that this posture is appropriate for the infant when suckling at the breast (Gesell, 1938). Later, it was recorded that at four weeks of age normal infants spent 56 % of their day in ATNR positions (Gesell & Ames, 1950). Capute studied 177 normal infants from birth to 1 year of age. They found the reflex to be present at 2 weeks of age, to peak in activity at 2 months, and thereafter to decline smoothly throughout the first year. It could only be visibly elicited in 25 per cent of infants at 9 months of age (Capute et al., 1982).

The ATNR has an active part of play from the time of its emergence in utero at 18 weeks, until approximately six months of life. During uterine life, the ATNR should facilitate movement (kicking) and develop muscle tone and provide vestibular stimulation. It also provides continuous motion which stimulates the balance mechanism and increases neural connections (Fiorentino, 1963).

During the neonate period, the ATNR is important as it ensures a free passage of air

when the infant is in the prone position. It increases extensor muscle tone, training one side of the body at a time, and forms the basis for later reaching movements. The reflex seems to play an important role in visuomotor development (Holt, 1991). It is present at the time that visual fixation upon nearby objects is developing, and it seems that the nervous system is making sure that the appropriate arm stretches out towards visualized objects. As the hand touches the object, the seeds of awareness of distance e.g. arm's length and eye-hand co-ordination are sown.

The 6 month old baby who still has this reflex will find it difficult to make the normal transition from being able to pass an object from one hand to the other. This skill is normally acquired at about 28 weeks. The ATNR becomes an invisible barrier to crossing the midline. The child will not be able to establish a preferred hand, leg or ear and if there is no dominant side, there will always be a slight hesitancy in executing movement. The entire body will still want to execute tasks using one side at a time, and thus fluent interchange of bilateral movement will be impaired. It will not be possible for the infant to crawl on the stomach with a fluent cross-pattern movement if the ATNR persists. Crawling and creeping are important for the further development of hand-eye co-ordination and the integration of vestibular information with other senses. Myelination of the central nervous system is enhanced during these processes.

The child who still has an ATNR when he learns to walk may find his balance is insecure. Movement of the head to either side will result in straightening of the limbs on that side, upsetting the centre of balance and enforcing homolateral movement. It is only during the second half of the first year that the child starts to acquire good far-distance vision. A retained ATNR may tether the child's vision to arm's length, preventing the next stage of development. Eye movement will also be affected as the child will remain 'stimulus bound' at the midline. Tracking of objects will also be impaired, which will later affect smooth ocular pursuit when reading, writing and spelling. It is not known if a persistent ATNR directly interferes with saccadic eye movements when reading or if it disrupts general development of visually guided motor behaviour.

In the classroom, handwriting will be the most obvious casualty of a retained ATNR. Each time the child turns his head to look at the page, his arm will try to extend and fingers will open. Thus, holding and manipulating a writing implement for any length of time will require enormous effort. The child may learn to compensate by using an immature pencil grip or by using excessive pressure and this is often seen in young dyslexic children. The physical act of writing will always require intense concentration at the expense of cognitive processing and writing may never be fluid (Goddard, 1996). Similarly, fluent

expression of ideas in written form may show a marked discrepancy from the child's ability to express himself orally and this is another of the indicators of dyslexia in children.

3.15 Tonic Labyrinthine Reflex (TLR)

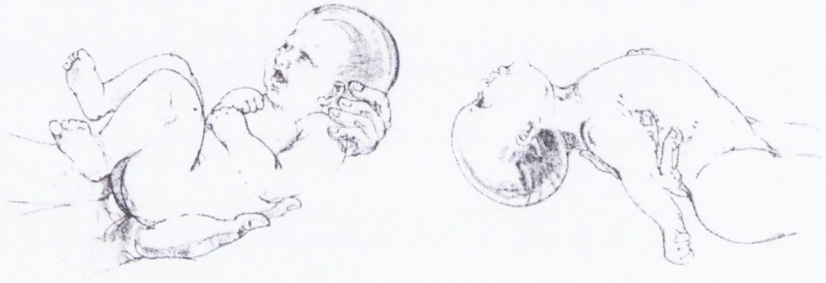

Figure 3.6: *An infant exhibiting TLR Reflex.*

The Moro and Tonic Labyrinthine Reflex (TLR) are closely linked in the early months of life. Both are vestibular in origin, and both are activated by movement of the head forwards or backwards, above or below the level of the spine. It is thought that flexus habitus (the position of the fetus utero) is the earliest manifestation of the TLR in the forward position. The TLR should be fully developed in both positions from birth. Extension of the head below the level of the spine causes immediate extension of the arms and legs. The TLR emerges during the fetal period. Inhibition of the TLR forwards should be accomplished when the infant is 4 months old. Inhibition of the TLR backwards starts at 6 weeks and should be completed when the infant is 3 years of age. See Figure 3.6. This involves the simultaneous development of the Symmetrical Tonic Neck Reflex and the Landau reflex which are bridging reflexes between primitive and postural reflex development (Goddard, 1996).

The TLR exerts a tonic influence upon the distribution of muscle tone throughout the body, literally helping the neonate to 'straighten out' from the flexed posture of the fetus and the newborn. Thus, balance, muscle tone and proprioception are all trained during this process. The TLR also assists the infant at 3 months in raising the head up when placed in the prone position as the arms are extended in support (Fiorentino, 1972). Continued TLR activity will prevent the head-righting reflexes from developing fully. If head control is lacking, eye functioning will also be impaired as the eyes operate from the same circuit in the brain - the vestibulo-ocular reflex arc.

If the TLR is strongly persistent at 8-9 months the infant will find it very difficult to achieve the simultaneous arm extension and leg flexion necessary for getting up onto hands and knees into the crawling position, as movement of the head will result in extension of the legs. The STNR will also remain 'locked' in the system in a futile attempt to override the TLR preventing creeping on hands and knees. Crawling and creeping fulfill both training and inhibitory processes. Both facilitate integration of sensory information as vestibular, visual and proprioceptive systems all start to operate together for the first time. During this period of developmental movement, the child acquires a sense of balance, a sense of space and a sense of depth. It is through crawling and creeping that the raw materials of seeing and moving synchronize for the first time to provide a more complete picture of the environment for the baby.

The persistence of a TLR into early childhood will almost inevitably disrupt the development of gross-motor skills and balance (McPhillips, 2003). A further complication may arise when the extensor tonus is released when the head is extended. The tongue may be pushed forward in the mouth and may protrude. This will have repercussions for speech production and articulation. The persistence of such reflexes may go some way to explain the comorbidity of specific language impairment and dyslexia.

3.16 Symmetrical Tonic Neck Reflex (STNR)

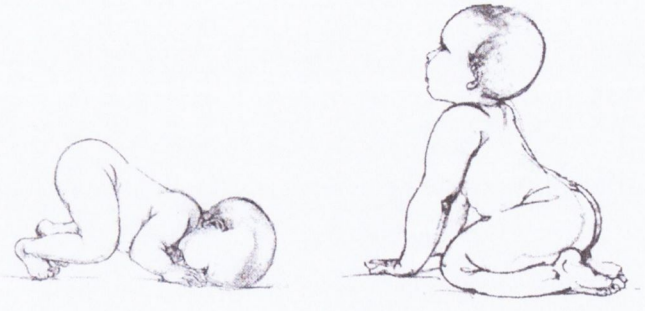

Figure 3.7: *An infant with retained STNR Reflex.*

The Symmetrical Tonic Neck Reflex (STNR) should have a lifespan of about two months. Its function is to help the infant defy gravity and raise it up onto its hands and knees. As mentioned earlier it may not be a true reflex but is crucial in facilitating the inhibition of the TLR (Capute et al., 1982).

Bending of the legs as a result of the head being lifted above the level of the spine will also encourage the infant to fixate the eyes at far distance. Bending of the arms in response to a lowering of the head below the level of the spine will automatically bring the focus back to the bear distance. This trains the eyes to adjust from far to near distance and back again. It has been suggested that the STNR helps to complete a sequence of eye training which commenced with the ATNR (Goddard, 1996). Having helped extend the infant's ability to focus from 17 cm at birth to arms length, the ATNR is then inhibited at 6 months of age and the field of vision is extended further to distance objects. See Figure 3.7.

While the STNR will assist in bringing the child into a crawling position, it must be inhibited before the child can actually initiate crawling movement. If the STNR predominates, head flexion will be accompanied by collapsing of the arms and over-extension of the legs pushing the child forwards onto the head. Similarly head extension will lead to over-flexion of the knees with straightening of the arms, pushing to extend and flex different sides of the body. Usually the infant goes through a period of rocking on the hands and knees which gradually inhibits the STNR. If the STNR remains strongly active crawling may not be possible and the infant may 'bottom-shuffle' or 'bear-walk' (with limbs extended) to get mobile.

Crawling is an important movement pattern which helps the eyes cross the midline, as they focus on one hand and then the other. It is through crawling that the vestibular, proprioceptive and visual systems combine to operate together for the first time. Without this integration there would be no sense of balance, space and depth.

In a study to check for the presence of a STNR in children with SLD, Bender found that 75% of children with learning disorders may be expected to show behavioural signs of a STNR - a primitive reflex persisting without regard for chronological age or IQ. The achieving children in the study showed no significant levels of reflex immaturity (Bender, 1976).

3.17 Cerebral Palsy

It is important at this stage to refer to Cerebral Palsy (CP) as aberrant primitive reflexes are more obvious in children with cerebral palsy (Capute et al., 1982) than those with reading difficulties. Test batteries and movement programmes that were originally devised

to help with the inhibition of reflexes in such children have been adapted for use with children with reading difficulties (Delacato, 1959; Bobath, 1969; McGlown, 1990).

Cerebral Palsy is a congenital abnormality of motor function which affects about two per 1000 live births. Affected children will usually show a combination of weakness, incoordination and involuntary movements. There are a number of causes including pre-peri- and post-natal brain injuries. Infections in utero, such as rubella, syphillis, or intoxication of the mother with drugs or alcohol, may also be responsible. In many children no specific cause may be identified.

There may be abnormal postures, clumsiness and incoordination and involuntary movements. The affected limbs are commonly spastic with increased tone and exaggerated reflexes (as in the ATNR). Many mildly affected children will show abnormal added movements in the arms, e.g. supination or odd postures, when attempting to walk on their heels or the outsides of their feet. A proportion of children with cerebral palsy may appear floppy and hypotonic.

3.18 Retention of Reflexes

The persistence or retention of primitive reflexes beyond the newborn period has long been a classical sign of central nervous system dysfunction (Holt, 1991). Both primitive and postural reflexes comprise a substrate for the development of voluntary motor control with which they are eventually integrated. As postural reflexes are smoothly integrated into adult motor behaviour, they are rarely seen except under test conditions (McPhillips et al., 2000; Goddard, 1996). It is claimed that the continued persistence of a reflex may interrupt a developmental sequence directly or prevent the emergence of other reflexes. This, indirectly, may delay the development of other skills (e.g. crawling) and change how the developing child interacts with its environment (Morrison, 1985).

McGlown (1990) uses the terms 'retained' to indicate the reflex in its original form, and 'residual' to indicate the presence of the reflex in terms of altered tonus of extensor and flexor muscles It is his observation that the ATNR is residual in normal infants until 11 months of age.

A major aspect of early motor development is the complex interplay of the primary and secondary reflex systems. Serious problems will arise if there are problems in the inhibition or integration of the primary system (Morrison, 1985). Furthermore, this will

interfere with the expression of the secondary system and will prevent maturation of motor function.

If primitive reflexes are active beyond 6-12 months of life, they are said to be aberrant, and are evidence of motor delay or immaturity within the CNS (Fiorentino, 1972). Depending on the degree of aberrant reflex activity, this poor organization of nerve fibres can affect one or all areas of functioning: not only gross muscle and fine muscle co-ordination, but also sensory perception, cognition and expression. Capute produced a comprehensive review of primitive and postural reflexes with the aim of producing a quantitative profile of the reflexes to be used as a predictive examining tool in brain-damage syndromes, covering the spectrum from cerebral palsy to 'minimal brain dysfunction' (Capute et al., 1982).

While retained primitive reflexes are accepted signs of pathology in conditions such as cerebral palsy, persistent primitive reflex activity in the absence of identified pathology has been a grey area for many years, with some experts denying that it can persist in the general population. However research in the 1960s noted that the ATNR was found to be active in normal persons especially when the subject tested was under stress or using effort (Hirt, 1967; Waterland, 1967). In these cases, as the tonus change exercises only slight influence on the distribution of postural control tone, and does not dominate motor behaviour or interfere with either automatic or voluntary movement, Bobath argues that it is a misnomer to refer to them 'reflexes' (Bobath, 1969). She states '*True reflexes are stereotyped, unalterable responses to definite stimuli, and tonic reflexes - neck or labyrinthine - occur in this way only in patients with spasticity when they are release phenomena and abnormal.*' p19. This statement did not deter more recent researchers looking to support the theory that abnormal primitive and postural reflex activity can exist within the general population (Blythe, 2005; McPhillips & Sheehy, 2004). However much depends on what is classified as a reflex response.

For many years the prevailing medical view has been that retained primitive reflexes were an indication of pathology and as such would not respond to remedial intervention. However a study at the University of Purdue found that the STNR was present in 75% of a group of learning disabled children but not present in any of a comparison group of children who had no history of learning disabilities. A series of exercises were designed to help inhibit the STNR, and many of the children improved (Bender, 1976). Further research undertaken at the Miriam Bender Institute found that exercises based on movements which involved crawling against resistance were of value in overcoming hyperactivity (O'Dell & Cook, 1996). Recently a study in the Lancet showed that a retained

ATNR responded to remediation in primary school children (McPhillips et al., 2000).

In previous comparisons of academic performance a study in 1971 set out to assess the prevalence of abnormal reflex responses in normal second grade children compared to a group of learning disabled children. Children with normal reflexes scored consistently higher on the achievement tests than those with abnormal reflexes (Rider, 1972)

Some theorists argue that not only are reflex remediation programmes successful in inhibiting reflexes in brain damaged children, success has been reported in inhibiting reflexes in children with specific learning difficulties. Ayres found that a retained ATNR and TLR affect the ability of a child to master educational skills (Ayres, 1972). Research in Ireland and the UK claims dyslexics and poor readers have shown improvement in reading performance (Jordan-Black, 2005; McPhillips et al., 2000; Blythe, 2005). These claims will be dealt with in Chapter 4.

3.19 Inhibition of Reflexes

Reflex control is maintained by nerve impulses transmitted to the muscles to maintain normal reflex action. Inhibition of a reflex is the reduction of a reflex or other activity as the result of an antagonistic stimulation. Abnormal reflexes are involuntary responses to a stimulus which are exaggerated, decreased or absent, and this is seen mainly in brain damaged patients. The Neuromaturational Theory argues that as the cortex develops it inhibits some of the functions of the subcortical layers and assumes neuromuscular control. This is evidenced by the phasing out of reflex behaviours and the assumption of voluntary movements by the infant (Hebb, 1949). Inhibition allows more sophisticated neural structures to develop which then allow the infant control of voluntary responses. Prolonged primitive activity may also prevent the development of the succeeding postural reflexes, which normally emerge to enable the maturing child to interact effectively with his environment.

Brodal reports that electrical stimulation with electrodes surgically implanted at the cerebellar surface has been used in patients with epilepsy and cerebral palsy. The theoretical basis is that the inhibitory action of the Purkinje cells subsequently reduces abnormal neuronal activity and muscle tone. Although some patients report favourable results, there is no agreement as to whether the effect is due to the cerebellar stimulation or some other factor (Brodal, 2004).

It has been claimed that if reflex inhibition is not fully completed, the fundamental systems essential for learning will be faulty or inefficient despite adequate intellectual ability. It is as if later skills remain tethered to an earlier stage of development and instead of becoming automatic, can only be mastered through continuous conscious effort (Goddard, 1996). It is thus suggested that if reflexes could be inhibited in school age children through a daily reflex inhibition programme, it may be that a change in cortical organization can take place.

3.20 Laterality and Lack of Dominance in the Body

The idea that reading disability is associated with anomalies of cerebral dominance dates back to Samuel Orton. The term refers to the idea that one half of the brain takes a leading role in specific functions and that one cerebral hemisphere was in some way dominant over its partner (Orton, 1925). A lack of strong preference for one hand or the other reflected a lack of dominance or immature state of 'sideness'. The argument grew that incomplete lateralisation at the level of the hand and/or eye reflected a failure of specialisation of the cerebral hemispheres

According to Ayres, lateralisation is the tendency for certain processes to be handled more efficiently on one side of the brain than on the other. Usually the right hemisphere becomes more efficient in processing spatial and musical patterns, while the left hemisphere specialises in verbal and logical processes (Ayres, 1979).

It is suggested that an underactive vestibular system often interferes with this specialisation. If a child develops similar skills with each hand and cerebral hemisphere, he finds that instead of using just one hand for fine motor work he tends to use the right hand for a task on the right side of the body and the left hand for tasks on his left side. The child may be considered ambidextrous, but in reality he is not especially skilled with either hand, or he may become left-handed, while genetically he is meant to be right handed. Meanwhile, both of his cerebral hemispheres may be doing similar things instead of specialising for greater overall efficiency. If the child tries to develop language in both hemispheres he may not perform well with either one. This may cause difficulties in speech, reading, and writing. Ayres described these children as having vestibular-bilateral disorder. Usually of average or above average IQ, the children may have been labelled as dyslexic when in fact the problem is a sensory integrative disorder. Ayres claims that after a year of therapy these children can learn more easily, though no studies are cited (Ayres, 1979). It

is advised that to give the children more academic work at this stage would be premature and sensory integrative therapy along with school would yield a better performance.

Recent research confirms the emergence of lateralized behaviours in early fetal development. Observations of the left and right arm movements of 17 human fetuses were made at 3 week intervals from 12-27 weeks (McCartney & Hepper, 1999). Eighty three percent of fetuses exhibited significantly more right arm than left arm movements at every gestational age. The number of arm movements peaked at 15 to 18 weeks gestation. They concluded that this early emergence of lateralized behaviour is probably under muscular or spinal, rather than cortical control and points to a 'genetic' origin for such behaviour. It is suggested that the presence of lateralized motor behaviour in early gestation may have a potential causative role for subsequent lateralization of behaviour and asymmetric brain development. Hepper suggests that handedness is the *cause* not the consequence of brain asymmetries. Asymmetric motor behaviour may determine differential hemispheric development. Neural activity may influence brain organization (Purves, Riddle, White, & Gutierrez-Ospina, 1994) and prenatal motor patterns may influence the development of neural connections in the CNS (Reigger-Krugh, 1993). It is argued that fetal behaviour lateralization differentially stimulates the CNS and advances the development of neurological structures controlling right sided movements and it is most likely that the development of initial motor asymmetry is under genetic control (Morgan, 1977).

The literature on the relationship between handedness, cerebral asymmetry and reading disability has been reviewed by a number of authors (Annett, 2002; Beaton, 1985; Bryden, 1988; Satz & Fletcher, 1987; Bishop, 1990b). These reviews note an inconsistency in the definitions of both handedness and reading disability. Bishop (1990b) reviewed 21 studies and concluded that the rate of left-handedness found in dyslexics was roughly twice that found in controls - 11.2% versus 5.8%. However, it was advised that a sample size of nearly 400 would be required to reliably detect an effect of this size.

These studies suggest that, though not large, there is a significant increase in the incidence of non-right-handedness among poor or dyslexic readers (Eglington & Annett, 1994). Beaton cautions that this does not mean that most dyslexics are left-handed or that most, or even many, left-handers are dyslexic (Beaton, 2004). McGlown (1990) asserts that although some children are cross-lateral and not dyslexic, more dyslexic children have unusual handedness patterns or more are cross-lateral than one would expect to find in the normal population. It is not left-handedness as such that causes difficulty other than that the world is designed for right handed people - it is the lack of laterality or dominance in hand, foot, eye and ear that may affect the efficient execution of tasks and

so may be linked to learning difficulties. Gazzaniga argues that to some extent Minimal Brain Dysfunction may be the result of subtle software programming abnormalities that occur in the presence of poorly established cerebral dominance (Gazzaniga, 1973). He goes on to state that if dominance is not clearly established there is no central point through which various cognitive acts are channelled, where their relative importance is ranked and proper commands for motor responses are programmed.

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As long ago as 1947 Gesell and Ames related the lack of development of hand dominance, one aspect of cross-laterality, to the ATNR (Gesell & Ames, 1947). Linking reflex immaturity and lack of dominance, McGlown contends that reflex immaturity prevents normal motor development, which in turn may lead to both laterality problems and eye-muscle difficulties, inevitably resulting in perceptual problems (McGlown, 1990).

The current view seems to be that a minority of children are left handed and some of them may be dyslexic. Left-handedness on its own is not an indicator of dyslexia. It may be more informative to find out how many dyslexics and non-dyslexics have little or no hand and/or eye dominance and whether this poses daily motor and learning challenges for them. De Quiros highlights the issue as follows: '*The most important thing will always be to establish which is the body's lateral preference. The second most important thing is to determine the extent to which the misuse of the lateral potential hand is able to generate neuropsychological conflicts which produce human communication disorders and learning disabilities*' (de Quiros & Schrager, 1979), p44.

Efficiency of the cerebral hemispheres and the functional independence of each side of the body so that balance is automatic and co-ordination smooth is an adaptive end result of human motor development. Free from the conscious adjustment to gravity, the child can perform the smooth movements necessary for co-ordination and speech, learning new skills and literacy acquisition.

3.21 Development of Posture and Equilibrium



Figure 3.8: *An infant maintaining posture.*

Posture is the reflex activity of the body in relation to space. Posture is based on muscular tonus. Equilibrium or balance is the interplay between gravity and the motor power of skeletal muscles. Equilibrium has been achieved when the body can maintain and control postures, positions - the characteristic posture of a species; and attitudes - reflexes that lead to the return to a species-specific position (de Quiros & Schrager, 1979). See Figure 3.8. Equilibrium is based on proprioception, vestibular function and vision. The cerebellum is the principal coordinator of this information. Posture and equilibrium are the bases of motor activities, and these are the platform for the learning process.

If the primitive reflexes lay the foundations for all later functioning, then the postural reflexes form the framework within which other systems can operate effectively (Goddard, 1996). The transition from primitive reflex reaction to postural control is not an automatic one, but a gradual processes of interplay and integration during which both reflex types operate together for a short period of time. As reflex movement sequences are practiced over and over again more mature patterns of response can supercede primitive reflexive response. Postural or secondary reflexes are mediated from the level of the midbrain, and their development signifies the active involvement of the higher brain structures over brain stem activity, and are a sign of increased maturity in the CNS. Secondary reflexes are concerned with posture, movement and stability and are comprised of righting reflexes when the child is still on all fours and equilibrium reactions which are bipedal.

Righting reactions emerge between 3 and 12 months and should remain present through-

out life. They consist of the oculo-headrighting reflex, the labyrinthine headrighting reflex, amphibian reflex, Landau reflex and segmental rolling reflexes. As the oculo- and labyrinthine headrighting reflexes develop, they ensure that the head and trunk are maintained in a specific position when the body is altered in any way. Operating from visual and vestibular cues they synchronize to supply accurate data upon which head position is adjusted. The latter reflexes help the inhibition of the TLR and ATNR. They facilitate movement through rolling, crawling and creeping, and will later permit coordinated gross motor movement. The amphibian reflex allows automatic flexion of the arm, hip and knee when the pelvis is elevated. This marks an important stage for crawling on the tummy. The segmental rolling reflexes develop in the shoulders and the hips when the infant is six months. They allow the child to roll from prone to supine and later from supine to prone followed by sitting, four point kneeling and eventually standing.

Equilibrium reactions are controlled by the cortex, first appearing between 3 and 6 months of age and persisting throughout adult life. They comprise protection and tilting reactions if balance is lost or centre of gravity altered (Goddard, 1996; Morrison, 1985). They include the 'startle' and parachute reflexes. The startle reflex replaces the Moro which is inhibited. The child tenses muscles, blinks, seeks out the source of danger and then makes a conscious decision about how to react.

Parachute reactions emerge around six months of age and should remain throughout life (Illingworth, 1987). If a young child is held in ventral suspension and suddenly lowered towards a supporting surface, the arms will extend to meet the surface. This is a vital protective reaction. In children with cerebral palsy, this reflex may not emerge or only partially emerge and the strong flexor tonus of the TLR (flexor) is stimulated by the movement in this position. In this instance, the child is unable to extend the arms and it is therefore critical that the TLR is inhibited so that the parachute response can be released. The propping actions should emerge around the same time so that if the child is tilted to one side when in a sitting position, the arms extend to that side as a protective reaction.

The emergence of protective reactions redefines the relationship of the infant to gravity as they parallel the ability of the child to come up into a standing position. The protective reactions provide a safety net if equilibrium is lost, while the equilibrium reactions seek to prevent the infant from falling. The central reaction is curvature of the spine in the opposite direction to the gravitational pull.

Some studies have shown significant differences in equilibrium reactions between samples

of children with and without learning difficulties. Bruininks and Bruininks (1977) compared two groups of 55 children on a range of tasks. The learning disabled group scored significantly lower and their greatest deficiencies were on tasks requiring body equilibrium, controlled fine visual-motor movements and bilateral coordination of movements involving different parts of the body. These areas include complex motor patterns and require the integration of visual and kinesthetic senses with motor responses (Bruininks & Bruininks, 1977).

3.22 The Cerebellum

The cerebellum or 'little brain' plays an important role in the integration of sensory perception and motor output. Many neural pathways link the cerebellum with the motor cortex and the spinocerebellar tract. The former sends information to the muscles causing them to move, the latter provides feedback on the position of the body in space (known as proprioception). The cerebellum integrates these pathways using constant feedback on body position to fine-tune motor movements.

As a result of this 'updating' function of the cerebellum, lesions within it are not so debilitating as to cause paralysis but present as feedback deficits resulting in disorders in fine movement, equilibrium, posture and motor learning. Physiologists in the 18th century observed that patients with cerebellar damage presented with motor coordination problems. Research into cerebellar function during the 19th century was done via lesion and ablation studies in animals. It was noted that such lesions led to animals with strange movements, awkward gait, and muscular weakness. These investigations led to the conclusion that the cerebellum was a motor control structure (Fine, Ionita, & Lohr, 2002). Recent research has suggested that the cerebellum has a broader role and may affect cognitive functions such as attention, processing of language, and other sensory temporal stimuli (Allen, Buxton, Wong, & Courchesne, 1997; Levisohn, Cronin-Golomb, & Schmahmann, 2000; Raichle et al., 1994).

3.22.1 Cerebellar Structure:

The cerebellum is located in the inferior posterior portion of the head (the hindbrain), directly dorsal to the pons, and inferior to the occipital lobe. Figure 3.9 shows the relevant anatomy. The cerebellum contains nearly 50% of all neurons in the brain, although

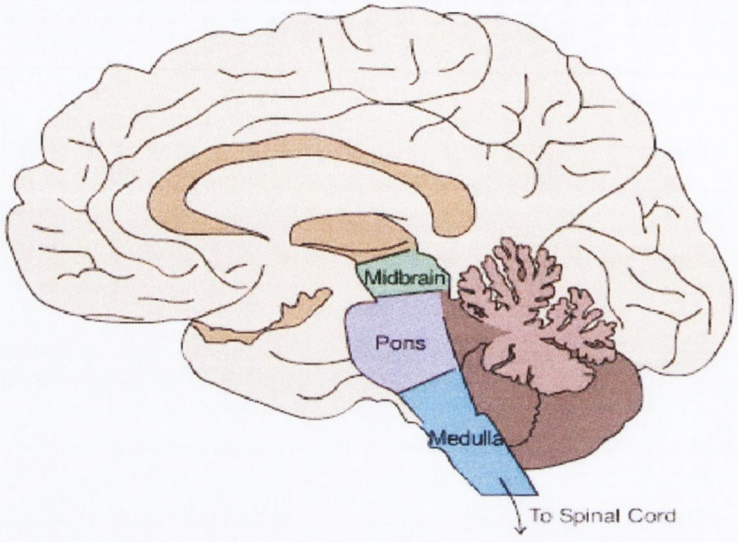


Figure 3.9: *The Brainstem.*

it constitutes only 10% of total brain volume. The cerebellum is divided into two large hemispheres, like the cerebrum, and contains ten smaller lobules. The cellular architecture of the cerebellum is highly uniform, with connections organized into a rough, three-dimensional array of perpendicular circuit elements.

The archicerebellum (or vestibulocerebellum) is associated with the flocculonodular lobe and is mainly involved in balance (vestibular system) and eye movement functions. It receives input from the inferior and medial vestibular nuclei and sends fibres back to the vestibular nuclei, creating a feedback loop that allows for the constant maintenance of balance (Kingsley, 2000). As the vestibulocerebellum receives inputs from a number of sensory systems it is difficult to isolate a pure vestibular input. However, the importance of vestibular input may be demonstrated by reading under two different conditions. If a page of text is held in front of the eyes and moved rapidly up and down or from side to side the text blurs and is extremely difficult to read. If the text is held still and the head is moved rapidly either up or down or from side to side the text remains constantly in focus.

In the second condition the vestibular apparatus in the inner ear senses the movement of the head and compensatory movements of the ocularmotor muscles of the eyes are generated so that the eyes move in the opposite direction to the head movements (the vestibular-ocular reflex). This shows that eye position control is much better when there is vestibular input than when only information from the visual system is available. It illus-

trates, also, the importance of the vestibular system (including the vestibulocerebellum) in activities such as reading that involve a complex interaction of head and eye movements. Similarly, saccadic eye movements when reading involve cerebellar and frontal cortex inputs to the cranial nerves so that the eyes progress in a series of rapid ballistic movements.

The paleocerebellum (spinocerebellum) controls proprioception related to muscle tone (constant, partial muscle contraction that is important for the maintenance of posture). The spinocerebellum receives its inputs from the dorsal and ventral spinocerebellar tracts, which carry information about the position and forces acting on the legs. The spinocerebellum then sends axonal projections to the deep cerebellar nuclei.

The neocerebellum (cerebrocerebellum) receives input from the pontocerebellar tract and projects to the deep cerebellar nuclei. The pontocerebellar tract originates at the pontine nuclei, which receive their input from the cerebral motor cortex. Thus, the neocerebellum is associated with motor control, in particular, the coordination of fine finger movements such as those required by typing. Whereas the other parts of the cerebellum function in the manner of feedback correction of motor activity, the neocerebellum is ideally arranged to work also in a feed-forward manner. It operates in conjunction with the cortical motor centres to plan movement which is just about to occur, presumably drawing on motor memory either within itself or within the cerebral cortex.

3.22.2 Development of the Cerebellum

The cerebellum is more highly developed in man than in any other species and it accounts for 11% of the entire brain's weight. From birth to 5 years of age it grows at a faster rate than the cortex, attaining 80% of its adult size by the age of 2 years and completing a major period of myelination by the age of 4 years, although some further development continues up to the age of 11 years (Chilton Pearce, 1992). As early movement patterns are learned and practised, they are filed away in the basal ganglia and the cerebellum to be released on cue whenever required. The cerebellum records the muscular actions involved in complex and habitually used movements, and then plays back entire sequences on command, modifying parts of the sequence to match the demands of the task. Like the motoric equivalent of building up a vocabulary, the cerebellum learns by synaptic connections being repeatedly fired and the neurons involved becoming stronger and more effective with practice (Marr, 1976).

The cerebellum is involved in motor control but is not responsible for the initiation of movement (Brodal, 2004). Rather, information comes from the cerebral cortex regarding the planning of movements. The cerebellum sends information to cell groups that give origin to central motor pathways, like motor cortical areas and the reticular formation of the brain stem. Damage to the cerebellum results in jerky movements. The cerebellum receives information from the skin, joints, muscles, vestibular and visual systems.

The number of fibres leading into the cerebellum compared to those leading out is about 40:1. It may be that the cerebellum has a role in inhibition via the amount of sensory information it receives. This high degree of convergence shows that a considerable amount of integration of information takes place before an answer is issued but how processing is performed is still largely unknown. In contrast to the cerebral cortex, the cerebellar cortex has no association and commissural connections. Put simply, different parts of the cerebellum do not talk to each other. This suggests that the cerebellum consists of many functional units each carrying out a specific task. In this way it resembles the basal ganglia, which appear to be organized in several parallel circuits starting and ending in the cerebral cortex.

3.22.3 Excitation and Inhibition

The cerebellum comprises the only group of cells within the CNS whose output function is to inhibit rather than to excite. The cortex initiates a movement by sending a flow of messages from the motor cortex through descending fibres to the brain stem where they cross over and send messages to excite the cerebellum. Using memory of how a movement should proceed, the cerebellum computes the adjustments which are required to match cortical intent to muscular response. The muscles then send the messages back to the cerebellum which will change or monitor the movement taking place. It is the job of the cerebellum to sift and direct relevant instruction and to ignore any that are surplus. In this way, the cerebellum acts as a fine tuning monitor for every movement made and is essential for fine muscle coordination.

All signalling out of the cerebellum is mediated by the axons of the Purkinje Cells. The three main subdivisions of the cerebellum act on the parts of the central nervous system from which they receive their afferents. The vestibulocerebellum sends fibres mainly to the vestibular nuclei, the spinocerebellum influences the spinal cord, and the cerebrocerebellum acts on the cerebral cortex.

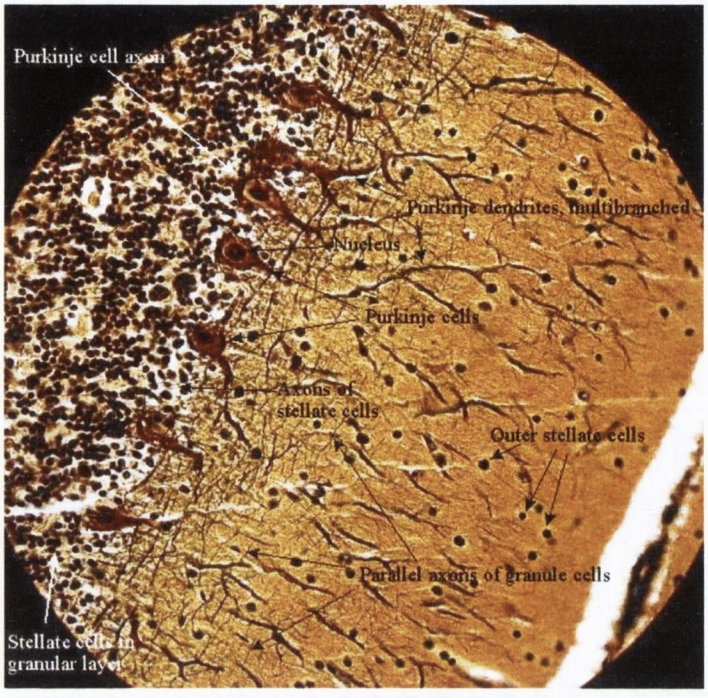


Figure 3.10: *Cerebellar Purkinje Cells*

Vast amounts of information provided by all of the afferents is processed in the cerebral cortex and outputs are issued to various motor centres of the brain and spinal cord. The numerous afferent fibres to the cerebellar cortex fall into two categories, mossy fibres and climbing fibres. Both have excitatory synaptic action, but the climbing fibres all come from the inferior olive, whereas the afferents from all other nuclei end as mossy fibres. Each mossy fibre influences many Purkinje Cells, but the excitatory effect on each is weak, so that many mossy fibres must be active together to provide sufficient excitation. Figure 3.10 shows an image of Purkinje cells with some salient features labelled.

The Purkinje cells receive excitation from both mossy and climbing fibre afferent inputs, but with very different spatial and temporal characteristic of their actions. In addition, the signal traffic within the cerebellar cortex is influenced by several kinds of inhibitory interneurons. These interneurons are also excited by afferent impulses to the cortex and serve in general to increase the precision of signal traffic through the cerebellar cortex.

The basal ganglia and cerebellum are large collections of nuclei that modify movement on a continuing basis. The motor cortex sends information to both, and both structures send information right back to the cortex via the thalamus. The output of the cerebellum is excitatory, while the basal ganglia are inhibitory. The balance between the two systems

allows for smooth, coordinated movement, and a disturbance in either system will show up as movement disorders.

Patients with cerebellar dysfunction experience problems in walking, balance and accurate hand and arm movement. However recent brain imaging studies using functional magnetic resonance imaging (fMRI) show that the cerebellum among other brain areas is in involved in word reading (Mechelli, Gorno-Tempini, & Price, 2003) and selective attention (Allen et al., 1997) and the cognitive role of the cerebellum is dealt with in the next section.

3.22.4 Is the Cerebellum involved in Cognition?

The cerebellum has been traditionally regarded as involved in various aspects of motor functions (Marr, 1969; Albus, 1971; Ito, 1986). Its role was in part to measure temporal intervals with great accuracy. This conceptualisation was modified to emphasize its role in the control of movement sequences and sequential behaviours, because of the regular arrangement of the parallel fibres (Brodal, 2004).

Classic studies of the cerebellum before the middle of the twentieth century established the structural entity of the cerebellum and characterized its function as enabling animals and humans to carry out smooth and accurate movements, even at a high speed and without visual feedback (Ito, 2002). Later patients with cerebellar damage were found not only to be impaired in their ability to reproduce certain rhythmic tapping movements but also in discriminating different sound rhythms (Tallal, 1984). Reduced ability to judge the velocity of visual stimuli has also been reported in patients with cerebellar lesions (Nawrot & Rizzo, 1998).

Although the cerebellum may be specially designed for accurate timing of movement (Ivry, Keele, & Diener, 1988), there is debate that it may also be involved in cognitive tasks (Kim, Ugurbil, & Strick, 1994). It is proposed that the lateral cerebellum is strongly engaged during the acquisition and discrimination of sensory information, when different objects were grasped in two hands (Gao et al., 1996). However a specific role was not identified and sensory and motor components of task performance have not yet been well dissociated.

Schmahmann hypothesizes that the cerebellum functions to improve mental performance, and that there are clinically relevant deficits that result from cerebellar lesions (Schmahmann & Caplan, 2006). They found that patients, both adults and children, demonstrated

a Cerebellar Cognitive Affective Syndrome, characterized by disturbances of executive, visual-spatial, linguistic, and affective behaviour (Levisohn et al., 2000). Schmahmann argues that these clinical manifestations reflect dysmetria of thought, and the loss of the cerebellar stabilizing/modifying influence on mental and emotional behaviours.

Glickstein is not convinced that the cerebellum has a role to play in cognitive functions, stating that the case for its involvement in tasks other than motor tasks has yet to be proven (Glickstein, 1993). Others claim that the evidence for learning, memory, attention, and visuo-spatial processing is less consistent than for speech and language (Justus & Ivry, 2001; Fiez, Petersen, Cheney, & Raichle, 2001), and that where cognitive effects are seen, these could be explained by cognitive or temporal aspects of the task. Fiez maintains that the evidence points to a blurring of the line between motor and cognitive functions (Fiez, 1996). There is debate about whether a process involving a thought about a movement should be classified as cognitive or motor. For example, mentally choosing a word or timing the space between tones, is very different from the straightforward coordination and planning of actual movements.

The role of the cerebellum in cognition continues to be contentious (Ivry, 1997) as these studies say nothing about what the cerebellum's role in thought might be. Thach rejects the new views of the cerebellum arguing that its apparent role in cognition could be explained by well-established motor-related function of the cerebellum (Thach, 1996). The cerebellum is active when someone is planning or even thinking about movements.

Ivry's meta-analysis finding that the cerebellum is activated on more difficult tasks fits with the thinking that the cerebellum may be preparing for possible moves, helping the brain to focus attention on sensory stimuli independent of any motor involvement (Allen et al., 1997; Gao et al., 1996).

Table 3.1 lists some possible roles for the cerebellum (Barinaga, 1996).

Proposed Function	**Evidence from damaged cerebellar functioning**
Motor coordination	Poorly coordinated movements
Timing	Failure at tapping rhythms and judging timing of tones
Sensory Discrimination	MRI of lateral cerebellar output
Cognitive Function	Failure on specific cognitive tasks

Table 3.1: *Some Possible Roles for the Cerebellum motivated by evidence in humans with damaged cerebellar functioning*

In a study to determine whether cerebellar activation occurs during cognitive tasks that differentially engage the component processes of word identification in reading, 42 neurologically normal adults underwent functional magnetic resonance imaging (fMRI) of the cerebellum while performing such tasks. The cerebellum was engaged during reading and differentially activated in response to phonologic and semantic tasks. These results indicate that the cerebellum contributes to the cognitive processes integral to reading (Fulbright et al., 1999).

Ito envisages new developments toward the fusion of knowledge of the cerebellum at molecular and cellular levels and those in systems and computation. In the 1980s, long-term depression (LTD) was discovered and considered as a memory process in the cerebellum. In the 1990s, complex signal transduction processes underlying LTD were revealed. Also in the 1980s computational approaches were advanced for modelling control system functions of the cerebellum (Ito, 2002).

Recent reports suggest that children prenatally exposed to alcohol have deficits in cerebellar processing similar to those with dyslexia, and that these functional deficits are related to disabilities in learning (Coffin, Barody, Schneider, & O'Neill, 2005).

3.23 Postural Development in Early Childhood

Postural development in early childhood appears to be characterized by a smooth increase of postural stability and versatility, as shown by standard motor tests (Bruininks & Bruininks, 1977). The ponto-cerebellar tracts which are known to be a central pathway connecting the cerebellum with its cortical project areas, undergo final stages of maturation at the age of four (Yakolev & Lecours, 1967). Children are seldom able to maintain equilibrium with both feet together and eyes closed before that age (Romberg Test). This is believed to be due to the late myelinization of these pathways. Similarly, tests requiring unsupported standing on one leg are not passed before this age period. The passage of the Romberg Test is considered an important milestone of postural maturation (de Quiros & Schrager, 1979). Similarly the suppression of synkinetic or involuntary movements in hand and fingers of the contralateral hand, when the child is asked to perform the 'oppositional finger test', is another developmental landmark. These tests are described later as part of the motor control battery in the Methodology Chapter. The oppositional finger test also shows the possibility of acting independently with each side of the body. This is a necessary starting point for laterality.

During what Kohen-Raz calls the stage of 'school readiness', there is a spurt in postural autonomy (Kohen-Raz, 1996). It is manifest in the ability to use vicariously the three main postural input systems - visual, proprioceptive and vestibular - to the extent of being able to counteract the pull of gravity by using the vestibular system almost exclusively. De Quiros postulates that the passing of these 'milestones' is the precondition to acquiring two basic psychomotor skills, the suppression of synkinetic movements and the awareness of body laterality. This naturally involves discrimination between left and right. During the transition from pre-school to primary school the co-ordination and simultaneous activation of basically independent motor systems matures intensively. This is seen when executing complex motor acts, such as playing musical instruments, or when running whilst manipulating an object, as in sport.

Kohen-Raz reviewed studies undertaken in the previous five decades into the relationship between postural control and higher cognitive functions such as intelligence, reading skills, and overall scholastic achievements. Some of the research reviewed found that there was no relationship between stabilometer [3] performance and academic achievement in male college students (Ryan, 1963). It was also noted that studies reporting positive correlations between intelligence and motor performance were done mostly on children with general learning disabilities. A study of the inter-relationship of physical, perceptual-motor and academic variables in elementary school children concluded that none of the motor and physical variables, including balance, correlated significantly with intelligence (Singer, 1968).

A large scale study carried out systematic and replicative investigations which showed that static as well as dynamic balance were significantly related to intelligence and reading ability in normal American and British pre-adolescents aged 11-12 years (Ismail, Kane, & Kirkendall, 1969). Another found correlations between scholastic achievements, static balance and gross motor co-ordination in normal first graders (Chissom, 1971).

Significant linkages between academic and motor skills, including balance tests, have been reported in 6-7 year old children (Jones, Calder, & Hughes, 1975). In a large scale Japanese study (N=6979) carried out on the development of static balance ability, significant relationships between monopedal standing (with eyes open) and academic achievement were found in age groups 7-8 and 10-12 years (Report, 1982).

Studies have been sparse and results are not always consistent. However comparisons are difficult to make as there has been considerable variation in research design and

[3] instruments that measure postural control

methodology among the investigators. Unfortunately this is still a problem today. In an review of 17 published studies that compared balance function between dyslexic and control samples it was concluded that balance deficits were associated with dyslexia, but that effects seem to be more strongly related to third variables other than to reading ability (Rochelle & Talcott, 2006). While deficits of balance may indicate increased risk of developmental disorder, they are unlikely to be associated uniquely with dyslexia.

3.24 Summary

In this chapter the emergence and integration of the primary-reflex system, in particular, has been highlighted because this parallels the most sensitive early fetal and neonate periods of development for the vestibular system, brain stem nuclei and cerebellum. The importance of the inhibition of reflexes to the child's control of balance, posture, and eye movement has been described. Difficulties that may occur if reflexes are retained were discussed. There is still much debate on the function of the cerebellum, however there is growing evidence that the cerebellum may play an important role in cognitive as well as motor and balance activities.

To summarise, Figure 3.11 illustrates the stages in the developmental pathway that may be affected and result in a Specific Learning Difficulty. From conception, a fetus with a genetic predisposition to dyslexia is vulnerable to the environment within the womb. Inadequate nuitrition or exposure to toxins such as alcohol or drugs may interfere with pre-programmed rhythmic fetal movement. If movement patterns are not repeated sufficiently, lateralization of brain hemispheres and emergence of reflexes may be delayed or disrupted. This will have an impact on the general development and efficiency of the CNS, perhaps slowing down myelination and cerebellar development. Thus after birth, the development of postural control is disrupted by failed inhibition of primary reflexes and development of secondary and righting reflexes described in section 3.12.1. Balance may be impaired. Hand-eye coordination and the development of fine and gross motor control is impeded. As a result, the pre-school child lacks adequate attention skills due to inadequate sensory and motor control. Readiness for learning in the first years of school is delayed due to inadequate visual perception and/or phonological skills and the child misses the window of learning where his peers grasp the orthography and phonetics of the alphabet.

In this study we were particularly concerned with the effect of retained reflexes and cerebellar dysfunction on reading ability. The next chapter reviews movement programmes

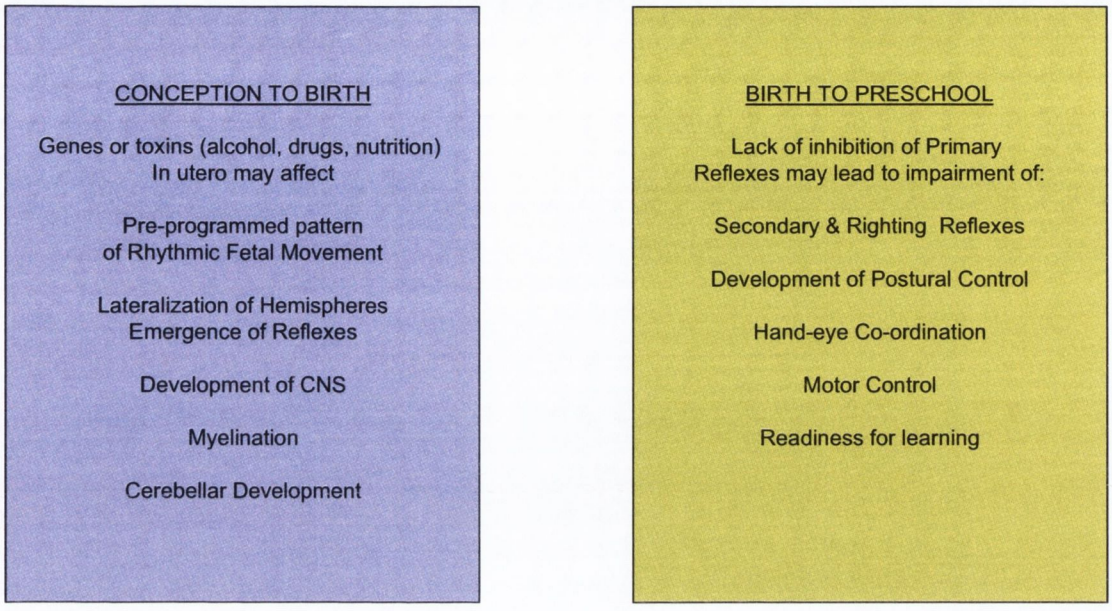


Figure 3.11: *Stages in the development pathway. If these stages are affected Dyslexia may result.*

which claim either to remediate retained reflexes or develop balance skills to overcome poor reading performance.

4

Movement Programmes

It is important to note that while dyslexia was first described as 'word blindness' in 1896, (Hinshelwood, 1896) and (Morgan, 1896), movement programmes specifically for the remediation of dyslexia grew out of the field of physical therapy. At first glance the link between poor motor control and difficulties in reading, writing or spelling seems at best tenuous.

Programmes for motor training, remediating reflexes, and improving balance and co-ordination are not new. However it is difficult to differentiate between treatments as theory and practice tended to be amalgamated into newer treatments as the field of physical therapy expanded. This chapter aims to give a historical review of motor programmes developed in the USA and UK and their subsequent refinement and use in the remediation of reading difficulties. Though not exhaustive the emphasis is on programmes that influence the balance and reflex remediation programmes available today. This chapter will consider how movement programmes evolved from the treatment of cerebral palsy and brain injured children to use in reflex and motor remediation in children with specific Learning Difficulties. The first section gives a brief summary of the evolution of motor programmes and the principles of perceptual motor programmes are described. A

review of motor programmes from 1950's to date is followed by a summary of what can be concluded from research on these programmes.

4.1 Classification and Evolution of Motor Programmes

It is difficult to categorise movement programmes which have evolved since the 1940's. However Figure 4.1 attempts to show how they are linked and how they developed over time.

During the first half of the 1900's the primary treatment approach used for neuromuscular dysfunction was known as muscle re-education. This technique was effective in the remediation of polio but was of little use in the treatment of individuals with upper motor neuron lesions. Claims of improvements in motor skill in cerebral palsy (CP) patients receiving sensory stimulation and exercise programmes first appeared in 1954 (Fay, 1954). From the late 1950's through to the 1970's, several clinicians began to apply the reflex/hierarchical theory into their clinical practice. Collectively these methods became known as 'neurofacilitation' approaches. Examples of these are Karl and Bertha Bobath's neuro-developmental treatment (NDT) approach, and Signe Brunnström's Synergistic Movement Patterns. Margaret Rood created the neuro-physiological approach and Jean Ayres applied these principals to a sensory integration theory.

Doman and Delacato's programmes in the 1960s put pressure on parents to complete lengthy exercise regimes, often with teams of volunteers, for 8-10 hours per day, on cerebral palsy children for little improvement in motor control (Cummins, 1988). Subsequently the field received a controversial reputation. Doman and Delacato's theory, and the pronouncement against it by the American Academy of Paediatrics (Pediatarics, 1999) and other organisations, are reviewed briefly later in this chapter. The first claims that movement programmes improved reading and academic performance were published in 1959 (Delacato, 1959).

Meta-analyses undertaken on research studies, including those of Doman and Delacato, showed that visual and perceptual motor training programmes have not demonstrated any effect on academic achievement (Kavale & Mattson, 1983) and (Hammill, Goodman, & Wiederholt, 1974). However a 1983 study demonstrated a significantly greater experimental effect of psychomotor training on cognitive performance of boys aged 6 (Laporte, Musch, G. Vander Mersch, & Benoir, 1983).

Movement Programmes Categorised by Type and Aims of Treatment

Cerebral Palsy

Pető 1940's: Conductive Education aims to make CP children happy in their environment so can apply themselves to learning.

Phelps 1950's: Kinaesthetic & proprioceptive feedback with CP patients.

Bobath & Bobath 1960's: Inhibition of reflexes and improvement of muscle tone to aid posture & movement.

Hőlle 1970's: Devised treatment for CP children using knowledge of sensory integration, reflexes and primitive movement patterns.

Rehabilitation

Brain Injured

Fay 1950's: Progressive Pattern Movement Treatment based on recapitulation theory.

Rood 1950's: Neurophysiological approach. Stressed roles of reflexes and afferent stimuli.

Brunnstrom 1970's: Stimulation of reflexes in an attempt to regain movement in the patient.

B-I-R-D 1980's : Specialised set of neurophysiological exercises to inhibit reflexes. Programme works on eye-muscles, vestibular apparatus and claims if neurological dysfunctions are corrected, learning difficulties are resolved.

Reflex Inhibition

Sensory Integration

Ayres 1970's: Controlled sensory input programmes to reorganise the neurological functioning ofchildren who suffer from sensory integrative dysfunction.

Palmer 1980's: Year long developmentally-appropriate sequence of stimulation activities aimed to produce higher levels of academic readiness in young children.

Brain Gym 1970's: Treats educational and behavioura difficulties in children and adults. Programme stimulates brain function and relieves stress which inhibits learning.

School Readiness

Neuro Developmental Delay

Kohen-Raz 1960's: Psychomotor School Readiness Programme that trains general fitness in children. Researches postural control, school readiness and academic skills.

DDAT 2000: Balance Training Programme to target Cerebellar Developmental delay.

INPP 1970's: Reflex Inhibition Programme claims to improve motor control and academic progress.

Primary Movement 2000: Reflex Inhibition Programme claims improved reading performance.

Improved Motor Control and Reading Performance

Figure 4.1: *The evolution of movement programmes.*

Ismail found that static and dynamic balance was significantly related to intelligence and reading ability in normal American and British pre-adolescents (aged 11-12 years) (Ismail et al., 1969). It is important to note however that although balance skill is related to reading ability this does not indicate that it is a precursor of reading ability.

Although there is a gap between the scepticism of large scale meta-analytical evaluations mentioned above on the one hand, and smaller studies claiming improved reading performance on the other, perceptual-motor remedial methods have become more popular in special education and in the remediation of dyslexia. There is a long history of movement programmes for brain-injured patients and later claims of their successful use in remediating reading difficulties have been damaged by controversial or poorly conducted research. This has led to criticism of the efficacy of movement programmes in relation to both the improvement in motor skills and reading gain. Movement programmes have remained, for the large part, outside the mainstream curriculum in education.

This situation has changed somewhat in the UK and Ireland in recent years. Following publication of research results in the Lancet (McPhillips, 2002) claiming gains in reading of up to 1 year and 8 months for dyslexic children, motor programmes were once again in the media. This led to some teachers volunteering to train in a reflex inhibition programme called Primary Movement which asks children to repeat movements associated with the Asymmetrical Tonic Neck and Moro reflexes. Returning to their classes after 2-3 day courses, the teachers conduct a ten minute programme with their pupils once a day over the school year. A review of the reflex remediation studies carried out in primary schools in Northern Ireland by both Primary Movement and the Institute for Neuro-Physiological Psychology is presented later in this chapter.

Parents also send children with Specific Learning Difficulties to private therapists for assessment and reflex remediation programmes in the Republic of Ireland. Other families travel to the UK to avail of individual reflex remediation or balance programmes.

The Dyslexia Early Years Project (DEYP) while not undertaken as a replication of the study published in the Lancet (which featured 8-11 years olds) aimed to look at early indicators of dyslexia in children aged 3-7 years, while also evaluating both a reflex and balance remediation programme.

4.2 Principles of Perceptual-Motor Programmes

Perceptual-Motor Programmes are, in principle, based on the assumption that postural mechanisms, sensori-motor circuits, and perceptual processes are relatively 'primitive' phylogenetically [1] and ontogenetically [2]. These behaviours have developed unusually early and are implicitly controlled by mainly subcortical parts of the central nervous system. It is further assumed that primary postural reflexes, quadruped locomotion, gradual mastery of bipedal walk, etc. are genetically pre-programmed developmental sequences which are:

a) necessary antecedents of more complex motor responses, such as bimanual skills, execution of simultaneous movements, fine finger coordination etc., b) essential precursors of academic learning ability.

Some would argue that any impairment or immaturity of dysfunction of the basic sensori-motor apparatus and its neurological counterparts will hamper scholastic progress. The treatment of these sources of developmental deficit by appropriate 'perceptual motor' training and therapy is a way to academic rehabilitation. This basic assumption was adopted by Delacato, who postulates a strict hierarchy of stages of 'neurological organisation' (Delacato, 1966), as well as by Barsch, who considered movement to be the origin of mental processes (Barsch, 1968).

De Quiros asserts that the postural system is established on the interrelationships of primary body schema (de Quiros & Schrager, 1979). It develops towards corporal potentiality, which is when the individual excludes or inhibits from a conscious level, body afferences in order to obtain human learning. Postural equilibrium, primary body schema, and the integration of the postural system are basic for (1) the use of instruments or objects; (2) the independence of both halves of the body; (3) the learning of nonconditioned language; (4) the possibility of developing creativity and (5) the capacity for higher-level learning.

In the child with language organisation deficiency, de Quiros advocates greater body knowledge, better information from body postures, and better motor realization for the child. All of these permit improved performances in reading, drawing and writing and eventually better articulation in speaking. The programme should be designed according to whether postural and motor development are normal or abnormal. He advises against imposing postures according to the development of reflexes in infancy, saying these would

[1] The race history of an organism.

[2] The life stages of an organism.

not be acceptable at this later age. Three fundamental positions are used: lying on the back, sitting and standing. In each of these positions static exercises (modification of tonus with variation of speed) and dynamic exercises (body swinging, marching, jumping) are carried out. Both the static and dynamic series of exercises provide some items based on equilibrium and combine coordinated movements (starting, moving, stopping). De Quiros & Schrager refer to their publications in Spanish from Buenos Aires in 1962 and 1965 for further details (deQuiros, Della-Cella, Carrara, & Allegro, 1962; deQuiros & Della-Cella, 1965).

Kephart, although emphasizing that motor exercises such as walking, balancing, jumping and oculomotor tracking, are essential components of his programme, allocates considerable space to direct and indirect stimulation of body parts, manual tracing of geometric figures, 'clock' games and other activities. Thus the effect of perceptual motor training is believed to operate not necessarily by re-enacting ontogenetic sequences of sensori-motor maturation, but through associating motor acts with intellectual activity.

Cratty (1970a) openly criticises the perceptual-motor model of mental development, asserting that '*Movement is not the genesis of intelligence... Movement is a vehicle through which men and children interact with and influence their environment*' (Delacato, 1966). Frosting's programme of 'Visual Perceptual Training' (Frostig & Horne, 1964) while emphasizing the importance of training the oculomotor apparatus and eye-hand co-ordination, focuses on the integration of sensori-motor skill and the cognitive ability of visual spatial orientation, without pretending that the former predetermines the latter.

Closer inspection of Ayres' methods (Ayres 1972) reveals that, although there is an emphasis on stimulating the ontogenetically primary tactile and vestibular systems, exercises of cognitive mapping, motor planning and discrimination of spatial cues are intimately interwoven in her curriculum. This recognises the importance of integration (and not sequential restructuring) of the sensori-motor-mental behaviours.

The rationale of perceptual-motor intervention programmes turns out to be a continuum of conceptualisations, starting from models which treat perceptual-motor processes as necessary antecedents of higher mental functions, and ending with theories which consider motor and mental processes as in need of association and integration.

Kohen-Raz notes a general consensus in the field and lists the common structure and content of perceptual motor programmes in his book 'Learning Disabilities and Postural Control', (Kohen-Raz, 1996). It may be that both reflex-based and perceptual/balance-

based motor programmes are of benefit to individual children across the spectrum with autistic, attention, motor and reading difficulties.

There has been some debate as to whether unstructured sensory integration or perceptual-motor control programmes versus strict hierarchical reflex remediation programmes are better able to target any neurological dysfunction or neuro-developmental delay of children with specific learning difficulties. The aim of both fields is to develop motor control in the first instance and to unlock retained reflexes to facilitate learning. Different modalities are targeted such as vestibular, ocular, proprioceptive, kinaesthetic and reflex pathways. It may be that some or all of these inputs work for some children but on a very individual basis. The key may be to pinpoint the particular need of the child and provide the appropriate stimulation over a particular length of time, check the child is ready to learn, and follow up with an intensive remedial reading programme.

The Dyslexia Early Years Project (DEYP) has sought to evaluate generic balance and reflex intervention programmes which form the basis of programmes that claim to remediable dyslexia among other conditions.

As mentioned above most of the movement programmes suggested today for the remediation of SLDs evolved from the field of physiotherapy for cerebral palsy or brain-injured children. Cerebral Palsy is a disorder usually caused by brain damage occurring at or before birth and marked by muscular impairment. Often accompanied by poor coordination, it sometimes involves speech and learning difficulties. Brain injuries, however, can occur at any time in life. They may be caused by an impact to the head hard enough to cause the brain to move within the skull or to directly damage the brain, infectious disease, or heart attack. '*An acquired brain injury commonly results in a change in neuronal activity, which affects the physical integrity, the metabolic activity, or the functional ability of the cell. Acquired brain injury may result in mild, moderate, or severe impairments in one or more areas, including cognition, speech-language communication, memory, attention and concentration, reasoning, abstract thinking, physical functions, psychosocial behaviour, and information processing*' (see Brain Injury Association at www.biausa.org.).

4.3 Review of Reflex and Balance based Movement Programmes

The following chapter goes on to present the particular movement programmes developed for the current study - the Dyslexia Early Years Project (DEYP). The next sections present a review of movement programmes and their cross over into use in reading remediation.

4.3.1 W.M. Phelps: USA 1950's

Phelps was a pioneering orthopaedic surgeon who took the term 'cerebral palsy' (CP) first used by Osler in 1889 and established the concept in the literature. He classes those with CP as characteristically non-progressive brain-injured (Phelps, 1952). He was the first to establish the principle that children with CP could and should be helped to achieve their full potential as persons. Though mainly known for the braces and callipers designed and developed by him to help mobility, Phelp's system also employed periods of rest and relaxation techniques, conscious letting go of the body and its parts, and techniques of kinaesthetic and proprioceptive feed-back via alternate tensing and relaxing of parts of the body.

4.4 Temple Fay: USA 1950's

Temple Fay was a neurosurgeon in Philadelphia (Fay, 1954) and working with Doman and Delacato, founded The Institutes for the Achievement of Human Potential. They first proposed the controversial Progressive Pattern Movement treatment. Fay believed in the recapitulation theory which states that ontogenetic development in man recapitulates the phylogenetic development of the species. He argued that the brain-injured should be taught mobility in the same patterns as it has developed in evolution. Fay recommended building up mobility from primitive reptilian squirming movements, to amphibian creeping, through mammalian crawling movements which involve reciprocal motion on all fours, to the primate erect walking. He argued that these early developmental mobility patterns were carried out by lower animals with a simple nervous system and normal cerebral cortex. If the neocortex was injured, Fay reasoned that the old brain - hindbrain, pons and medulla - could be involved in the stimulation of primitive patterns of movement

and of primitive reflexes which activate the handicapped parts of the body. He developed 'progressive pattern movements' and also described unlocking reflexes which reduced hypertonias and in this manner 'patterning' as an approach to the brain-injured was born.

Patterning is a method of physical therapy in which a rigid pattern of exercises is imposed to stimulate weak or paralysed nerves or muscles to act on their own. Patterning involves a series of exercises that are intended to improve the neurological organization of the child with neurologic impairments. These exercises must be performed over many hours during the day with several persons. These persons must manipulate the child's head and extremities in patterns that are thought to stimulate the prenatal and postnatal movements of children who are not impaired.

However, how much improvement can be seen in a brain-injured individual after such treatment is still unpredictable. There were varied individual responses to stimuli depending on the type of injury.

4.5 Glen Doman and Carl Delacato: USA 1950's

Doman and Delacato developed Fay's theory, working initially with stroke victims, brain-injured children and subsequently with children with severe learning difficulties (Delacato, 1959). At a later stage Doman developed his approaches to early reading and arithmetic in normal children.

The theoretical basis of the Doman-Delacato approach is that 'Use Precedes Function' in that limbs, muscles, and nerve pathways require to be used before a given functional ability can develop. They argued that their techniques were aimed at feedback to the injured brain the required stimulation with the correct intensity, frequency and duration of stimulus. The authors' recommendations were that teams of volunteers would deliver programmes of eight to ten hours duration daily, seven days per week, to the brain-injured child.

Shorter programmes were thought to breach the requirement of intensity, frequency or duration of stimulus feedback. If the child was unable to creep or crawl these movement patterns were imposed passively. Additional sensory stimulation was used including brushing and pinching, and programmes to establish uniform cerebral cortical dominance consisted of sensory or motor restrictions. These included occlusion of one eye, as this was thought to strengthen the use of the dominant hand. The programmes of 'neurological

organisation' came to be used as treatments not only for children with severe difficulties but for children with milder learning difficulties and reading problems as well.

This method received extensive criticism from a number of viewpoints including concerns about the promotion and efficacy of the treatment. Major professional bodies in the US have pronounced against the use of the Doman and Delacato method because of its disputed claims of successful remediation and extensive emotional and physical demands placed upon parents and families involved in conducting the programme (American Academy of Pediatrics 1982; 1968). Double blind studies (Robbins, 1967) have shown the Doman-Delacato treatment to have no effect on the reading achievement of children with normal intelligence and reading difficulty.

Aside from the major ethical concerns, one criticism of the theory is that it is essential that the correct information should be fed back to the brain. Otherwise abnormal reflexes, postural tone, or incorrect movement patterns may be fed back with an intensity, frequency and duration that would ensure the child's abnormality remains unremediated.

The theoretical rationale of Temple Fay and Doman and Delacato's emphasis on the recapitulation of phylogenetic movement appears very weak as the developing brain does not recapitulate previous evolutionary stages such as fish, amphibian, reptile or mammal (e.g. Cummins, 1988). Doman and Delacato also proposed uniform cerebral dominance as the ultimate goal of neurological organisation but it is now generally accepted that neither cerebral hemisphere is uniformly dominant over the other, but that both sides of the brain have particular strengths.

Glen Doman is still the director of the The Institutes for the Achievement of Human Potential (see www.iahp.org) offering programmes for brain-injured children and early learning programmes for multiplying babies intelligence. The goal of this organisation is to raise significantly the intellectual, physical, and social abilities of all children. The Delacato method is based on the theory that children with behavioural, motor and learning disorders lack lateral development in the cerebral cortex. It is still being presented today as a treatment for specific learning difficulties and for children with cerebral palsy, see www.delacato.net.

In an updated statement in 1999, the American Academy of Pediatrics concluded that on the basis of past studies, patterning treatment continues to offer no special merit. It states that the claims of its advocates remain unproven, and that the demands and expectations placed on families are so great than in some cases their financial resources

may be depleted substantially and parental and sibling relationships could be stressed (Pediatarics, 1999).

4.6 Bobath and Bobath: UK 1960's

Karel Bobath a neuropsychiatrist, and Berta Bobath (Bobath, 1969; Bobath & Bobath, 1975, 1984) a physiotherapist, recognized that the central problem in cerebral palsy is the lack of inhibition of reflex patterns of posture and movement. Abnormal patterns are associated with abnormal muscle tone as a result of overactivity of the tonic neck reflex. Initially, the Bobaths placed emphasis on the inhibition of tonic reflexes such as the Asymmetrical Tonic Neck Reflex (ATNR), the Symmetrical Tonic Neck Reflex (STNR) and the Tonic Labyrinthine Reflex (TLR). They argued that once inhibition of reflex patterns and abnormal tone has been achieved more mature postural reflexes could be facilitated. Thus the Bobaths developed reflex inhibitory patterns to inhibit abnormal muscle tone.

The Bobaths claimed that treatment could not be standardized and should be adapted to the individual after a thorough assessment of their disability. As a result treatment tended to be available only from physiotherapists who undertook specialist training with the Bobaths. The Bobaths appreciated the role of sensory stimuli for inhibition of reflexes and facilitation of voluntary movement. The reversal of abnormal tone and and reflex movement gives the child the sensation of more normal tone and movement, which in turn promotes feedback to the brain and guides normal mobility. However this does not explain why the Bobaths advocated all-day management of handling in preference to treatment or exercise sessions. Inconsistencies arose in the description of their work. Later emphasis was on muscle tone rather than the possible inhibition of primitive and postural reflexes. Rather than taking a developmental perspective the Bobath approach considered that it would not be possible for the patient to carry over the obtained movement patterns into the activities of daily life. It was advocated that everything done in treatment should serve as a direct preparation for specific functional use. Physiotherapists and parents trained in the Bobath techniques were urged to get away from the concept of exercises and patterns and should treat the patient, as far as possible, in situations of daily life.

A controlled study of two groups of CP children found no significant differences after twelve months between treated and untreated children (Wright & Nicholson, 1973). The children were assessed on motor function, range of movement of joints and loss of primitive

reflexes. A 2002 study found that children with CP children improved significantly in gross motor and self care skills following a 6-week course of Bobath therapy (Knox & Evans, 2002). However a small sample size (n=15) and no separate control group limits the results of this study. Another study in 2004 (Tslorakis, Evaggelinou, Grouios, & Tsorbatzoudis, 2004) examined the effect of neurodevelopmental treatment (NDT) on the gross motor function of children with CP. Thirty-four children were assigned randomly to groups, one group receiving NDT twice a week the other 5 times a week for 16 weeks. The second group performed better and showed significant improvement in gross motor function. However again there was no control group.

4.7 Britta Hollë: Denmark 1970's

Britta Hollë (Hollë, 1976) developed her treatment for both handicapped and CP children. She noted that the first stage of development in the child is sensory-motor, and until this stage has been completed the child cannot develop further, that is, he cannot be expected to learn to read and write. Hollë pointed out that in the newborn the cortex has no influence over the lower regions of the brain. Myelination [3] is necessary for the development of movement. These movements are not yet inhibited by the cortex and are not voluntary. She concluded that interaction between the development of nerve tissue and its practical use are mutually enhancing and that practice is required for the establishment of neural pathways. Hollë saw the development of movement occurring in well-defined stages as follows:

1. Reflex movements (uncontrolled by the brain)
2. Symmetrical movements (brain control just beginning)
3. Voluntary, motivated, differentiated movements
4. Automatic or habitual movements

Hollë points out that good co-ordination is not inborn. It develops by the maturation of the central nervous system, aided by kinaesthetic sense - the sensations involved in active muscle movement. Every new movement must be learned, then repeated until it becomes

[3]Where an insulating envelope of merlin surrounds the core of a nerve fibre or axon and so facilitates the transmission of nerve impulses.

automatic. In a more specific emphasis than any of the other schools of rehabilitation, Hollë urged that practictioners develop a knowledge of reflexes and primitive movement patterns.

4.8 Brunnström: USA 1970'S

Signe Brunnström (Brunnström, 1970) was a contemporary of Doman and Delacato. Brunnström developed a movement programme, Synergistic Movement Patterns, which had a different emphasis from her contemporaries. Before others realized the importance of primitive infantile and postural reflexes in the brain-injured, Brunnström was already stimulating the reflexes and attempting to enlist them in regaining movement in the patient. Working with adult hemiplegics [4], she developed a programme that stimulated early tonic neck and labyrinthine reflexes that was followed by righting reactions and later, balance training. Flexion and extension were stimulated using primary reflex patterns to overcome limb spasticity and so 'scaffolding' the initiation of voluntary muscular control.

4.9 Margaret Rood: Canada & USA 1950's

Operating in Canada and the US in the 1950's and 60's, Rood was both a physiotherapist and occupational therapist. Employing a neurophysiological approach to the problem of rehabilitation, she stressed the role of reflexes and afferent stimuli applied in an ontogenetic sequence (Rood, 1954). She aimed to relieve certain motor neuron pools from excessive excitation and others from excessive inhibition. Rood used reflexes such as the tonic labyrinthine reflexes, tonic neck reflexes, vestibular reflexes and withdrawal patterns in her therapy called Sensory Stimulation for Activation and Inhibition. Her approach resembled the work of Brunnström in that they both dealt with more primitive stages of development than those covered by the Doman-Delacato approach. She was criticized for her strict ontogenetic emphasis, and naivéte of its physiological rationale along with the use of tactile, temperature and proprioceptive stimulation (McGlown, 1990).

[4] paralysed on one side of the body

4.9.1 Bender: USA 1970'S

Retiring after service as a physical therapist during World War II, Dr. Miriam Bender entered Purdue University and earned a doctorate in 1971. With a background in physical therapy, she extended Kephart's studies (Bender, 1976) of human movement from the gross-motor to basic reflex level. Bender's research claims that many children experience behavioural and academic difficulties because of an immature Symmetric Tonic Neck Reflex (STNR). O'Dell and Cook established the Miriam Bender Diagnostic Center, a clinic at the University of Indianapolis.

A study at the University of Purdue found that the STNR was present in 75% of a group of learning disabled children but not present in any of a comparison group of children who had no history of learning disabilities. A series of exercises were designed to help inhibit the STNR, and many of the children improved (Bender, 1976). Further research undertaken at the Miriam Bender Institute found that exercises based on movements which involved crawling against resistance were of value in overcoming hyperactivity (O'Dell & Cook, 1996).

4.10 Ayres: USA 1970'S

Jean Ayres proposed that disordered integration of vestibular, tactile and proprioceptive sensory inputs led to a range of learning and motor difficulties. Sensory integration difficulties were seen as underlying a wide range of problems such as hyperactivity, poor speech development, disorders of muscle tone and co-ordination, learning and reading difficulties, and autism as well as problems with social behaviour and delinquency (Ayres, 1977, 1980).

The aim of sensory integration is to provide and control sensory input, especially input from the vestibular system, muscles and joints, and skin in such a way that the child spontaneously forms the adaptive responses that integrate those sensations. Therapy is most effective when the child directs his own actions while the therapist unobtrusively directs the environment, providing various pieces of equipment for the child to play on or directly applying sensory stimuli to the child such as brushing, rubbing or deep pressure sensations.

The purpose was not to teach or train specific perceptual, motor or academic skills, instead

the aim was to help the child function better physically, emotionally and academically. It is thought that perceptual-motor functioning and academic performance will improve indirectly as a consequence of improved sensory integration. Thus improved reorganisation of the brain could lead to inhibition of primary reflexes, the emergence of equilibrium reactions and improved oculo-motor control.

Sensory integration therapy involves both passive and active sensory stimulation using exercise equipment such as scooter boards, rotating swivel chairs and bolster swings, to provide vestibular stimulation. Sensory integration theory places considerable emphasis on vestibular dysfunction as a fundamental neurological deficit.

Two research studies claimed support for the efficacy of sensory integration therapy on academic performance (Ayres, 1972b; 1978). However both of these studies lack adequate controls and in the later study there was no experimental effect on a variety of academic, perceptual and language measures (Morrison, 1985). The American Academy of Pediatrics (AAP 1985, p.648) stated that '*physicians, educators, and parents parents must be aware that, although visual-motor perceptual disabilities are correlated with reading and writing problems, there is no definitive evidence that these disabilities can be helped by perceptual motor training*'.

4.11 Andreas Petö: Hungary 1940's-1980's

By 1987 Conductive Education was well established in Hungary having developed over the previous forty years. The Petö Institute was a state organisation in a socialist country which provided Conductive Education free of charge to Hungarian children and adults with motor disorders. Petö trained specialist professionals, called 'conductors', who made up its own workforce. The Petö method or Conductive Education never claimed to be a treatment, rather a 'learning model'. This approach integrated therapy and education, where a specially trained conductor (acting as mother, nurse, teacher and therapist) along with one or two assistants, interacted with the children in groups of fifteen to twenty, in all-day specially constructed programmes. The problem, as Petö saw it, for cerebral palsy children was their inability to learn from their environment, their insecurity and their confusion. The conductors undertook a four year training course. The children's daily tasks were analysed and motor, communication, functional, learning and psychological goals were set for the children, following a structured timetable for daily living, including dressing, feeding, movement training, speech, reading, writing and other school work.

The Petö method used an integrated team approach to education which was not used in the West. However Conductive Education as practised by schools in the UK has failed to achieve the remarkable results reported from Hungary. Janet Read reviews the situation in her book 'Conductive Education, 1987-1992: the transitional years' (Read, 1992) and concludes that it may have been applied piecemeal, as the time needed to be invested in each child is considerable. It should be noted that the method also relies very heavily on the training, dedication and sheer persistence of staff.

In Ireland a less intense method has been used to educate CP children in special schools. It was radical at the time to use an integrated team, as children had previously been treated by the various specialist separately. Teams work together and the exercise class was guided by a physiotherapist. The children had to have a minimum IQ level to participate and the aim was to make them comfortable and happy in their physical environment so that they could then apply themselves to learning. Though not used as much now in Irish special schools, its ethos of an integrated approach to therapy and learning has had a lasting effect in special education.

4.12 Kohen-Raz: Israel 1969

It is worth looking at work on postural control in Israel over the last few decades. Kohen-Raz in his book 'Learning Disabilities and Postural Control' (Kohen-Raz, 1996) states that Perceptual-Motor Programmes are, in principle, based on the assumption that postural mechanisms, sensori-motor circuits and perceptual processes are relatively 'primitive'. This means that they occur in an early stage of development and are implicitly controlled by mainly subcortical parts of the central nervous system. It is further assumed that primary postural reflexes, quadruped locomotion, gradual mastery of bipedal walking and so far are genetically preprogrammed developmental sequences which are a) necessary antecedents of more complex motor responses, such as bimanual skills, execution of simultaneous movements, fine finger coordination and b) essential precursors of academic learning ability. The logical consequence of adopting such a perspective is that any impairment or immaturity of dysfunction of the basic sensori-motor apparatus and its neurological counterparts will hamper scholastic progress. Therefore the treatment of these sources of developmental deficit by appropriate 'perceptual motor training' is the way to academic rehabilitation.

The relationship between postural control, school readiness and academic skills was ex-

plored in three studies using the tetra-ataxiametric technique (Kohen-Raz, 1996). Instruments that measure postural control are known as stabilometers which measure quasi-dynamic equilibrium, and ataxiameters which measure static balance. This technique developed by Kohen-Raz (1970) uses four footplates operated by pressure transducers, one each for the left and right heel and toe respectively. Each plate is exclusively sensitive to vertical pressure and, whatever the position of the heel or toe within the area of the plate, the output will depend solely on the weight borne by each of the parts of the foot. Thus, instead of considering the upright human body as an inverted pendulum or a prisms in an unstable state of equilibrium, it is viewed as a 'quadruped' resting upon four distinct areas of support. The output is essentially a graphic or electronic representation of force fluctuations, or weight displacements over the four footplates. Both posterior-anterior and sway along the transverse axis can be obtained by combining the heel of one foot with the contralateral toe, and measures of diagonal sway can be obtained (Kohen-Raz, 1979).

Results of a pilot study carried out in California in 1969 indicate that school readiness in the kindergarten, as evaluated by teacher observation, Bender Test Performance (Bender, 1976) and understanding of simple arithmetic problems, is negatively correlated with the amount of postural sway, as measured by postures such as standing on one foot and standing with eyes closed. According to de Quiros (1979) these are critical indicators of postural maturation at this age.

In the first grade (age 6) significant correlations were obtained between postural stability in monopedal postures and reading scores, as measured by the Stanford Achievement Tests (**www.harcourtassessment.com**). In the kindergarten (51 children aged between 4-5 years) and third grade (21 children aged 8)) samples, the correlations between body sway and reading were higher in girls than in boys. This finding is independent of the fact that girls score consistently higher on static balance tests. The amount of postural sway, as measured by the One leg Stand and Romberg tests (de Quiros & Schrager, 1979), negatively correlated with performance on the Bender Test, teachers' assessment of school readiness and understanding of simple arithmetic problems.

Significant relationships between reading ability and postural control were also found in 46 boys and 44 girls who were part of a large scale French Study (Zazzo, 1978). The patterns of sex differences were also similar as in the Californian study, that is the girls were superior to boys on balance scores, and the relationships between balance and reading were more pronounced in the female sample. The French study included both middle class and disadvantaged students. The French study found differences between the pos-

tural control and reading relationships of the two groups. In the disadvantaged group however, this relationship was blurred by the high incidence of subjects with relatively good balance ability but poor reading because of extreme environmental stress, which could be documented from individual case studies.

The sex-difference in strength of posture-reading correlations, which has appeared in independent samples in two countries can be tentatively explained in two ways. The relationship between postural control and academic skills is transitory and contingent upon a 'critical growth period'. As girls pass this period earlier than boys, correlations may appear in the female sample while still be absent in males. Kohen-Raz states that inspection of the Californian data disproves this hypothesis, as the sex difference already appears in kindergarten (ages 4-5) and re-emerges at the third grade (age 8). If the hypothesis were true, the sex difference should disappear or invert at higher grades.

Kohen-Raz's alternative hypothesis is based on the assumption that, like other cognitive functions, reading skill develops as a result of interaction of maturational processes with environmental factors. As boys are more vulnerable to environmental stress and are also under higher pressure of expectations to be academically successful, emotional-social factors may interfere to a greater extent with their learning process. On the other hand, the level of scholastic skills in girls in the elementary grades appears to be primarily a function of maturation, hence its relationship with postural performance, the latter probably reflecting 'postural autonomy' manifest on typical 'stressful' items of the ataxiametric test battery (Kohen-Raz, 1996).

Kohen-Raz argues that these cross cultural tetra-ataxiametric studies demonstrate the existence of relationships between postural control, school readiness and scholastic achievements in the lower elementary grades and that this provides an important baseline for the early detection and early differentiation of learning disabilities.

Kohen-Raz cannot explain the apparent success of the Israeli programme in 1982/1983 (Kohen-Raz, 1996). This programme trained general physical fitness in children between 5-7 years. It was administered by regular classroom teachers during a 40-50 minute lesson. The equipment was minimal and there was no prescribed sequence to the programme's exercises. The exercises included Spatial Orientation, Discrimination of Left and Right within Own Body, Synergetic Movements, Aiming at Targets, Control of Symmetric and Asymmetric Movements, Execution of Motor Acts with restricted Vision, Walking along Geometrical Patterns, and traditional competitive sports activities such as running, jumping, and climbing obstacles. The control groups did not receive any treatment. They

received irregular and non-systematic physical education devised by the class teacher.

The majority of pupils had parents with no more than 8 years of education; had fathers with unskilled or semi-skilled jobs; had more than three siblings; were in families where three or more people lived in one room and who lived in deprived areas. However dyslexia as a condition was not diagnosed.

A significant reduction was found in the percentage of pupils weak at reading and arithmetic in the experimental group. 'Weak readers' were pupils who were unable to read more than single bi-syllabic or mono-syllabic nouns set in large print, which described a depicted object among three distracters. 'Normal readers' should be able to read single sentences printed in regular size by the end of first grade. Weak performers in Arithmetic had difficulties with additions within the range of 1-5.

Kohen-Raz (1996) reports that the experimental effect was consistent when comparing the two studies, and when inspecting results in single subgroups recruited from different schools. An unexpected finding was the apparently greater experimental effect of the physical training programme on the reading progress of boys. This was consistent across the two studies but absent on the arithmetic readiness test. He notes that although the interaction between gender and treatment does not reach statistical significance in his study, the consistency of findings over different studies warrants further investigation of the differential effects of psychomotor and perceptual motor training on the two sexes.

There is no mention whether the children had undergone IQ tests or had a diagnosis of dyslexia in any of his studies. It may simply be that the results were due to the Hawthorne effect - an increase in performance produced by the psychological stimulus of being singled out and made to feel important.

Again, there has been no independent replication of the work done by Kohen-Raz's work. It is also important to bear in mind that just because correlations are found in these studies the results do not imply causality. Indeed, Kohen-Raz notes that although the overall results of his Psychomotor School Readiness Programme are significant, consistent, and based on relatively large samples, they do not yet provide proof that the stimulation of motor systems which are closely related to the vestibular and postural subsystems, leads to academic progress. However he argues that a physical education programme based on theories of psychomotor and postural school readiness is apparently effective in reducing the high risk of learning disabilities in disadvantaged first graders.

4.13 Brain Gym: 1970's

Developed by Paul Dennison Ph.D. over twenty five years ago, Brain Gym claims to be effective in the treatment of educational and behavioural difficulties in children and adults. Brain Gym is a movement programme based on the premise that physical movement stimulates brain function and that stress inhibits learning. It claims that overall performance and quality of life improvements have been seen in people with difficulties such as autism, dyslexia, dyspraxia and downs syndrome, the learning challenged or truants (see www.braingym.ie).

Its key concepts are intended to impact on learning styles proposing that every learning situation deals basically with the same steps: sensory input, integration and assimilation, and action. Brain Gym claims to facilitate each step of the process by waking up the mind /body system, and bringing it to learning readiness. Brain Gym is a programme of physical movements that purports to enhance learning and performance in all areas. Brain Gym includes 26 easy and enjoyable targeted activities that integrate body and mind to bring about rapid and often dramatic improvements in concentration, memory, reading, writing, organizing, listening, physical coordination, and more.

Brain Gym is not just targeted at individuals with a learning or motor co-ordination difficulty but at people of all abilities in making wide-ranging changes in their lives. Brain Gym is used in more than 80 countries and is taught in thousands of public and private schools worldwide and in corporate, performing arts, and athletic training programs (www.braingym.org).

In a 1994 pilot study Dr. J. Donczik presented his findings on how Dennison Laterality Repatterning (DLR) provided by Brain Gym, helped to lessen errors in reading, memory and comprehension of those considered to have language disabilities. The purpose of the DLR movement process is to help the learner discover how to cross the visual/auditory/kinesthetic midlife of the body for improved bilateral processing. Between 1995 and 1996, based on the 1994 study, additional controls were added to show how the DLR influences rate of reading, as well as learning and memory processes. The basic elements of the DLR are as follows. In part one, the student points the eyes up to the left while doing the cross crawl. Then the student points the eyes down to the right while doing a homolateral (one-sided) crawl. In part two, the student moves in a contralateral (cross crawl) pattern while moving the eyes in all directions: vertically, horizontally, in circles, near and far. The eye movement is then repeated during the homolateral movement

pattern.

In this control study (n=37), the reading scores of those with language disabilities who did not receive DLR decreased with each trial. Those who received DLR in the 1994 study improved from trial to trial. It must be noted that the DLR was offered between the first and second trials and it is unclear whether the DLR was usually part of a long-term daily programme. It is also unclear how many of the control group were diagnosed as dyslexic. In a number-sequencing test, the reading rate increased after DLR while it stayed the same for those without DLR. Finally, it was also found that long-term memory retention improved after DLR, while no such improvement was evident without DLR. However this research was published in the Brain Gym journal and no placebo group was used (Donczik, 2001)

In research into reading abilities, published in the Brain Gym journal (Koester & Sherwood, 2001), 205 children were randomly assigned into one of two groups. One doing 15 minutes of Brain Gym a day and a control group who did no exercises throughout the 1998-99 school year. Comparison of their test scores indicated that the Brain Gym group reading ability improved more than the control group on a standardized test. Again no placebo group was used and the results were not published in a peer reviewed journal. Brain Gym International currently offers over 50 training courses at various levels in areas referred to as Total Core Repatterning, Integration of Reflexes and Reactions, and Optimal Brain Organisation.

4.14 Brain-Injury-Rehabilitation-Development: UK 1982

After the publication of Delacato's book: 'The Treatment and Prevention of Reading Difficulties' (Delacato, 1959) reflex remediation has been suggested as a way of remediating poor readers. This idea was brought to the UK and influenced the thinking of those working with brain damaged children and those with reading difficulties.

B-I-R-D, a neurodevelopmental treatment charity (www.b-i-r-d.org.uk) was established by Dr. David McGlown in 1982. His method, known as Developmental Reflexive Rehabilitation, was originally used with brain-injured patients. It works on the premise that in normal development, 'primitive infantile and postural reflexes' are present at birth and are inhibited by the brain during the first year or two of life. In cases of brain injury,

these reflexes either are not inhibited as they should be, or, if the injury occurs later in life, they are released and reappear. The continued presence of these reflexes obstructs normal development and normal functioning, not only physically, but also mentally and emotionally. Only when the brain has inhibited these reflexes can the individual develop transformed, 'adult' reflexes which are employed for the rest of their lives.

McGlown claims that, along with collaborator Dr. Peter Blythe of the Institute of Neuro-Physiological Psychology, he discovered the relevance to learning difficulties of uninhibited primitive and postural reflexes, and the absence of transformed 'adult' reflexes, in children with a specific learning difficulty who otherwise appeared perfectly normal. They claim to have found direct evidence of abnormal development in these children, and more importantly discovered that if the child's neurological dysfunctions were corrected, the original presenting learning difficulties were resolved.

B-I-R-D's programme aims to eliminate 'primitive infantile and postural reflexes'; to induce and transform them into 'adult' reflexes, to encourage unilaterality and, if possible, the correction of eye-muscle dysfunctions. The systematic treatment of perceptual problems promotes more normal development and functioning, thus enabling the patient to develop or regain abilities previously denied to them.

McGlown states that some approaches seek to help a child to perform a specific task in whatever turns out to be the best way possible for the child, whereas B-I-R-D seeks to help a child to develop the correct neurological equipment, the goal being to treat the associated dysfunction. Seeming to criticize the practices of the Doman & Delacato and Temple Fay Schools, McGlown notes that 'intensive' programmes require teams of volunteers and their long daily duration can result in neurological overloading of the patient. Such programmes also ask for behaviours for which the patient may not yet have the correct neurological equipment. With a shorter programme of treatment, and with two people helping the patient, he states that B-I-R-D attempts to uncover abilities and free the patient to obtain additional input from other therapies and education. With the B-I-R-D approach parents or carers of brain-injured patients are taught how to help perform the routines designed for each individual patient, so even the most physically disadvantaged are not excluded from the treatment approach. The treatment programme takes 30 - 60 minutes per day.

In his book 'Developmental Reflexive Rehabilitation' (McGlown, 1990) McGlown does not agree with the Doman and Delacato theory and many of their practices. McGlown (1990) argues that some credit is due to these innovators who introduced the concept

of maximum stimulation and input at a time when the orthodox approach to comatose patients was to nurse them behind closed curtains and in circumstances amounting to sensory deprivation.

McGlown also argues that the part played by the primitive reflexes in neurophysiological development has given rise to a programme which is not merely a 'motor-developmental programme' which encourages improvements in mobility, but rather represents a systematic correction of development in all aspects. Its greatest value lies in locating and pinpointing where development has gone wrong. He contends that by going back to the point where development has gone wrong, and systematically correcting aberrant reflexes, a more normal development is promoted from that point forwards.

4.14.1 Use of Reflex Therapy in Reading Remediation

Blythe and McGlown (1978) reported that when reflex abnormalities were present in the child who was failing at school, this child was very likely to display aberrant motor developmental patterns of creeping and crawling, significant problems with laterality, a range of eye-muscle dysfunctions and perceptual problems including visual-motor integration difficulties and/or visual discrimination problems. It has proposed that these problems stemmed from underlying reflex abnormalities and that it is essential for intervention to adopt a bottom up approach based on the inhibition and integration of primary reflexes. Unfortunately, in common with most motor intervention programmes, evaluative research of their effectiveness with children or adults with learning difficulties has been very limited or poorly conducted.

In 1982, a study of 25 children diagnosed with 'organic brain dysfunction' and Specific Learning Difficulties was undertaken in mainstream schools (McGlown, 1990). The study aimed to investigate

- which aberrant reflexes and their dysfunctions were present;
- how long it took to inhibit the relevant reflexes and reduce dysfunctions after the implementation of a reflex-inhibition programme;
- and what the effects on the children were in terms of the educational attainment in reading and spelling.

Of the 25 children, 19 had a variety of specific learning difficulties and 6 were diagnosed as dyslexic by independent authorities. Four of the children were dyspraxia, 3 had speech difficulties and 2 had severe behavioural problems. One child exhibited attention difficulties and one was enuretic (urinary incontinence). The age range was from 7.5 to 17 years and the sex ratio was 7:1 boys to girls. McGlown claims an average increase of 31 months in reading age and 13 months in spelling age after a reflex inhibition programme averaging nine months. It is not stated what attainment tests were carried out, and by whom, pre and post the intervention. The performance level of the children at the onset of the study with regard to reading or spelling was not reported. A control group of children with similar levels of difficulty was not followed up over the same period. It is unclear whether the assessments where carried out 'blind' or independently.

It is unclear whether B-I-R-D's treatment is similar for both brain damaged children and those with Specific Learning difficulties. If it is, the question has to be asked whether the same programme is appropriate for both. There has been no objective empirical research reported on the effectiveness of B-I-R-D's treatment. This is not to criticise the individuals involved who are dedicated and hard working in their treatment of children however whether these treatments actually benefit individuals long term is still largely unknown.

Mainstream practictioners have been reluctant to accept that a motor development programme can produce improvements in areas of functioning other than mobility, and usually even if a child makes some small gains in mobility, he or she is still left with gross deficits in perception and cognition, and with obvious mental retardation.

Bleck (1987) discards the idea that a learning disability is caused by the same mechanism as brain damage in children. Bleck quotes Feagans (1983) in McGlown (1990): '*Treatment programs have not generally been effective in preventing academic problems, nor has a learning disability disappeared. The basis of these special treatment methods for perceptual-motor problems was their presumption of a neurological mechanism. This concept has been discounted. The idea that a learning disability is the same mechanism as in brain-damaged children has been discarded.*' (McGlown, 1990) p42.

One important fact to note is that most children, even severely mentally retarded children, still grow and develop, although on a slower curve than average. Therefore, any child admitted into any treatment programme will make some progress as an inevitable consequence of time and their natural development, even if that treatment is completely worthless. Without adequate controls, it is therefore impossible to evaluate any such

treatment.

McGlown himself states that the conflicting theoretical assumptions and differing practical approaches of the major schools leave little room for common ground, or for an encompassing neurophysiological theory which explains fully the abnormal motor behaviour presenting in brain-injured children, and the effects of treatment procedure.

It is not known whether brain-injured children and those suffering from a Specific Learning Difficulty are on the same continuum. The impairment in the development of movement and or reading ability in CP or brain injured children may indicate a loss of use of one or more areas of the brain. However with dyslexia, despite years of research, it is not known whether a 'noise' problem, confusion in messages sent across the corpus callosum, lack of adequate synapse connections, lack of neural organisation in the visual and/or auditory perception areas of the brain, or indeed in the cerebellum, is at the root of dyslexia. Indeed it may be a combination of some or all of these problems. It is difficult to argue that movement programmes of any description help in remediation. A whole field of Specific Learning Difficulty therapies has evolved in the UK and Ireland in the last 10 years. There has been some anecdotal evidence from parents which is difficult to investigate, but recently some interesting results have been reported in a few empirical studies, namely those published in the Lancet and the Journal of Research in Special Educational Needs (McPhillips et al., 2000; Jordan-Black, 2005) and these will be discussed in section .

4.15 The Institute for Neuro-Physiological Psychology (INPP) UK 1975

The Institute for Neuro-Physiological Psychology (INPP) was established in Chester in 1975. This organisation offers reflex stimulation and inhibition exercises for children suffering from Neuro-developmental Delay (NDD). Neuro-developmental delay is a term which describes the presence of a cluster of aberrant reflexes which are present due to an omission or arrest at a stage of early development. Certain combinations of retained reflexes exhibit themselves in ways that affect emotional and social well-being and academic progress.

INPP's diagnostic assessment for NDD includes tests for gross and fine muscle co-ordination, balance, patterns of motor development, the presence of aberrant reflexes, laterality, oculomotor functioning, visual-perceptual ability and visual-motor integration performance.

Following assessment the child is given a movement programme which consists of specific physical, stereotyped movements (Thelen, 1979), practiced for five to ten minutes per day over a period of nine months in their own home. The movements are based on a detailed knowledge of reflex chronology. INPP maintain that specific movement patterns made in the first month of life contain within them a natural inhibitor to aberrant reflexes. If a child has never made these movements in the correct sequence, primitive reflexes may have remained active as a result. INPP argue that by practising the stylized movements daily, it is possible to give the brain a 'second chance' to register the reflex inhibitory movement patterns which should have been originally made at the appropriate stage of development. They claim that as the aberrant reflexes are inhibited many of the physical, academic and emotional problems of the child will disappear.

Six weeks after the child has commenced the home programme he is tested again to ascertain the efficacy of the movement programme, and the exercises are altered if appropriate. Progress is monitored at intervals of 6 - 8 weeks and the reflex stimulation/inhibition programme may be amended depending on the child's progress. On average, treatment lasts for approximately one year. Quasi experimental studies are presented on the INPP website (www.inpp.org.uk).

An article published in Child Care Practice journal in 2005 presents a summary of separate studies carried out using the INPP Test Battery and Developmental Exercise Programme (Blythe, 2005). The studies took place in the UK and Northern Ireland and the aims of the studies were to answer whether:

- neurological dysfunction is a significant factor in children who are under achieving at school
- neurological dysfunction responds to a specific programme of developmental exercises carried out at school every day for one academic year
- there is a cross over from change in neurological status to improvement in academic measures (reading, reading comprehension and drawing).

The difficulty in reviewing this work is that results from four UK schools and the Northern Ireland schools are presented in one article and are difficult to compare as the criteria for selection, duration of exercise programme and types of educational assessment varied between schools. All participants were assessed using the neurological tests from the INPP Test Battery and specific education measurements at the beginning of the programme.

Teachers and other professionals were trained to administer a short battery of tests to assess three reflexes, namely the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR) and the tonic labyrinthine neck reflex (TLR). Other tests from the battery were used to identify soft signs of neurological dysfunction, visual tracking, integration, discrimination and visual-motor integration.

As mentioned earlier, selection criteria were different between schools. For example, in two of the UK schools, children in both the experimental and control groups were selected on the basis of having a reading age of one year or more below their chronological age. This however is not sufficient for a diagnosis of dyslexia which typically states the child must be reading at a level of two or more years below their peers. It must also be noted that children master reading at different rates and those that were classified as poor readers in this study may catch up as they reach developmental stages.

For the other UK school and the schools in Northern Ireland, no pre-selection was made. In all the schools, the children in the experimental groups performed the INPP exercises at school under teacher supervision for 10 minutes a day, for periods of between 8 and 14 months. The control groups did not undertake the INPP exercises and one UK school introduced a third group, which carried out non-specific exercises for the same period each day. All groups were re-assessed at the end of the programme using the neurological tests. The educational assessments varied between the schools and the type of reading or spelling tests used are not reported.

Results from the UK schools showed that there was a significant decrease in scores on the neurological tests. While analysis of the difference in reading and spelling performance between two groups at one of the primary schools did not reach statistical significance, the general trend was for greater improvement in reading and spelling in the experimental rather than the control group. In the school where the third group performed general PE exercises, no significant difference in reading progress between the groups was reported. However the INPP exercise group showed the greatest improvement. The author states that general PE exercises carried out on a daily basis appear to improve balance and coordination but do not necessarily transfer across to educational improvement.

The North Eastern Education and Library Board (NEELB) in Northern Ireland undertook two pieces of research in the academic year 2003-2004. The aim of the NEELB study was to evaluate the effectiveness of the programme by measuring changes in retained reflexes, balance, reading, spelling, handwriting, cognitive development, visual-motor integration, visual tracking and integration, and concentration/co-ordination. A total of 663 children

took part. It was found that:

- 35% of children aged 9-10 years (113 children) and 48% of children aged 6-7 years (163 children) showed elevated levels of retained reflexes at their first assessment.
- 15% (49) of children aged 9-10 years had a reading age below their chronological age, however the size of the reading discrepancy is not reported.
- Elevated levels of retained reflexes were correlated with poor educational achievement at baseline, but only in 28 out of 49 cases (57%).
- Children who undertook the exercise programme showed a statistically significant greater decrease in retained reflexes than children who did not undertake the exercises. This would be expected as the programme was designed in the first instance to inhibit reflexes.
- Children who undertook the INPP exercise programme showed a highly significant improvement in balance and co-ordination over children who did not undertake the programme. No difference was found in reading, handwriting or spelling in children who were already achieving at or near their chronological age, but for children with high levels of retained reflexes and a reading age below their chronological age, those who undertook the programme made greater progress, although this progress was not statistically significant.
- Retained reflexes were correlated with poor cognitive development, poor balance, and teacher assessment of poor concentration /co-ordination in children aged 6-7 years.

Goddard concludes that neurological dysfunction (reflex scores greater than 25%) was a significant factor in educational underachievement (children's reading age below their chronological age). Neurological dysfunction did respond to the INPP Developmental Exercise Programme. Children in the experimental group showing significantly greater improvement in reflex scores and tests of balance and coordination than the control or comparison groups, but only 57% of children had retained reflexes.

The study reports a general trend whereby children who did fit the criteria for using the INPP programme (reflex scores greater than 25% and reading age below their chronological age) showed greater improvement in educational measures after using the INPP

programme than comparison groups that did not take part in the programme. However there was no significant improvement in reading and spelling performance.

The findings suggest that within the general population there exists a group of children for whom neurological dysfunction is a significant factor, and that neurological dysfunction is linked to educational performance. These results may indicate which specific group of children are likely to benefit both developmentally and educationally from the INPP programme. It may be that good neurological functioning increases the potential for learning. If this dysfunction can be remediated among poor readers or those with dyslexia, then the child's capacity for learning is increased.

More extensive use of tests for neurological dysfunction within the school system could help to identify those children who are underachieving as a direct result of underlying neurological dysfunction, so that their developmental problems can be corrected enabling them to perform to a higher level.

The results from children aged 6-7 years (n=339) in the NEELB study suggest that a number of children are developmentally immature in terms of physical skills connected to balance, coordination and reflexes at the time they enter school at four to five years of age. This lack of developmental maturity does appear to have an effect upon performance in the classroom and echoes other researcher's conclusions that motor maturity is an important part of school readiness (Kohen-Raz, 1996). Only when the child can control its own body and can concentrate as well as conduct itself socially within the classroom, can it learn.

The authors conclude that there was considerable variation in research design between each of the independent studies. It is unclear if the claims can then be upheld or if each study should be treated separately, given the difference in number of participants, criteria for selection and unknown attainment tests. Another confound was that children in one of the schools came from an area where 80% of pupils come from homes where English is a second language.

Further longitudinal studies need to be carried out to assess the long-term effects of change in neuro-developmental status upon academic achievement. Goddard recommends that any future controlled studies employing the INPP Developmental Exercise Programme should be designed as two-year projects, to enable the control groups to be offered the same intervention as the experimental group during the second year. More importantly, if balance, coordination and motor skills provide a stable platform on which higher skills are

built, it may be necessary for that platform to be stable over time before other educational skills can catch up. Thus it is suggested that future studies assess participants a year after completion of the programme to see if educational performance continues to improve after the neurological changes take place.

4.16 Primary Movement: Northern Ireland 2000

Following on the work of the anthropologist Raymond Dart (Dart, 1996), Martin McPhillips at Queen's University of Belfast developed a reflex remediation programme, Primary Movement. The programme is offered as a possible way of remediating dyslexia, possibly in conjunction with reading programmes via a non-profit making charity. Primary Movement was established to bring a specific movement programme to the public domain through the provision of training courses and other facilities for those working with children with specific learning difficulties www.primarymovement.org.

The Primary Movement programme is a series of exercises based on the primary reflex system that emerges during foetal life and which plays a role in the survival of the newborn. These reflexes include large movement patterns which should be inhibited or integrated during the first year of life. Persistence beyond one year of age is associated with significant learning problems. The programme came to public and media attention in 2000 and is now used in some schools in Northern Ireland.

An article published in the Lancet (McPhillips et al., 2000) claimed that children who completed the experimental movement programme, which was based on primary reflex replication, made very significant progress in reading, saccadic frequency (eye movements), writing speed, phonological sub-test, and naming speed, with a concurrent significant inhibition of the ATNR. In a randomised, individually matched, double-blind, placebo-controlled design, 60 children were enrolled into one of three treatment groups: experimental (children were given a reflex inhibition movements), placebo-control (children were given non-specific movements), and control (children were given no movements). Children selected for the study were at least 24 months behind on the Neale Analysis of Reading Ability test and 18 months behind on Wechsler Objective Reading Dimension (WORD). They also had a persistent Asymmetric Tonic Neck Reflex level of 2.9-3.1 on a scale of 1-4.

It is suggested that the repetition of primary reflex movements plays a major role in

the inhibition of primary reflexes. It assumes that inhibition can be brought about at a much later stage in development than had been previously assumed. The reading gains achieved by the experimental group in this study were very significant. The experimental group showed a significant decrease in the level of persistent ATNR over the course of the study. Corresponding reading skills improved by between 9 months and 1 year 5 months on the WORD and between 1 year 3 months and 1 year 8 months on the Neale Analysis of Reading Ability, over a period of 12 months. An average child without reading difficulties would be expected to achieve a reading gain of 12 months over the same period. There was no significant change for the placebo and control groups.

Only the experimental group showed a significant decrease in saccadic frequency post-test. All groups showed a significant improvement over time in writing speed although the difference between the groups post-test was not significant. There was no group by time interaction for spelling although all groups showed a significant improvement in spelling age over time. McPhillips reports that there was no evidence of a placebo effect for the placebo-control group. The 7 month reading gains for both control groups contrast with an expected 4-6 month reading gain over 12 months. A follow-up questionnaire showed that the control group who did not received a movement intervention, received more private tuition. This highlights a difficulty with intervention studies where awareness of suspected difficulties is heightened and parents naturally find it difficult to do nothing. However McPhillips does not state whether the other groups too had received private tuition or speculate whether the placebo group's reading gain could be due to non-specific exercise or to the Hawthorne Effect.

This may indicate that the reflex inhibition programme is targeting motor control in saccades and hand-eye co-ordination. McPhillips claims that these results confirm the previous work of Morrison that effects of persistent primary reflexes (in particular, the ATNR) extend beyond the obvious disruption of motor development into cognitive areas (Morrison, 1985). McPhillips reports that the difficulty in finding a fourth group of children with similar reading difficulties to the three groups in the study, but who did not have a persistent ATNR, was not forseen.

A study of the prevalence of persistent primary reflexes in children with reading difficulties was then carried out (McPhillips & Sheehy, 2004). Three groups of 41 children were drawn from a representative, cross-sectional sample of 409 children aged between 9-10 years, attending 11 ordinary primary schools in Northern Ireland. The three groups represented the bottom, middle and top 10% respectively of readers from the sample based on percentile scores on the WORD (Basic Reading)Test. It was found that 50

children or 12% of the total sample were dyslexic. However of the 123 children selected, only 15 from the lowest reading group, 4 from the middle reading group, and none of the top reading group were classified as dyslexic.

Results showed that the lowest reading group had a significantly higher mean level of ATNR compared with the middle and top reading group. The study also found that boys rather than girls had higher ATNR persistence. The ratio was almost 2:1. It was also found that that there was a significant difference between the lowest and highest reading group on a standardised test of motor ability but no significant differences in motor and balance performance between dyslexic and non-dyslexic children with reading difficulties.

While the McPhillips and Sheehy study highlights the high levels of primary reflex persistence and motor/balance difficulties in children with reading difficulties regardless of an IQ discrepancy, they caution that the persistence of primary reflexes cannot be used as a causal model for reading difficulties including dyslexia. Rather the authors suggest that there is a significant population of school children who should be receiving specific motor interventions to remediate aberrant reflexes. However such methods should not be seen as a panacea for remediation of reading delay as is sometimes portrayed in the media. Many other factors are important in the development of literacy such as phonological skills, child temperament, attention, parental involvement, motivation, quality of schooling, exposure to books and speech at a young age.

A subsequent study was carried out on the effect of the Primary Movement programme on the academic performance of children attending ordinary primary schools in 2002 (Jordan-Black, 2005). The effectiveness of a specific movement intervention in reducing primary reflex persistence and improving academic attainment was also evaluated. This included a comparative study of the progress of 683 children over a two-year period who completed the Primary Movement programme. A second, quasi-experimental study followed the progress of four parallel groups in each of two large schools with the experimental group completing the movement intervention programme while the other group acted as the control.

It was found that ATNR persistence was significantly associated with lower levels of attainments in reading, spelling and mathematics. Boys were more at risk than girls for ATNR persistence as seen in the previous study. The reflex movement intervention programme had a significant impact on reducing the levels of ATNR persistence in children and this was associated with significant improvements in reading and mathematics.

However, the study used classroom based samples and controls and so the study was not confined to dyslexic children. The quasi-experimental study had no placebo programme and the children were not tested again until two years later (2004). It is argued that this was to minimize attention or novelty of the intervention effects, reduce possible impact of particular teachers, and to allow for post-intervention 'slippage' and 'wash-out' effects. The decision may have been due to the logistics of testing such large numbers. Another point to note is that there is no mention as to whether the children had received other interventions, such as private tuition in the intervening time period. This study was not aimed at dyslexic children but designed to investigate the impact of an intervention programme on the whole class, so numbers of children with an SLD were not reported. McPhillips and Sheehy (2004) had previously found that some children without obvious learning difficulties experience a degree of primary reflex persistence.

Jordan-Black notes that there are children with learning difficulties who do not experience ATNR persistence and it is apparent from the individual scores that these children were least responsive to the intervention. Warning against media claims of a panacea for the remediation of learning difficulties, she suggests that the programme may be of considerable help to those at risk of primary reflex persistence. It is claimed that the 'research provides further evidence of a link between the attainments of core educational skills and the interference that may result from an underlying developmental deficit'.

4.17 Dyslexia Dyspraxia Attention Deficit (DDAT) Treatment Centres: UK 2000

The DORE exercise treatment was developed by Wynford Dore, at the first DDAT Centre in Kenilworth, England. These are now called Dore Achievement Centres (see www.dore.co.uk.) The underlying concept of the intervention is that children with learning disabilities have central nervous system immaturities and, in particular, 'cerebellar developmental delay'. The rationale for the DORE programme was initially based on the work of Harold Levinson in the USA (www.levinsonmedical.com) and Nicolson and Fawcett's Cerebellar Deficit Theory. Levinson (Levinson, 1998; Frank & Levinson, 1973) argues that mild cerebellar dysfunction is a causal factor in dyslexia and Nicolson and Fawcett implicate the cerebellum in developmental dyslexia (Nicolson & Fawcett, 1990; Nicolson et al., 2001a). Dore and Rutherford in a presentation to the British Dyslexia Association in 2001, proposed that given that the cerebellum remains plastic throughout

childhood it should be possible to retrain the dyslexic cerebellum (Dore & Rutherford, 2001). A systematic Balance Remediation Exercise Training Programme was developed based on the principles of balance training and the Cerebellar Deficit Hypothesis.

Typically the client is assessed and an individual programme is then devised to be carried out for ten minutes, twice a day, over a year, with visits every six weeks to test cerebellar function. This is in order to assess the areas which need to be stimulated and appropriate exercises are prescribed accordingly.

Sophisticated methods of testing vestibular and cerebellar function are used. A posturography system measures balance. This test evaluates input from the main senses used by the cerebellum to control balance and movement. It does this by isolating input from the somatosensory (the feelings transmitted through the feet, joints, and muscles), the vestibular (inner ear balance organ), and the visual systems. Special equipment designed for the DORE programme is used for this assessment.

An electronystagmography (ENG) system is used to assess all parameters of eye movement control. Using sensors placed close to the eyes, the equipment measures the movement of the eyes as they track a moving light. The argument is that the cerebellum is known to be involved in controlling the coordination of some eye movements, which can be directly related to reading and writing.

The Dyslexia Screening Test (Fawcett & Nicolson, 1996) looks at a range of skills known to be affected in individuals with learning difficulties, including memory, reading, spelling and writing. The test provides an index which assesses an individual's risk for dyslexia.

An ability questionnaire provides information on a client's perception of the skills involved in their daily functioning. The questionnaire addresses areas such as reading, writing and spelling skills, general disposition and relationships, and coordination and motor skills.

Practitioners say that by testing cerebellar function, it has been found that those affected by learning disorders exhibit very poor use of auditory and/or visual balance systems. This condition is called Cerebellar Development Delay (CDD). Exercises incorporated in the DORE programme are simple to perform, but complex in their effect on the cerebellum. They stimulate the cerebellum to function more rapidly, and to enable the development of previously poor motor and cognitive skills. The exercise programme directly impacts motor skills, while cognitive skills slowly improve, this is attributed to the exercise's stimulatory effects.

Dore claims that after completion of the DORE programme, while results may vary, many DORE clients no longer suffer from many of the symptoms they once experienced. For some, symptoms are completely eliminated. Dore also claims that clients continue to improve even after they have completed the programme. Students regularly report a higher level of achievement in school, and adults experience better work performance, organizational skills and confidence. Most clients also experience significant motor skill improvement, including writing, sports, balance and coordination.

In recent research it was claimed that the DDAT movement programme can bring about significant neurological improvements through a combination of exercises that avoids 'habituation, over stimulation and automatisation' (Reynolds, Nicolson, & Hambly, 2003). The key elements of the programme include the use of balance boards, throwing and catching bean bags, the practice of dual-tasking and a range of stretching and co-ordination activities. The authors claimed that the findings suggested a far transfer of the training to some aspects of literacy. The intervention group improved significantly on postural stability, dexterity, and phonological skill. There were significant gains in reading and semantic fluency but not on spelling.

4.17.1 Criticisms of the research

The formal evaluative study mentioned above (Reynolds et al., 2003), has been subject to extensive criticism from other researchers in the field because of four serious methodological flaws: low-start, where the intervention group had a lower initial literacy score than the control group; possible Hawthorne effect, there was no placebo-control group included to check this; transient change, no long term data was provided to properly assess the claims; non-dyslexic children, improvements may have been from non-dyslexic children who had been underachieving but got back on track easily.

The authors used a two group design with experimental and control groups. The experimental group completed the DORE movement programme at home. It was decided not to use a placebo-control on 'ethical grounds'. The use of a placebo-control group is however standard ethical practice and an ethical imperative, particularly where the study may influence the type of intervention that vulnerable parents of children with difficulties choose to pursue. It is important that placebo movements are designed to have face-validity and are as interesting as the experimental programme. It is also important for all evaluative movement studies to acknowledge that there is the possibility that the placebo-control

group may outperform the experimental group and that 'intervention' minus the specific content of experimental exercises may be as much or even more effective.

Singleton and Stuart (2003) argue that the Reynold's et al. study does not demonstrate that exercised-based treatment improves literacy skills and its findings cannot be used as evidence that the DORE programme would be beneficial for children with literacy difficulties. Specifically, they question why the participants did not have significant difficulties in literacy and show that the literacy measures used are not suitable for this study and cast very serious doubt on the conclusions drawn by the authors.

Richards et al. in their commentary also identify significant flaws in the methodology, analysis and interpretation of results (Richards et al., 2003). Reynolds et al. report that 35 children were selected who were potentially at risk of dyslexia. Apart from the difficulty of the small sample size it is clear that the groups were not adequately matched, most pertinently on reading ability. This compromises the authors' ability to make strong inferences about the effectiveness of the intervention.

Also without an adequately sampled and treated control group, it is not possible to assess whether any changes reported can be attributed to the treatment programme rather than to placebo effects based on the novelty of the programme and the extra attention received by the children. Even if there had been no objections to the methodology of the DORE study, full details of the treatment are not provided as they are 'commercially sensitive', and it is impossible for the study to be replicated by independent research. It is argued that the Reynolds et al. study provides no evidence that the DDAT programme has any specific effect on reading, spelling, memory or language performance for people with dyslexia, dyspraxia or ADD (Rack, 2003).

Reynolds and Nicolson recently published a follow-up of the 2003 study (Reynolds & Nicolson, 2007) aiming to address some of the criticisms from researchers in the field and claiming that the 'exercise treatment was indeed associated with significant and lasting improvements'. They reported data on 29 of the original 35 participants, assessing them between 12-18 months after the original intervention. There is no indication of any support or activities the children may have been taking part in over the intervening two years. It appears that for most of the skills measured on the DST, the upwards trend continued after the intervention, however this would be expected due to the children's development. Changes on only 6 of the 11 DST subtests were statistically significant; these included bead threading, balance, rapid naming, semantic fluency, test of segmentation and working memory. Significant gains were not seen on tests of speeded reading, spelling, writing and

nonsense word reading and on a second measure of verbal fluency see (Rack, Snowling, Hulme, & Gibbs, 2007). However there was a significant improvement in age-adjusted reading (NFER). A general improvement in attention was also reported however the authors cautioned that small group sizes were involved (Reynolds & Nicolson, 2007). Currently it is felt that the evidence does not support the claim that DDAT is effective in improving children's literacy skills.

4.18 Summary

This chapter reviewed the history of motor programmes that grew out of the treatment of cerebral palsy and brain-injured children. Such Movement Programmes were modified by various organisations to be used in the remediation of balance and motor difficulties, retained reflexes, specific learning difficulties, and behavioural problems. After Delacato's claim of improvement of reading performance in children with milder learning difficulties and reading problems, B-I-R-D and INPP started to treat dyslexic children with reflex inhibition programmes.

It is known that cerebral palsy does not have the same cause as a specific learning difficulty. Cerebral palsy children may be affected by brain damage occurring at or before birth. In dyslexia, it is suspected that a combination of both genetic and environmental factors may contribute to poorly organised neurons in the brain and vestibular system of the fetus and this may lead to a specific learning difficulty. Thus it would not be expected that similar treatments for both these conditions would be equivalently effective. However, in both cases motor and reflex control may be affected. One possibility is that motor training programmes may strengthen postural control in both CP and SLD children, thus allowing them to master their bodies and attend to learning in the classroom. Reflex inhibition programmes may improve the processing of information in the brain by reducing noise in the system. However looking back on the programmes reviewed in this chapter, it must be reiterated that very few evaluative research studies have been done by independent researchers. Most organisations appear reluctant to allow outsiders to review their practices. Only one study appears to have been worthy of being published in a respected medical journal and because of inadequate details provided, it is very difficult to replicate any of the other studies to give an objective evaluation of their claims.

That said, what can we understand from the experimental evidence provided for improved reading performance? Kohen Raz reported evidence for the efficacy of his 'psychomotor

school-readiness training programme' in reducing the risk of learning disabilities in first graders (Kohen-Raz, 1996) following large scale studies in Israel (n=760). The intervention was a physical education programme run for 2 hours per week for 7 months. The children taking part were between 5 and 7 years of age and 30% were deemed likely to be at risk of learning disabilities.

McPhillips et al.(2000) report a significant Group $\times$ Time interaction for the reduction in retained reflexes and also for improvement in reading scores as measured on the Neale analysis (Neale, 1989) and WORD (Wechsler, 1993) tests. However it is hard to judge the severity of the dyslexia given the lack of IQ data. McPhillips reported a difficulty in finding a group with similar reading difficulties but without a persistent ATNR. All of the dyslexic children had retained reflexes, and it may be that this was a group of children for whom nothing else worked. This may indicate that the children had a more severe form of dyslexia. A later study confirmed that reading impaired children exhibit higher levels of retained ATNR than do normal and above average readers, and boys rather than girls had a higher incidence of retained reflexes, and surprisingly low levels of retained reflexes were found in children who were reading well beyond their chronological age (McPhillips & Sheehy, 2004).

A more recent study reported significant differences in reading and mathematics performance between experimental and control groups of poor readers after a year long reflex remediation intervention (Jordan-Black, 2005). However not all children in the classroom sample were dyslexic.

We can only conclude tentatively from the somewhat weaker experimental work that children undertaking the INPP reflex remediation programme performed significantly better on balance, co-ordination, reflex and drawing tests but there was no significant improvement in their reading and spelling performance (Blythe, 2005).

Similarly the Dore group, basing their intervention programme on the Cerebellar Deficit Hypothesis (Nicolson et al., 2001a) claim interesting results using NFER/Nelson standardised tests of literacy and the Standardised Attainment Tests of writing, comprehension and maths (SATS). The experimental group improved by 19 months on the NFER tests of reading and significantly on the SATS comprehension and writing (Reynolds et al., 2003). However a major drawback was that the control group started on their DDAT programme before they could be assessed at the end of the study. It was therefore not possible to investigate if there was an interaction of group over time on these measures. The study was also compromised by poor design. Selection was made on the basis of

Dyslexia Screening Test (DST) scores well below the recommended 'At risk Quotient' of 1.0 (Fawcett & Nicolson, 1996).

This raises the question whether these children were even at risk of dyslexia to begin with. No placebo-control group was included in the study despite this being common research practice. The intervention treatment was not described in the research as it was 'commercially sensitive'. Lack of norms on the electroneurophysiological tests and lack of comparison on the literacy tests weaken the study. While at first glance the results of the original study looked impressive unfortunately there are few solid findings. Reynolds and Nicolson recently published follow-up data on the 2003 study (Reynolds & Nicolson, 2007) however it is argued that while the follow-up study may clarify some issues about short and transient effects it does not evaluate the specific effects of the programme (Rack et al., 2007).

To summarise, the evidence so far shows that school readiness programmes may be effective in reducing the risk of SLDs. Some primary school children who are reading 2 years behind their peers have responded to reflex remediation and have shown gains in reading performance. Balance programmes alone are not proven to have long term benefits on reading or writing ability but a small group study shows significant improvement in motor skills, speech and language fluency, phonology and working memory.

A cerebellar deficit and aberrant reflexes may affect motor and reflex control in a pre-reader. Figure 4.2 below is a model of the development of a reading difficulty and possible benefits of movement programmes. Take for example a child with floppy, jerkey or immature motor control whose attention is being taken up in controlling body movements such as, sitting still and comfortably, maintaining pencil grip and hand-eye co-ordination. Little attention can be spared for phonological or visual tasks and so the child misses out on the practice of grapheme-phoneme conversion. Much of what he needs to absorb and retain in the classroom is lost because of excess sensory noise in his system. Reading practice therefore suffers and does not become automatized, and academic performance shows little progress over the course of the school year.

Movement programmes may benefit such a child. With practice, balance and motor skills or exercises to control aberrant reflexes may lessen their draw on the child's conscious attention. Not only can attention to simple tasks benefit, noise in the system may be 'filtered out' so the child can attend to the sound of phonemes. Improved motor control in the body helps motor and ocular control, preventing jerky eye movements, creating efficient saccades, thus resulting in improved visual perception and recognition when con-

centrating on letters. Thus the basic techniques of reading and writing such as sounding out letters while viewing the orthography, smooth control of the pencil, and the conversion of phoneme to grapheme may also improve.

The Dyslexia Early Years Project (DEYP) was set up as an independent study of generic reflex and balance (cerebellar and vestibular stimulation) programmes. The goal was to investigate whether any improvement could be observed over a year in the performance of children who were at risk of developing dyslexia, on balance, motor, reflex, oculo and phonological tests. Two exercise programmes based on reflex inhibition and balance training were devised from what was known of charitable and commercial programmes. In addition a placebo programme which had face validity for the children but little reflex or cerebellar stimulation was developed. The next chapter details the content of these programmes.

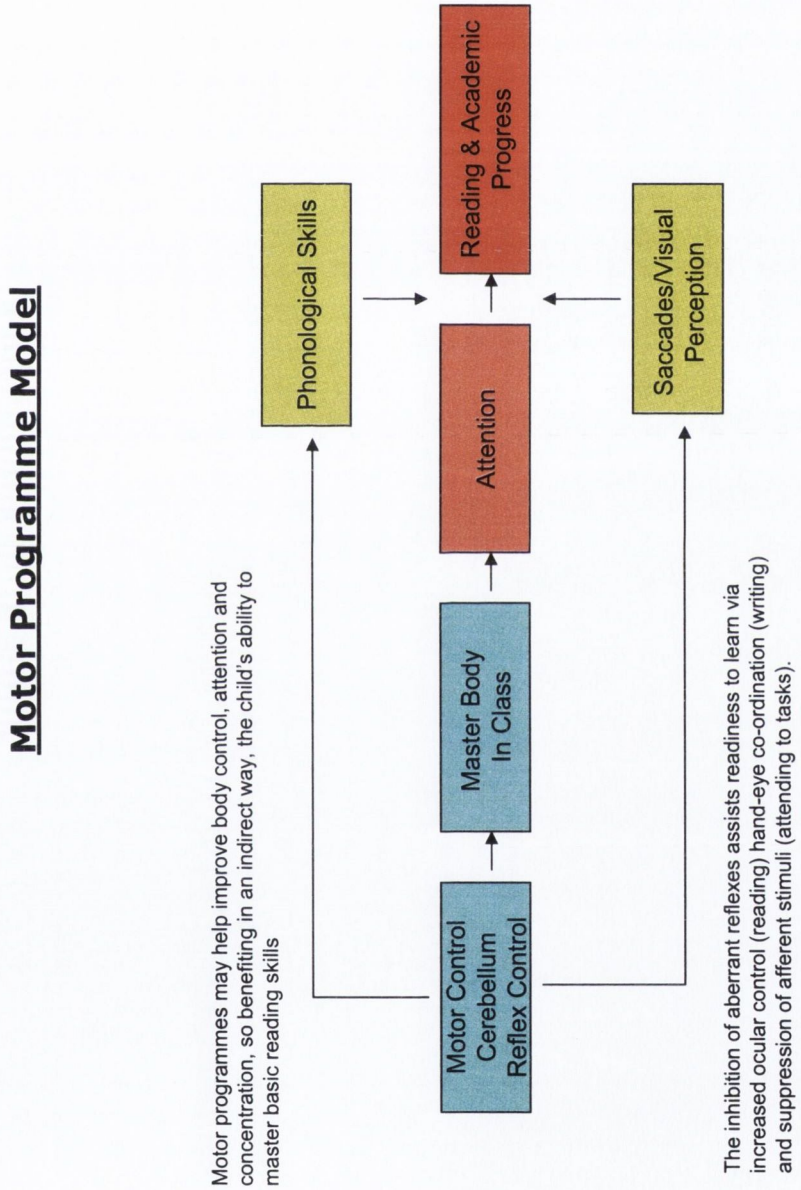


Figure 4.2: *Suggested benefits of Motor Programmes.*

5

Programme Design

The Programme design created three interventions to be delivered to two experimental groups and a placebo control group. Children in both experimental groups and the placebo control group (groups 1-3), received a movement programme to undertake at home for ten minutes per night. Videos and manuals were prepared for each of the programmes to instruct the parents in the exercises the children were to perform each night (see Appendices L, K, M and next section). A fourth group, the delayed treatment, or control group, received no programme in the first year and continued with their daily life but were tested like the rest of the sample. All participants were assessed at the start, at 6 months and at 12 months. Parents were told before they consented to have their child take part in the study, that their child might be randomly assigned to the 'delayed treatment group'. If this happened, these parents were then offered a programme at the end of twelve months.

After reviewing the programmes in Chapter 4, it was felt that generic programmes similar to the programmes detailed in Figure 5.1 below would be the most suitable to investigate. They were also the most relevant programmes to study in the Irish context as similar programmes were available to Irish children. These programmes were: Programme 1 -

Reflex Remediation, Programme 2 - Balance Training and Programme 3 - Placebo.

The design of these programmes was influenced by reflex, balance and facial movements as laid out in Figure 5.1. Details of the content of each programme will be described later in the chapter.

5.0.1 Manuals:

A manual was prepared for each movement programme to accompany the relevant video (see Appendices L, K and M). Each one followed the same format below:

- Introduction
- Letter to parents
- Exercises with a story line
- Timetable and log

The parents were referred to the back of the manual for the timetable of the exercises. In order that compliance could be checked they were asked to fill in the start date and tick the box if the relevant exercise has been completed by the child each night. Boxes were to be left blank if the exercise was not done. If the children had missed some exercises due to illness or holidays the parents were asked to contact the researchers for advice if a child refused or was unable to do the exercises. In the first week parents were asked to try out the exercise and not to worry if the child did not complete the movements properly in the first few nights. An amount of practice time was built into the programmes. It was important that the child concentrated on doing the movements competently for the required amount of time and become accomplished at the movements after a few weeks. Stories were added to help keep the interest of the child and to keep the movements flowing.

Still photographs were included in Movement Programme 1, the reflex remediation programme, to indicate the precise start and finish positions. These exercises were different from the running, jumping and hopping exercises that children would be accustomed to in Movement Programme 2, and the body and facial movements in Movement Programme 3. It was very important that Programme 1 movements were done precisely and as slowly as possible. According to McPhillips et al. (2000) this is necessary.

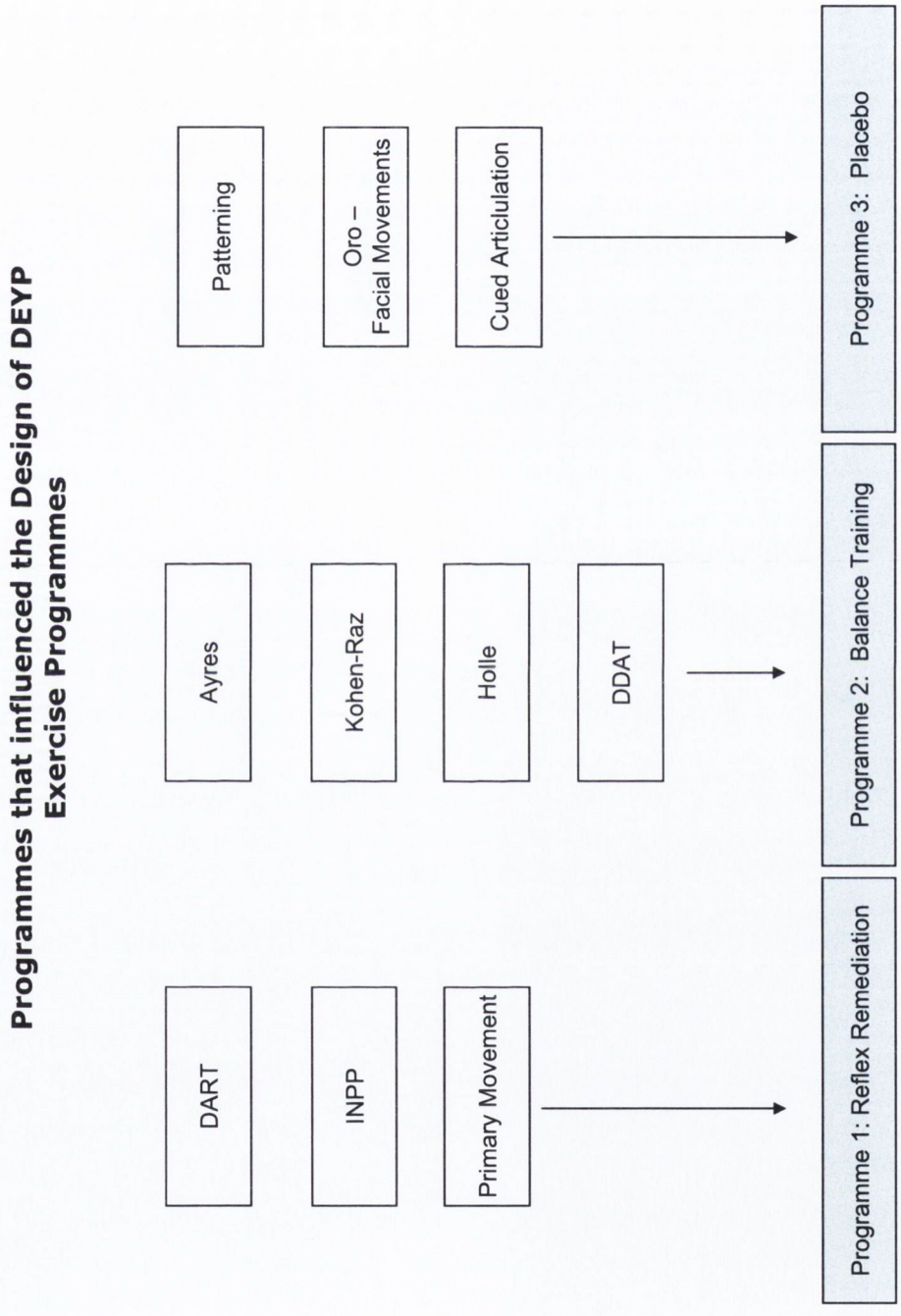


Figure 5.1: *Motivation for DEYP Programme Design.*

5.0.2 Videos:

A video of each movement programme (recorded on digital video tape for good quality and copied onto VHS) was prepared for the parents/guardians to accompany the manuals described above and to demonstrate the exercises which would take up to ten minutes per night. Parents were asked to view the video first and then look through the manual to become familiar with their particular exercise programme before they commenced instructing the children on their exercise each night. Each of the three videos followed a similar format of the manuals as follows:

- Introduction to the study
- Letter to parents
- Exercises with a story line
- Contact numbers for advice on the programmes

The aim of the DEYP study was not to evaluate or compare the DORE or Primary Movement programmes but to evaluate generic reflex inhibition and balance training movements which are used in many programmes. Detailed content of each programme is illustrated in Table 5.1. A DVD of this material is available on request from the author.

5.1 Movement Programme 1 for Group 1:

The programme devised for Experimental Group 1 (Reflex Remediation) was based on a reflex remediation programme for younger children originally devised by McPhillips (McPhillips, 2003) and consisted of variations of the Primary Movement Early Years programme. At home each evening the participating child was asked to sit in a low chair so that his feet were flat on the ground before he began. The parent was asked to sit opposite the child and to demonstrate the exercise after viewing the video and using the manual. Once participants became familiar with the movement some of the stories could be told at a slow pace as they went through each stage of the exercise.

The Primary Movement Early Years Programme (PMEYP) delivered in schools included songs and dances in the first term, the ATNR movements in term two and a series of

Programme 1 **48 weeks** **Reflex Remediation**	**Programme 2** **48 weeks** **Balance Training**	**Programme 3** **48 weeks** **Placebo Programme**
Blythe & McGlown INPP Primary Movement (PMEYP*) Dance element removed to avoid confound (vestibular stimulation) with Programme 2 ATNR: 12 weeks Moro Part 1: 4 weeks Moro Part 2: 4 weeks Moro Part 3: 4 weeks Repeated for 24 weeks	Training of static & dynamic balance vestibular stimulation, unilateral, bilateral, cross-lateral movements **Kohen-Raz:** Crosslateral walk, march, run Skip & Gallop with turns Leap/Jump/crawl Balance on one foot/two feet Shake limbs / twirl & spin Animal walks: Stand & wobble/Walk & waddle **Ayres:** Crosslateral walk, march,jog Run - arms out Bow & hang from waist/touch toes Jump one leg & two/crawl Roll along floor **Folio & Fewell:** Crosslateral walk, march, run & Gallop with turns Jump one leg & two Balance on one foot/two feet Hop on spot/ Hop along line Roll along floor **Crutchfield & Barnes:** Crawl / March Rock backwards/forwards/side to side Standing & sitting bounce **O'Dell & Cook:** Balance on one foot/two feet Leaning backwards/forwards/side to side Arm twirls Bow & hang from waist **Kephart:** Crosslateral walk, march, run Skip & Gallop with turns Jumping Jacks Animal walks: Leaping, kicking Stand & wobble/Walk & waddle	Random aided limb movements by parents - 4 exercises over 48 weeks mixed with random oro-facial movements - 4 exercises over 48 weeks (child does not move body)

Table 5.1: *Content of Motor Programmes. (* Primary Movement Early Years Programme)*

Moro exercises in the last term. However for the purpose of this study it was felt that the songs and dances could provide a confound between the balance and reflex inhibition programmes and so song and dance elements were not included in Movement Programme 1. Instead the initial part of the programme was repeated to ensure that the children were doing the reflex movement regularly and to provide some practice weeks for each exercise (see table 5.2 below).

Starting with an exercise to inhibit the Asymmetrical Tonic Neck Reflex (ATNR), the movement was done on both sides of the body for 12 weeks (this corresponded to the first term in school in the PMEYP). This was followed by the Moro exercise Part 1 for 4 weeks, the Moro Part 2 for 4 weeks and Moro part 3 for 4 weeks (corresponding to the second term in school in the PMEYP). This brought the programme up to 24 weeks duration. At this stage the full programme was repeated again to bring the programme up to 48 weeks. This structure allowed for practice weeks at the beginning of the programme to enable mastering of the exercise. It also allowed some catch-up time if a child missed an exercise due to illness, holidays or other reason. However the most important reason was that as these exercises were being done with younger children than those in the McPhillips (2000) study and they were being attempted at home rather than with a group in school, it was important the some time was built in for the child to go from 5 seconds on the first few nights to the goal of 30 seconds by the end of the week.

The reflex remediation exercises lasted a maximum of 4 minutes compared to 10 minutes for programmes 2 and 3, however the exercises required a lot more attention and control of slow limb movement when compared to programmes 2 and 3.

Reflex Prog	**First Night**	**Time: Week 1**	**Time: Week 2**
ATNR: 12 weeks	5 secs	30 secs	30 secs
Moro Part 1: 4 weeks	5 secs	30 secs	60 secs
Moro Part 2: 4 weeks	5 secs	30 secs	60 secs
Moro Part 3: 4 weeks	5 secs	30 secs	60 secs

Table 5.2: *Reflex Programme Design. This timetable was repeated again to bring the programme up to 48 weeks.*

5.2 Movement Programme 2 for Group 2:

Experimental Group 2 received a balance programme which was designed with reference to age appropriate exercises from the work of Folio and Fewell, Britte Holle and Kohen-Raz, (Folio & Fewell, 2000; Hollë, 1976; Kohen-Raz, 1996; Ayres, 1979; de Quiros & Schrager, 1979).

The newly designed balance programme was based on movements that a child could achieve between the age of 3 and 6 years. Kohen Raz suggests the training of static and dynamic balance, vestibular stimulation and the stimulation of body awareness should be included in a motor programme. Both static and dynamic movements were used in the balance programme. They included vestibular and somatosensory stimulations such as hopping, running, skipping, jumping, walking on tiptoes, marching, standing on one foot, on two feet and swaying and rocking. As equipment could not be used at home, stretching, touching toes, crawling, rolling, and twirling were used. DeQuiros and Schrager (1979) suggest the inclusion of some exercises without visual stimulation. This is important in order to maximise head and body balance. Crawling, falling, lumbering, standing on one leg, walking, hopping, kicking etc. are all suggested as aids to improve balance and postural integration. Such exercises they report 'will develop control of the complex neuromuscular systems on which reaidng, writing and speech depend'. Spinning, rotating, bouncing, rolling and rocking are traditionally those used for normalising vestibular sensitivity (Crutchfield & Barnes, 1993). Cratty (1974) suggests that in static tasks, the area of performance should be made smaller and the base of support should be decreased by asking the child to lift his legs or arms or stand on one foot. Movements should include arm-leg integration such as Jumping Jacks; travelling tasks such as rolling; and loco-motor tasks such as skipping and galloping.

A range of movements were incorporated into storylines taken from (Evetts-Secker, 1998) and games in order to engage the children in the exercises. The programme lasted for 10 minutes per night, see Appendix L. The full balance training programme lasted one week and was repeated again each week for 48 weeks. See table 5.3 below.

Balance Prog	Per night	Practice	Duration
1-7	10 mins	3 days each to day 21	random exercise 1-7 for 48 weeks

Table 5.3: *Balance Programme Design*

There was no training of the oculomotor or auditory systems as the aim of the study was

to investigate balance training only and not other aspects of perceptual motor training such as perception and discrimination of music or rhythmical movements, fixation on objects or ocular pursuit.

It was recommended that an area at home that was at least 4 metres wide was used. Each movement was to be performed by the child as accurately as possible. Static movements (those that could be performed on the spot) were to be continued for up to 10 seconds. Dynamic movements (those that involved movement along the 4 metre line) were to be repeated up to 6 times. Parents were asked to ensure that the area they used was safe (no jutting out furniture) and had plenty of protection (e.g. mats, carpets, cushions) so that the child did not hurt himself should he lose his balance.

5.3 Movement Programme 3 for Group 3:

This movement programme lasted a total of 12 months. There were 8 different exercises carried out through stories and games which were offered in a random order. The programme was made up of two parts: random supported arm and leg movements and facial movements. In the four 'Parental Help Stories' the parent was actively engaged and took responsibility for moving the limbs of the child. During these stories the child lay on the ground on a rug, or on a bed. The child was asked to let their body 'go floppy'. The parent would take the weight of every limb in every movement. The child was not to control any of the movements. Each movement was to be held for approximately 10 seconds. If the parent wished they could count aloud to 10. It was felt that as research showed that prolonged stimulation of the limbs proved to have no effect (Pediatarics, 1999), a few minutes per day of random supported limb movement in Part I would have little or no effect on reflex remediation.

In the four face games the child was asked to imitate the face of the parent as they performed an expression. The child sat comfortably in a high backed chair and was only permitted to move the facial muscles. The parent demonstrated and asked the child to copy and hold the expression for five seconds. These exercises lasted approximately 10 minutes each night. If the game did not last that long then it was to be extended or even repeated to bring the time up to 10 minutes. See table 5.4 below.

Placebo Prog	Per night	Practice	Duration
1-8	10 mins	3 days each up to day 24	random exercise 1-8 for 48 weeks

Table 5.4: *Placebo Programme Design*

This programme was designed as a passive placebo control so that children received the same attention each evening as those in the experimental groups. It was also designed so that minimal reflex stimulation or balance training took place. Pattering style exercises were used in the placebo-control programme as patterning has been shown not to work beyond chance levels. Randomising the programmes order has been found to be even less effective than not randomising it (Kavale & Mattson, 1983). The programme has face-validity as it 'looks' like a movement programme and it is important that parents believe this is a treament group.

The second part of the programme used oro-facial movements only. These were similar to exercises developed in 1995 by Cogan (2002) [1] for use with stroke patients who had lost the use of their oral muscles and were suffering from Dysarthia. Permission was granted for their use in this study. Only the muscles of face and tongue are moved, while the head and body were kept as still as possible. Examples of the facial muscles are smiling, licking lips, scrunching up the nose, sticking out the tongue, biting bottom lip, puffing out cheeks, pulling random faces. Neither of part of the placebo programme required the crossing of the midline of the child's body.

It was most important that any facial movements used would not activate the vestibular system, the cerebellum or affect balance. Movements such as these do not affect cranial or spinal nerves. They only work from the brainstem up. Another possible confound was that movement of the tongue or mouth may help improve pronunciation on the Nonword Repetition test used as a test of phonological working memory. In order to avoid any practice effects arising from the placebo programme, a speech and language programme called Cued Articulation was explored (Passy, 1993). This is a method of cueing articulation by using simple hand signs. Each hand sign represents one phoneme. The shape of the hand suggests lip and tongue positions and movements. In Movement Programme 3 while the parent gave verbal instructions as to what facial exercises were to be attempted, at no time was the child asked to produce any sounds nor did any cueing of articulation take place. All the exercises were performed randomly to a storyline.

[1] Cogan, P. (2002): Personal communication, Dublin 2003. Cogan designed these exercises as an M.A. student in neurology and linguistics at the Brugmann Hospital (Salle 16) Belgium.

Pilot Study:

The three programmes with their accompanying stories were filmed using two children aged 7 years and 11 years for demonstration purposes. Copies of the video and manual for each of the three programmes were then given to parents of children in the 3-6 year age range (n=10) to see if the children could manage the exercises and if the games with accompanying stories appealed to them.

Feedback from this pilot study indicated that each exercise needed to be practiced for a few nights before moving onto the next one. It was also indicated that the exercises should be done in a quiet place to avoid distractions and that sometimes the children got a little bored.

Feedback on Programme 1

When the children completed the reflex remediation programme it was found that a small chair was needed to allow their feet to rest firmly on the floor. The younger children found it difficult to do five seconds of the ATNR exercise on the first night. One of the mothers used the idea of a snail in her hand to get the child to slow the movement down. This difficulty was dealt with by building extra weeks into the programme to allow the children to build up to the designated time for each movement.

The six-year old children however managed to hold the movement for 30 seconds by the third night. It was sometimes difficult to get the boys to sit down and concentrate but once they engaged in the task they mastered it. There was no difficulty in stretching the arms out in the ATNR or Moro movements but sometimes they shifted their feet. Thus a period of settling down was allowed for in the first few weeks. It was reiterated that the start position should be accurate and that the movement should be completed properly by the end of the first week.

Feedback on Programme 2:

The children enjoyed the balance training programme. The children enjoyed the games and wanted to do more. They had no difficulty balancing with eyes closed but it was noted that the eyes should be closed in the static position only. Feedback indicated that the stories were helpful and the instructions were clear. In the 'hopping on the spot' exercise the children sometimes confused the right and left leg. It was decided to take out reference to right and left and instead instruct them to hop 'on one leg and then the other'. The younger children found it difficult to hop on one leg for any length of time,

this had been noted in previous research (Kohen-Raz, 1996). They also found some of the animal swaying movements difficult, however they attempted them. The parents felt that the children would master these movements over a course of a few nights.

Feedback on Programme 3:

In the placebo programme, the younger children found it difficult to 'go floppy' and wanted to move their limbs. In the face games they found it difficult to puff out one cheek at a time or reach their nose or chin with their tongue. As this was a placebo programme this was not critical and they were told to do as best they could.

The older children had no difficulty being 'floppy'. They found the facial movements easy to do but as they were sitting opposite the parent they often mirrored them. Again it was decided to take out references to right and left to avoid any confusion in the manual.

Parents suggested that more stories would be needed to last the full length of the programmes and also suggested that they used their own stories to keep the interest of the child. Taking these comments into account, a video to accompany each of the exercise manuals was then edited together with a voiceover explaining the position of each exercise.

The next two chapters will now deal with the development of the test battery and the methodology.

6

Test Development

Following on from the discussion of early movement, reflex elicitation and inhibition this chapter deals with the selection and development of the test battery used in the Dyslexia Early Years Project (DEYP). This study cast a wide net, initially aiming to assess the balance skills and degree of retention of primary reflexes of 136 children from dyslexic families. It also aimed to assess the children during and after completion of year long balance and reflex remediation programmes. Children presenting with dyslexia at the age of 7+ often have problems with ocular pursuit and gross or fine motor skills (Goddard, 1996). Tests of visual tracking, motor and phonological skills were also included in the battery in order that correlations could be made between those skills and the incidence of retained reflexes.

The balance tests were selected to assess static and dynamic balance for each year within the 3-7 year age range. Tests in the literature (Kohen-Raz, 1996; McPhillips, 2002; Folio & Fewell 2002; Holle, 1976) were compared and adapted and they are listed below.

The Reflex tests were chosen to assess a cluster of specific reflexes thought to be present in dyslexic children (McPhillips, 2002; Goddard, 1996). The Asymmetrical Tonic Neck Reflex (ATNR), the Symmetrical Tonic Neck Reflex (STNR), the Tonic Labyrinthine

Reflex (TLR) and the Moro Reflex are often found in children with Specific Learning Difficulty (dyslexia). Retention of these reflexes can be responsible for vestibular and balance difficulties, poor ocular pursuit, and visual-perceptual problems (see Chapter 3 for a detailed description of each of the reflexes mentioned here).

Research has shown that letter knowledge, phoneme deletion and non-word repetition tests which tap phonological skills are good indicators of poor readers at age 9 (Muter & Snowling, 1998) and these were added to the battery.

In preparation for testing, researchers attended courses with Neuro Developmental Therapy (NDT) Ireland, the Institute for Neuro-Physiological Psychology (INPP) Chester, and Primary Movement (www.primarymovement.org) in order to train in balance and reflex testing. Testing by these organisations was mainly aimed at children over 5 years of age, however advice was given that some tests used in the Primary Movement for the Early Years Programme (2002) could be used on children as young as 3. Children in this study, the Dyslexia Early Years Project were aged between 3-7 years when they attended for their initial assessment and so some tests had to be adapted for the younger age range. The final test battery comprised six sections which were administered in the following order:

A. Leg and Hand Dominance

B. 8 Balance and Gross Motor Tests

C. 6 Reflex Tests

D. 4 Oculo-Motor Functioning Tests

E. 5 Motor Tests

F. 3 Phonological Tests

A full set of the tests administered can be found in Appendix E. Table 6.2 at the end of this chapter lists the individual tests in the order that they were given.

6.1 Scoring

As mentioned previously no individual set of published standardized tests of reflex, motor and balance skills was available for the 3-7 age range. Tests had to be adapted from different sources. Authors differed in the length of time required or number of steps to be taken in the balance tasks. Descriptions of the response to be observed after reflex testing also differed, so each test chosen had to be carefully checked for practicality of observation and against the literature available. More detailed information on each test follows in the relevant sections below.

The scoring range for the balance and reflex tests was adapted from Primary Movement's Early Years programme devised by Martin McPhillips. That scheme was quite vague hence a new scheme was defined as follows:

1. Perfect undertaking of the task
2. Slight degree of motor difficulty, sway in balance or reflex presence
3. Significant degree of motor difficulty, sway in balance or reflex presence
4. Unable to complete task or strong evidence of reflex
5. Unable to attempt task due to anxiety, poor muscle tone etc.

In fact a score of 5 was quite rare and usually cases where the child had obvious balance or co-ordination difficulties (hopping sometimes proved difficult), where tiredness was a factor (for example, keeping the arms up in the Schilder test), or where poor attention or anxiety prevented him from completing the tasks (such as not being comfortable with the Moro reflex test).

6.2 Test Battery

6.2.1 Pilot Study

The non-standardised tests used in the DEYP were piloted on four children of the ages 3, 5 and 7 years to check if indeed they could complete the tasks set for their age group. All

the children managed to complete the basal task in each test. The only concern was that although children who were just 3 years old may be able to complete the age appropriate test they may not in fact be able to understand the instructions. It was decided that children would not be called for assessment until they were 3.5 years old.

Each test was demonstrated and the children were asked to watch and listen carefully to directions before they practised the task. The children were always given one practice on each task. The tests are listed in Table 6.2 at the end of the chapter and dealt with in detail below. Full copies of the tests can be found in Appendix E.

6.2.2 Leg and Hand Dominance

The children were asked to kick a small soft ball 5 times at a designated wall to see which was their dominant leg. The children were offered a pencil and asked to hold it in their writing hand. The mothers confirmed if this was in fact the preferred writing hand. The children were then recorded as right/left dominant or mixed.

6.2.3 Balance and Gross Motor Control

The successful performance of motor skills depends in many instances upon the individual's ability to establish and maintain balance (Kohen-Raz, 1996). Balance is achieved through maintaining a specific relationship between the centre of gravity of the body and its supporting base (Williams, 1983). Eight tests of balance and gross muscle control were used. The first four tests required the maintenance of static and dynamic equilibrium while standing or moving unsupported in the erect position. Moderate stress is induced by a) standing on one foot; b) changing foot position; c) narrowing the area of support (e.g. standing heel to toe, or on tiptoes); d) closing the eyes. Dynamic balance, gait and gross motor control were assessed in the last six tests.

The children were requested to watch and listen carefully before attempting the tasks and a practice trial was always given (Kohen-Raz, 1996). The general criteria of failure included: a general loss of balance i.e. putting foot down before the required time, stumbling etc. or resorting to support; the position of arms not retained as per instructions; the feet moving out of the boundary area. Scoring was in the range of 1-5 depending on criteria reached, see Appendix E.

Two static balance tasks were included, the One Leg Balance Test and the Advanced Romberg Test. These required the maintenance of a single position of the body. In adapting the **One Leg Balance Test** test it was noted that the literature differed in the precise amount of time a child should balance on one leg, however a general consensus between Holt (1991), Kohen-Raz (1994), and Goddard (2001) indicated that children should be able to balance on one leg for 3 seconds at 2 years plus, and up to 10 seconds at 6 years. The first 50 children in the DEYP were timed on each foot for up to 10 seconds. It was found that 10 seconds was ambitious even for the older children and an average of 5 secs at 4 years, in line with Folio & Fewell (2000) and 6 seconds at 5 years plus was decided on.

It should be noted that balance tasks performed with vision are different from those performed without vision. Vision provides an objective source of information that the child can use to judge his position and/or movement in space. When vision is occluded the demands place on the vestibular and proprioceptive systems becomes greater (Williams, 1983).

Therefore in the **Advanced Romberg or Mann Test**, the children were asked to stand heel to toe with eyes open for 8 seconds and then repeat the task for the same amount of time with eyes closed. Kohen-Raz (1996) states 50% of 5 year olds and 75% of 6 year olds should be able to attain 15 seconds. With eyes closed, 25% of 6 year olds and 50% of 7 year olds should be able to attain 10 seconds. As the children in this study ranged from 3-7 years it was decided that 8 seconds was a realistic target after observing the first 20 children.

The tradition of clinical postural diagnosis dates back to the middle of the 19th century when Romberg introduced his classical test of standing with feet parallel and eyes closed. This elicited equal intensities of sway in anterior-posterior and left right direction. Kohen-Raz (1996) notes that in developmental research children under the age of 4 or 5 years may be unable to keep their balance with their eyes closed. Thus, if tested at school age, a 'positive Romberg' may be a sign of immaturity and, not necessarily a symptom of brain damage. De Quiros (1979) noted that Romberg's test, which can be normally given to children over three years old, indicates clearly that without vision and only with proprioceptive vestibular inputs, the child can perfectly control his balance. This is a major step in the development of equilibrium, posture, and tonus. From this, intentional and coordinated motor activities, which some would argue, are the basis of the human learning processes develop. The use of postural control tests is debated in the Discussion Chapter.

Two tests of dynamic balance followed requiring the maintenance of equilibrium while the body was in motion. Firstly the **Tandem Walk** required the child to walk heel to toe for 10 steps along an 8ft x 4 inch line. The under fives's were allowed to have their hands outstretched to aid balance, to look down and not necessarily have their feet exactly heel to toe. They were only required to do the forwards task. Six year old children and upwards were to place hands on hips, walk heel to toe both forwards and backwards along the length of the line.

Folio and Fewell in their Peabody Developmental Motor Scales (2000) found that children of 42 months (3.5 years) should be able to walk an 8ft line. Similarly children of 49-54 months (5-6 years) should be able to complete both the forwards and backwards task with hands on hips and toes touching heels without putting a foot down outside the 4 inch line. McPhillips requests the child to walk heel to toe for up to 15 steps forwards up to 5 years of age and both forwards and backwards up to 15 steps over 5 years (McPhillips, 2002).

Research suggests that the development of dynamic balance may begin with the younger child shuffling his feet along a relatively wide base especially in the case of a raised beam. This stage is then followed by one in which the child uses an alternating step pattern. However as this task involved walking between two lines marked on the floor the children were all instructed and encouraged to attempt the alternate heel-to-toe walk. Ataxia of gait can be exaggerated by this test. If ataxia (loss of ability to co-ordinate muscular movement) is due to sensory loss, it becomes much worse with the eyes closed (Romberg's sign) (Marsden & Fowler, 1989).

The second task, **Walking on Tiptoe**, was similarly set up. This was more challenging for them. The child was requested to take at least 10 small steps on tiptoe forwards with arms out at shoulder height up to the age of 5, and forwards and backwards with hands on hips after 5 years. Holt (1991) states that a 3 year old should be able to walk on tiptoe along a line 25mm wide and 3m long, without stepping off. Folio and Fewell (2000) suggest a child under 4 years should be able to walk hands on hips along a 4 inch wide 8ft long line without the heels touching the floor.

The Slalom test was adapted from McPhillips (2002). In addition to gross motor functioning this task assesses both dynamic balance and the child's ability to cross over the midline alternately with the feet and still maintain forward locomotion. Such a task requires the cooperation of the two brain hemispheres. This is made possible through the corpus callosum, which consists of millions of nerve fibres, through which information is

exchanged back and forth in both directions (Blythe, 2004). Many interchanges can take place within a fraction of a second, allowing the two sides to work together in perfect harmony.

The child stands to the left of a 9ft line with hands on hips and lifts the left leg, bending the knee and places the foot on the other side of the line. The goal is to cross over the line rather than to walk on it. The child is requested to walk 10 steps forward at 5 years and both forwards and backwards at 6 years plus. This task targets balance while crossing over the mid-line from one foot to another and also left-right co-ordination.

Hopping on the Spot measures dynamic balance on one foot and challenges both the vestibular and proprioceptive systems. According to Holt (1991) and McCaskill & Wellman (1938) this exercise can be done 5 times by 4 year olds and 10 times by 5 year olds upwards. The goal is to hop on the spot with hands on hips, without either moving around or putting the raised foot down between hops. The child should also lift the hopping leg fully off the ground.

The **March and about Turn** test targets the ability to move in a cross lateral pattern. The child is shown how to march on the spot lifting the opposite arms and legs. The child is then required to march around a 7ft $\times$ 8.5ft mat in a cross lateral pattern. If a homolateral or mixed gait is observed this may mean immature development. A cross lateral gait should be be initiated automatically from the cerebellum.

Some children had difficulty marching at all in the testing environment, so they were requested just to walk normally while swinging their arms so their gait could be observed.

Crawling on All Fours: Crawling is mastered earlier than walking at about 6 months of age. Not only is it important in getting the child mobile, it provides a stimulus for the eyes to cross the midline of the body. See Chapter 3. The child has to switch focus from one hand to another as it crawls. The focusing distance and hand-eye coordination skills used in the act of crawling will be the same as that eventually used for reading and writing. This task also challenges the vestibular, proprioceptive and visual systems to work together. Without the continued integration of these systems the child would not develop a sense of balance, body orientation in space, or perception of depth in his environment.

This test demonstrates whether the child has homolateral, mixed or crosslateral movement of the limbs. The child was asked to crawl along a diagonal line in front of the camera and observed for a homolateral or cross lateral gait. The former indicated lack of integration

of limbs affecting general efficiency of movement and difficulty crossing midline which may affect eye tracking across the page in reading (Goddard, 1996). Lack of gait automaticity may indicate immature cerebellar development.

However not all children crawl before walking, preferring to tuck one leg under the bottom and shuffle across the floor. Pavlides (1987) observed that a high percentage of children with reading difficulties omitted stages of crawling and creeping on the tummy in infancy.

6.2.4 Reflex Tests

Six reflex tests were used. The aim was to assess whether a cluster of reflexes were present in children from dyslexic families. The children were shown what position to assume for the tests and reassured that there would be no discomfort in the moving of the head or limbs. They were also asked to be as relaxed and attentive as possible. It was expected that most children with retained reflexes would perform poorly on more than one of the reflex tests. The tests were not administered in the order that they are discussed below, but are listed here for ease of description. The full testing procedure is detailed in the next chapter. Scoring was in the range of 1 to 5, with 5 indicating that child was unable to perform the test due to anxiety, muscle tone, inability to stay up on all fours, keep arms in position etc.

Asymmetrical Tonic Neck Reflex: Three versions of the Asymmetrical Tonic Neck Reflex Test (ATNR) were used in this study as it was not clear from the literature which would be most suitable for the 3-7 year age group. The ATNR should be inhibited from about 6 months of age (Goddard, 1996). If not this retained reflex will cause difficulty when the child crosses the midline of the body and this produces problems with balance, crosslateral movements, ocular pursuit which leads to poor handwriting, tracking across a page when reading, and visual perceptual difficulties with symmetrical representation of figures.

ATNR (Lying Down): This is the standard test and was designed initially to be used on young babies but may be used to elicit a response in an older child (Fiorentino, 1963) who has developed musculature and methods of compensation and control. It is particularly sensitive in children with a high ATNR.

The child lies supine with arms flexed away from the body and hands resting on finger tips. The subject's head is relaxed at the midline. The head is rotated to the left and

held in that position for 5 seconds while reactions in the arms and legs are observed. The head is brought back to the midline and paused for several seconds. Then the head is rotated to the right, held for 5 seconds for limb observation and returned to midline. This test is performed twice with eyes open and twice with eyes closed.

Observation: Any movement in the body on the side to which the head is turned is noted. Particular attention is paid to the hand, arm, foot and leg on this side. Any tendency to increased extensor tone on the side to which the head is turned suggests that an ATNR might be present. Inability to relax the neck muscles or permit turning of the head beyond a specific point may also suggest a controlled ATNR.

Scoring: Note only the side of the body to which head is turned is assessed.

Arms Score:

1 No movement on the side to which the head is turned

2 Tremor

3 Fingers move

4 Hand and arm move

5 Unable

Feet Score:

1 No movement

2 No score

3 No score

4 Feet move

5 Unable

ATNR (Ayres): The second test is adapted from Jean Ayres work with learning disabled children (Ayres, 1972). The child assumes the four point kneeling or 'table' position with straight arms and hands facing forward. Usually the tester kneels in front of the child to move the head however as these tests were recorded on video, it was necessary for the

tester to kneel to the right of the child. The tester places their hands on the child's head being careful not to cover the ears. The subject's head is held at the midline. The head is rotated to the left and held in that position for 5 seconds while reactions are observed. The head is brought back to the midline and paused for several seconds. Then the head is rotated to the right, held for 5 seconds and returned to midline. This test is performed twice with eyes open and twice with eyes closed.

Observation: The essential responses of the reflex, which is elicited by stimulation of receptors in the neck, is facilitation of extensor tone in the muscles of the arm toward which the head is turned and a relative increase in the flexor tone in the opposite arm. Any movement in the arms is noted. Particular attention is paid to the elbow. In fact from observing the children in the study it was felt that flexion of the opposite arm may indicate that the child is resisting ATNR movement on the ipsilateral side. Inability to relax the neck muscles or resistance to turning of the head is believed to be an attempt by the child to avoid the disorganizing influence of eliciting the ATNR.

Scoring for both arms:

Arms Score:

1 No movement on the side to which the head is turned

2 Tremor

3 Elbow flicks -trying to keep arm straight

4 Definite bend in the arm

5 Unable

ATNR (Schilder): This is the least invasive of the ATNR tests. Standing with feet together the child is requested to hold the arms straight out in front at shoulder level, but with the hands relaxed at the wrists. The tester stands behind the subject and gives the instruction: '*When I turn your head, I want you to keep your arms straight out in front of you, as they are now. This means your arms remain in the same position and only your head moves*'. The tester then slowly rotates the subject's head to the left until the chin is parallel with the shoulder. The position is held for 5 seconds and the head is returned to the midline. The head is then rotated to the right, and after a pause for 5 seconds, again returned to the midline. This test is performed twice with eyes open and twice with eyes closed.

Observation: Any movement of the hand and arm on the side to which the head is turned is noted, i.e. do the arms automatically follow the movement of the head?

Scoring:

Lateral Movement: Only the side of the body to which head is turned is assessed.

1 No movement or $0 - 10^o$ in children under 5 years

2 Movement $10 - 25^o$ in direction of head movement

3 Movement $25 - 45^o$

4 Arms move $+45^o$

5 Unable

Horizontal Movement: Score drop of the arms which indicates opt out of the task.

1 Drop of $0 - 10^o$ in children under 5 years

2 Drop of $10 - 25^o$

3 Drop of $25 - 45^o$

4 Drop of $+45^o$

5 Unable

Symmetrical Tonic Neck Reflex: It has been suggested that the Symmetrical Tonic Neck Reflex (STNR) may help to complete a sequence of eye training (Goddard, 1996). The ATNR extends the baby's ability to focus from about 17cm at birth to arms length between 4-6 months, it then is inhibited at about 6 months of age, the field of vision is extended to distant objects. The STNR then brings the vision back to near-distance once more, training the readjustment of binocular vision. The focusing distance and hand-eye coordination skills used in the act of creeping are at the same distance that the child will eventually use for reading and writing.

To test for the STNR the child kneels in the four point 'table' position. The child is instructed to maintain the test position but to slowly move the head to look down 'as if looking between your thighs'. The position is held for up to 5 seconds and the the head

is moved slowly upwards as if to look at the ceiling'. This is repeated once again with eyes open and twice with eyes closed.

Observation: Bending of the arms as a result of head flexion is noted. Lurching or sitting back on heels as the head goes into extension is also scored indicating that the child is unhappy on 'all fours'.

Scoring:

Arms Score:

1 No movement

2 Tremor in the arms

3 Flick in the arms

4 Definite bend

5 Unable

Trunk and leg score:

1 No movement

2 Lurch backwards and corrects it

3 Lurch backwards x 2

4 Goes backwards but does not correct it and sometimes sits on heels

5 Unable

Tonic Labyrinthine Reflex (TLR: Erect Test) As discussed in the previous chapter the TLR and Moro reflexes are closely linked, both are vestibular in origin and activated by stimulation of the labyrinths. Though the response to them is similar, it is thought that position of the fetus in utero is the earliest manifestation of the TLR in the forward position. The TLR is a big reflex and just before birth the backwards reflex kicks in, launching the baby into extension, straightening out from the fetal position, thus allowing the head to engage and aiding in the birth process.

If the tonic labyrinthine reflex fails to be inhibited at the correct time, (at 4 months for the forward reflex and up to the age of 3 years for the backwards reflex) this will have a profound effect on the child. Difficulties include vestibular, visual-perception, spatial awareness difficulties, poor sequencing skills, poor sense of time. This test primarily assesses balance. However posture and poor muscle tone are also noted.

The child stands with feet together and arms straight at the sides of the body. The head is slowly tilted back into the extended position. This was done by asking the children to look at a picture high up on the opposite wall. The tester stands behind the child to support in case there is loss of balance. After 5 seconds the child is asked to slowly move the head forwards as if looking at the toes. This position is maintained for 5 seconds. The sequence is repeated with eyes open and then twice with eyes closed.

Observation: Any loss of balance or alteration of balance as a result of head position, or as a result of head movement from above to below the level of the spine is noted. Any compensatory change in muscle tone at the back of the knees, or movement of kneecaps, twitching, or gripping of the toes as a result of head movement is also scored. Goddard (1996) mentions possible dizziness or nausea due to head movement, suggesting faulty vestibular functioning and/or residual TLR, however this was not observed in our age group.

Scoring:

When the head is down the observer assesses flexor movement in the legs, front and back of knees, and body sway.

1 No movement

2 Tremor in the knees

3 Little flicks in the knee

4 Definite bend in knees

5 Unable

When the head is back the observer assesses extension in the arms.

1 No movement

2 Definite sway in body

3 Sway with arms

4 Loss of balance

5 Unable

MORO Reflex (Erect Test): If the Moro reflex fails to be inhibited at 2-4 months of life, the child will be hypersensitive in one or several sensory channels. This may cause him to over-react to certain stimuli. Sudden noise, light, movement or alteration of position or balance may elicit the reflex at unexpected moments, so that the child is constantly 'on alert' and in a heightened state of awareness. Such a child may cope in one of two ways: either by being fearful and 'withdrawing' from situations, or by being aggressive and highly excitable and has a need to dominate situations.

Among other things the Moro reflex affects oculo-motor functioning and visual perception. The child is stimulus bound and cannot ignore irrelevant visual material with the visual field. The eyes tend to be drawn to the perimeter of a shape and so the perception of internal features suffers. There is also poor pupilliary reaction to light resulting in photosensitivity with a difficulty with black print on white paper. The child may have poor auditory discrimination skills and have difficulty shutting out background noise (Goddard, 1996).

As the Moro is in effect the 'fight or flight' reflex the tester has to raise the child's anxiety level slightly in order to elicit the reflex. Testing using loud noises etc. was not advisable as the child may become upset and lose trust in the tester. McPhillips (2002) suggests that with the younger children a game of a tree swaying in the wind would be most appropriate as follows:

The child stands with feet firmly on the floor looking straight ahead. The tester places their hands on the waist of the child with the thumbs on the back. The child is talked and guided through the test and then rocked slightly when relaxed (unawares) on his heels 2-3 inches forwards and backwards 'like a tree blowing in the wind'. This test is performed twice with eyes open and twice with eyes closed.

Observation: The observer assesses leg and arm movement during backward and forward motion. Upward movement of the toes while being swayed is normal behaviour. A sharp intake of breath on the backward movement is also a good indicator of presence of the Moro Reflex.

Scoring:

1 No problems with backwards and forwards movement

2 On backward movement arms come up

3 Child goes backwards but falls out of position

4 Child opts out of forwards/backwards movement by placing foot out to stop movement

5 Unable

6.2.5 Oculo-Motor Functioning Tests

Preschoolers who are even mildly delayed in perceptual development can be disadvantaged in their school progress. Early perceptual deficit may be related to right hemisphere dysfunction and may indicate innate specialization of the right hemisphere for traditional visuoperceptual and motor skills (Nass & Ross, 1998). Difficulties in visuomotor integration are relatively common in the preterm child and may stem from perinatal white matter damage. Nass & Ross (1998) warn not to label these problems as maturational too quickly as children who show perceptual delays are at increased risk for hyperactivity and neurologic soft sign syndromes. The following tests were adapted from Blythe (2001):

Visual Tracking: The tester sits in front of the child who stands with feet together arms by their sides. The child is instructed to follow the top of a pencil with his eyes only, and not to move his head. A 'cat in the hat' pencil top was placed on top of the pencil to add some interest to the task, and the child is instructed to focus on the striped hat. The pencil is held at a distance from the face equivalent to the distance between the end of the child's fingertips and elbow, and three inches below eye level. The tester moves the stimulus slowly from side to side for 10 movements.

Observation: The child's ability to track the pencil smoothly across the midline is observed and scored in the range 1-3. An inability to attempt the task is also scored in keeping with the other tasks.

Scoring:

1 Ability to follow the movements of the pencil without anticipation

2 Eyes Jumping

3 Head movement e.g. tracking the pencil with the head and not just the eyes.

5 Unable to focus on and follow the pencil.

Hand-Eye Tracking: The procedure is the same for this test except that the child is now requested to hold the pencil in his preferred hand and is requested to focus the eyes on the pencil and watch it as he moves it 10 times from side to side without moving the head.

Observation: The child's ability to track the pencil as he moves it smoothly across the midline is observed and scored in the range 1-3. An inability to attempt the task is scored as 5.

Scoring:

1 Ability to follow the movements of the pencil without anticipation

2 Eyes Jumping

3 Head movement

5 Unable to focus on and follow the pencil.

Fixation with Eyes: Again the tester sits in front of the child as before. The child is instructed to fixate on the pencil top with his eyes. He is then requested to hold that fixation while moving the head from side to side 10 times. The child should move the chin out to one shoulder slowly maintaining fixation on the pencil top. The the head should be moved back across the midline to the opposite shoulder.

Observation: When the child's performance is stable the eyes are observed for any deviation from the fixation point indicating an ocular-reflex.

Scoring:

1 Maintains fixation point

5 Does not maintain fixation point

Measure of Near Point Convergence and Re-establishment of Binocular Vision: The child stands with the left shoulder to a wall with a centimeter scale placed on the wall at eye level. The tester stands opposite the child and requests the child to focus on the non-writing end of a colouring pencil. The pencil is held at eye level at a distance of an arm's length from the face and is instructed to follow the coloured dot in the centre of the pencil. This is moved towards the child until the eyes converge.

The child is asked to say 'stop' when the image begins to blur/or they feel a strain on the eyes. The pencil is then moved away and the child is again asked to say 'stop' when the coloured dot becomes clear again.

Observation: The distance between the coloured point going out of focus and returning into focus again is measured from the centimetre scale. If the distance exceeds 6-8 centimetres, re-establishment of binocular vision is slow.

Scoring:

1 Convergence is normal

4 Convergence is slow

6.2.6 Tests of Motor Control and Rapid Alternate Movement

Disorders of motor execution that accompany paralysis, spasticity, and movement disorders may be categorized as disorders of primary motility. Any type of motor abnormality will impair the capacity to execute rapid fine arm and finger movements or the ability to walk normally. These tests assess a different type of motor disorder that is manifest by clumsiness and inadequate performance of sequential motor acts.

Neurological soft signs (NSS) are minor neurological signs indicating non-specific cerebral dysfunction. They may be defined as minor abnormalities in the neurological examination in the absence of other features of fixed or transient neurological disorder. They have been associated with behaviour, coordination, and learning difficulties. Other authors believe they represent a developmental lag rather than a fixed abnormality (Fellick, Thomson, Sills, & Hart, 2001). Studies have found a high incidence of soft signs in children following premature, or low birthweight birth, meningitis, and malnutrition.

There are a number of soft sign batteries published that include tests of sensory function,

coordination, motor speed, and abnormal or associated movements. Some have been validated and tested longitudinally (Stokman, Shafer, & Shaffer, 1986). Tests may be performed quickly in the clinical situation and do not require special equipment.

In Fellicka et al. (2001) children's higher scores on the soft sign battery were related to significantly worse performance on measures of cognition, coordination, and behaviour. However, although soft sign assessment may be of interest it cannot accurately predict which children are likely to have impairment in other areas.

These tests are all demonstrated slowly and the child is given a practice trial. As with the other tests above, most children who are presenting with motor problems will have difficulty with a group of tests rather than just one.

Fingers-to-nose This task tests cerebellar co-ordination of the upper extremities via the skilled movement of large proximal arm movements. The child stands with their eyes open, feet together and arms by the sides. The child is requested to raise the arms at the sides up to shoulder height. The tester stands in front of the child and demonstrates bringing the index finger tip on each hand alternately to the tip of the nose and back out to shoulder height 10 times. The arms are relaxed for 5 seconds and the task is repeated with eyes closed.

Observation: Observe how the finger tips the nose. It is rare but hitting side of the nose, or hitting the cheek may be a sign of dysmetria (a tendency to under or over-shoot the target).

Scoring:

1 Perfect finger tip to tip of nose action

2 Compensating, bring the head to the nose, or the side of the finger to the nose

3 Hitting side of nose

4 Hitting face

5 Unable

Heel on shin Autistic and Aspergers children will struggle with these tests (McPhillips, 2002). Failure on this test may indicate problems with the cerebellum and brain stem and other balance regions of the brain. The heel-shin knee-ankle manoeuver further tests co-ordination of the lower extremities.

In this task the child and tester sit on chairs opposite each other. A child's chair is used so that height allows the child's feet to be flat when placed on the ground. The left heel is brought to rest at the top of the right shin just below the knee. The heel is pushed down the front of the leg and stretched out in front as it reaches the foot. Repeat with right heel on left leg.

Observation: The position of the heel is noted as it goes down the leg. Lack of smooth movement or the inside of the foot going down the leg is seen in children with Developmental Co-ordination Disorder.

Scoring:

1 Perfect: the heel goes down the front of the leg and stretches out

2 The heel goes to the side of the leg

3 The inside of the foot goes down the leg

5 Unable to complete the task

Finger Tapping/Oppositional Finger Test This task uses rapid alternate movement to measure pyramidal tract function. The task is demonstrated to the child. The child sits on a chair opposite the tester. Starting with the index finger on the left hand, the child is requested to approximate the pulp of the thumb to the pad of each finger in succession rapidly and accurately. The child is instructed to bring the finger and thumb together in a rhythmic tapping manner, forwards to the little finger and back again to the index finger. The child is allowed one practice forwards and backwards. At least 10 consecutive taps on each hand should be attempted.

Observation: Inability to complete rapid alternate movement with the fingers may indicate non-specific neurological impairment (Marsden & Fowler, 1989). According to De Quiros (1979) this test is used in routine neurological examinations as an indicator sensitive to cerebellar dysfunction. However occasionally children younger than four may find it difficult to bring the little finger and thumb together due to lack of dexterity maturation. Both hands are observed and scored as follows:

Scoring:

1 Perfect: the tapping has a rhythmic automatic ripple

2 Can complete task but conscious of doing it

3 Can complete task but slow and laboured

4 Cannot do movement with one or more fingers

5 Unable to attempt task

Rapid Reversal of Hands This test requires the child to rapidly reverse the hands targeting the co-ordination of both sides of the brain and body. With cerebellar disorders movements frequently assume an extremely erratic, nonrepetitive pattern. This test is demonstrated slowly and movement should be in a rhythmic alternating fashion. The tester and child are in the sitting position as before with hands placed with palms face down on the knees. One palm is then turned over. Both hands are raised to chest level and then turned so that they reverse their orientation, before they are placed back on the knees. The child should attempt 10 lifts and rotations.

Observation: There must be a definite up/down rhythm with the palms being reversed fully. Often the speed is slow as the child has to think about what he is doing. Sometimes both palms are facing the same way as the child cannot move the left hand in the opposite direction to the right.

Scoring:

1 Perfect: palms are lifted and reversed automatically, speed is fast

2 Slower rhythm

3 Child really thinking about the task but can do it

4 Child cannot turn opposite hands

5 Child unable to attempt task

Finger-to-thumb The nursery rhyme 'Incy Wincy Spider', may have been familiar to some of the children but not the actual finger movement. Again in the sitting position, the child is instructed to put opposing index fingers and thumbs together and to tuck the other fingers into the palms. The hands are twisted to release the lower finger and thumb which then turn and meet at the top. Five practice twists were given. The children were scored on 10 rotations.

Observation: Observe that the children are placing the fingers in the correct start position and twisting the hands in the right direction. Finger and thumb must meet at the top. Often children lose their concentration/place and the wrong fingers are linked up. Ten rotations are necessary to show the children have mastered the task.

Scoring:

1 Able to complete 10 rotations

5 Unable to complete 10 rotations

6.2.7 Phonological Tests

As the majority of tests in the whole battery were motor based, it was advised that standard phonological tests should also be included. These could indicate any correlation between motor and phonological difficulties in the sample. The following tests were chosen as they were known to be good predictors of reading ability of children in primary school.

Muter & Snowling(1998) in a replication of earlier longitudinal studies (Muter, Hulme, Snowling, & Taylor, 1997) found that scores on a test of Letter Name Knowledge at age 4 showed statistically significant correlations with reading performance at age 9. They also found that rhyming and segmentation skills are relatively stable during childhood, with skills evident at ages 4, 5, and 6 enduring through to age 9. They conclude that rhyming and segmentation skills represent two independent subskills within the phonological domain. Their findings show that the best predictor set was the Phoneme Deletion and Nonword Repetition scores obtained at ages 5 and 6.

Letter Name Knowledge The test of Letter Name Knowledge required the child to supply the names of each of the 26 letters of the alphabet, presented in lower case on individual flashcards and presented in random order (Muter & Snowling, 1998).

Phoneme Deletion The children's awareness of phonemes was assessed by a phoneme deletion test. This required the child to remove the first phoneme of a single syllable word (e.g. 'bus' with out the /b/ is.... [the correct response being 'us']). Four demonstration items were followed by ten test items (Muter & Snowling, 1998).

Non-Word Repetition This is a test of phonological working memory. In this test (Gathercole & Baddeley, 1989) the children were required to repeat 40 nonwords of be-

tween one and four syllables in length (e.g., *tull, ballop, thickery*, and *perplisteronk*) spoken by the tester at the rate of one word every 3 seconds. As some of the children in the DEYP were aged under 3.5 years when starting they were also first asked to repeat 10 simple consonant-vowel sounds before attempting the Gathercole and Baddeley test. See Appendix E. Correct repetitions were scored as 1 and incorrect repetitions scored as 0. The minimum raw score was 0 and the maximum was 50.

6.3 Screening for Dyslexia

All the children were given either the DEST-2 or the DST depending on their age at their last session. These tests were devised by Nicolson and Fawcett (1996) and (2004). A summary of the test batteries, and what constitutes an 'At Risk' score are described below.

6.3.1 Dyslexia Early Screening Test - 2

The Dyslexia Early Screening Test (D.E.S.T.-2) is designed for children between the ages of 4:6 and 6:5 years. It consists of 12 different tests on which dyslexic children can perform poorly. The results provide a profile of strengths and weaknesses which may be used as a guide for the child's academic support in school.

The battery comprises eleven tests, two attainment and nine diagnostic. The attainment tests, Digit Naming and Letter Naming measure pre-requisites for learning to read. Digits are normally learned before a full set of letters, and skills in letter naming continue to be recognised as one of the strongest predictors of good reading (Muter & Snowling, 1998). The tests were administered in the following order:

1. Rapid naming: This involves correctly naming different pictures as quickly as possible and it is based on Denckla's (1976) work on Rapid Automatised Naming.

2. Bead threading: This represents a test of fine motor skill requiring hand-eye coordination.

3. Phonological Discrimination: This tests the child's ability to judge the sounds of a word. Phonological difficulties are one of the most potent causes of failure to learn to read.

4. Postural stability: This involves a gentle push in the back to determine whether the child has a problem with maintaining balance.

5. Rhyme/First Letter: This assesses two skills significantly associated with learning to read, the child's ability to detect rhyme and alliteration.

6. Forwards digit span: This is a test of working memory, requiring the child to listen to a sequence of single digits then repeat them back in the same order.

7. Digit naming: This tests the child's knowledge of numbers.

8. Letter naming: This tests the child's knowledge of letters.

9. Sound order: This gives an indication of whether the child may have difficulty in determining the order in which 2 different tones played close together, are presented. This may indicate difficulties in phonological discrimination.

10. Shape copying: As writing neatly and fast can be difficult for dyslexic children, this test assesses pencil control. The importance of visuomotor skills to future academic achievement is attested to by the predictive power of similar tests like the Bender Gestalt Test (Doppitz, 1963).

11. The Frog test: A test of the child's spatial memory.

12. Vocabulary: This is designed to test the child's reasoning abilities.

The aim of DEST-2 is to provide an overall risk measure. A weighted mean is taken of the individual at risk scores, ignoring those scores that did not show risk. An 'At Risk' Quotient (ARQ) of 0.6-0.8 indicates a mild risk whereas an ARQ of 0.9 or greater is strong evidence that a child is 'at risk' of developing dyslexia.

6.3.2 Dyslexia Screening Test

The Dyslexia Screening Test is designed for children in the 6:6 to 16:5 age range and provides an indication ('At Risk' Quotient) of whether a further, full psycho-educational assessment should be sought.

There are eleven tests in all in this battery. The three tests of attainment which correspond directly to the accepted difficulties of dyslexic children are:

1. One Minute Reading test devised to measure speed and accuracy of reading.
2. Two Minute Spelling test devised to measure ability to spell everyday words.
3. One Minute Writing test to show evidence of poor writing speed.

Seven diagnostic tests are used to measure the range of skills known to be affected in dyslexia. The final test that measures semantic fluency is also included as Frith et al. (1995) suggest that a profile of good semantic fluency and poor verbal fluency might be characteristic of dyslexia. The diagnostic tests are as follows:

1. Rapid naming: This involves correctly naming different pictures as quickly as possible (Denckla & Rudel, 1976).
2. Bead threading: This represents a test of fine motor skill requiring hand-eye coordination.
3. Postural stability: This involves a gentle push in the back to determine whether the child has a problem with maintaining balance.
4. Phonetic segmentation: This assesses the child's phonological skill, that is, their ability to break down the sounds of a word, as well as assessing their short-term memory.
5. Backwards digit span: This is a test of working memory, requiring the child to listen to a series of numbers then repeat them back in reverse order.
6. Nonsense passage reading: This tests the child's ability to read words with which they are not familiar, such that they must break down the word into chunks to work out how it sounds.
7. Verbal fluency measures the ability to generate a list of words beginning with the same sound e.g. words beginning with 'S'.
8. Semantic Fluency measures the ability to generate a list of words from some category, for example, 'food'.

Having determined the At Risk Index for all 11 tests the ARQ is then calculated. An ARQ of 1 or greater is strong evidence that a child is 'at risk' of developing dyslexia.

6.4 Screening for Attention Deficit/Hyperactivity Disorder (ADHD)

Research has raised a possible confound between dyslexia and Attention Deficit/Hyperactivity Disorder (ADHD). Wimmer et al. (1999) investigated a link between poor balance control and ADHD rather than dyslexia in German children. As ADHD can be co-morbid with dyslexia (Portwood, 1999) it was important to ascertain how many of the children in the study scored highly for ADHD type behaviour and if poor balance skills could be attributed to this.

ADHD is a common neurobehavioural disorder of childhood and can persist through adolescence into adulthood. Currently causes are unknown. The American Psychiatric Association's Diagnostic and Statistical Manual IV, Text Revision (DSM-IV-TR), estimates that 3%-7% of children suffer from ADHD. It is diagnosed approximately three times more often in boys than in girls. The individual with ADHD has a chronic level of inattention, impulsive hyperactivity, or both such that daily functioning is compromised. The symptoms of the disorder must be present at levels that are higher than expected for a person's developmental stage and must interfere with a person's ability to function in different settings (e.g., in school and at home) for a diagnosis to be made. A person with ADHD may struggle in important areas of life, such as peer and family relationships, and school or work performance. Three types of ADHD have been established according to which symptoms are strongest in the individual: Predominantly Inattentive Type; Predominantly Hyperactive-Impulsive Type; Combined Type. See (APA, 2000) for diagnostic criteria.

6.4.1 ADHD Indicator

At the child's last assessment, parents were asked to rate their child's behaviour in the previous month. The Conners' Parent Rating Scale - Revised: Short Form was used. This short form comprises of 27 questions relating to common behavioural problems in children. They included items such as:

- Inattentive, easily distracted
- Fidgets with hands or feet or squirms in seat

- Easily frustrated in efforts

For each item the parent asked themselves: 'How much of a problem has this been in the last month?' and then circled the most relevant number below:

0 Not True At All (Never, Seldom)

1 Just A Little True (Occasionally)

2 Pretty Much True (Often, Quite a Bit)

3 Very Much True (Very Often, Very Frequent)

See Appendix F for a copy of the short form.

Scores were totalled for each of the subscales:

A: Oppositional (6 items)

B: Cognitive Problems/Inattention (6 items)

C: Hyperactivity (6 items)

D: ADHD Index (12 items)

Raw scores were converted to T-scores by plotting them on the appropriate male or female profile form. A full diagnosis of ADHD was not among the aims of the study. This would have entailed detailed psycho-educational and neuropsychological tests, careful and thorough developmental, familial, medical, academic and social histories in conjunction with the Conners' Rating Scales from both parents and teachers.

As this instrument was just used as an indicator, Conners recommends using the ADHD Index only. Conners states that empirical analysis shows that the items on the ADHD Index are the best set of items for identifying children 'at risk' for an ADHD diagnosis. See Appendix F for those questions directly related to the ADHD Index. In general higher T-scores are associated with a greater frequency of reported problems. T-scores of 65 and above are usually taken to indicate whether further exploration is necessary and this is the

T-Score	percentile	Guideline
70+	98+	Markedly Atypical (Indicates Significant Problem)
66-70	95-98	Moderately Atypical (Indicates Significant Problem)
61-65	86-94	Mildly Atypical (Possible Significant Problem)
56-60	74-85	Slightly Atypical (Borderline: Should Raise Concern)
45-55	27-73	Average (Typical Score: Should Not Raise Concern)
35-39	6-15	Mildly Atypical (Low scores are good: Not a concern)
30-34	2-5	Moderately Atypical (Low scores are good: Not a concern)
< 30	< 2	Markedly Atypical (Low scores are good: Not a concern)

Table 6.1: *Conners'(2001) Diagnostic Guidelines*

score that was used to indicate children at risk for ADHD. See Table 6.1 for interpretive guidelines from Conners (2001).

The development of the test battery used in this study has been dealt with in detail. The next chapter looks at the methodology employed in this study.

Balance	**Reflex**	**Oculo-Motor**	**Motor/Adiadochokinesia**	**Phonological**
Leg Dominance	ATNR: Lying Down	Visual Tracking	Fingers-to-Nose	Letter Name Knowledge
Standing on One Leg	ATNR: Ayres	Hand-Eye Tracking	Heel on Shin	Phoneme Deletion
Advanced Romberg	STNR	Fixation with Eyes	Finger Tapping	Non-Word Repetition
Tandem Walk	ATNR: Schilder	Near Point Convergence	Palm Reversal	
Walking on Tiptoe	TLR: Standing		Finger to Thumb	
Slalom Walk	MORO: Standing			
Hopping on the Spot				
March and About Turn				
Crawling on All Fours				

Table 6.2: *Test Battery*

7

Methodology

At the end of Chapter 1 the main questions to be asked were whether:

a) a reflex remediation programme or a balance training programme completed over a year could reduce the risk of developing dyslexia in children between the ages of 3-7 years, and

b) whether reflex, balance motor, oculo-motor and phonological tests could predict the development of dyslexia in that age range.

In relation to b) the previous chapter deals with why the tests described here were selected, how they were put together, and how they addressed the various research questions.

In Chapter 5 the balance training and reflex remediation programmes used are described fully. Manuals are included as Appendices L, K and M. A DVD of the individual programmes are available from the author.

7.1 Study Design and Participants

In order to answer the research questions this study is based in part on a mixed factorial design with two main factors:

- type of treatment (4 levels)
- time sample (3 levels), with repeated measures on this last factor.

The statistical design for the outcome variable, dyslexia risk status, was a 4 × 2 Anova with type of treatment and initial dyslexia risk as main factors.

Treatment groups were matched for age and treatment delivery was blind as to the retained-reflex status of the participants and condition assignment. Participation was voluntary. Initially 190 families expressed an interest in participating in the study. One hundred and seventy-eight children commenced the study. They were recruited from families with a member (either parent or sibling) who had a positive diagnosis of dyslexia. One hundred and thirty-six completed all three assessment sessions. Of these, 115 were boys aged between 3-7 years. Twenty-one girls of the same age, also from families of known dyslexia status, but who were presenting with dyslexia type difficulties were also included. Hence, approximately 40-50% of the experimental groups were at risk for dyslexia. Of the 178 children who started, 76% completed the study.

At their first session, after meeting the criteria above, all children were assessed for evidence of retained reflexes. Their scores on a set of 6 Reflex tests were used to identify each child as being either a high or low risk individual. This information was used to ensure equal representation on the basis of this at risk status in each of the four conditions of the study, of which two were experimental and two control. It was not intended for use as main independent variable. The experimental conditions consisted of a reflex remediation programme and a balance development programme. Control conditions consisted of a placebo control group and a non-intervention group. The primary dependent variable was a reliable measure of dyslexia status; secondary dependent variables were measures of retained reflexes, balance control and phonological awareness. See Figure 9.1 for the design of the study.

At the end of the study the children were screened for dyslexia using the Dyslexia Early Screening Test - 2 (DEST - 2, Nicolson & Fawcett, 2004) for children aged 4.5 years to 6.5 years and the Dyslexia Screening Test (DST, Nicolson & Fawcett, 1996) for those

aged 6.6 years to 16.5 years. The Conners' Parent Rating Scale (Conners, 2001) was used to investigate the link between ADHD and (1) risk of dyslexia, (2) balance,(3) retained reflexes.

Table 7.1 below summarises the assignment of participants to each of the experimental conditions (n=136):

Group 1	**Group 2**	**Group 3**	**Group 4**
Reflex Prog	**Balance Prog**	**Placebo Prog**	**No Prog**
46	46	23	21

Table 7.1: *Study Design*

The tests used at the different time intervals are presented in Table 7.2:

Tests Time 1: Start	**Tests Time 2: + 6 months**	**Tests Time 3: + 12 months**
Ocular-Motor Functioning	Ocular-Motor Functioning	Ocular-Motor Functioning
Motor/Adiadochokinesia	Motor/Adiadochokinesia	Motor/Adiadochokinesia
Balance	Balance	Balance
Reflex	Reflex	Reflex
Phonological	Phonological	Phonological
		DEST-2/DST
		CPRS: R-S

Table 7.2: *Tests used in each session*

7.2 Recruitment

Recruitment was ongoing between April 2003 and November 2004. The Dyslexia Early Years Project was launched with two presentations at the Dyslexia Association of Ireland (DAI) AGM in April 2003. The presentation 'Dyslexia Uncovered' summarised the causal theories to date. The presentation 'Why Movement Programmes: what does the research say?' focused on movement therapies in particular and also elaborated on programmes currently offered by charitable as well as commercial organisations. Details about the Dyslexia Early Years Project were then disclosed and parents, teachers, and DAI branch co-ordinators were invited to contact the Dyslexia Research Group if they knew of families who would be interested in participating in the study. Information talks for parents were arranged in Trinity College Dublin for May and June 2003. Interested parents and teachers

came along to learn more about the study. A website was set up for the Project with information and contact details, see www.dysvideo.org.

In an attempt to recruit voluntary participants from all over the country and from each socio-economic group, primary schools in all counties nationwide were contacted by letter between May and November 2003. (see Appendix A for a copy of the letter and advertisement). School principals were asked to forward information to parents who either suspected that they may be dyslexic themselves, and/or those who already had a child diagnosed, in an effort to recruit boys, in the 4-7 years age range, and girls in the same age range if they were actually presenting with dyslexic type difficulties. Gilger (1991) estimates that the risk of a son being dyslexic if he has a dyslexic father at about 40%.

Branches of the Dyslexia Association of Ireland's around the country were also contacted with the same request. The DAI also placed a notice in their newsletter and on their website (www.dyslexia.ie) during the summer of 2003.

In the Spring of 2004, in order to continue recruiting suitable families, montessori schools, nursery schools and playgroups in the Dublin area were contacted by letter and a notice was put on the parenting website www.Rollercoaster.ie. An advertisement was also placed in the Evening Herald of 1st and 2nd July, 2004. As some Speech and Language therapists see children with speech disorders from families with a history of dyslexia, the Irish Speech and Language Therapists Association members in the Health Boards across the country were contacted. They kindly agreed to inform such families about the study.

Radio stations were also contacted to publicise the study and interviews were given as follows:

- Lite FM: Dublin Today, June 2003.
- East Coast Radio The Declan Meehan Show, October, 2003.
- South East Radio: The Alan Maguire Show, November, 2003.
- RTE Radio 1: Future Tense, Science programme, March 2004.

National newspapers and specific magazines listed below also printed details of the study:

- Sunday Independent, August 8th, 2003.
- Irish Times, November 18th, 2003.

- In Touch: The Irish National Teachers Organisation (INTO) magazine, Summer 2004
- National Parents Council newsletter, Newsbrief, Summer 2004.

Interested parents contacted the Dyslexia Early Years Project in Trinity College, Dublin, and those who wished their children to be involved in the study were sent a **Parent Pack** (See Materials Section below). Although some children aged 3-3.5 years were recruited and tested in the first 100 of the sample, it was decided not to call children until they were at least 3 years 6 months as they were often too young or shy to understand or complete the tasks. Appointments were then made for the first of three assessments, 6 months apart, for 178 children, the original number who started the study.

7.3 Materials

Parents who requested that their children be involved in the study were sent a Parent Pack that included the following items:

- Information Sheet
- Preliminary questionnaire to be completed and returned
- Consent form to be signed and returned
- Disclaimer form to be signed and returned
- Video disclaimer form

See Appendix B for the Parent Pack information.

7.3.1 Questionnaires:

A preliminary questionnaire was designed to verify the eligibility of the child for the study. Data collected in this questionnaire included details on the diagnosis or history of dyslexia in the family and the child's development and medical history. Based on this the children were then were categorised into three groups:

E1B: Boys who were immediately eligible in the study e.g. those who had a parent or sibling with a diagnosis of dyslexia

E2B: Boys who had a parent or sibling with a suspicion of dyslexia

E3G: Girls who were already presenting with difficulties.

Children who did not fall into these categories were not included in the study.

After the initial assessment each child was randomly assigned to one of four groups (Haahr, 1978). See Table 7.1. The three treatment groups received a package containing the manual and video for their particular movement programme within 3 weeks of their initial appointment. Parents were requested to complete a retrospective questionnaire (see Appendix C) at each child's last assessment session. Questions about possible co-morbid conditions such as: ADHD; Autism; Dyspraxia; Hearing problems; Speech and Language difficulties; were asked. Comorbidity results are reported later in Chapter 9. The data from the two questionnaires were entered into a web database which allowed transfer of data to SPSS for analysis later (see Chapter 8).

Of the 178 voluntary participants initially tested, 136 (M= 5 years, 6 months, S.D. = 12.2, consisting of 115 males and 21 females, completed the study.

7.3.2 Assessment Materials:

The Balance and Reflex section of each assessment was recorded on video. The T1, T2 and T3 assessments used the following observational setup and materials:

- Floor outlined for optimal camera positions - See section 7.4
- Digital video camera and mini tapes
- Palm pilot to allow recording of child ID onto video tape (see Chapter 8)
- Child I.D. sheets
- Score sheets
- Stop watch
- Measuring tape

- Soft medium ball
- Alphabet Cards
- Child's Chair
- Cassette Player

Tests used were as follows:

- Balance Tests
- Reflex Tests
- Oculo-Motor Functioning Tests
- Motor/Adiadochokinesia Tests
- Phonological Tests

At the final assessment the following were also used:

- Retrospective Questionnaire
- Conners' Parent Rating Scale - short form (Conners, 2001)
- DEST-2 (Nicolson & Fawcett, 2004) for children between 4.5-6.5 years
- DST (Nicolson & Fawcett, 1996) for children between 6.6-16.5 years

Children wore shorts and t-shirt to allow limbs to be seen clearly and researchers wore black to avoid blending in with the child on video. This facilitated the attempt at computer measurement of reflexes (see Chapter 8).

7.3.3 Intervention Materials:

Videos and manuals were prepared for each of the movement programmes (see Appendices L, K, M) to instruct the parents in the nightly exercises for the children. Refer to Chapter 5 for development of the programmes.

Movement Programmes for each Group			
Group 1 Reflex Remediation	**Group 2 Balance Training**	**Group 3 Placebo**	**Group 4 Control**
Programme 1	Programme 2	Programme 3	No Programme
Video 1	Video 2	Video 3	No Video
Manual 1	Manual 2	Manual 3	No Manual

Table 7.3: *Movement Programmes*

7.4 Procedure

To facilitate video recording and the reproducibility of the tests the room was set up as follows (see also section 7.7):

- Dimensions: test mat area = 260 cm × 200 cm
- Green background to enable flesh detection
- Green mat with white lines on floor
- Camera angle fixed
- Fixed fluorescent lighting

Two researchers were always present. The first greeted the parent and child, filled out forms, and directed the child through the tests. The second researcher operated the camera and palm pilot.

7.4.1 Initial Assessment:

The children were assessed three times over a year. At the start (T1) they were given the Motor, Oculo-Motor, Balance, Reflex, and Phonological test batteries. After the first assessment the children were randomly assigned to one of four groups. Groups 1-3 were given an exercise programme. Group 4, the control or delayed treatment group did not receive a programme but were offered a programme at the end of the study (see the Ethics section 7.5). Testers were blind as to what treatment group the children were assigned to.

It was found that if the tests were carried out in the following order the children were less tired and could complete the session within 45 minutes. The tests were carried out as follows:

- Leg Dominance
- 8 Balance tests
- 6 Reflex tests
- 4 Oculo-Motor functioning tests
- 5 Motor tests
- 3 Phonological tests

See Appendix E for a copy of the tests and Appendix I for the scoresheet.

After the first assessment session each parent was advised on the randomisation process for assignment to conditions and the status of delayed treatment group. The six month appointment was arranged. The parent was contacted by letter within three weeks of the initial assessment session confirming the next appointment and the group to which the child was assigned. The relevant video and manual was enclosed if the child was not assigned to the delayed treatment group.

7.4.2 Intervention Phase - Movement Programmes:

Between assessments, all children other than those in the no-treatment group undertook one of three movement programmes, refer to Table 6.2. Children in groups 1-3 undertook the movement exercises for 12 months, attending for their interim assessment at the six months stage. Group 4, the delayed treatment group, or control group, received no programme in the first year but continued with their daily life and were tested like the rest of the sample at T1, T2, and T3. Parents were told before they consented to have their child take part in the study that they may be randomly allocated to Group 4, the 'delayed treatment group'. They were then offered a programme at the end of twelve months. See Appendices L, K, and M and Chapter 5 for the content of the programmes.

A few months into the programme the parents were contacted to assess the progress of the children and to deal with any difficulties that had arisen. At this stage, those who

had failed to start the programme due to unforeseen circumstances were reassigned to the control group if they desired to continue in the study.

7.4.3 Interim Assessment:

Six months later (T2), the children were again scheduled for assessment and received the same test battery. This session was also a chance to confer with parents on the progress of their child in completing the exercise programme at home.

7.4.4 Final Assessment:

At 12 months (T3), Motor, Oculo-motor, Balance, Reflex, Phonological test batteries were again administered. After a short break the child was assessed for dyslexia risk using standardised tests. The DEST-2 (Nicolson & Fawcett, 2004) was used for children between 4.5-6.5 years. The DST (Nicolson & Fawcett, 1996) was used for children between the ages of 6.6-8 years. See (Table 7.2 above). Parents were also asked to complete the short form version of the Conners' Parent Rating Scale. After the final assessment the scores for each test and DEST/DST scores were calculated and entered into the database. See Appendices F and G for information on the Screening Tests.

A small token of thanks was given to each child before they left the final assessment. This consisted of a 'Dyslexia Early Years' certificate see Appendix O and a t-shirt with the study logo. They and their parents were thanked for their cooperation and their help with the research. It was explained to the parents that they would receive a copy of their child's 'Dyslexia Screening Test' report see Appendix H in the post within a few weeks. This would indicate their child's individual test results and their degree of risk for dyslexia. They were also advised that if they had any questions they should contact us immediately. Furthermore, the following points were explained carefully:

- This report was not a substitute for a full psycho-educational assessment and as such could not be used in the application for special waivers and resource hours from the Department of Education and Science.
- Regardless of the risk level, there was always the chance of a 'false-negative' or 'false positive' result and they should take academic performance and /or family history into consideration in monitoring their child's progress at school.

- If the parents were particularly concerned about their child's progress they were advised to send their child for a full psycho-educational assessment. The Dyslexia Association of Ireland's contact numbers and details were supplied to them.

7.5 Ethics

The Dyslexia Early Years Study was passed by the Ethics Committee of the Department of Psychology, Trinity College in November, 2002. Parents were advised that the children would be randomly allocated to one of four groups, and it was not known which, if any, of the programmes would show a benefit to their child's concentration, co-ordination, or academic progress. Those in the delayed treatment group did not receive an exercise programme at the start of the study. They were offered a programme at the end, or could choose to wait until results on the efficacy of the programmes were known to avail of a programme. In all cases parents would be informed if any programme was shown to be of benefit to the children and all would be offered this programme. Results of the whole study would be posted to the families.

In addition, three weeks after each child completed their final assessment, a report on the child's 'risk of dyslexia' as per the DEST/DST screening test was forwarded to the parents. For ethics approval see Appendix J.

7.6 Scoring

The child's scores were logged on a scoresheet on each day of observation. The Balance and Reflex tests were recorded on digital video for later analysis. A video browser was used to review the recorded sessions. It allowed scores to be confirmed and added an element of repeatability for the scoring process. It also allowed cross scoring at a later date. See section 7.7 for more details on this system.

A scoring range of 1-5 was used for the Balance, Reflex and Motor tests. The Oculo-Motor Functioning tests had a scoring range of 1-3. A score of 5 was assigned if the child was unable to complete the test due to poor muscle tone, poorly developed balance skills or anxiety. In the Phonological tests - Letter Name Knowledge, Phoneme Deletion, and Non-word Repetition - the child received 1 point for every correct answer.

The scores for the Balance and Reflex tests were totalled and averaged and the child was assigned as high or low risk. A score of 2 or below was considered low risk, and above 2, high risk. The children were then randomly assigned to one of four groups using a random number sheet.

7.6.1 Special Cases:

There were four cases where children were supervised in their intervention programme by their teacher in school during the week and by their parents at weekends. Two of the children were siblings from a disadvantaged family. The other children had siblings which were not involved in the study but had another disability, or required speech therapy in the home.

It transpired that three other children were already engaged in a reflex remediation programme in class for the year and two children were undertaking a similar programme with a private therapist over the course of their involvement in the study. These children were assigned to Programme 1.

7.6.2 Inter-rater Reliability

The main researchers scored 10 per cent of the other researcher's data to check inter-rater reliability. Other independent scorers also rated 18 per cent of the final sample and these were correlated to obtain a measure of inter-rater reliability using Pearson's Correlation. Results are presented in Section 9.6 of Chapter 9.

7.7 Data Management

Every child's Balance and Reflex tests were recorded on video at each of their three test sessions. The video data for each child could be 15 to 30 minutes long depending on the co-operation of the individual child. It was originally estimated that up to 400 children might have to be tested 3 times over the 12 months relating to their part of the study. This could amount to between 400 - 600 hours of video data. It would have been a very time consuming task to manually browse that amount of video to find the appropriate test to view and score. A joint project 'Dysvideo', funded by Enterprise

Ireland, was set up between the Department of Electronic & Electrical Engineering, and the Dyslexia Research Group in the School of Psychology, TCD. The team built a system to electronically tag and segment this data into the 14 critical Balance and Reflex tests. The sections of the video session which were not useful, including set-up, errors, and when there was nothing happening on camera, were not included in the viewing segment and thus saved scoring time. Computer measurement of the children's reflex reaction was also attempted. For more details see Chapter 8.

Three web-based databases were set up by the Dysvideo Group. The first, the Contact Database, and the third, the Retrospective database, allowed entry of data from the initial and final questionnaires. The second, the Test Session Database, was linked to the video browser so that data entry could take place as the scorer viewed the video on a PC. The Browser was designed to include password access so that the two main researchers had administrator privileges and had the option to view all the data including the objective scores for comparison later. However those doing cross scoring for inter-rater reliability could only view their own scores. The Browser consisted of a front page which was designed for entry of the following items: Age at session; Oculo-Motor scores; Motor Adiadochokinesia scores; Phonological scores; Leg Dominance; and Session Comments. Once that data was entered, the browser allowed the children's Balance and Reflex scores, from Tests 1-14 to be entered in fields beside the video screen. Total scores for Reflex and Balance batteries were then automatically calculated.

Once scores from each of the three sessions and background data from the questionnaires were entered in the web database, a computer programme allowed the automatic transfer of data from the database to SPSS. The SPSS file was formatted so that variable headings corresponded exactly to fields in the web database. This allowed a quick and accurate transfer of data to SPSS and a second entry of an enormous amount of data was avoided.

The issues faced during the design and set-up of the video analysis technology, data handling and reflex measurement are discussed in Chapter 8.

8

Data Handling

The Dyslexia Early Years Project[1], like many observational studies, involved handling a large amount of data collected for analysis. This created its own challenges and raised issues dealing with repeatability in particular. A new digital video based technology was developed and exploited in this research to address these challenges and is an important new development. This chapter describes the characteristics of this technology.

[1]Work from this chapter was published in three separate papers:

1. *Exploiting Temporal Discontinuities for Event Detection and Manipulation in Video Streams,* Hugh Denman, Erika Doyle, Anil Kokaram, Niall Rea, Rozenn Dahyot, and Ray Fuller, 7th ACM SIGMM International Workshop on Multilevel Information Retrieval, November 10-11, 2005, Singapore;

2. *Motion-based parsing for video from observational psychology,*, A. C. Kokaram, E. Doyle, D. Lennon, L. Joyeux, R. Fuller, SPIE Multilevel Content Analysis, Management, and Retrieval 2006, San Jose , USA, Jan 17-19, SPIE Vol 6073;

3. *Content based access for a massive database of human observation video,* Proceedings of the 6th ACM SIGMM international workshop on Multilevel information retrieval table of contents New York, NY, USA Pages: 46 - 52 2004 ISBN:1-58113-940-3 , L. Joyeux, E. Doyle, H. Denman, A. C. Crawford, A. Bousseau, A Kokaram, R Fuller.

One hundred and thirty six children attended for three sessions during the course of this study. As discussed in previous chapters, the underlying idea was to observe the children as they executed a battery of tests. Their performance was ranked subjectively and associated with a score. In any programme of this magnitude two questions immediately arise i) how can the scoring be made repeatable and reliable? and ii) how can the researchers be sure that all the movements that occur have indeed been noticed by the observers? Both of these issues can be addressed by recording each session on video. The recorded sessions can then be assessed later by different scorers, thus addressing reliability and repeatability concerns. The sessions can be reviewed to check accuracy, hence addressing the second concern.

This is fine in principle and in fact video is now more routinely used to record data in observational studies. However there is one major problem that a study of this magnitude poses: the amount of video recorded is so large that it is almost impossible to browse the video afterwards to locate the portions of interest with any efficiency. In this research, a subset of 14 tests, with a duration of about 20 minutes, was recorded on digital video tape[2]. In all this amounts to $20 \times 136 \times 3 = 8160$ minutes or 136 hours of recorded video. Within the recording of 20 minutes, just 5 minutes contained useful material since the child performed the tasks for a small portion of the time. This is because much of the time was spent putting the child at ease and in setting up each test. It was extremely difficult therefore to manually browse the recorded video to locate the actual episode for later assessment as shown in the timeline of a test in Figure 8.1

In addition there is the problem of actually viewing the video. There is currently no digital video editing/browsing package that considers comparative issues with respect to video browsing for observational psychology. Many researchers still use generic editing tools like Adobe Premiere for this purpose but these are consumer editing tools and not observational tools. Companies like Noldus (www.noldus.com) and Mangold (www.mangold.de) provide tools for the use of video in Psychology but again they cannot deal with observational studies of this magnitude that require both video analysis and a maintenance of extensive textual records.

To address this need in the observational psychology field a collaborative project, Dysvideo, was established between the Dyslexia Research Group (DRG) in the School of Psychology and the Sigmedia research group in the Electronic and Electrical Engineering Dept; both at Trinity College. This team of researchers will be referred to as the Dysvideo

[2]Using a Canon 3CCD DV Camcorder model XM2

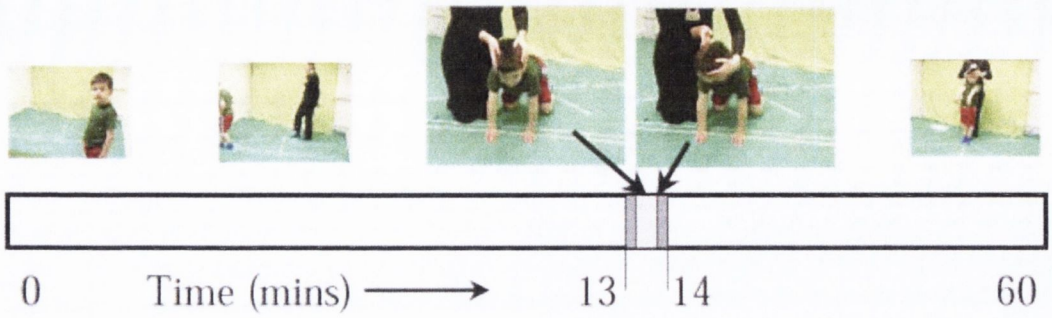


Figure 8.1: *An example of content throughout a typical recording of 60 mins. The location of the audio markers coarsely indicates the relevant video for one test. This is shown at mins 13 and 14. The actual useful content lies inside this period, indicated by the two larger frames. Note that the idea of coarse indexing is to quickly reject the outlier content e.g. when the child is not in view, not co-operating, or not assuming the start position. Examples of these views are shown in the remaining (smaller) images on the timeline.*

team in the rest of this chapter. The project received funding from Enterprise Ireland from 2002-2006 in two competitive rounds of research application procedures: Research Innovations and Proof of Concept Programmes. One person from the DRG was involved in driving the system design, specifications and user feedback. Various Sigmedia team members were involved in technical developments including Signal Processing Algorithm design and software programming.

The key questions addressed by the project were as follows:

- How to capture and record video data in each session.
- How to automatically index the relevant portions of video in each recording.
- How to record child identification number simultaneously with video information.
- How to transfer video data to a database for retrieval and browsing in 12 hours.
- How to present the video data for browsing.
- How to allow interactive scoring as the video is being reviewed.
- How to associate the recorded scores and other data with the video material for each scorer.

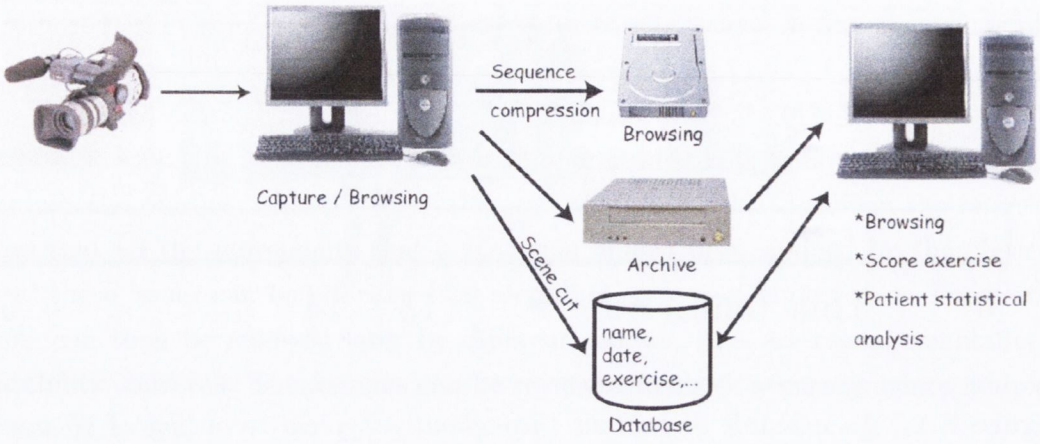


Figure 8.2: *The System Workflow*

- How to allow data access by scorer, or child.
- How to interface successfully with a statistics analysis package.

The remainder of the chapter describes the solutions developed by Dysvideo. First, the overall working process is described and then the novel technology developed as part of this research is explained.

8.1 The System Workflow

A typical recording flow proceeds as follows:

1. A child ID tone, and a start ID tone are played into the camera audio input
2. The tester takes the child through one test
3. An end tone is played into the camera input to mark the end of the test

This is repeated until the 14 tests are completed.

Sessions with the children lasted about one hour. The testing room was arranged so that participants were filmed against a green backdrop to facilitate image analysis later. In addition markers on the carpet surface enabled the testers to orient the child correctly in



Figure 8.3: *A typical view of a test in progress*

the camera view. Figure 8.2 shows the workflow, and Figure 8.3 shows a typical camera view. The camera was recording continuously as the 14 tests were executed. The testers used a handheld computer to create audio tones (typical keypad phone tones) that were recorded on one of the two stereo channel inputs into the camcorder.

It was possible to record up to three children on each video tape. When the tape was full it was processed by the Dysvideo Server System overnight. A software module in a PC read the digital video data off the tape and automatically extracted each clip showing each test. The timecodes marking these clips were then written to a database. The clips were themselves compressed in two ways. A high bandwidth clip of extremely high quality was created (MPEG2 format) for archiving. A lower bandwidth clip of good enough quality for human observation was also created (MPEG4 format) and used for browsing by the testers.

This processing was completed overnight and by the next morning, the database had been automatically updated with the data from the previous day's sessions. This database was accessible by the Dysvideo Client Browser. The Client Browser is a dedicated video and data viewing interface that facilitates the management of the data by the testers. It is the chief analysis tool for observational psychology in this project. The key factors that make this system invaluable to the execution of this project were:

1. The video was parsed *automatically* each night and this allowed the clips to be available for browsing the next day.
2. Scoring was possible the next day because the database was automatically updated with new child information.

The underlying ideas behind this new technology are described next.

8.2 Automatic video parsing: audio tagging

The idea behind automated video indexing is to locate the events of interest without the researcher's intervention. The Dysvideo team initially considered visual means for performing this indexing. Ideally, if it were possible to identify the orientation of children reliably in one camera view, then this alone would indicate when a useful episode starts and stops. This is because every test involves a unique orientation of the human body. However, it is well known that this is a difficult problem and from the user point of view no errors can be tolerated. This is because errors in the parsing require manual correction which takes up to 30 mins per error. A simple visual key would be to use coloured cards held in the camera view to index the start and end of each test. Unfortunately the colours available were not stable under fluorescent lighting and holding up cards at the start and end of each test was cumbersome.

The solution developed was to use phone tones: audio markers recorded simultaneously with the video. Six consecutive tones indicated an individual child's ID. The start of each test was indicated by two digits between (01-14) and the symbol # indicated the end of a test. If there was an error the symbol * was pressed to indicate a mistake in the input of digits immediately preceding it, which the computer program could then ignore.

The accuracy of parsing with audio markers depends on the reliability of automated identification from the audio stream off the tape. The background noise in the room was occasionally too loud for over-air recording of the tones, hence the tones were recorded directly into the stereo input of the camera on a separate channel. The reliability of the audio tone extraction was then measured as 100%. This is exactly what was desired.

8.3 The Browser

The Browser allows the user to select for viewing a particular exercise from an individual child's three sessions for viewing. It not only allows quick and efficient viewing from the start of the relevant test, but allows browsing through surplus data if something has been missed, and editing of the test time, and data entry on the screen of the PC. It uses MPEG4 compressed video sequences (1Mbit/sec) and a database (the indexing or key file), which contains time codes to allow random access to particular sessions. Figure 8.4 shows the main browser panel which allows the user to view up to three different tests simultaneously if needed; a window is split horizontally or vertically, when a test is

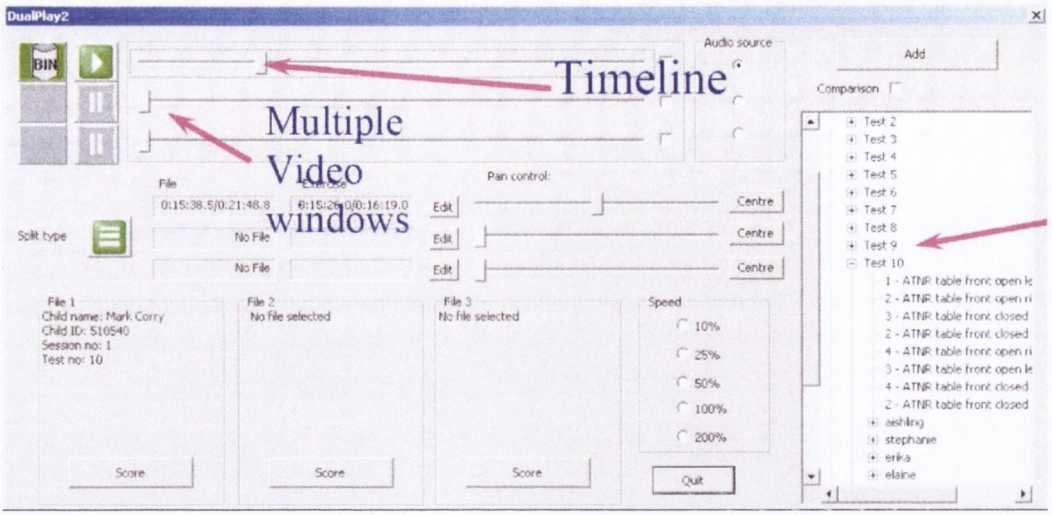


Figure 8.4: *Main Browser Panel showing timeline buttons for 3 windows and on the right the index of scores*

selected. Three sliding buttons are used to navigate along the timeline of the sequence, allowing the user to repeatedly view the important sections of the session and the action to be stopped at any stage.

Sometimes the audioparsing may not have been totally correct. It could happen that the researcher pressed the start or end tone too late and valuable data were recorded outside the indexed section of the sequence. On other occasions the child may have been asked to restart a test as they were not concentrating. The length of the test sequences had to be altered and so a test edit panel was designed as in Figure 8.5 to allow the start and end time of each test to be adjusted if needed.

When a test is viewed, a score button is pressed which drops down a box into which scores are inputted. These scores are saved directly into a web database. On the right hand side of the window, a tree displays information on all the tests undertaken by a particular child in addition to the current tester's scores. Other tester scores can be displayed depending on access rights. The browser also allows the average balance and reflex scores to be computed. Phonological, ocular, and motor tests were not filmed as they were not the main tests being analysed, however these data were inputted onto the front page of the browser, along with the session details, for later use. Figure 8.6 shows this panel on the right hand side of the picture; and the drop down score box into which scores are entered for each individual test on the left. When all the data from the study were complete they

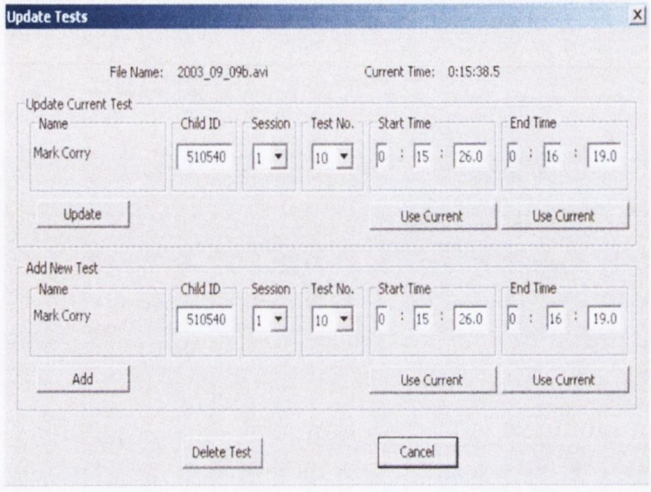


Figure 8.5: *Panel that allows parsing to be corrected*

were transferred automatically into SPSS for analysis.

8.4 Visual Content Analysis

The problem with the subjective scoring of these tests is that scoring may not be reliable. By using motion analysis through image processing it may be possible to measure the motions of the child objectively and then use that information to compare with the tester's scores. However, to do this it was found that a more precise mechanism for delineating *exactly* when the test begins, was important. This was because the audio markers were accurate to within about ± 5 secs and so there may have been information between the start of a marker and the actual start of the useful video that could impair the automated measurement of movement.

Efforts were concentrated on the ATNR (Schilder) and ATNR (Ayres) Tests. It is not the intention here to describe the details of the new image processing techniques developed in this study, but rather to assess the impact of this technology on these kinds of studies. However, an understanding of the underlying image processing concepts will help the reader to appreciate the potential of this kind of work. The implications of the motion measurements described here are discussed later in the Discussion Chapter.

The first step was to identify the limbs of the child in the field of view. The limbs are

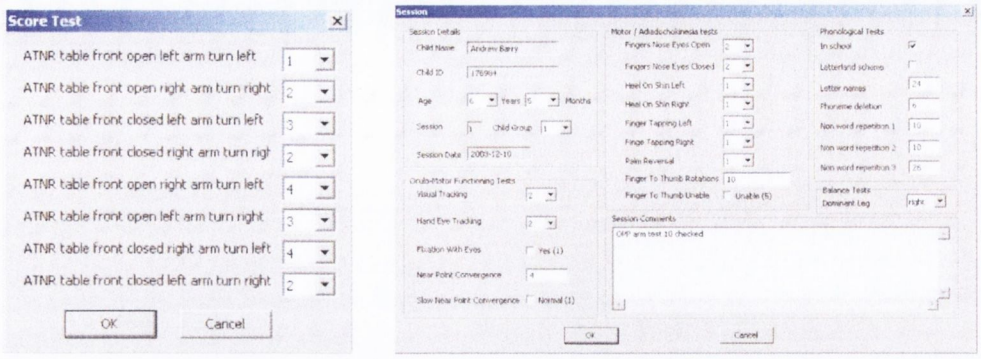


Figure 8.6: *Left: Individual Test Scoring Panel; Right: Browser's front page for test data that were not recorded on video.*

known to occupy a particular range of colour, therefore by identifying pixels having the same colour as skin, it is possible to identify the limbs. Figure 8.7 shows the application of this idea on a frame, (see (Joyeux et al., 2004) and (Kokaram, Doyle, Lennon, Joyeux, & Fuller, 2006), for further information about the technology).

In both tests the skin regions were then processed to identify the end of the hand or the elbows accordingly. This was quite an involved operation since errors in skin measurements need to be smoothed out over a number of frames. The details of the algorithms used are discussed in (Kokaram et al., 2006), and (Pitié, Berrani, Dahyot, & Kokaram, 2005).

The last step involved modelling the identified limb in such a way that the motion measurement could be made. In the Ayres test, the orientation of the lower arm with the horizontal is an indicator of the bend in the elbow, which is the key feature being observed. By modelling the midpoints of the arm with a straight line, the angle of that line with the horizontal can be measured and used as an index of elbow-bend. See Figure 8.7 for an example. The idea is that this measurement might be correlated well with the observer's ratings.

In the Schilder test, the tips of the fingers are tracked through several frames and the subsequent motion trajectory assessed for movement to the side to which the head is turned and for vertical drop. This is another feature that the Dysvideo team is currently evaluating. The automated tracking alone in this test was found to be very difficult because the tips of the fingers are quite small in the field of view. Figure 8.8 gives some



Figure 8.7: *This figure shows one frame of a child performing the ATNR (Ayres) test. The limbs are automatically detected using colour analysis. In effect, all pixels having the typical colour of skin are detected as belonging to limbs. Other objects (sometimes hair) can be confused with the skin because of the colour. This problem was resolved by locating the arms as rectangular areas of skin, so improving the detection. The area automatically selected for processing is shown by the black lines. The orientation of the arms can then be measured and this is represented here by green lines superimposed in the middle of each arm. The angle the lines make with the horizontal are an indication of arm bend. In this frame the right arm of the child shows a definite bend as can be seen by the angle of the green line angle which is larger than that from the other arm.*

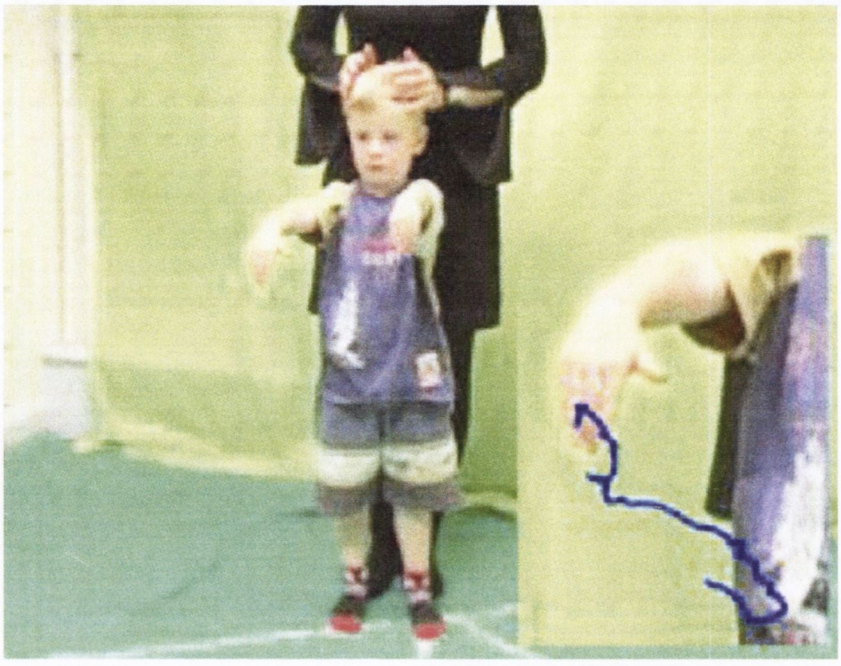


Figure 8.8: *In this test the idea is to track the fingers of the child and assess deviation of movement from the centre and the horizontal. The method developed for automated tracking is hampered by the lack of image resolution sufficient enough to resolve the fingertips. The inset on the right of the image shows in blue the estimated track for this movement.*

idea of a typical performance of the process. However the results here show that there is still much work to be done in automated tracking for this application (see (Joyeux et al., 2004) for further details about the video tracking technology).

Regardless of whether the machine measurement correlates well with observer scoring or not, it was found that the machine measurement could be used to detect more precisely the start and end of each test. In the Ayres test, it is possible to measure the head rotation quite well from the image and this is a very good indicator of start and end of testing. This is shown in the Figure 8.9 (see (Kokaram et al., 2006) for a detailed result).

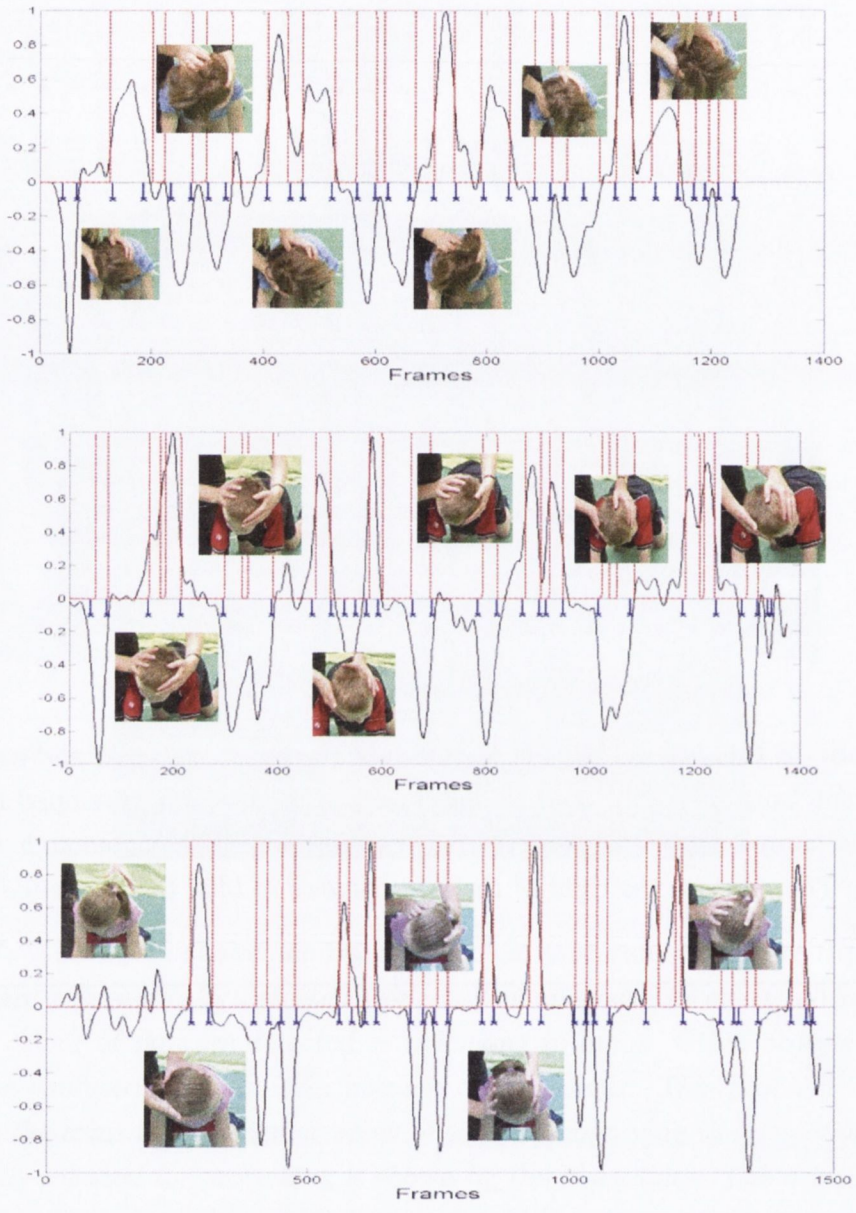


Figure 8.9: *Estimated rotation versus time in frames. The solid line (black) shows a graph of head rotation from frame to frame. Several observers were asked to manually index the start and end of each rotation thus giving a marker for comparison with automated estimation. The dashed line (red) shows this manually created marker indicating when rotation occurs. The short solid line (blue stem) shows the automated estimated start of rotation. The regions detected as containing rotation agree with the markers very well. The pictures show typical content at these times. The pictures above the line indicate the head turning to the child's right and below the line to the left. On average fewer than 5% of frames are missed, and there are fewer than .01% falsely detected frames.*

8.5 Final Comments

The work discussed here presents a new tool for psychologists to exploit content retrieval technology not only in relation to motor control in dyslexic children but in any observational setting. The system allows video on demand as well as automated indexing, data entry into a web database that is compatible with a statistical analysis package and video analysis. By exploiting user context, the system is able to deploy 100% reliable indexing which allows efficient use of research time when dealing with this amount of observational data. In using interactive audio cues, which is a novel idea, this level of reliability is achieved.

Current work focuses on quantitative evaluation of motion characteristics in dyslexic children. Video sequences showing indexing and parsing output as well as the browser interface may be found by scrolling down the page at www.sigmedia.tv/research/indexing/dysvideo.

9

Results

Initially 190 children were recruited from families with a member (either a parent or sibling) who either had a positive diagnosis of, or was suspected of having dyslexia. One hundred and seventy-eight of these children commenced the study. Forty-two children withdrew from the study for various reasons including illness or death in the family, separation of parents, arrival of a new baby etc. Three sibling pairs withdrew (1 in Group 1 and 2 in Group 3) and this was mainly due to the difficulty of delivering a programme to two children in a busy household where there were other family difficulties. One hundred and thirty six children completed all three assessment sessions. Of these, 115 were boys and 21 were girls aged between 3-7 years. Table 9.1 summarises this information (n=136):

No. of Children who Started Study	178	100%
No. who Withdrew	42	24%
Total no. who completed the study	136	76%
No. of Males who completed study	115	85%
No. of Females who completed study	21	15%

Table 9.1: *Participant Breakdown*

9.1 Participants

The 178 children recruited at Time 1 were randomly assigned into four different treatment groups. Fifty-eight in the reflex programme, 49 in the balance programme, 33 in the placebo-control programme and 38 in the no-treatment control group. Forty-two children withdrew within the first few months and 10 failed to start a programme (i.e. Groups 1-3). The parents of these children agreed to continue bringing their children for assessments and so they were reassigned immediately to the no-treatment control group, Group 4. As the study progressed a further 9 children who had been assigned a programme either could not or would not continue with it and were reassigned to the control group. Reasons included family bereavement and illness of either the child or parent. Table 9.2 illustrates the final group assignment.

		Group 1	**Group 2**	**Group 3**	**Group 4**
	Total	**Reflex**	**Balance**	**Placebo**	**Control**
Original assignment	178	58	49	33	38
42 withdrawn	136	-12	-3	-10	-17
Starting assignment	136	46	46	23	21
10 reassigned to Grp.4	136	45	41	19	31
9 reassigned to Grp.4	136	41	36	19	40

Table 9.2: *Final Group Assignment of Sample*

The final sample comprised 41 children in the reflex group, 36 children in the balance group, 19 in the placebo group and 40 in the control group. [1]

9.1.1 Testing the Programmes for Drop Out Rate

Nineteen children were reassigned to the control group before the study commenced. There was little difference in the drop out rate from the three treatment groups. Overall 12% of Group 1, 28% of Group 2 and 21% of Group 3 dropped out of their programmes.

[1] For consistency the 4 groups will be referred to by their programme names or group numbers as follows:

Group 1: Reflex replication programme will be referred to as the 'reflex group'.

Group 2: Balance programme will be referred to as the 'balance group'.

Group 3: Placebo control programme will be referred to as the 'placebo group'.

Group 4: No-treatment control group will be referred to as the 'control group'.

Ten children dropped out for family reasons and nine children, 4 (11%) from Group 1 and 5 (19%) from Group 2 did not engage with the programmes.

9.1.2 Age of Participants

The mean age of the sample as a whole (n=136) at the start of the study was 5 years and 5 months with a standard deviation of 12.2 months. There was a range of 4 years between the youngest at 3 years, 3 months to the oldest at 7 years, 3 months. Table 9.3 summarises mean age of participants in each of the experimental conditions (n=136):

Age	Group 1	Group 2	Group 3	Group 4
	Reflex	Balance	Placebo	Control
Mean age in years	5,7	5,2	5,8	5,4
S.D. months	12	13	11	12
N = 136	41	36	19	40

Table 9.3: *Age of Children at Time 1*

9.2 Proportion of Dyslexics and Co-morbidity with ADHD

The numbers of the final sample (n=136) expected to be at risk of dyslexia when tested at the end of the study, was expected to be approximately 50% (see section 1.6). All 136 children were screened for dyslexia at Time 3 using either the Dyslexia Early Screening Test (DEST) for children between 4.5 and 6.5 years, or the Dyslexia Screening Test (DST) for children over 6.5 years. Fifty-four children were found to be at risk using the milder band (At Risk Quotient > = 0.6 on DEST/ 1 on DST) and 41 children were found to be at risk using the higher band (At Risk Quotient > = 0.9 on DEST/ 1 on DST). These children represent 40% and 30% of the full sample respectively. This is similar to the familial risk rate for dyslexia of 35-45% reported from the Colorado Family Reading Study (Gilger, Pennington, & DeFries, 1991; Pennington, 1990). Table 9.4 shows the number of children by group found to be at risk of dyslexia at T3 according to DEST/DST Screening Tests.

Eleven children were previously diagnosed with dyslexia of which only 6 were picked up on the DEST/DST screening tests. One hundred and five children had a father, mother

Dyslexia Risk	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group**
	Reflex	**Balance**	**Placebo**	**Control**	**Total**
DEST	6	6	1	10	23
DST	7	12	6	6	31
Total	13	18	7	16	54
% of group	32%	50%	37%	40%	40%

Table 9.4: *No. of children at risk of dyslexia at the end of the study by group using milder risk of Dyslexia (i.e. risk > = 0.6 on DEST) n = 136*

or sibling diagnosed with dyslexia of which 54 scored highly on the DEST/DST at the milder level.

It is important to report the proportion of children in the full sample who presented with other conditions. Thirty-one children out of the full sample n=136 scored at risk for ADHD, of which 1 child already had a diagnosis of ADHD and 1 had a diagnosis of ADD. See Table 9.5 below. It has been suggested that up to half of those diagnosed with dyslexia or ADHD may present symptoms of the other condition. The current study found that of those classed at risk for dyslexia at the milder criterion (n=54), 35% of children were also at risk of ADHD. At the higher risk criterion, 41 children were at risk of dyslexia, of whom 39% also had ADHD. Of those scoring at risk for ADHD (n=31), 52% also scored at risk for dyslexia. This rose to 62% when the milder criterion of risk was used. These findings reflect those of other studies regarding the co-morbidity of dyslexia and ADHD (Willcutt et al., 2007; Stevenson et al., 2005; Stein, 2004).

Table 9.5 presents ADHD Index scores at T3.

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Total**
	Reflex	**Balance**	**Placebo**	**No Prog**	
ADHD Index Scores	7	7	6	11	31
Already Diagnosed	1*	2	-	-	3
Total	7	9	6	11	33
% of group	17%	25%	32%	28%	24%

Table 9.5: *No. of children with high ADHD Index scores and a full ADHD diagnosis at T3 by group (n=136). *Child having both high ADHD Index score and previous diagnosis.*

The child in Group 1 had a full ADD diagnosis which was picked up by the Conners'

Parent Rating Scale-Revised (CPRS-R). The two children in Group 2 with a diagnosis, scored just outside the risk threshold on the CPRS-R. Chi-square analysis found a significant association between 'high risk for dyslexia' and 'risk of ADHD' as per the CPRS-R ($\chi^2(1) = 8.786, p = 0.004$). There was also a significant association at the milder criterion ($\chi^2(1) = 7.814, p = 0.007$). No association was found between 'high/low compliance' and 'risk of ADHD'.

9.2.1 Co-Morbidity with Speech and Language Problems

Parents of 45 children (33%) reported that their children had hearing and speech difficulties at the start of the study. Thirty children went on to receive speech and language therapy of between 6 weeks and 1 year. Twenty-three of the 45 children also scored highly on the DEST/DST.

9.2.2 Age issues

Eleven of the children were under 4 years of age when starting the study. Their ages ranged between 40 months and 47 months. Although they could perform the tasks, they often found understanding what was being asked of them difficult. Levels of concentration required to undertake the tasks were high. Special care was taken to make sure the children understood the instructions for each task. After these initial assessments it was decided that subsequent new recruits would not be called until they were at least 3.5 years old.

9.2.3 Participation in Sport

Of the 136 children in the study, 122 played sport regularly, usually once a week. Some children played up to 4 sports though these were in the minority. Fourteen children did not play any sport. At the beginning of the study it was thought that children taking extra exercise might present a confound with the remediation programmes if only a proportion were doing so. However as the vast majority were taking part regularly this was not an issue.

9.2.4 Remedial and Other Activities

Fifty children received resource or remedial help of between 6 weeks and 1 year during their participation in the study. As a group 20 or 40% were identified as having a risk of dyslexia (9 of these already had a full diagnosis of dyslexia). Forty-eight (35%) children participated in extra-curricular activities such as drama, art or music.

Three children were already following a primary movement programme in school and two children were already attending reflex remediation therapy privately. These children were automatically assigned to Group 1 and asked to follow that programme correctly. A sixth child attended Brain Gym once a week for one month during their intervention year. As this did not reach the minimum programme days criterion it was not deemed necessary to reassign that child to Group 1. She was randomly assigned to another group.

The table below gives a breakdown of remedial, speech and other therapies that some of the children received during their treatment year.

Activity	Grp 1	Grp 2	Grp 3	Grp 4	Total
Primary Movement/NDT	5	-	-	-	5
Remedial at school	15	14	6	15	50
Speech therapy	5	12	5	8	30
Physiotherapy	1	-	-	1	2
Brain Gym	-	-	-	1	1
Neuro-Linguistic Programming	1	-	-	-	1
Sound Therapy	2	-	-	-	2

Table 9.6: *No. of children doing other treatments*

9.3 Compliance with the Programmes and participation in other activities

Since one of the main aims of this study is to establish the effect of motor programmes on dyslexia risk, it is important that those participants in intervention groups have indeed undertaken the relevant treatment. This means in effect determining a minimum number of days below which a participant is considered not to have completed the treatment. Initially, 96 children were assigned to the programme groups and 40 to the non-programme

or control group, see Table 9.2. At the end of the study compliance with the programmes (for Groups 1-3) was investigated for quality and the number of days completed. This was done through a retrospective questionnaire (see Appendix C completed by the parent on the last assessment day.

Table 9.7 shows the average days of exercises completed by children in each Programme Group.

	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Mean	239	252	258	7	79	154
S.D.	75	58	59	14	19	121
Min.	120	163	156	0	52	0
Max	364	336	350	50	104	364
Range	244	178	194	50	52	364
n	36	26	16	40	18	136

Table 9.7: *Programme Completion: Group 5 represents the data for those who did not meet the minimum no. of days criterion*

As in the McPhillips et al. (2000) study, the DEYP children were requested to perform their exercise programme daily for a period of 12 months. It was expected that daily compliance would not reach 300+ days, as normal life would involve breaks in the treatments for holidays, illness, tiredness, moving house or bereavements. Thus as completion rates ranged from 0 to 364 days it was decided that a minimum of 120 days of programme completion was necessary if any of the programmes were to have an effect. This was calculated by summing the amount of days allocated to ATNR and Moro movements used in the classroom-based Primary Movement Early Years Programme which is carried out during the school year (e.g. 5 days a week). The first term (12 weeks) includes song and dance exercises and as these may have proved a confound with the balance programme they were not used. However the latter two terms consist of reflex replication 5 days a week (24 weeks x 5 days = 120 days). In effect the programme was offered for 48 weeks (240 days) as these exercises were being done with younger children than those in the McPhillips et al. (2000) study and they were being attempted at home rather than with a group in school. For consistency, the balance and placebo programmes also had a minimum 120 days as their compliance criteria.

Of the 96 children undertaking a programme, 78 or 74.28% actually completed 120 or more days and it was expected that this would show an effect. The remaining 40 made

up the control group and so the final sample size was n = 118. Table 9.8 summarises the final assignment of participants to each of the experimental conditions using the 120 days completion criteria (n=118). Of the 36 in the reflex group, 5 participated in school based and private versions of reflex remediation therapy.

Final Assignment	**Group 1**	**Group 2**	**Group 3**	**Group 4**
	Reflex Prog	**Balance Prog**	**Placebo Prog**	**No Prog**
Total	36 (30%)	26(22%)	16 (14%)	40 (34%)

Table 9.8: *Final group reassignment after criteria of 120 days completion applied (n=118)*

The non-compliant group (n=18) were not included in the control group for further analysis as the group had an average of 79 programme days with a maximum of 104 and a minimum of 52 days. It was felt that as it was unknown what effect the programmes may have, this group may confound the control group.

9.3.1 Compliance and Dyslexia Risk

Following Pearson chi-square analysis, no association was found between 'high/low compliance' and 'high risk of dyslexia' across the entire sample (N=136) ($\chi^2(1) = 4.295$, p = 0.058). To better understand this association the analysis was repeated on each treatment group separately. The results for all the groups are as follows:

Group	**Compliance × Risk of Dyslexia**
Group 1	$\chi^2(1) = 0.060$, p = 1.000
Group 2	$\chi^2(1) = 5.713$, p = 0.024
Group 3	$\chi^2(1) = 0.891$, p = 1.000
Group 4	no non compliance, 9 at risk of dyslexia

Table 9.9: *Association of Compliance and high Dyslexia Risk by group N=136*

The table shows that there was a significant association between compliance and high risk of dyslexia in Group 2. Ninety-three percent of children (n=15) with a high risk of dyslexia completed a minimum of 120 days of programme 2 whereas 62% of children with a low risk completed a minimum of 120 days. There was no significant association at the milder risk criterion for this group. There was no significant association in the other groups.

Note that although the result for Group 3 is reported, the number of children in this group (n=16) is below that necessary for power of 80%. See section 9.5.

9.4 Quality

Additional questions were asked of the parents in the retrospective questionnaire relating to movement control exercised by the child during the exercises and other activities their child engaged in over the year.

Chi-square analysis was performed on the '120 days' compliant sample (n=118) to examine whether other activities had an influence on the time and quality of programme performance. The following were investigated:

- estimated average length of time spent undertaking the programme per day by the three treatment groups
- estimated general quality of programme performance (e.g. whether rushed or controlled) by the three treatment groups
- participation in academic (e.g. resource or remedial help in school, or private tuition) by the four groups
- participation in sports by the four groups
- participation in other specialist help (e.g. speech and language therapy, physiotherapy) by the four groups
- participation in extra-curricular activities (e.g. drama, art, music, hobbies) by the four groups

There was a significant relationship between group membership and length of time spent undertaking the programme each day. Eighty-one per cent of the placebo group spent between 6 and 10 minutes on their programme compared to 70% of Group 2 and 40% of Group 1. Chi-squared analysis showed no significant group differences on the remainder of these variables. Thus, it is unlikely that any differences found in later analyses might be due to the confounding effects of specialist or remedial help or inadvertent motor-improving activities in sport or extra-curricular activities. The results of the analyses are

presented in Table 9.10 and the percentage breakdown for each are presented in Table P.1 in Appendix P.

Variable	Value	Significance
Time in Minutes	$\chi^2(6) = 12.909$	$p = 0.041$*
Quality	$\chi^2(6) = 1.836$	$p = 0.943$
Sport	$\chi^2(3) = 1.057$	$p = 0.803$
Remedial	$\chi^2(3) = 2.106$	$p < 0.551$
Speech	$\chi^2(3) = 3.917$	$p = 0.280$
Extra-Curr	$\chi^2(3) = 6.534$	$p < 0.088$

Table 9.10: *Possible Factors affecting Programme Performance N=118 (* = significant)*

Note that exact significance is reported when the contingency table has any cell less than 5.

Chi-Square and Pearson correlations were also performed to see if there were any differences between the proportions of dyslexics v non-dyslexics, and ADHD children v non-ADHD children in terms of the number of minutes spent doing their programme each night and quality of the control they they exerted over the exercises. There were no differences between dyslexics and non-dyslexics in terms of time or quality. However, there were differences between those at risk of ADHD and those not a risk, on both of these measures. Proportionately more of those at risk of ADHD performed the shortest duration of programme (Table A.9) and had rushed movement quality (Table A.12).

The results of the chi-square analyses are presented in Table 9.11 and the percentage breakdown for each is presented in Appendix P.

Variable	Value	Significance
Time in Minutes/ dyslexia high risk	$\chi^2(3) = 0.676$	$p = 0.91$
Time in Minutes/ dyslexia mild risk	$\chi^2(3) = 0.207$	$p = 1.000$
Time in Minutes/ ADHD risk	$\chi^2(3) = 12.29$	$p < 0.01$*
Quality/ dyslexia high risk	$\chi^2(3) = 0.231$	$p = 0.96$
Quality/ dyslexia mild risk	$\chi^2(3) = 0.563$	$p = 0.91$
Quality/ADHD risk	$\chi^2(3) = 6.97$	$p < 0.10$

Table 9.11: *Possible Factors affecting Programme Performance N=136 (* = significant)*

Note that exact significance is reported when the contingency table has any cell less than 5.

The retrospective questionnaire also asked parents about the child's attendance at school, and the possibility of co-morbid disorders such as ADHD, Asperger's Syndrome and dyspraxia. Apart from ADHD these data were not analysed as a review of the material showed little variability. No child missed more than a few days at school and there were very few diagnoses of other co-morbid conditions.

9.5 Power

Previous research in this area has assumed a strong effect size (McPhillips et al., 2000). A strong effect size was also adopted by the DEYP. With 80% power 18 children per group are required in order to detect a significant difference between groups when evaluating treatment efficacy (Cohen, 1992). Both the reflex and balance groups met this requirement (n= 35 and n = 26). The placebo group contained 16 children which was just under the criterion.

For chi-square analysis with 2 degrees of freedom, for 80% power it was necessary that group numbered 39 or more. This became an issue with smaller group sizes. Results are still reported for those groups but a note to this effect is made alongside in the appropriate section.

The same assumptions were made when Pearson correlations were used. Twenty-eight children per group were required to detect a significant correlation between variables. The total number of children used in the predictive tests was 78.

9.6 Inter-Rater Reliability

As with all observation studies, there can be a large degree of subjective interpretation when measuring human behaviour. There is also the possibility of missing one type of behaviour (leg movement for example) while looking for another specific behaviour (such as movement in the arms). Assessment sessions were recorded on video to allow for repeat observation, checking of scores and noting any other relevant behaviours.

Scoring was done on pen and paper by the researcher on the day. The following day the video data were parsed and made available for viewing. The researcher checked the scores while viewing the assessments a second time. In order to check inter-rater reliability early on in the project, a second scorer was used. After training and administration of the test sample this scorer was instructed to randomly select a sample of 25 children. All three of the children's sessions were scored blind to group membership and the original researchers' scores.

It must be noted that analysis of the data was carried out on the original, not the revised scores, as these were the scores obtained by the researchers on the day of testing and judged to be the most accurate. Scatterplots of the relationship between the original and second scorer were examined for comparisons between reflex scores at time 1, 2 and 3 and balance scores at time 1, 2 and 3. None of the scatterplots showed any evidence of curvilinear relationship or the undue influence of outliers and so Pearson correlations were calculated for each relationship. There was a statistically significant positive correlation in the case of all pairs of measures ($p<.01$). Those children who scored poorly on tests of balance and reflex retention according to one scorer, also scored poorly according to the second scorer. The correlations for each comparison are as follows:

- Reflex tests (time 1) $r = .993$, $n=25$, $p < .01$, two-tailed test.
- Reflex tests (time 2) $r = .889$, $n=25$, $p < .01$, two-tailed test.
- Reflex tests (time 3) $r = .728$, $n=25$, $p < .01$, two-tailed test.
- Balance tests (time 1) $r = .923$, $n=25$, $p < .01$, two-tailed test.
- Balance tests (time 2) $r = .890$, $n=25$, $p < .01$, two-tailed test.
- Balance tests (time 3) $r = .850$, $n=25$, $p < .01$, two-tailed test.

This represents a strong and acceptable level of inter-rater reliability, and, thus it may be assumed that the scoring method is reasonably reliable.

9.7 Aims of the Study

The main aims were to evaluate the efficacy of two motor interventions in remediating dyslexia as follows:

Aim 1: To investigate whether a movement programme designed to reduce the persistence of retained reflexes reduces the risk of dyslexia as measured by the Dyslexia Screening Test/Dyslexia Early Screening Test (DST/DEST) and phonological measures of pre-reading skill.

Aim 2: To investigate whether a movement programme designed to stimulate the vestibular system and improve balance skills reduces the risk of dyslexia as measured by the DST/DEST and phonological measures of pre-reading skill.

In the event of no treatment effects, it was also proposed to test the efficacy of a motor test battery in predicting dyslexia in young children as follows:

1. Whether the balance test battery as a whole was a predictor of risk of dyslexia as per the DEST/DST.
2. Whether the reflex battery as a whole was a predictor of risk of dyslexia as per the DEST/DST.
3. Whether the oculo-motor functioning tests were a predictor of dyslexia as per the DEST/DST.
4. Whether the motor/adiadochokinesia tests were a predictor of dyslexia as per the DEST/DST.
5. Whether the phonological tests were a predictor of dyslexia as per the DEST/DST.

Finally a model of how motor and reflex remediation programmes may affect reading development will be discussed in the light of the results in the next chapter.

9.8 Design of the Study

The following section reports the findings of analysis on the treatment efficacy of the reflex (Group 1) and balance (Group 2) programmes. There were 7 dependent variables in total, see Figure 9.1. The major dependent variable was the 'Dyslexia Risk' score as measured by the DEST/DST at Time 3. There were 5 minor dependent variables which consisted of: retained reflexes, balance skills, visuo-motor functioning, fine motor skills and phonological skills. Scores were available for each of these dependent variables at

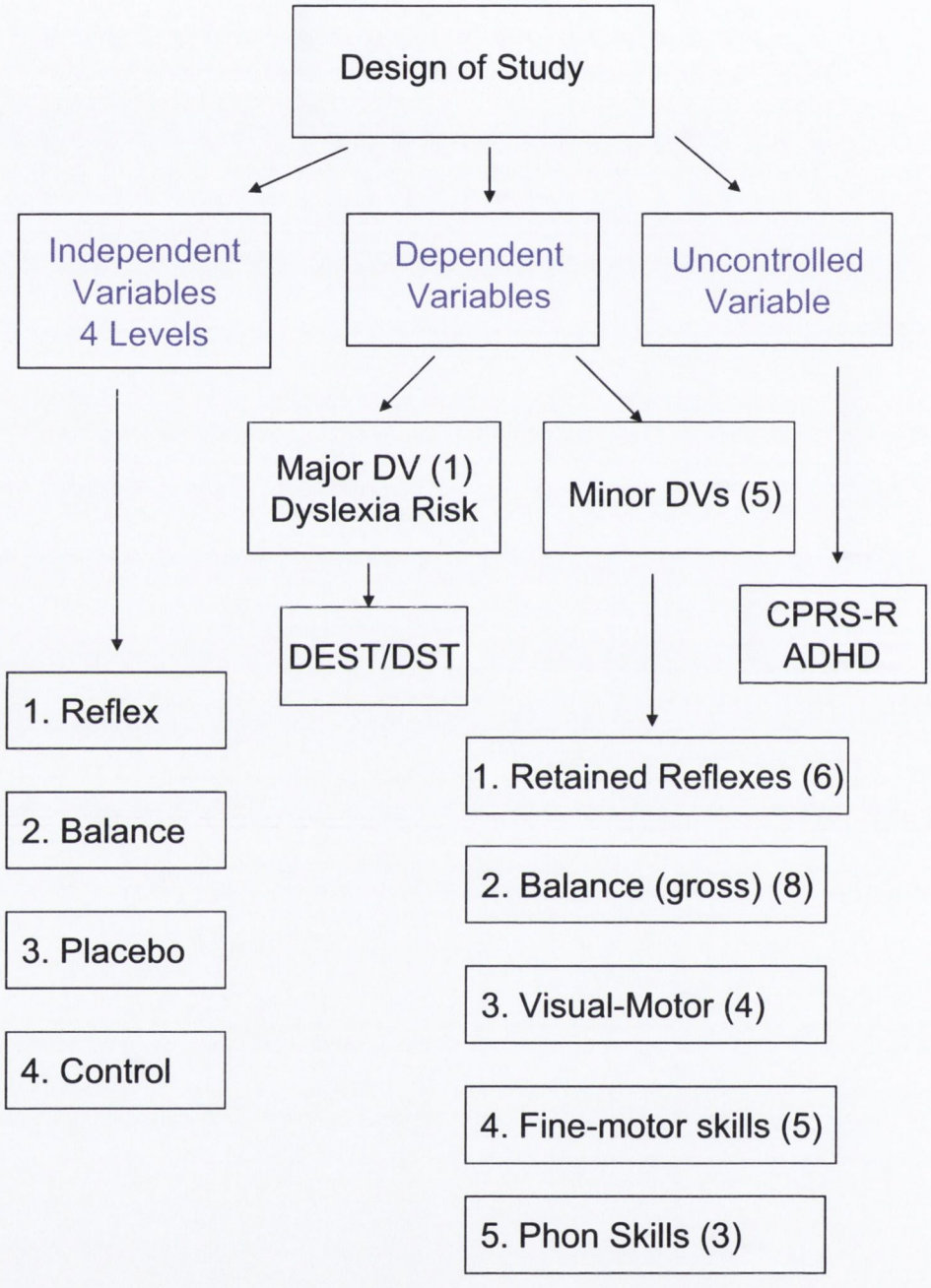


Figure 9.1: *Design of the Dyslexia Early Years Project (DEYP).*

the 3 time intervals. The uncontrolled variable from the 'Conners' Parent Rating Scale-Revised (CPRS-R)' was a measure of ADHD risk and this data was recorded at time 3.

In exploring the relationship between treatment group and outcome variable, data were analysed by means of chi-square and analysis of variance. As stated previously, the cut-off point of high 'dyslexia risk' was 0.9 on the DEST, with 0.6-0.9 representing milder risk. The cut-off on the DST was always 1.00.[2]

Group	Reflex		Balance		Placebo		Control		Total
Gender	F	M	F	M	F	M	F	M	
Age (years)									
3	0	1	0	5	0	0	(1)	(1)	6 (8)
4	3	6	0	5	0	5	(1)	(13)	19 (33)
5	2	9	1	5	0	4	(2)	(9)	21 (32)
6	4	7	0	10	2	5	(1)	(10)	28 (39)
7	0	4	0	0	0	0	(0)	(2)	4 (6)
Total	9	27	1	25	2	14	(5)	(35)	78 (118)
Mean age	5,7		5,5		5,8		5,5		5,6
S.D. Months	12		13		11		12		12

Table 9.12: *Number of children, by group, age and gender when criterion of minimum 120 days programme compliance applied*

9.9 A Description of the 120 days compliant Sample S_{118}

The full sample initially comprised 136 children (115 boys and 21 girls). However it was felt that analysis should be done on only those children who had complied with the '120 minimum days' criterion and the control group. This '120 days' minimum sample comprised 118 children, 78 of whom completed a programme, and 40 who received no programme. Seventeen were girls and 101 were boys. Table 9.12 describes the age and gender of the '120' days compliant sample. This sample will be referred to as sample S_{118}.

[2]The 2nd edition of the Dyslexia Screening Test (DST-2) also defines 0.6 as a cut-off for 'mild risk', however this was not specified in the first edition which was used in the current study.

Forty children received remedial help at school and parents of 30 children (25.4%) reported that their children had problems with speech and language at the start of the study. Fourteen of these children also scored at risk for dyslexia on the DEST/DST when the milder criterion was used. Twelve scored highly on balance and reflex scores at Time 3. Twenty-nine children were at risk of ADHD and 105 children had an immediate family member with a diagnosis of dyslexia.

9.10 Other Samples

In order to remove the confounding variables of ADHD and non-compliance, four additional sample sets were created for analysis as follows:

Sample Set	Description
S_{113}	S_{118} minus 5 school/private
S_{89}	S_{118} minus ADHD Risk
S_{29}	ADHD Risk group
S_{18}	Non '120 days' compliant group

Table 9.13: *Samples used in the analysis*

Summary information on age, gender, mean scores and repeated measures ANOVA are reported for each sample in Appendix P. For Sample S_{113} chi-square analysis was performed on the four programme groups to investigate the association between initial 'at risk' indicators and risk of dyslexia. The number of subjects in Group 3 were not sufficient for 80% power. It was not possible to perform chi-square analysis on Group 3 in Sample S_{89}, and Group 2 in Sample S_{29} as there were not enough cases. This information is reported in Appendix P. For Sample S_{18} all the group numbers were too small for chi-square analysis of initial indicators and high risk of dyslexia.

9.11 General Trends Sample S_{118}

Box plots were used to visualise the data gathered and to assess the likelihood of any trends as well as to give the reader a good appreciation for the spread of performance by group and time. Box plots show the important aspects of a distribution. The *boxed* area shows the location of the centre 50% of the distribution from the lower to the upper

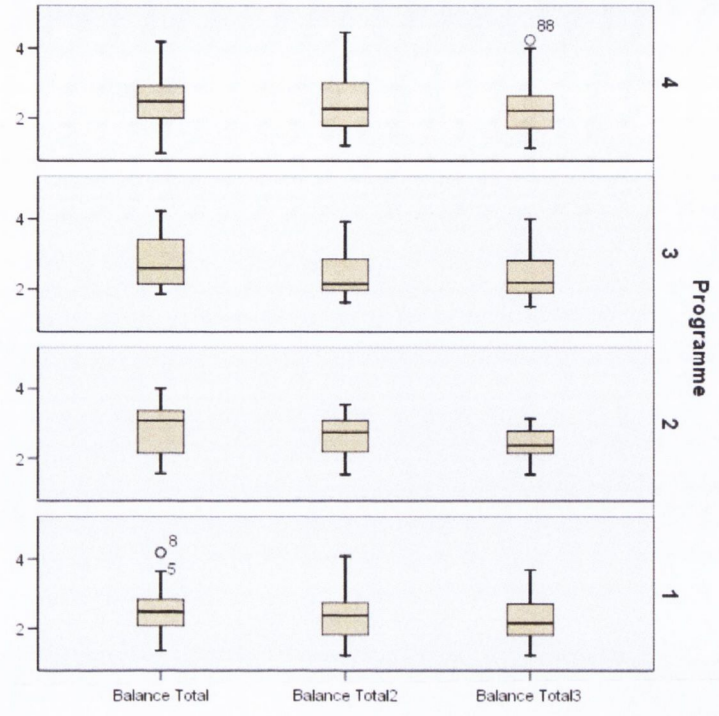


Figure 9.2: *Summary of Balance Totals over each session (columns) and for each of the four programme groups (rows). Note: Lower score = better performance*

quartile while the median is shown as a line at the relevant position within that box. Data which are within ±1.5 interquartile distance from the median are considered to be inliers and this limit is shown as the extent of the vertical line in the plot. Any data that lie outside these limits are considered outliers and are shown as individual points on the plot.

Because of the large number of variables measured in this experiment (79×3) it is not possible to present a visualisation of each variable. Instead, the scores from the Balance set of measures were averaged to create a single measurement *Balance TotalX* for X=1,2,3 each of the 3 sessions in time. Similarly the Reflex test battery was summarised in a single variable. Note that the scores were between 1 and 5 with 1 being perfect execution of the task and 5 being complete failure.

Figure 9.2 shows the summary of Balance Totals over each session and for each group. From these data, Programme Groups 2 and 3 show the most visible change in performance while 1 and 4 show almost no change in performance. It is interesting that in general there

are no outliers, with just 2 cases in Programme 1 at the first visit, and one in Programme 4 at the last visit. Group 2 also shows an interesting change over time in that the spread of performance decreases with time. In general none of the other groups show as distinct a change in the spread of the distribution. It was decided not to remove the outliers as they represent children who are performing either poorly or well on balance or reflex tests. The two outliers in Group 1 who performed poorly at Time 1 performed better at Time 3 but still had high scores. Both children had a sibling with dyslexia diagnosed and played sport but did not receive remedial help during the year. Both had a score near the threshold for ADHD. One child had a high DEST score, while the other received speech therapy and also was an outlier on the reflex tests.

Figure 9.3 shows the summary of Reflex Totals over each session and for each group. From these data, none of the groups show a marked change in performance from the first to the last session. However, Groups 1,2,3 all show some kind of fluctuating behaviour at the 2nd session. All groups show either a stable spread of distribution or a decrease in spread. Groups 3 and 4 show particular decrease in spread implying that the participants in these groups are converging to some kind of *typical* behaviour. In contrast to the Balance scores, these scores show many more outliers, although by the last session the distributions all seem to be more stable and no outliers appear. It is interesting that in Group 4 there appears to be no change in the distribution nor any outliers. At this stage it could be argued that the performance being measured in Group 4 is not changing.

The two outlier children in Group 2 at Time 1 scored highly on the DEST/DST. One child had a full dyslexia diagnosis and scored highly on the ADHD screening test but did not receive any remedial help. The other child had no familial diagnosis and received remedial help in school. Both played sport.

At Time 2, two children (Group 2 and Group 3) were outliers at the lower end of the scale. Both had a sibling diagnosed with dyslexia and one child also had a diagnosis, this child also scored highly on the DST and ADHD test. Both played sport, partook in extra-curricular activities and received remedial help at school.

Three children were outliers at the higher end of the scale at Time 2 (1 in Group 1, the child who had been a balance outlier at Time 2, and 2 in Group 3). None had a diagnosis of dyslexia, one was dyspraxic, and one had a dyslexic brother. All played sport and received speech therapy. Two received remedial help and also scored highly on the DST. Of these one scored highly for ADHD. It is interesting to note that there were no outliers at Time 3 in any of the groups.

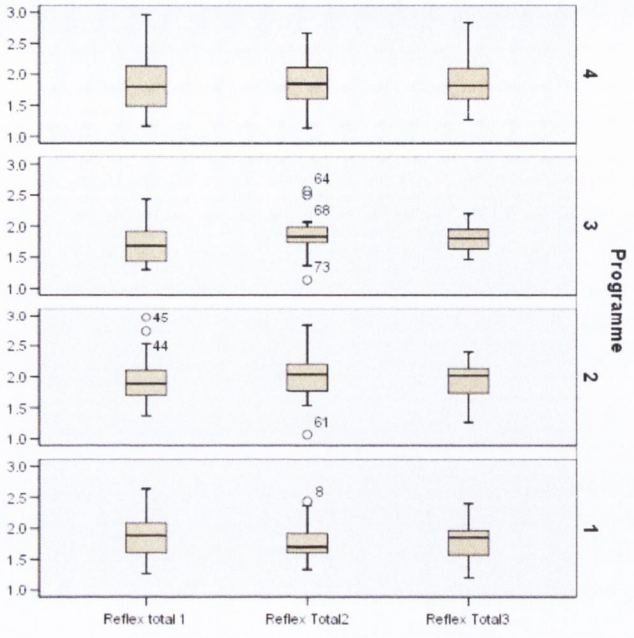


Figure 9.3: *Summary of Reflex Totals over each session (columns) and for each of the four programme groups (rows). Note Lower score = Lower level of retained reflexes.*

9.11.1 Visual Correlation with DEST

It is interesting at this stage to examine visually any correlation between the final scores for Reflex and Balance with the DEST scores attained by participants at the end of the study. This is best achieved by scatterplots of the final score for each participant against their DEST score. These are shown in Figures 9.4 and 9.5. Should there be any correlation then visually, the scattergram should show some clustering or trend behaviour. A scatterplot is not a definitive plot from which to gather this information, but it will give the reader a feel for any significant relationships and allows further analysis to be conducted in context. Unfortunately both scatterplots do not show any obvious trend. The information given by these plots is entirely visual and not sufficient for drawing any conclusions at this stage. In the next section further analysis is given to assess the significance of any changes that may have been observed.

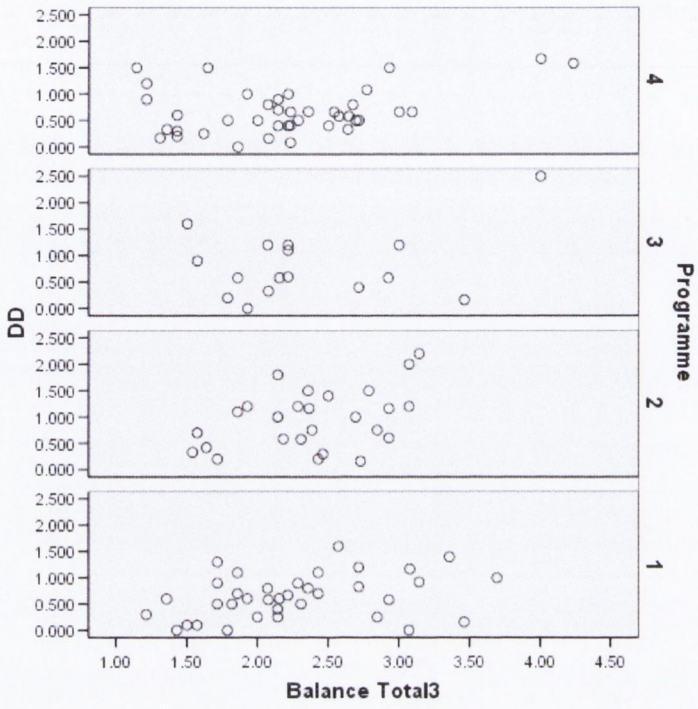


Figure 9.4: *Scatterplot of DD score (combined DEST/DST) versus Balance Total at Session 3.*

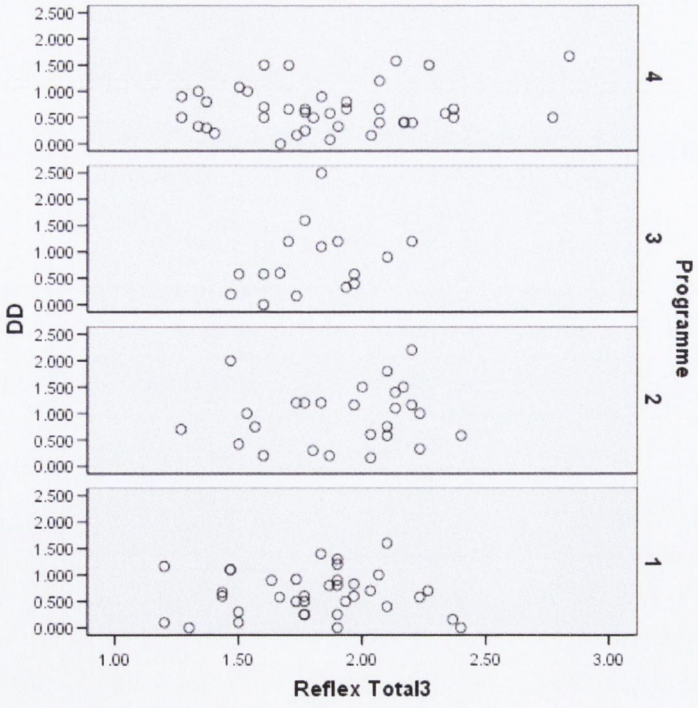


Figure 9.5: *Scatterplot of DD score (combined DEST/DST) versus Reflex Total at Session 3.*

9.12 Testing the Balance and Reflex Score Means

The first question to answer was whether there was a significant reduction in balance and reflex scores over time and by group. If there was a group interaction with time, this would indicate whether any of the programmes were having an effect on the children's integration of reflexes and/or improvement in balance skills. A one-way ANOVA was conducted between the programme groups at Time 1 to make sure that there was no significant difference between their means at the start of the study. The mean scores for the full compliant sample are shown in Table 9.14. Group means are reported in Tables 9.15 and 9.16.

Scores	**Time 1**	**Time 2**	**Time 3**
Balance	2.63	2.43	2.29
S.D.	.727	.677	.626
Reflex	1.86	1.87	1.85
S.D.	.393	.349	.321

Table 9.14: *Mean of Balance and Reflex scores at Time 1-3 (n = 118).*

However, before ANOVAs were performed the combined scores [3] were tested for normality. It was found that balance, reflex and DEST/DST scores were not normally distributed. In keeping with common practice the logarithms (Log10) of these scores were tested for normality. It was found that the Log combined reflex score was normally distributed for all groups, however, the Group 2 balance score was still not normally distributed. It is sensible to ensure that measurements are compared at the same scale (Brace, Kemp, & Snelgar, 2000). Hence it was decided to use the Log score for all analyses of variance and in the case of balance Group 2, to report the results of the Kruskal-Wallis test since that is known to be appropriate for non-normal data (Salkind, 2004; Spiegel, 2000). This found a significant change in the Mean Rank of balance scores over time for Group 2 in Sample S_{118} ($\chi^2 = 6.699$, df=2, p = 0.035). To investigate similarly what was happening, a Kruskal-Wallis test was carried out on Group 1's reflex scores. This found that there was no effect of Time for Group 1 on their reflex scores ($\chi^2 = 1.657$, df=2, p = 0.437).

A one-way ANOVA was performed on balance and reflex scores separately and no significant differences were found between groups over time. See Table 9.17.

[3]The combined reflex score comprised 6 subtests and the combined balance comprised 8 subtests.

	Time 1		Time 2		Time 3	
Balance Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	2.55	.692	2.35	.687	2.27	.627
Group 2	2.82	.715	2.61	.577	2.38	.480
Group 3	2.79	.785	2.39	.624	2.35	.691
Group 4	2.51	.732	2.39	.747	2.22	.690

Table 9.15: *Mean of Balance scores at Time 1-3 by Group (n = 118).*

	Time 1		Time 2		Time 3	
Reflex Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	1.86	.348	1.77	.283	1.80	.304
Group 2	1.93	.393	2.00	.362	1.92	.292
Group 3	1.70	.319	1.86	.354	1.80	.208
Group 4	1.86	.450	1.88	.377	1.86	.384

Table 9.16: *Mean of Reflex scores at Time 1-3 by Group (n = 118).*

Time	**One Way ANOVA**
T1 Balance Scores	$F_{(3,114)} = 1.433$, P = 0.237
T2 Balance Scores	$F_{(3,114)} = 1.046$, P = 0.375
T3 Balance Scores	$F_{(3,114)} = 0.744$, P = 0.528
T1 Reflex Scores	$F_{(3,114)} = 1.217$, P = 0.307
T2 Reflex Scores	$F_{(3,114)} = 1.983$, P = 0.121
T3 Reflex Scores	$F_{(3,114)} = 0.784$, P = 0.505

Table 9.17: *Balance and Reflex Scores at three separate time intervals*

A repeated measures ANOVA was performed on Log_{10} balance, reflex, motor, oculomotor, and phonological scores separately and no significant differences were found between groups over time. This is shown in Table 9.18.

ANOVA	Group × Time
Balance Scores	$F_{(6,228)} = 0.433, P = 0.856$
Reflex Scores	$F_{(6,228)} = 1.095, P = 0.366$
Motor Scores	$F_{(6,228)} = 1.140, P = 0.775$
Oculo-Motor Scores	$F_{(6,228)} = 0.543, P = 0.212$
Phonological Scores	$F_{(6,228)} = 1.622, P = 0.142$

Table 9.18: *ANOVA Group × Time,* S_{118}

Note that there was no interaction of Group by Time for balance scores, in comparison to the Kruskal-Wallis results.

9.12.1 Results for children at risk of Dyslexia Sample S_{118}

The two tables below describes the number of children from S_{118} sample found to be at risk of dyslexia at T3 according to DEST/DST Screening Tests:

Dyslexia	Reflex		Balance		Placebo		Control		Total	
Mild Risk	No.	%	No.	%	No.	%	No.	%	Total	%
Yes	12	33%	16	62%	6	37.5%	16	40%	50	42%
No	24	67%	10	38%	10	62.5%	24	60%	68	58%
Total Group	36	100%	26	100%	16	100%	40	100%	118	100%

Table 9.19: *No. of children at risk of dyslexia at the end of the study by group using milder risk of Dyslexia (i.e. risk > = 0.6 on DEST)* S_{118}.

A chi-square analysis was performed which showed that there was no significant difference in the incidence of risk of dyslexia at the milder criterion by group ($\chi^2(3) = 5.36$, p < 0.151).

A chi-square analysis was then performed which showed that there was a significant association of 'risk of dyslexia' at the higher criterion by group ($\chi^2(3) = 8.36$, p = 0.038). Fourteen children or 53.8% of the balance group, were at risk for dyslexia at the higher level at Time 3 (see Table 9.20). At this stage it was decided to use the higher dyslexia risk criterion in any further analysis as chi-square analysis showed no difference in the incidence of risk of dyslexia at the milder criterion.

It is interesting to note that a frequency analysis on the DEST and DST scores combined

Dyslexia	Reflex		Balance		Placebo		Control		Total	
High Risk	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**Total**	**%**
Yes	9	25%	14	54%	6	37.5%	9	22.5%	38	32%
No	27	75%	12	46%	10	62.5%	31	77.5%	80	68%
Total Group	36	100%	26	100%	16	100%	40	100%	118	100%

Table 9.20: *No. of children at risk of dyslexia at the end of the study by group using higher risk of Dyslexia (i.e. risk > = 0.9 on DEST)* S_{118}.

showed that milder 'At Risk Quotient' score of 0.6 fell at the cumulative 49th percentile of Sample S_{118} and the higher 'At Risk Quotient' score of 1 fell at the 73rd cumulative percentile.

ADHD RISK	Reflex		Balance		Placebo		Control		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**Total**	**%**
Yes	7	19%	5	19%	6	37.5%	11	27.5%	29	25%
No	29	81%	21	81%	10	62.5%	29	72.5%	89	75%
Group	36	100%	26	100%	16	100%	40	100%	118	100%

Table 9.21: *No. of children at risk of ADHD at the end of the study by group.*

Table 9.21 shows the number of children at risk of ADHD when screened at the end of the study. A chi-square analysis was performed which showed that there was no association between the incidence of risk of ADHD and group membership ($\chi^2(3) = 2.538$, $p = 0.477$). Twenty-nine children or 24.6% of the sample was at risk for ADHD at the end of the study. Three children already had a diagnosis, only one of which was picked up by the Conner's Screening Test.

9.13 Initial Indicators and Risk of Dyslexia

To investigate whether balance and reflex scores could be considered to be initial 'at risk' indicators of dyslexia, from sample S_{118} were categorized into low and high classes. Then chi-square analyses of low and high classes versus final dyslexia 'at risk' indicators (DEST and DST scores) were undertaken. To understand why the categorization was necessary, recall that the reflex and balance test batteries involve different types of observations. This implies that although each test was subsequently scored on a scale of 1 to 5, the meaning of each score is different on each battery. Hence scoring 2 on a reflex is not

necessarily the same as a 2 on the balance scale. The original assessment scale of 1-5 was based on a subjective ranking and subsequent scores represent non-linear behaviour, which might be expected from a dyslexic population. The reflex score range proved to be narrower than that of the balance scores. This was obvious in the daily assessments, as it proved more difficult to either elicit or observe reflex reactions, whereas balance skill was easily assessed. It was also obvious that children had a wide range of skill. Hence a high/low categorisation helps to compare scores across tasks.

The reflex score range was 1.80, with a minimum score of 1.17 and a maximum score of 2.97. It was decided that a score of 2 or lower would be categorised as a low incidence of retained reflexes. Scores between 2.01 and 2.97 would be categorised as high incidence of retained reflexes.

In effect 72% fell into the low range, and 28% into the higher range and so a binary split was used for the main analysis. A chi-square analysis was initially performed to investigate whether low and high reflex scores were distributed evenly between the age groups 3-7 years at Time 1. The result ($\chi^2(4) = 15.890, p < 0.003$) was significant at the p = .05 level. Seventy-two percent of children in Sample S_{118} had low reflex scores indicating few persistent retained reflexes. A breakdown by age is shown in Table 9.22. Low reflex scores were more typical of all age groups except 4 year olds, for whom low and high scores were equally represented. Analysis also revealed that high and low reflex scores were evenly distributed between the treatment groups (see Appendix P).

AGE	Low Reflex Score	High Reflex Score	Total
3	6 (75%)	2 (25%)	8 (100%)
4	16 (48.5%)	17(51.5%)	33 (100%)
5	23 (72%)	9(28%)	32 (100%)
6	34(87%)	5(13%)	39 (100%)
7	6(100%)	0 (0%)	6 (100%)
Total	85 (72%)	33 (28%)	118 (100%)

Table 9.22: *Breakdown of Reflex Scores by age at Time 1,* S_{118}

Similarly balance scores were separated into low and high ranges. However, here the range was much larger (3.23) with a minimum score of 1 and a maximum score of 4.23. When assessing the children, a score of 2 or lower represented little or no difficulty with balance.

Again a chi-square analysis was undertaken on the distribution of initial high and low

balance scores by age and the result was not significant at the p= .05 level ($\chi^2(4) = 4.039, p = 0.406$). A chi-square analysis failed to find any evidence of a significant association between 'low and high' balance and reflex scores and group membership (for a breakdown see Tables P.13and P.14 in Appendix P).

In order to investigate whether there was a significant association between initial 'at risk' indicators (i.e. high scores on balance or reflex batteries at Time 1 or at Time 3) and high scores on the Dyslexia Screening Tests, chi-square analysis was undertaken as shown in Tables 9.23 and 9.24.

Time 1: Bal/Reflex Scores × Dyslexia Risk	**Chi-square**
Balance Group 1	$\chi^2(1) = 1.235$, p = 0.396
Reflex Group 1	$\chi^2(1) = 0.875$, p = 1.000
Balance Group 2	$\chi^2(1) = 0.851$, p = 0.598
Reflex Group 2	$\chi^2(1) = 0.348$, p = 0.683
Balance Group 3	$\chi^2(1) = 3.200$, p = 0.234
Reflex Group 3	$\chi^2(1) = 0.027$, p = 1.000
Balance Group 4	$\chi^2(1) = 1.672$, p = 0.227
Reflex Group 4	$\chi^2(1) = 0.335$, p = 1.000

Table 9.23: *Time 1: High Low Scores × High Dyslexia Risk Sample* S_{118}

Time 3: Bal/Reflex Scores × Dyslexia Risk	**Chi-square**
Balance Group 1	$\chi^2(1) = 1.403$, p = 0.432
Reflex Group 1	$\chi^2(1) = 0.0005$, p = 1.000
Balance Group 2	$\chi^2(1) = 1.321$, p = 0.365
Reflex Group 2	$\chi^2(1) = 0.0005$, p = 1.000
Balance Group 3	$\chi^2(1) = 0.950$, p = 0.588
Reflex Group 3	$\chi^2(1) = 0.152$, p = 1.000
Balance Group 4	$\chi^2(1) = 0.455$, p = 0.694
Reflex Group 4	$\chi^2(1) = 0.455$, p = 0.694

Table 9.24: *Time 3: High Low Scores × High Dyslexia Risk Sample* S_{118}

Note that Group 3 contained only 16 children and so did not have power of 0.80, however the result is still reported above. The chi-square results in Table 9.23 and Table 9.24 show that there was no relationship between balance and reflex scores and dyslexia risk at either Time 1 or Time 3 for Sample S_{118}.

9.14 Correlations/Predictors of dyslexia

Pearson's correlation was used to test the efficacy of the test batteries in predicting dyslexia in young children. See Table 9.25 for those tests that were found to be correlated with high and mild 'at risk' scores for dyslexia at Time 3. [4]

Comparison	r (2 tailed)	p	Significant
Balance T1 V High Dyslexia T3	0.151	= 0.104	No
Balance T1 V Mild Dyslexia T3	0.226	= 0.014	Yes
Balance T3 V High Dyslexia T3	0.256	= 0.005	Yes
Balance T3 V Mild Dyslexia T3	0.336	< 0.001	Yes
Reflex T1 V High Dyslexia T3	0.037	= 0.688	No
Reflex T1 V Mild Dyslexia T3	0.098	= 0.292	No
Reflex T3 V High Dyslexia T3	0.068	= 0.463	No
Reflex T3 V Mild Dyslexia T3	0.059	= 0.527	No
Oculo-Motor T1 V High Dyslexia T3	-0.016	= 0.862	No
Oculo-Motor T1 V Mild Dyslexia T3	0.008	= 0.928	No
Oculo-Motor T3 V High Dyslexia T3	0.134	= 0.148	No
Oculo-Motor T3 V Mild Dyslexia T3	0.177	= 0.055	No
Motor T1 V High Dyslexia T3	0.027	= 0.772	No
Motor T1 V Mild Dyslexia T3	0.205	= 0.026	Yes
Motor T3 V High Dyslexia T3	0.204	= 0.026	Yes
Motor T3 V Mild Dyslexia T3	0.250	= 0.006	Yes
Phonological T1 V High Dyslexia T3	-0.126	= 0.174	No
Phonological T1 V Low Dyslexia T3	-0.263	= 0.004	Yes
Phonological T3 V High Dyslexia T3	-0.231	= 0.012	Yes
Phonological T3 V Mild Dyslexia T3	-0.284	= 0.002	Yes

Table 9.25: *Efficacy of the test batteries Sample* S_{118}

The results of the correlations described in Table 9.25 show a pattern with the balance, motor and phonological subtests at Time 1 all significantly predicting dyslexia at the milder criterion at Time 3. At Time 3, these subtests also predict dyslexia at both the milder and higher criteria at Time 3. The variability in the results at Time 1 could be due to a variation in general experience among the children. At Time 3 the children would

[4]Note: Log10 scores of the measures were used for the correlations.

have had more practice on the various tests and they may then be more reliable measures and so the real differences emerge at Time 3. Practice may level out early experience, leaving the reading difficulty at Time 3. Note that the reflex and oculo-motor subtests prove not to be predictors of dyslexia. This may be due to the validity of these measures and this is discussed in section 10.2 in the next chapter. Note that while the significant correlations appear to be useful indicators statistically, they would only reliably predict about 4% of the variance.

9.15 Results for girls versus boys

As there were only 21 girls compared to 115 boys in the full sample (n=136) and 16 girls v 102 boys in the 120 days compliant sample (n=118) it was not possible to do a comparison. Similarly as only 5 children undertook reflex remediation programmes either in school or privately it was not possible to do any analysis on such a small sample.

9.16 Phonological Scores as Outcome Measures Sample S_{136}

Tests of Letter Name Knowledge, Phoneme Deletion and Nonword Repetition have been shown to be good predictors of reading accuracy at age 9 (Muter & Snowling, 1998). Hence, these short tests were incorporated into the test battery to see if there were any associations between phonological skill, performance on balance and reflex tasks and treatment group. As no treatment effect was seen between the groups when measured by the DEST/DST it was subsequently decided to use the phonological tests as outcome measures. Note that high scores on the phonological subtests indicates a good performance whereas in all the motor subtests investigated previously, a high score indicated a poor performance. Before presenting the results for these measures, an initial analysis by age as an estimate of their validity was undertaken.

Letter Name Knowledge Task

All 136 children in the full sample performed the Letter Name Knowledge task. Table 9.26 gives the breakdown of the performance of the sample by age at Time 1. The maximum possible score was 26, the mean score was 13 and scores were divided into

high and low ranges as follows: Low = 0-13, High = 14-26. Chi-square analysis found a significant association between age and score on the Letter Name Knowledge (LNK) subtest ($\chi^2(4) = 56.819$, p = 0.0005).

Age at Start	LNK Low	LNK High	Total
3	10	1	11
4	31	6	37
5	15	24	39
6	5	38	43
7	0	6	6
Total	61	75	136

Table 9.26: *Breakdown of Letter Name Knowledge scores by age for Sample S_{136} at Time 1*

Phoneme Deletion Task:

All 136 children in the full sample performed the Phoneme Deletion task. Table 9.27 gives the breakdown of the performance of the sample by age at Time 1. Phoneme Deletion scores were divided into high and low ranges and categorized as follows: Low = 0-4, High = 5-8. This task was scored out of 8 rather than 10 as the words 'meat' and 'hat' were not used. It was found that some of the younger children could not understand two of the researchers who had strong accents and many of the other children with country accents were not making themselves understood with these words. It was felt that this problem was specifically related to the varying Irish accents and it was prudent not to use these two particular words. Note that chi-square analysis found a significant association between age and score on the Phoneme Deletion subtest ($\chi^2(4) = 25.47$, p = 0.0005) at Time 1 (see Table 9.27).

Age at Start	Phoneme Low	Phoneme High	Total
3	11	0	11
4	35	2	37
5	35	4	39
6	28	15	43
7	2	4	6
Total	111	25	136

Table 9.27: *Breakdown of Phoneme Deletion score by age for Sample S_{136} at Time 1*

Nonword Repetition Task:

Poor Nonword Repetition scores have consistently been found to distinguish groups of children of low reading ability from normal children of the same age (Kamhi & Catts, 1986). The very low performance of reading-impaired individuals in repeating nonwords has been reported in detailed single case investigations (Hulme & Snowling, 1992).

The association between children's age, group membership, and Nonword Repetition scores was investigated at Time 1 (S_{136}) using chi-square analysis. Firstly, the Nonword Repetition (NRep) scores were divided into high and low categories. This was marked out of 50, as along with Gathercole and Baddeley's test, ten simple nonwords were included for all children at the start of the task. That was specifically intended to introduce 3 year olds to the task as previous research had used this task with 4 to 6 year olds (Muter & Snowling, 1998). Scores below 30 were considered low (nonwords with two syllables or less) and scores between 30 and 50 were considered high. Gathercole et al. (1994) reported that children began to have difficulty when nonwords were composed of more than two syllables. Chi-square analysis showed significant association between children's age and Nonword Repetition scores ($\chi^2(4) = 11.180$, p = 0.033).

9.16.1 Group × Time Interactions

A chi-square analysis was undertaken to ascertain if there were any associations on the phonological tasks by group at Time 1 and then at Time 3. Table 9.28 and Table 9.29 show that there were no significant associations at either of the Time intervals for the full sample.

Chi-Square	Group × Time
Letter Name Knowledge	$\chi^2(3) = 4.271$, p = 0.235
Phoneme Deletion	$\chi^2(3) = 2.070$, p = 0.571
Nonword Repetition	$\chi^2(3) = 4.032$, p = 0.282
Total Phonological Scores	$\chi^2(3) = 2.628$, p = 0.459

Table 9.28: *Phonological Subtests Scores by Group at Time 1,* S_{136}

Chi-Square	Group × Time
Letter Name Knowledge	$\chi^2(3) = 1.905$, p = 0.636
Phoneme Deletion	$\chi^2(3) = 4.518$, p = 0.215
Nonword Repetition	$\chi^2(3) = 4.984$, p = 0.193
Total Phonological Scores	$\chi^2(3) = 1.388$, p = 0.719

Table 9.29: *Phonological Subtests Scores by Group at Time 3,* S_{136}

A two-way repeated measures ANOVA was then performed for the individual subtests, Letter Name Knowledge, Phoneme Deletion, Nonword Repetition scores, on the total phonological scores at Times 1, 2, and 3 by group. There was no interaction between group scores and time on any of the variables as shown in Table 9.30.

ANOVA	Group × Time
Letter Name Knowledge	$F_{(6,264)} = 1.050, p = 0.394$
Phoneme Deletion	$F_{(6,264)} = 0.689, p = 0.659$
Nonword Repetition	$F_{(6,264)} = 1.348, p = 0.236$
Total Phonological Scores	$F_{(6,264)} = 1.234, p = 0.289$

Table 9.30: *Phonological Scores Group × Time ANOVA,* S_{136}

This indicates that there was no treatment effect on pre-reading skills in any of the groups.

9.16.2 Phonological Tasks as Outcome Measures Sample S_{118}

ANOVA and chi-square analysis was undertaken to see if there was any effect of treatment in the four groups over time. However first an initial analysis by age was undertaken as an estimate of the individual subtests validity. A significant association was found between children's age and performance on the Letter Name Knowledge task, with 87.5% of 3 year olds compared to 0% of 7 year olds scoring in the low range on this task ($\chi^2(4) = 50.978$, p = 0.0005). See Table 9.31.

Similarly, as expected, a significant association was found between children's age and performance on the Phoneme Deletion task, $\chi^2(4) = 29.091$, p = 0.0005. One hundred per cent of 3 year olds, 94% of 4 year olds, and 91% of 5 year olds scored in the low range on this task.

Age at Start	LNK Low	LNK High	Total
3	7	1	8
4	28	5	33
5	14	18	32
6	4	35	39
7	0	6	6
Total	53	65	118

Table 9.31: *Breakdown of Letter Name Knowledge scores by age for Sample S_{118} at Time 1*

There was also a significant association between age and Nonword Repetition scores at Time 1, $\chi^2(3) = 11.152$, p = 0.028. Unexpectedly one hundred and ten of the 118 children scored in the high range on the Nonword Repetition task, pointing to a possible ceiling effect on this task. Over 80% of children in each age group scored in the high range. This result may relate to the way the task was presented and this is discussed in the next chapter.

9.16.3 Group × Time Interactions

To investigate whether there was any change in scores in the treatment groups compared to the control groups between Time 1 and Time 3, a two-way repeated measures ANOVA was performed on the total phonological scores at Times 1, 2, and 3 by group. There was no interaction between group scores and time. It was then decided to look at the subtests individually. Table 9.32 presents the results.

ANOVA	Group × Time
Letter Name Knowledge	$F_{(6,228)} = 0.853, p = 0.530$
Phoneme Deletion	$F_{(6,228)} = 0.359, p = 0.904.$
Nonword Repetition	$F_{(6,228)} = 2.033, p = 0.062$
Total Phonological Scores	$F_{(6,228)} = 1.160, p = 0.329.$

Table 9.32: *Phonological Scores Group × Time ANOVA, S_{118}*

The results of the ANOVA found that there was no interaction between group scores and time on Letter Name Knowledge,Phoneme Deletion, or Nonword Repetition scores at Times 1, 2, and 3.

The association between group membership and individual phonological scores was then investigated at Time 1 for Sample S_{118} using chi-square analysis. As before, the individual subtest scores were divided into high and low categories. There was no association between group membership and any of the phonological scores at Time 1, see Table 9.33.

Group × Time	**Chi-Square**
Letter Name Knowledge	$\chi^2(3) = 1.376$, p = 0.711
Phoneme Deletion	$\chi^2(3) = 1.290$, p = 0.764
Non-word Repetition Task	$\chi^2(3) = 5.155$, p = 0.150
Total Phonological Scores	$\chi^2(3) = 1.312$, p = 0.722

Table 9.33: *Phonological Scores by Group at Time 1, Sample* S_{118}

Chi-square analysis was repeated for the phonological scores at Time 3, see Table 9.34.

Group × Time	**Chi-Square**
Letter Name Knowledge	$\chi^2(3) = 1.484$, p = 0.687
Phoneme Deletion	$\chi^2(3) = 4.589$, p = 0.204
Non-word Repetition Task	$\chi^2(3) = 5.105$, p = 0.156
Total Phonological Scores	$\chi^2(3) = 0.541$, p = 0.916

Table 9.34: *Phonological Scores by Group at Time 3, Sample* S_{118}

The Mean score for Letter Name knowledge rose from 14 at Time 1 to 20 at Time 3. Exactly 50% of children fell into the high and low ranges of the Phoneme Deletion score at Time 3. One hundred and fourteen (97%) of children scored in the high range of the Nonword Repetition task at Time 3. However there was no significant association by group on any of these tasks at Time 3 indicating no effect of treatment found using the phonological tasks as outcome measures.

9.17 Checking DEST/DST and Phonological Scores

Total phonological scores at Time 1 were significantly associated with those 'at risk of dyslexia' at Time 3, at the milder criterion in Sample S_{118}, ($\chi^2(1) = 4.847$, p = 0.023). Letter Name Knowledge and Phoneme Deletion scores at Time 1 were also significantly associated with those 'at risk of dyslexia' at the milder criterion. Fifty-six percent of

children who scored poorly on Letter Name Knowledge were at risk of dyslexia at the milder criterion, and 63% of children who scored highly on Letter Name Knowledge were not at risk at this level. Ninety per cent of children who scored poorly on the Phoneme Deletion task at Time 1, $\chi^2(1) = 5.724$, p = 0.021 were at risk of dyslexia at the milder criterion. Chi-square analysis showed that of those with 'high dyslexia risk', 83% who performed well on the Phoneme Deletion task had no risk of dyslexia at the higher level. However the result was just outside the significant range, $\chi^2(1) = 3.331$, p = 0.053. Letter Name Knowledge did not have a significant association with dyslexia risk at the higher level. These results indicate that in general poor phonological skill is a good indicator of risk of dyslexia, a result that is not unexpected given the well-established relationship between dyslexic and phonological processing deficits. However, subsequent chi-square analysis showed no association between performance on the Nonword Repetition task and 'high dyslexia risk', $\chi^2(1) = 1.245$, p = 0.434, although this could be due to a problem in the administration of the test.

As the Phoneme Deletion task proved to be a good indicator of dyslexia with Sample S_{118}, it was decided to investigate whether it was associated with dyslexia risk within groups. However, as shown in Table 9.35, no association was found between Phoneme Deletion as an initial risk indicator and risk of dyslexia for any group.

Phoneme Deletion Scores	**Chi-square**
Group 1 v High Dyslexia	$\chi^2(1) = 1.235$, p = 0.396
Group 1 v Mild Dyslexia	$\chi^2(1) = 2.667$, p = 0.219
Group 2 v High Dyslexia	$\chi^2(1) = 0.028$, p = 0.641
Group 2 v Mild Dyslexia	$\chi^2(1) = 0.266$, p = 1.000

Table 9.35: *Phoneme Deletion as Initial Indicators × Dyslexia at Time 3, Sample* S_{118}

9.18 Initial Risk Indicators × Phonological Tasks

In order to investigate whether initial risk indicators (high and low balance and reflex scores at Time 1) were associated with performance on phonological tasks at Time 3, chi-square analyses were performed as shown in Tables 9.36, 9.37 and 9.38.

Letter Name Knowledge Task	Chi-square
Balance Scores Group 1	$\chi^2(1) = 1.935$, p = 0.302
Reflex Scores Group 1	$\chi^2(1) = 3.005$, p = 0.119
Balance Scores Group 2	$\chi^2(1) = 1.126$, p = 0.555
Reflex Scores Group 2	$\chi^2(1) = 7.043$, p = 0.020*
Balance Scores Group 3	$\chi^2(1) = 0.356$, p = 1.000
Reflex Scores Group 3	$\chi^2(1) = 4.662$, p = 0.188
Balance Scores Group 4	$\chi^2(1) = 2.167$, p = 0.298
Reflex Scores Group 4	$\chi^2(1) = 0.272$, p = 1.000

Table 9.36: *Balance and Reflex Initial Indicators × letter Name Knowledge Scores at Time 3, Sample S_{118} (* = significant)*

Note in Group 2, low reflex scores were significantly associated with good performance on the Letter Name Knowledge task.

Phoneme Deletion Task	Chi-square
Balance Scores Group 1	$\chi^2(1) = 7.636$, p = 0.014*
Reflex Scores Group 1	$\chi^2(1) = 2.597$, p = 0.140
Balance Scores Group 2	$\chi^2(1) = 0.494$, p = 0.591
Reflex Scores Group 2	$\chi^2(1) = 2.497$, p = 0.190
Balance Scores Group 3	$\chi^2(1) = 6.857$, p = 0.019*
Reflex Scores Group 3	$\chi^2(1) = 0.788$, p = 0.375
Balance Scores Group 4	$\chi^2(1) = 1.584$, p = 0.293
Reflex Scores Group 4	$\chi^2(1) = 6.535$, p = 0.016*

Table 9.37: *Balance and Reflex Initial Indicators × Phoneme Deletion Scores at Time 3, Sample S_{118} (* = significant)*

For the phoneme deletion outcome variable, it was found that in Group 1 (reflex remediation programme), there was a significant association between high/low balance scores at Time 1 and Phoneme Deletion scores at Time 3. Children with low balance scores at Time 1 performed well on the Phoneme Deletion at Time 3.

In contrast, in Group 3 (placebo-control) children with low Balance scores at Time 1 performed poorly on the Phoneme Deletion task at Time 3. However, note that the group size was 16 and for Chi-square analysis at one degree of freedom, group size must

be 26 for power of 0.8.

In Group 4, there was a significant association between reflex scores at Time 1 and Phoneme Deletion scores at Time 3. Children with low reflex scores performed well on the Phoneme Deletion task at Time 3.

Nonword Repetition Task	**Chi-square**
Balance Scores Group 1	$\chi^2(1) = 0.343$, p = 1.000
Reflex Scores Group 1	$\chi^2(1) = 2.674$, p = 0.278
Balance Scores Group 2	$^{\triangle}$
Reflex Scores Group 2	$^{\triangle}$
Balance Scores Group 3	$\chi^2(1) = 0.762$, p = 1.000
Reflex Scores Group 3	$\chi^2(1) = 9.905$, p = 0.025*
Balance Scores Group 4	$\chi^2(1) = 0.389$, p = 1.000
Reflex Scores Group 4	$\chi^2(1) = 0.440$, p = 1.000

Table 9.38: *Balance and Reflex Initial Indicators × NRep Scores at Time 3, Sample* S_{118} *(* * *= significant)*

For the Nonword Repetition Task, in Group 3, low reflex scores at Time 1 were significantly associated with high Nonword Repetition Scores at Time 3 (see Table 9.38).

$^{\triangle}$ Note: Within Group 2, it was not possible to undertake chi-square analysis to investigate any association between balance or reflex scores at Time 1 and Nonword Repetition scores at Time 3, as the Nonword Repetition scores did not vary (i.e. all Group 2 scored in the high range on this task).

9.19 Summary of Significant Findings

The main aims of this study were

- to investigate whether a movement programme designed to reduce the persistence of retained reflexes reduces the risk of dyslexia as measured by the Dyslexia Screening Test/Dyslexia Early Screening Test (DST/DEST) and phonological measures of pre-reading skill,

- to investigate whether a movement programme designed to stimulate the vestibular system and improve balance skills reduces the risk of dyslexia as measured by the DST/DEST and phonological measures of pre-reading skill.

The main finding was that neither experimental treatment reduced the frequency or degree of dyslexia risk in their respective groups. However, there was a significant association between high Dyslexia risk and group membership ($\chi^2(3) = 8.364$, $p = 0.038$) in the compliant sample S_{118}. Fifty four per cent of Group 2 (14 out of 26 children) who underwent the balance training programme, were at risk for dyslexia at the higher criterion at the end of the study compared with 25% of Group 1, 38% of Group 3 and 23% of Group 4. Furthermore, using the balance and reflex scores as initial indicators for dyslexia risk (as measured on DEST/DST) did not result in any significant associations.

Using the phonological scores as outcome measures, again no effects of the experimental treatments were found. However, Time 1 balance scores for Groups 1 and 3 were related to Phoneme Deletion at Time 3 and Time 1 reflex scores were associated with Letter Name Knowledge scores at Time 3 for Group 2, and for Group 4 were associated with Phoneme Deletion scores at Time 3.

Other findings were:

- Before the compliance criterion was applied to the full sample S_{136}, in Group 2, greater compliance was associated with increased risk of dyslexia.
- Similarly, there was a significant association between presence of ADHD and risk of dyslexia on both the milder and higher criteria.

9.19.1 Results relating to the efficacy of the motor test battery

The third aim was to test the efficacy of a motor test battery in predicting dyslexia in young children, in the event of no treatment effects being shown in the intervention programmes. The results of correlations showed a pattern with balance, motor and phonological subtests at Time 1 all significantly predicting mild dyslexia risk at Time 3, and balance, motor and phonological subtests at Time 3 predicting both mild and high dyslexia risk at Time 3. These subtests appear to be useful indicators statistically, however they would only reliably predict about 4% of the variance. The reflex and oculo-motor subtests proved not to be predictors of dyslexia.

The next chapter will interpret these findings and discuss the possible reasons for these results in the context of the intervention programmes.

10

Discussion

As a reminder to the reader, the main aims of this study were as follows,

- to investigate whether a movement programme designed to reduce the persistence of retained reflexes reduces the risk of dyslexia as measured by the Dyslexia Screening Test/Dyslexia Early Screening Test (DST/DEST) and phonological measures of pre-reading skill,
- to investigate whether a movement programme designed to stimulate the vestibular system and improve balance skills reduces the risk of dyslexia as measured by the DST/DEST and phonological measures of pre-reading skill.
- In the event of no treatment effect, the third aim was to test the efficacy of a motor test battery in predicting dyslexia in young children.

This chapter reviews the main findings of the study and their implications for motor programmes as interventions for dyslexia. The efficacy of motor tests as initial risk indicators and as predictors of dyslexia is also discussed. The model presented in Chapter 4

explaining how motor and reflex remediation programmes may affect reading development is discussed in the light of the study findings. Finally limitations of the current study are presented and recommendations for future research in this area are proposed.

10.1 Review of Findings

Given the treatments that were applied under the conditions of the study, no positive effect of the balance and reflex movement programmes was found. The two movement programmes have been devised on the basis of previous research and current remedial practice, and evaluated over a sustained period in a sample of young children with a dispositional risk of dyslexia. It was thought that these treatments may have had an effect with younger children, but in fact this was not the case. Indeed the balance group tested significantly worse for dyslexia. When balance and reflex scores at Time 1 were used as initial 'at risk' indicators they did not yield any significant associations for dyslexia risk when the DEST/DST was used as an outcome measure. However when the phonological scores were used as outcome measures significant associations were found between both balance and reflex scores as initial risk indicators and phonological scores within groups. Balance, motor and phonological subtest scores also proved to be predictors of dyslexia when the milder criterion on the DEST/DST was used. As expected ADHD proved to have a significant association with risk of Dyslexia at both the mild and high criteria.

To be clear, these are the principal findings:

1. There was no effect of the experimental treatments. Results of group by time interactions from ANOVA and chi-square analysis indicate no significant improvement in balance, reflex, motor, oculo-motor and phonological scores scores between Time 1 and Time 3 for any of the treatment or control groups.

2. A significant association was found between high Dyslexia risk and group membership in the compliant sample S_{118}. Fifty four per cent of Group 2 (14 out of 26 children) who underwent the balance training programme, were at risk for dyslexia at the higher criterion at the end of the study. This indicates that the balance training programme was having no remedial effect despite high compliance with the programme. This finding is further supported as there was no change in phonological scores over the year.

3. The total balance and total reflex scores did not provide reliable 'at risk' indicators for dyslexia (as measured on DEST/DST). It was then decided to use the phonological scores as outcome measures of pre-reading skill. In the '120 days' minimum compliance sample S_{118}, Time 1 balance scores were used across the groups in a chi-square analysis with Phoneme Deletion Scores at Time 3. Contradictory results were found in that for Group 1 a significant association was found between initial balance scores and phoneme deletion scores at Time 3 (better balance scores predicted better phoneme deletion performance) but the opposite was found for Group 3 (however this group had lower power - see section 10.6).

   When retained reflex scores were used as the initial 'at risk' indicator at Time 1, low reflex scores were significantly associated with good performance on Letter Name Knowledge task at Time 3 in Group 2. In Group 4, there was a significant association with Phoneme Deletion scores and in Group 3, there was a significant association with Nonword Repetition Scores at Time 3. These findings are discussed in section 10.6.

4. There was a significant association between risk of ADHD and risk of Dyslexia at both the mild and high criteria.

5. Using balance, motor and phonological subtests as predictors of dyslexia risk, Time 1 scores were significantly associated with mild dyslexia risk at Time 3, and balance, motor and phonological subtests at Time 3 were associated with both mild and high dyslexia risk at Time 3. The reflex and oculo-motor subtests proved not to be predictors of dyslexia.

These findings pose the main question, 'Why did the treatments have no effect?'. There are many issues that could have impacted on this outcome including age, sensitivity of tests, programme content, compliance and ADHD. These points are dealt with in subsequent sections.

Given the apparent lack of success of the treatments, it is worthwhile to ask whether they had any effect over time on the types of performance being treated as opposed to dyslexia risk. In other words, 'Was there a significant decrease in reflex or balance scores with time?'. Unfortunately, none of the analyses of performance with time for Sample S_{118} showed any significant change. Consider the reflex group. Reflex scores for Group 1 (reflex remediation group) decreased at Time 2 and increased slightly at Time 3. There was an overall reduction in this group's scores between Time 1 and Time 3 but this was

negligible. Group 2, 3 and 4 reflex scores increased slightly at Time 2 but either returned to the initial level at Time 3 (Groups 2 and 4), or increased slightly (Group 3). Thus the reflex programme had no effect on reflex retention.

Considering balance scores, there was a slight decrease in the mean score over time for the full Sample S_{118} and for both treatment and control groups, indicating improved balance skill, this finding was not significant. So we can conclude that although there was some improvement in balance performance over time it is not known whether this improvement was due to the treatment programme or the children's general development over the year of the study.

Therefore the fact that reflex and balance scores did not change with time means that even if the treatments were successful in improving balance skill and reflex retention, we cannot conclude that this would have led to a reduction in the children's risk of dyslexia. The discussion continues in the next section with the impact of age on the findings.

10.2 Age of Participants and Sensitivity of Tests

One main limitation of this work is the wide age range of the children who participated in the study. This could have had an impact on children's performance in the treatment programmes. Initially a call was put out for boys in the 3-5 year age group from families with a sibling or parent diagnosed or suspected of having dyslexia. The study was later opened up to girls who had a diagnosis or definite symptoms of dyslexia as there were fears that numbers would not reach the original target of 200 children. The study was also opened up to six year olds as it was necessary to make the sample large enough for analysis. This then led to sample of children with an age range of 3 to 7 years with their associated range of developing abilities. It was decided to stop recruiting 3 year olds fairly promptly as this age group found it difficult to concentrate for the full testing session.

Assessments at Time 1 and Time 2 took approximately one hour. At Time 3 an additional half hour was needed to administer the DEST or DST after a short break. It was obvious that the testing sessions were very demanding on younger participants and the researchers worked hard to maintain the motivation of the child. With more manpower the DEST/DST could have been administered later in the day or in the week to avoid putting excessive demands on the children. However this would have placed other demands on the family to either wait around or travel again to attend such sessions. Although 8 research

assistants, in addition to the two main researchers, were available part-time over the 2.5 year assessment period, they were only available for a couple of months at a time. This was not sufficient to allow for extra assessment time nor was extra lab space available. Thus it is possible that some of the measures taken, particularly towards the end of a session, may have been less reliable than would have been desired.

It is important to ascertain whether the tests used were appropriate for the age range in the study given that children as young as 3 years were involved. The phonological tests used have shown to be both reliable and valid when used in other research (Gathercole & Baddeley, 1989). However there were some questions regarding the suitability of fine and gross motor tests, oculo-motor and reflex tests. Details are discussed below.

Motor and Reflex Tests:

Along with the points made above, another question which arises from the results is whether the tests actually measured what they were supposed to. Although care was taken to use motor and reflex tests which had reliable discriminating power, it has been suggested that the Mann Test (Advanced Romberg) with eyes closed (Crutchfield & Barnes, 1993), and the fine-motor Finger-to-Thumb test may have been too difficult for the younger children (Levine & Sandler, 1996). It should also be noted that 'soft sign' tests such as those used in the fine motor section of the battery, although used in research (Dow & Moruzzi, 1958; Fawcett, Nicolson, & Dean, 1996), are only an indirect measure of cerebellar functioning. Although paediatricians have for decades documented 'soft neurological signs' in children referred for school learning difficulties, large epidemiologic studies have confirmed the independence of soft signs from other neuropsychological defects (Deuel & Doar, 1992). However while they are not viewed as a reliable early indicator of dyslexia, a correlation was found between soft sign as well as other motor test scores at Time 1 and Time 3 and performance on the DEST/DST in this study.

The gross motor tests proved more of a challenge for the younger children and they were adapted. In the One Leg Balance test, 3 and 4 year olds were permitted to hold their arms out at shoulder height to aid balance. The length of time they were requested to hold their balance was less than that for 6 year olds. This balance aid was also permitted in the Mann test and the Heel to Toe test. It was also acceptable if children under 4 did not quite walk heel to toe. There are several periods of brain maturation during childhood (Malina, 2004), the first occurring between the ages of 15 to 24 months, the second between 6 and 8 years and the others during adolescence. It may be that some children had reached a point of brain maturation which allowed them to perform better

on the motor tasks.

While there was little concern that the younger children could not complete the reflex tests once they understood what to do, from detailed observation the author felt that in some tests a true indication of reflex presence could not be measured. For example, it was noted that some children were reluctant to do the Moro Test. The Moro test required that they fall back into the testers arms, and some did not trust that they would be caught and so stiffened the body. Fidgeting during testing of the ATNR especially the 'Lying Down' version was also noted and the child had to be relaxed before an observation was made. The Schilder Test (standing with arms outstretched) often proved difficult to measure as the children tended to move the whole body instead of just the arms. Issues relating to scoring and reliable methods of measurement are discussed later in the chapter.

Oculo-Motor:

It is claimed that visual observation as a method of evaluating a vestibular-ocular reflex (VOR) is often inaccurate (Crutchfield & Barnes, 1993), and that VOR is independent of the vestibulospinal contribution to postural control (Horak, Shumway-Cook, Crowe, & Black, 1988). The relationship between VOR functioning and motor deficiencies has not been confirmed and this was supported in work with learning-disabled children which found that although they had poor balance skills they were normal on their VOR tests (Shumway-Cook, Anson, & Haller, 1987). In fact oculo-motor scores did not correlate with risk of dyslexia at either criterion in this study. The fact that younger children had some difficulty isolating head movements in the eye tracking subtest, suggests that the scores were not representative of oculo-motor ability. This is discussed later in relation to the theoretical model (section 10.6).

Phonological Tests:

There was no improvement in scores on the phonological tests in any of the groups over the duration of the study. This is consistent with the findings on the DEST/DST of no effect of any of the movement programmes. The three phonological tests proved to be correlated with DEST/DST and had a significant association by age as expected. Recent research showed that some children were unable to perform Phoneme Deletion tasks until they have developed word-reading skills. Thus this task may not have been appropriate for children in this study who were not yet in school (Blaiklock, 2004). This task has however been used in studies with children aged 4 and over (Muter & Snowling, 1998). As mentioned in Chapter 9, the Phoneme Deletion and Nonword Repetition tests were adapted slightly

for the younger age range in this study and the Phoneme Deletion task proved to be a useful outcome measure, see section 10.6. The results of the Nonword Repetition test proved disappointing. Part of the problem in hindsight was the presentation of the task. In the DEYP the experimenter turned their head away while saying the nonwords to avoid giving visual cues. Gathercole et al. (1994) recommend recording a female speaker reading aloud the nonword sequence in a neutral accent. Ninety-seven per cent of children in Sample S_{118} scored well on this task. It is presumed that the difference in repetition accuracy is due to the improved acoustic quality of a live presentation versus an audio tape.

Conner's Rating Scale (CPRS-R):

Twenty-five percent of Sample S_{118} were at risk of ADHD as measured by the CPRS-R. Parents rated their children's behaviour in the month prior to assessment at Time 3. As not all the children were in school, teachers' rating of the children's behaviour was not collected. Parents generally rate children in the study's age range higher on Oppositional subscale than teachers do, probably because parents are not exposed to large numbers of children as teachers are. However only the ADHD Index subscale was used. Three children had a full diagnosis, of which, only one was picked up by the screening test. This may have been a result of an improvement in behaviour since the time of the child's original diagnosis.

Finally, there is some concern regarding false negatives on the DEST/DST. These children's improvement in performance on the dyslexia screening tests tasks since their diagnosis may explain why they were not picked up. The DEST/DST is discussed in greater detail in section 10.8.1.

Scoring Difficulties:

Whilst the inter-rater reliability proved to be highly acceptable in this study, the scoring of the presence of retained reflexes raises important validity issues. For example, when scoring the ATNR (Ayres test - where child is on all fours), observation during assessments and the literature would suggest a bend in the opposite arm to which the head is turned and a reinforcement of the grasp reflex in the fingers on this side (Pacella & Barrera, 1940). McPhillips's method [1] however instructed scoring of the homolateral arm and fingers. It was decided to score signs of this reflex in the opposite arm. Other aspects of the McPhillips's scoring method raise some questions. Most reflex tests were scored out of

[1]Primary Movement Training Course, Dublin 2002

4, and there was no provision for scoring a child who could not undertake the task and so a score of 5 was used in these cases. There is also the question as to whether this scale was sufficiently sensitive to detect any difference in the degree of retained reflex presented by the children. From the experience gained in the study it is felt that retained reflexes are difficult to detect and degrees of retention even more so. Often fidgeting in the younger children presented a challenge for the administration and scoring of these tests. Also it may be questioned whether each reflex was tested for thoroughly. The general guidelines were to repeat the test up to four times, so two samples were taken for each reflex, with eyes open and eyes closed on each side of the body. Some research suggests that only 60% of newborns demonstrated signs of the ATNR and the chances of observing the reflex on one trial was 3/16 (Vasella & Karlsson, 1962) so it is not known what minimum number of observations are required for each of the reflex tests.

10.2.1 Tests - Conclusion

In concluding the discussion about age range and sensitivity of tests replication of findings in the literature relating to the phonological tests and correspondence with the DEST gives us confidence in the design and administration of the study. It is possible that sensitivity and validity was an issue with the reflex and oculo-motor tests.

These issues raise an obvious need for standardization of such tests which are used in different studies and by different agencies working with children. If the examiners are watching for and measuring different responses on non-specific scales, then there can be no consistency across the groups. If there is no consistency (i.e. reliability) then these measures are not valid. It is clear that the abilities of children across the 3-7 year age range differ across motor, fine motor, visual and phonological tests. One step towards standardisation is to run a large pilot study prior to testing to ascertain norms for each different age group. Due to resource and staff constraints this was not possible. However this would be advisable for future studies in order to allow standardised comparison of groups. Given the issues raised about the detection persistent reflexes and scoring of balance tasks, detection could be increased and measurement error reduced if an objective electronic device or video analysis was used to detect the extent of the reflex movement, see section 10.10.

While acknowledging the difficulties in recruiting specific age ranges, it would be advisable in future to accommodate more readily the testing needs of different aged participants to

enhance reliability of the measures taken. The balance, motor and phonological tests used in this study correlated with risk of dyslexia at Time 3, however they were not highly correlated and so would not be useful in an early indicator test battery. The current study used motor and reflex tests from the Primary Movement Early Years course as they were short and simple to administer given the age range of the children. They were also cross checked against developmental scales such as the Peabody (Folio & Fewell, 2000). Other possible age appropriate tests are the the Pediatric Extended Examination at Three (PEET) (Blackman, Levine, & Markowitz, 1986), the Paediatric Early Elementary Examination (PEEX2), or the Peabody Developmental Motor Scales (Folio & Fewell, 2000) however the administration time of these tests would have made them prohibitive.

10.3 Compliance with Programmes

Programme and study compliance are major factors in any intervention study and this may have been a factor in the failure of programmes to produce any remedial effect. Even though in this case parents were volunteers and should have been highly motivated because of the familial dyslexic background, 42 or 23.6% of the original sample withdrew entirely. Several others did not begin, or abandoned their programme early on. This resulted in 19 or 11% of the original sample being moved to the control group. Of those who managed to complete their programme, a further 18 failed to complete the minimum number of days considered appropriate.

Compliance at home may not have been as good as indicated. Parents with other dyslexic children in the household may have found it difficult to dedicate the time to the exercises and motivate young children. They may also have been tempted to let the child 'off' doing the exercises if they became tired and disruptive. In addition reporting of the quality of performance and time spent each night may not be reliable. The only way of verifying compliance outside of the testing sessions was via the manual (where parents ticked a box each night), one phone call during the year, and the retrospective questionnaire administered at the last assessment. It would have been desirable to be in touch with the families every two months, however due to lack of manpower this was not possible. There is no reason to doubt that those who were compliant were falsely reporting the numbers of days their children undertook their programmes. These families were highly motivated as they already had a family member with dyslexia. The study researchers felt that families took part enthusiastically. Thus the results indicate that despite parents reporting 120

days minimum compliance, these treatments had no effect on the treated variable over the year of the study. This has implications for empowering parents to undertake home-based interventions in the future. It may be that contact with specialist therapists on a regular basis is necessary to maintain the quality of programme delivery and to motivate both parent and child.

In other reflex programme studies (Jordan-Black, 2005; Blythe, 2005) programme delivery was in school where trained teachers monitored programme performance and compliance was not an issue as the programme was built into the daily curriculum. Implementing the programme in class has the logistical advantage of a group setting, so the children are more likely to join in at a set time everyday, and practically 100% compliance may be achieved. However the classroom based programmes rely heavily on the skill and co-operation of the teachers and the quality of the movements the children perform cannot be guaranteed as delivery of the programme is not one-to-one. As the DEYP was targeting a younger age range (some of the children had not started school) and had no vested interest in any type of programme, a home based intervention with 6 monthly assessments was decided upon. Reports of success with home based exercises were with older children who were responsible for their exercises and were motivated to complete them correctly (McPhillips et al., 2000). The quality of the exercise programme undertaken may have had an effect on this study's findings and this is explored in section 10.4.

A chi-squared analysis of compliance and dyslexia risk found that children in Group 2 were more likely to be at risk of dyslexia at the end of the study than children in the other groups. This is the second main finding of the study. Of the 15 children who were at high risk of dyslexia at Time 3, 14 undertook more than 120 days of the programme. This demonstrates that there was no treatment effect in spite of high compliance. It does not make sense that compliance on a balance programme could be associated with risk of dyslexia so it is now worth looking at what might have been happening in Group 2. Participants were assigned randomly to treatment groups and it is possible that children with a higher risk of dyslexia could have been assigned by chance to this group.

One way of checking this is to look at the distribution of high and low phonological scores across the groups at Time 1, as these tests correlated with the DEST/DST at the milder criterion. This would indicate if there was a cluster of children in Group 2 with possible dyslexia risk (as measured by phonological tests) at the start of the study. In fact the distribution of low scores, which indicate poor performance, on the Phoneme Deletion task was similar across all the groups (between 75% and 85%). Importantly, at Time 3 Group 2 still had 65% scoring poorly on this task, compared to 39-63% of children in the

other groups. Group 2 also had 10% more children scoring poorly on the Letter Name Knowledge task than the other groups.

While these findings were not significant, it may point to young age as being a factor in the children's performance but does not confirm that there was a cluster of children with high dyslexia risk in this group at the start of the study. It should be noted that, Group 2 balance scores were not normally distributed even when converted to Log10. This group had a higher proportion of children at the lower end of the age range. Five children were aged 3 in this group compared to 1 in Group 1, 0 Group 3 and 1 in Group 4. This may have contributed to lack of normality in the scores. A non-parametric Kruskal-Wallis test showed that there was a slight but significant decrease in the group balance scores between Time 1 and Time 3, however this was found not to be significant when Log10 balance scores were used with ANOVA or Chi-Square analysis.

The incidence of ADHD in Group 2 was the same as that in Group 1 (19%) and in fact Group 3 and Group 4 had much higher incidences of ADHD, 38% and 28% respectively. Group 1 and Group 2 children performed their programmes at a similar rate, with slightly more than half being slow and controlled, see Appendix P. This indicates that Group 2's performance of the balance training programme should not have been unduly biased by a greater representation of ADHD participants. However 25% of children in the compliant Sample S_{118} were at risk of ADHD and as these children were present in each treatment group this may also be a reason why no effect on either reflex retention, balance skill or dyslexia risk was found. Nineteen percent of each treatment group rushed their programme thus reducing the ability of the groups to perform their programmes properly. In reality only the remaining children's scores could be relied upon thus reducing the power available for detecting significant effects. This has implications for research in that adequate sample sizes must be used and where children present with both dyslexia and ADHD risk they should be treated and their performance analysed separately to those at risk of dyslexia.

When possible confounding effects of other activities were investigated for Sample S_{118}, no significant differences save for one, were found between the groups. Groups 1, 2 and 3 had similar numbers of children receiving remedial help in school. However, Group 2 had the largest number of children receiving speech therapy - 12 versus an average of 6 in the other groups. No significant association between speech therapy and group membership was found, however it is worth bearing in mind, that Group 2 had more children with speech problems and this is often a factor in delayed reading and also a co-morbid condition with dyslexia.

It is of course possible that the outcome measure may have underestimated the incidence of dyslexia risk in other groups. The DEST/DST did not pick up 6 of the 11 children with a previous diagnosis of dyslexia and this gives some cause for concern about the validity of these screening tests. But why this should have happened less in Group 2 remains unknown.

To conclude, a number of reasons why Group 2 performed poorly on the dyslexia screening tests has been considered and it is possible that a combination of these is the reason why more of these children were at risk of dyslexia at the end of the study than in any other group. The fact that a fifth of the children were in the lowest age range, nearly half the children in the group had speech problems and over half of the group had poor letter naming skills to begin with, points to a cluster of children who were unlikely to score well on the screening tests. Nevertheless the finding remains enigmatic.

10.3.1 Estimating Attrition Rates

In an attempt to inform other intervention and longitudinal studies on expected attrition rates it is calculated that the sample size may need to be overestimated by at least 45%. Twenty-four percent of the original sample withdrew before the study started. A further 11% either did not begin their programme or abandoned it early on. Eighteen children (10%) did not complete the 120 minimum programme days required. In order to achieve 80% power for a study with four participant groups it is necessary to have a minimum of 39 participants per group. Therefore it is estimated that in future studies it would be necessary to recruit at least 280 participants to allow for combined attrition, slippage and incomplete programmes.

10.4 Failure of Programmes to produce any detectable remedial effect

Another question raised by the findings is whether this study has tested the efficacy of the two treatment programmes given that so little change in the target behaviours was observed over time. One major difference between the current study and previous research (McPhillips et al., 2000; Reynolds et al., 2003) is the age of the participants. The former study participants were aged between 8 and 11 years while the latter were aged between

8 and 10 years. It could be argued that the older children benefited more because of their commitment to, and control in performing their movement programme.

The content of the reflex remediation programme was close to that of the Primary Movement Early Years Programme. The manual and video designed for the programme carefully explained the movements to be performed each evening. In the Lancet study, McPhillips et al. found it difficult to recruit dyslexic children with no retained ATNR in their sample aged 8-11 years. It was surmised that these children may have had a severe form of dyslexia. In the current study there were few children with a high reflex score, and therefore few with retained reflexes at the beginning of the study. This is a possible reason why no treatment effect was found in the reflex inhibition programme. If risk of dyslexia and presence of retained reflexes were low at Time 1, then the reflex programme regardless of its efficacy, would not have shown an effect. Three of the age groups had at least 72% of children with low reflex scores, the only difference was the 4 year olds. In fact of the 9 children aged 4 in Group 1 (reflex remediation), 5 had high reflex scores at Time 1 and 3 had high reflex scores at Time 3 and only one child was at a high risk dyslexia while 3 were at low risk. However, of the 14 children aged 4 in Group 4 (control), 10 had a high reflex scores at Time 1, but only 6 had high reflex scores at Time 3. While this association was not significant, it does show that there was a reduction in scores in both the reflex remediation and control groups. This may be due to the children's development over time. However, it could be possible that because of the make-up of Group 1, the reflex programme may not have had a chance to prove itself!!

The content of the balance training programme was similar but not the same as the DDAT programme. As this was considered commercial it was not available when the current study was designed. The DEYP was not intended as a replication of the DDAT study. In line with developmental theory, movements aimed at improving balance and motor development, and the stimulation of the cerebellum were included. However, it could be argued that the programme content was not specific enough for cerebellar stimulation. Recently, some of the content of the DDAT programme which is made up of somatosensory, visual and vestibular stimulation has been made available (Reynolds & Nicolson, 2007).

The placebo-control programme had face validity, indeed it may have been seen as aiding articulation or muscle control in the face. In the end, only 19 children undertook the placebo programme and in fact were no worse off at the end of the study than children in the other treatment groups. It was made clear to parents that if one treatment proved to be beneficial, all children would be offered this at the end of the study. One drawback with year long intervention programmes is that all programmes will become tedious with

time. Stories were provided to accompany all the programmes in an effort to keep the children interested. Parents were also told that they could make up or substitute their own stories to keep the routines fresh.

10.5 ADHD Findings

As presented in Chapter 9 there was a significant association between the risk of ADHD and risk of dyslexia. This was expected given the existing literature and gives us confidence in our methodology. As children with ADHD are at a higher risk of dyslexia than the general sample, future treatments and research should take account of this. Researchers must take into account the strong possibility of co-morbidity with both speech and attention disorders when designing studies and subsequent treatments, and report the proportion of children with these difficulties in their samples and how their data are to be used. Double-blind trials investigating the effect of balance training on children with both ADHD and dyslexia versus dyslexics only would prove interesting. Reynolds et al. in their 2007 'follow-up' study reported improved attentional ability among the 12 children with a diagnosis of ADHD and among their general sample.

10.6 Theoretical Implications

How do the findings of this study relate to the reading difficulty model proposed in Chapter 4. Nicolson and Fawcett's Cerebellar Deficit Hypothesis proposes that balance problems are a sign of a cerebellar deficit and are found to be associated with dyslexia. The automaticity deficit framework (Nicolson & Fawcett, 1990) holds that dyslexic children show incomplete automatization of key skills including balance, and therefore their need for conscious compensation leads to a reduction in effective mental resources while reading and would also lead to rapid tiring. Reynolds et al. (2003) propose that a balance training programme improves balance skill, attention and reading performance. Previous research argues that aberrant reflexes interfere with motor and oculo-motor development and so impact on the child's academic progress and propose a reflex remediation programme to ameliorate this problem. So do the findings therefore support any aspect of the model in Figure 10.1?

The results support a weak correlation between the motor and phonological subtests.

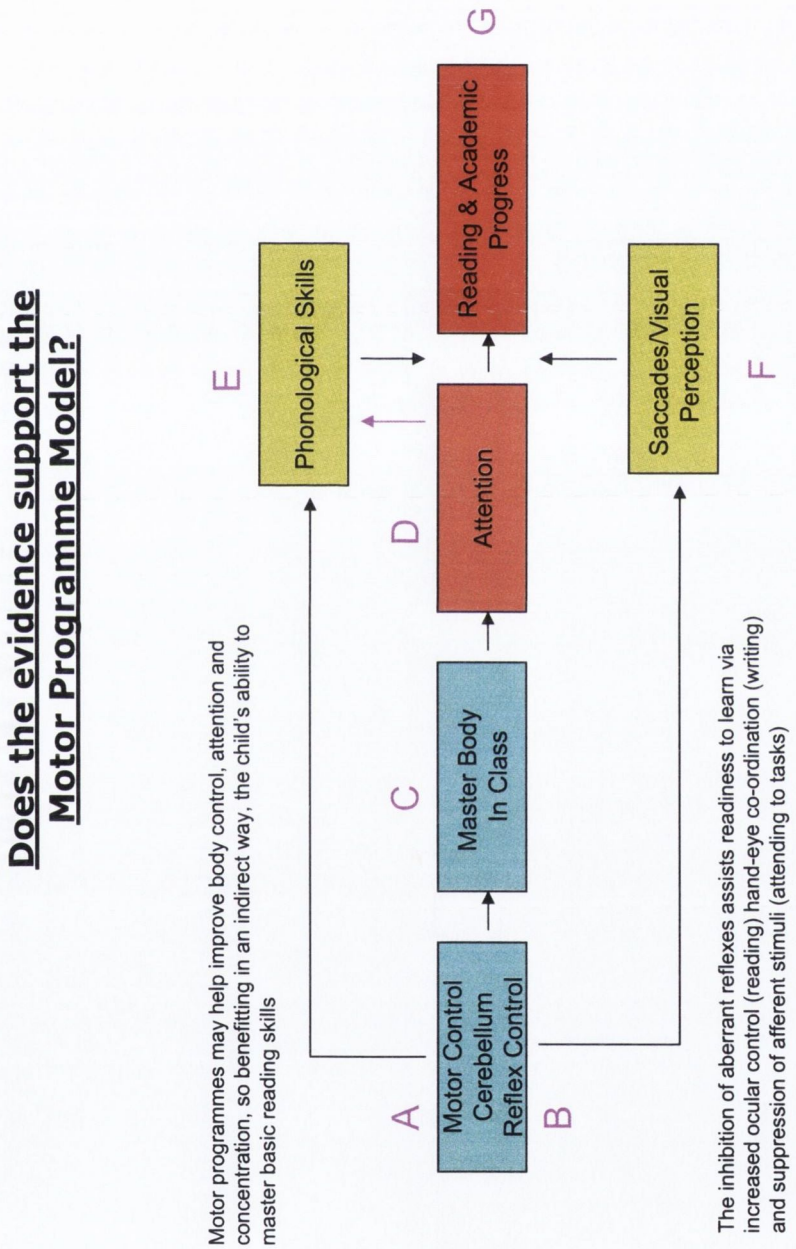


Figure 10.1: *Suggested benefits of Motor Programmes.*

Hence this supports the A to E link in the model. Furthermore, when the phonological subtests were used as outcome measures, balance scores proved to be an initial indicator of phoneme deletion skills for Group 1 and Group 3. Similarly, low reflex scores proved to be a good indicator of letter naming skill in Group 2, and phoneme deletion skill in Group 4.

In contrast the oculo-motor and reflex scores proved not to correlate with either scores for mild or high dyslexia risk and so our results did not support the B/F/G link. However this is not unexpected given the low prevalence of retained reflexes in the sample at the start and the method of administering the oculo-motor test. The link between E and G is expected and indeed supported by the study's findings. Pre-reading skill was measured at 'G' by both the DEST/DST and tests of phonological skill. These correlated well, whereas scores on measures of visual perception were not correlated with performance on reading outcomes, and oculo-motor performance did not improve with treatment. The lack of support for the B/F/G link could be explained because of the age of the participants and suitability of tests as mentioned before. Hence due to the limitations of the ocular tests there is no evidence to exclude the F/G link. Note that D/G is supported however as expected. The ability to concentrate is an important factor when acquiring pre-reading skills. This study found a significant association between ADHD and dyslexia risk (D and G). Future remediation should therefore tackle both difficulties so that levels of attention can be improved before intensive reading programmes are delivered. Whether improved attention can be achieved through general exercise or specific movement programmes is not yet concluded.

While poor motor skill may interfere with the attention a child can harness for learning to read (C and D), claims of transfer of literacy skills due to A or B to G are not supported. The results of this study indicate that children with good balance and no retained reflexes also have good phonological skill, however they do not indicate that training children to improve poor balance skill or remediate aberrant reflexes will improve phonological skill. Key reading skills are phonologically based and while aberrant reflexes and cerebellar deficit may detrimentally effect the acquisition of these skills, they may have no more an effect on them as good nutrition, parental support and quality of teaching. Making, maintaining and accessing phonological representations are crucial for the young child starting to read and whether this can be aided by improved motor control is still to be demonstrated.

10.7 Implications for Other Treatments

What are the implications of the current study's findings for motor and reflex treatments available to dyslexic children?

10.7.1 Reynolds et al.(2003)

Nicolson and Reynolds investigated three broad skills in a 'follow-up' to their 2003 exercise based study (Reynolds & Nicolson, 2007). They cited lasting improvements and cited improvement in physical and mental coordination which included working memory, phonological skill, rapid naming and attentional ability. Improvements in literacy attainment was less clear cut, and there were mixed results on SATs. There were no changes in speeded reading but in age-adjusted reading. Qualifying their claims, Nicolson and Reynolds state literacy was just one focus of the study and that attempts were also made to change the learning capabilities of the participants. However there was no improvement in spelling and this must be a key standard by which a dyslexia treatment is measured.

It is possible that 'affective' factors such as self-esteem, motivation and self-efficacy could be legitimate by-products of their intervention. However these data were not available. It is difficult to assess to what extent improvement is attributable to specific cerebellar stimulation.

However a novel treatment should be judged in comparison to a placebo group. A clinical trial model is not seen as appropriate by Nicolson and Reynolds, they argue that a large placebo effect is rarely seen in education. The DEYP found that on measures of dyslexia and pre-reading skills there was no difference between balance and placebo groups. There was also no difference in the performance of cerebellar tasks. Thus the balance training intervention failed to improve balance.

The lack of evidence for the remedial effect of a balance programme, while employing sound methodology, suggests that criticisms of DDAT claims that their programme leads to improved cerebellar functioning and reading in children, may be justified.

10.7.2 Reflex Remediation Programme: McPhillips et al. (2000)

While the content of the current reflex remediation programme was very close to that of the Primary Movement Early Years Programme which is designed for 3-5 year olds, the movements that the children undertook in McPhillips et al.'s 2000 study may differ slightly as the age group used was older. It is not possible to know for certain as the exact movements were not disclosed in the Lancet publication. A combination of motivated children of an older age group along with exercises targeting more precisely the aberrant ATNR and Moro reflexes may account for the positive findings reported in McPhillips et al.'s (2000) research. This question can only be answered if a direct replication of that study is undertaken.

The findings of this study suggest that it is preferable to offer children either at risk, diagnosed with, or showing early signs of the disorder, conventional intensive teaching methods to improve their reading skills. Despite their time-consuming nature and frustration that may be experienced, the current evidence suggests that literacy challenges will only be delayed, and not avoided, if motor-treatments are exclusively pursued. This does not mean that exercise programmes should be discarded. In conjunction with intensive literacy teaching and practice at home, general or even specific exercise movements during or after the school day can only be beneficial in helping improve motor control, concentration and alleviate tension to enable the child to focus on literacy challenges.

10.8 Other Limitations of this Study

Weaknesses in the tests and programme administration have already been discussed, it is necessary to review some of the other limitations of the study.

Every effort was made to recruit a large enough sample and a strong effect size was adopted by the DEYP. While most of the initial samples met the recommended size for statistical power (i.e. when using Sample S_{136} or S_{118}) by group analysis meant that one group was just below the required number and this is noted in the presentation of the results. Also subsequent removal of participants who were at risk of ADHD meant that the initial groups in Sample S_{89} and S_{29} were reduced in size. It is possible that there were group differences which could not be detected and this can only be ascertained by replicating the work using larger samples. For example, p levels which approached significance were noted across the analyses (e.g. $p = 0.074$ and $p = 0.073$), see * in Appendix P. Using a

larger sample would also enable analysis of boys v girls and school/private programmes v home programmes.

In order to avoid continuous sample slippage, those parents who wished to continue in the study, but did not have the time or found it too arduous to undertake them, were moved into the control group. It may be that these children had fewer problems or less risk of dyslexia which affected their parent's motivation for starting the programme. If this was the case it would explain why the higher risk children remained in the balance group, but it does not account for the finding that the reflex and placebo-control groups were no different to the control group as they were subject to similar slippage.

Two other major points were the lack of IQ data and no dyslexia screening at Time 1. Even though it would be desirable to control for low IQ and related poor reading, it was not possible to administer IQ tests to the children participating in the study due to time constraints. The assessment already took up to an hour and the children's concentration was starting to wane. A full IQ test could take more than an hour and although subtests could have been used in lieu, staff resources made it logistically impossible. Calling the children back on a different day also did not prove feasible as there was a full timetable of motor tests scheduled for up to two years. Also it would not have been appropriate to expect families to travel long distances again (children travelled from all over the country) for a second set of tests at Time 1. It was felt also that to request this attendance would lead to an increased withdrawal rate at the start of the study. It was hoped that random allocation of children would control for IQ differences between the groups. There is no way of knowing whether or not this was the case. However judging from the children's scores on the vocabulary subtest on DEST very few had difficulty and so low IQ was not an obvious factor in the sample.

The use of an abbreviated IQ test, or a test of vocabulary, which is highly correlated with IQ levels (Carver, 2000), is recommended for future work. Scores from the Vocabulary subtest on the DEST-2 could have been used to determine IQ levels, however there was no Vocabulary subtest available on the DST. This has now been amended with the publication of the DST-J which includes both vocabulary and rhyming subtests for the 6.6-11.5 age range (Fawcett & Nicolson, 2004b).

10.8.1 Dyslexia Screening Tests

The DEYP compared children from dyslexic families in four randomly assigned groups on one main outcome variable. Although a pre-post design was employed on the motor and phonological tests, this was not done on the dyslexia measures. This is a major limitation, however the study team had little choice because of the age of the children and lack of staff and financial resources. Further research could still use pre-school children but ensure that the lower cut-off age was 4.5 years if the DEST was to be used. This may have to be administered on a separate day to elicit a reliable assessment of the child although this would create logistic difficulties in terms of manpower, time and attendance for the families. An alternative to the DEST for the younger age group is the Pre-School Early Screening Test (PREST) designed for children aged 3 years, 6 months to 4 years, 5 months (Fawcett, Nicolson, & Lee, 2001).

Evidence has been reported of the predictive validity of the DEST (Nicolson & Fawcett, 2004). However this work has not been replicated to date, particularly on an Irish sample. The current study identified 30-40% of the sample as being at risk for dyslexia (depending on the criterion used). This is in line with expectations from previous research (Gilger et al., 1991). In the current work, it appears that the motor-based interventions had no effect on reducing the risk of dyslexia as measured on the DEST/DST. However poor performance on motor-based tests correlated with 'at risk' status for dyslexia. These interpretations are based on the ability of the DEST/DST to correctly identify the risk level of the child. If the DEST/DST failed to identify those at risk of dyslexia satisfactorily, then there is no way of evaluating the validity of the predictors, or the interventions in the DEYP. In fact only 6 of the 11 children diagnosed before starting the study were picked up by the DEST/DST and this is of some concern.

The predictive validity of the DST is not known, future work could include data relating to an Irish sample. It was hoped that by the end of the study official diagnoses for a large number of children would be available. This would allow chi-square analysis to be used to investigate these questions. However, to date only 11 children have had a full psycho-educational assessment. Ten of these have been diagnosed as dyslexic. This does not provide a large enough number of fully-assessed non-dyslexic children to use in a chi-square analysis. Although parents are generally aware if their child is having difficulties, however if they were a first child, they may not have been sent for a psychoeducational assessment until they were failing to read in school. Those who have made contact with

private or NEPS [2] psychologists are on waiting lists, which can be up to a year long. It is hoped to maintain contact with parents and collect this data, so that such results will be available within a couple of years.

Alternative methods of early screening are Nathalie Badian's early screening battery which comprises phonological processing and motor skill but is several hours long (Badian, 1994). The Cognitive Profiling System (COPs) is a computer based battery which includes a variety of tests of phonological skill and memory span but is normed on 4-8 year olds (Singleton, Thomas, & Leedale, 1996) and so would not have been suitable for the younger age range.

10.9 Conclusion

In contrast to the claims outlined in Chapter 4 made by Brain Gym, INPP, McPhillips et al. and DDAT that motor intervention programmes remediate motor difficulties, the current study found that in evaluating balance training and reflex remediation programmes there was no evidence of this. Indeed the programmes failed to accelerate any motor improvement. The findings of the Dyslexia Early Years Project do not support the idea that early motor training has an effect on motor difficulty let alone phonological difficulties.

The Dyslexia Early Years Project did not find any treatment effect on dyslexia risk or significant improvement in balance skill or reflex remediation. In trying to account for the positive findings in previous research it should be noted that in both the McPhillips et al., and Reynolds et al. studies, children were aged between 8 and 11 years, and 8 and 10 years respectively. These children may have been more proactive in taking responsibility for their individual programmes both at home and at school. At this age they were also failing to read - approximately two years behind peers - and so motivation for accurate compliance with the programmes would have been high. In the case of the DEYP, there was a younger age range and children involved may not have yet experienced failing to read and so could not see a purpose to the programmes. It may also have been the case that compliance may have been comprised as parents tried to supervise both an exercise programme and other children doing homework in the evenings.

Two main questions are raised by Kavale and Mattson (1983) in relation to intervention

[2]National Educational Psychological Service' part of the Irish Government's Department of Education and Science

studies: 1. Does it work? and 2. Does it cause undue harm, financially, emotionally or by removing the child from a better learning environment? Firstly, while the limitations of the current study are acknowledged, the design of this study was sound and the sample size deemed adequate, it is felt that the claims made by such treatments should be cautiously considered in light of current evidence. The response to the second question depends on the client's feelings about the cost and time invested in a commercial treatment programme. Parents and teachers would be advised to consider carefully the results of this study before committing children to the programme, as such time, money and emotional investment could be spent on a more useful pursuit of improvement in literacy.

In relation to a screening test, the findings of the Dyslexia Early Years Project do not support screening children for motor problems between the ages of 3 and 7 years to predict dyslexia. It would be prudent, nevertheless, to avail of phonological screening of those children who may be at risk of developmental dyslexia.

Although the current study casts doubt about the use of motor or reflex programmes in the treatment of dyslexia, the cerebellar deficit hypothesis and reflex theory should not be rejected outright. Both are descriptive theories and allow for different levels of impairment, from the genetic to the neurobiological, cognitive and behavioural, thus fitting Frith's three level frame work (see Figure 2.1). More precise cerebellar research may be able to examine the role of inhibition, either by directly measuring relevant neurotransmitters associated with the cerebellum or indirectly measuring behaviours associated with inhibition.

The fact that there is evidence that older children with retained reflexes and weak balance skills are remediated and show improvement on motor and reading measures is still an enigma. However, from this research there is no evidence to indicate that it is possible to accelerate either loss of retained reflexes or improvement in balance skills in younger children. These seem to develop at a normal rate independently of the experience provided by these two treatments. So the wider development issue is that perhaps it is the longer term retention of reflexes and failure to obtain balance skills beyond the age of 10, that interferes with reading acquisition. However to date there is no evidence that reading and motor difficulties have a common source.

10.10 Recommendations for Future Work

Further analysis of the rich dataset could include investigating the performance of the outliers on the test battery over time to investigate whether those who scored poorly made any improvement or were at risk of dyslexia at Time 3. Similarly, analysis of the individual scores of those children who scored highly on the ATNR at Time 1 may reveal further findings.

As the data contains scores on the DEST/DST of 136 children, further examination of the reliability and validity of the DEST and DST could be undertaken. In particular the validity of the balance measure is often questioned and in our experience there was very little variation in any of the children's scores on this measure. In addition, the follow up of these children as they get older could explore such factors as the relationship between the retention of a high ATNR and dyslexia status and scores on the DEST and later diagnosis.

One main point to come out of this work is the difficulty in undertaking intervention studies. Many things can be learned from this study and it is important to highlight pitfalls in order to prevent researchers repeating mistakes in research in this area. Care must be taken when testing younger children to ensure that age appropriate tests are used. Tests should be piloted for sensitivity and validity as many are not normed. Expert guidance from, and collaboration with, other research groups is necessary for the design of programmes targeted to stimulate the cerebellum or remediate reflexes. More control over programme delivery is necessary and there are arguments for delivery by specialist therapists and more frequent contact with the children over the duration of their programme.

This study employed a strong design and confirms some previous findings in the literature. However problems in repeatability of motor and reflex findings points to a question over the sensitivity of the tests and the problem of the reliable measurement of movement. Recording movement on video is clearly useful as part of the scientific process of assessment. That facilitates multi-observer rating as well as video analysis of motion. The DEYP has shown that the use of video recording must be accompanied with some smart method of browsing in order to reduce observer fatigue. However, as was mentioned previously the scale of movement rating is subjective, not continuous, and certainly non-linear. The change in observed motion that is represented by a change in score from 2 to 3 for instance is much smaller than 4 to 5. To avoid this problem it is possible to propose video

processing analysis for tracking body motion. This can be achieved either invasively with markers attached to the joints of the participants or non-invasively with image based motion estimation. Some efforts in this direction were taken during the course of this work in collaboration with www.sigmedia.tv. That attempt used a single camera view to track motion and yield a score based on the motion and orientation of the body in pixels per second. However the score was too noisy for any conclusions to be drawn. We expect that multi-view analysis should improve the situation. Nevertheless it is that kind of work that can bring a much needed objective assessment process to bear on studies such as this. It holds the potential to remove the doubt over scoring scale linearity and increase repeatability.

It would be useful to investigate individual cases in different age ranges (3-5, 5-7, 7-9, 9-11) following both reading and movement programmes, as anecdotal evidence is sometimes strong. Also it would be possible to administer age appropriate screening and pre-reading, reading and IQ tests, to take account of developmental changes. Large scale studies work on average scores or difference scores and so do not follow the individual changes closely.

Exercise programmes should always be complimentary to reading programmes. Continuing multi-disciplinary research is important in the areas of speech, dyslexia and ADHD. Possible future research could investigate dyslexic children's performance on both intensive reading programmes and motor programmes daily over the school year, with one group undertaking an intensive reading programme only. Pre- and post measures on a standardised reading test should be used and co-morbid conditions such as speech, ADHD, dyspraxia, autism should be noted and investigated. IQ levels should also be noted along with any remedial or extra-curricular activities the participants may be involved in. While the difficulties of undertaking a large scale intervention study are acknowledged, sample size should be large enough for adequate power among the groups when confounding samples are removed.

There are many reasons for dyslexia, and perhaps many we do not yet know about. Unfortunately with this type of research there are variables that cannot be controlled for such as past nutrition, exposure to toxins in the womb, and perhaps unknown inherited factors. However we must not lose sight of the fact that some children will continue to fail to read and this will have an adverse affect on their potential in life. This alone motivates continuing work in the area despite difficulties with controlling the variables. Therefore, collaborative research, new methods of investigation, and testing of theories, are all to be welcomed so the foundations of what we know can be built upon. The DEYP has been able to corroborate previous findings as well as quantify new relationships between

possible indicators and Dyslexia. The use of new technology for facilitating video analysis of such a large body of participants is also a novel contribution. It is hoped that the study has been able to continue the trend in understanding the elusive condition known as Dyslexia.

Evaluation of Movement Programmes in the Treatment of Dyslexia

APPENDICES

A dissertation submitted to the University of Dublin
for the degree of Doctor of Philosophy

Erika Doyle
Trinity College Dublin, March 2008

Dyslexia Research Group
School of Psychology
Trinity College Dublin



A

Letter to Schools

Dyslexia Research Group
01-608 2095

October, 2003.

Dear Principal

Re: Dyslexia Early Years Project

The Dyslexia Research Group within the Department of Psychology at Trinity College, Dublin has launched a year-long study into dyslexia. The study is to focus on the different motor treatments that are currently available, some of which are sold as commercial treatments without having been extensively scientifically tested.

For our research study we are contacting parents of young boys between the ages of three and six years who have someone in the family with dyslexia or chronic reading or spelling difficulty.

In order to do that we would be most grateful if you would pass on the enclosed advert and information sheet to the parents of dyslexic children or children with reading and spelling difficulties in your school. This way we may be able to access their younger male siblings. We are also being assisted by the Dyslexia Association of Ireland in contacting relevant families around the country. Interested parents can contact us directly for additional information.

Please refer to the website: **www.dysvideo.org** if you need to download additional copies of our advert and information sheet for your parents. If you have any queries, or need us to send on the information electronically, or simply wish to know more about the study please do not hesitate to contact us via the following:

Elaine Smith esmith@tcd.ie
Erika Doyle edoyle4@tcd.ie

or telephone us during normal office hours on **01-608 2095.**

Many thanks for your help.

Yours sincerely

Erika Doyle
Elaine Smith
Dr. Ray Fuller - Supervisor

DYSLEXIA

Reading / Writing difficulties?

Your participation in an experiment is needed!

The Dyslexia Research Group, located in the Department of Psychology, Trinity College, Dublin, has launched a 1 year experimental study into dyslexia and its treatment.

We are contacting families with children aged 3-6 years, where older brothers/sisters or parents suffer from either dyslexia or reading and spelling problems. Our study aims to recruit 400 **boys** between 3-6 years. However it is possible that in the near future boys aged 6+ and girls in the 3-6 year age range may be able to participate.

Our aim is to evaluate 3 different potential treatments for dyslexia, designed for young pre-school or early-school children. These treatments (versions of some of them cost well over 1000 Euro) may alleviate the problems associated with dyslexia and our aim is to determine which, if any, of these treatments will be effective. It is of course possible that none of them may be.

Participation in the study may involve a regular commitment of about 10 minutes each day over a period of approximately one year.

Contact Details

For further information or involvement in the study please contact:

Ms. Erika Doyle at edoyle4@tcd.ie or
Ms. Elaine Smith at esmith@tcd.ie or
telephone us during normal office hours on 01-6082095.

B

Parent Pack

Dyslexia Research Group
Dept. of Psychology
Aras an Phiarsaigh
Trinity College
Dublin 2.

Tel: 01-608 2095

Date

Dear

Thank you for your call today. Please find enclosed a parent pack which includes:

- Questionnaire
- Consent Form
- Disclaimer Form

If you wish your child to take part in the study please fill out the two forms and questionnaire and return them to us. We shall then contact you with an initial assessment date for your child.

Please do not hesitate to contact us if you have any further questions in the mean time.

Yours sincerely,

Erika Doyle

Information Sheet for Parents of Participants

Title of the study: Dyslexia Early Years Project

Researchers: Elaine Smith, BSc (Psychology), Erika Doyle, BA (Psychology)
Research Supervisor: Ray Fuller, MA, PhD, FPsSI, FTCD, MESI

Dear Parent,

We are conducting a longitudinal study, designed to look for early indicators of dyslexia in very young children and to assess a number of remedial interventions. We are hoping to recruit 400 boys between the ages of 4 and 7 years and girls if they are presenting with difficulties, to take part in a study over a one year period. As dyslexia is thought to be a genetic problem (i.e. one that runs in families) we are looking for children from families in which someone has been diagnosed as dyslexic or where there is at least one person with experience of a chronic difficulty with reading and or spelling. We are particularly interested in boys because the prevalence of dyslexia is about three times greater in boys than in girls.

Participant children will be initially assessed in order to determine whether or not they retain certain movement reflexes and to determine their balance skills. They will then be assigned to one of four groups. Three groups will perform different movement exercises with a parent for 10 minutes each evening. One group will be asked to defer implementing any intervention for about 12 months, by which time we should have evidence as to which intervention works best. The parents will then be instructed in that intervention, should they so wish.

As the parent/carer of the child you will be responsible for ensuring that a series of head, arm and leg movements or a balance programme is performed by your child during each session. In addition you will be asked to mark a record sheet, indicating that a session has taken place. We would like you to continue with your movement/balance programme for 12 months. However at 6 months your child will be re-assessed and for some children (perhaps even all) we may suggest that continuation of the programme will not be necessary. In any event, all participant children will be invited back at 12 months for a final assessment.

We appreciate that commitment to this study is a big decision. The main effort involved is the twelve months in which the exercise programmes are taking place. It is extremely important that these exercises are done every night for about 10 minutes during the study period. This information will be most valuable in increasing the knowledge we have of learning disabilities. Having said this, if you do get involved and subsequently feel unhappy being part of this study, you are, of course, at liberty to withdraw at any point that you wish.

If you do feel you would be interested in becoming involved in the study you would be making a great contribution to the knowledge of dyslexia in general as well as being of potential help to your own child's development.

This project satisfies the requirements of the Department of Psychology Ethics Committee and is consistent with Ethical Guidelines of the Psychological Society of Ireland. If you have any queries regarding this study please contact us or our supervisor, Dr. Ray Fuller, at the address below.

Yours sincerely,

Elaine Smith, BSc (Psychology)
Erika Doyle, BA (Psychology)
Department of Psychology
Trinity College
Dublin 2.

Tel: 608 2095/608 2426
Fax: 671 2006

SCREEENING QUESTIONNAIRE

Section 1: General

(1) Son's Details

(a) Surname: _____

(b) Forenames: _____

(c) Date of Birth (dd-mm-yyyy): | | | | | | | | |

(d) Age: | | (Years) | | (Months)

(2) Parent's Details

(a) Surnames
Mother: _____
Father: _____

(b) Forenames
Mother: _____
Father: _____

(3) Contact Information

(a) Address: _____
_____
_____

(b) Phone no: _____

(c) E-mail *(if available):* _____

(d) Mobile *(if available):* _____

Section 2: Child participating

(4) **Child's Developmental History**

(a) The following are a list of the normal motor stages through which a child should pass.
Please tick the box if your child *left any of them out.*

- Rolling (front to back) ☐
- Rolling (back to front) ☐
- Creeping on tummy ☐
- Crawling on hands and knees ☐
- Sitting alone ☐
- Standing alone ☐
- Walking ☐
- Running ☐
- Jumping ☐

(b) If he did not leave any of the previous stages out, what age, in months, was he when he began showing the following behaviours?

- Creeping on tummy ☐
- Crawling ☐
- Sitting alone ☐
- Walking ☐

(c) At what age, in months, was he when he began demonstrating the following language abilities?

- Imitating sounds (e.g.ma, da): ☐
- One word expressions: ☐

Babbling: ☐

Two word 'sentences:' ☐

Three or more word 'sentences:' ☐

(d) Does he know any nursery rhymes? ☐ Yes ☐ No

(e) Does he learn nursery rhymes easily? ☐ Yes ☐ No

(5) Child's Medical History

(a) Does he now or has he ever suffered from any of the following?
Please tick those that apply.

Feeding Problems: ☐

Sleeping Problems: ☐

Hearing Problems: ☐

Visual Problems: ☐

Speech Problems: ☐

Allergies: ☐

Asthma: ☐

Epilepsy: ☐

Other: ☐

Please give details of any of the above:

_____

_____

_____

_____

(6) Child's General Behaviour

(a) Does your child display any of the following behaviours?
Please tick those that apply.

- Unusual fussiness ☐
- Difficulty to control ☐
- Little interest in exploring his environment ☐
- Resistance to being held or cuddled ☐
- Over-activity ☐
- Under-activity ☐
- Poor posture ☐
- Poor attention ☐
- Poor balance / Clumsiness ☐
- Frequent falling ☐
- Fidgeting ☐
- Bed-wetting ☐
- Other ☐

Are there any details you wish to add regarding any of the above?

_____

_____

_____

_____

Section 3: Family member with reading/spelling difficulties

(7) Other Family Member

(a) Please specify the other family member who suffers from some form of reading/spelling problem.

Please tick the box that applies.

☐ Mother ☐ Sister

☐ Father ☐ Brother

(b) Has their problem been formally diagnosed as dyslexia by an educational psychologist / agency?

☐ Yes ☐ No

(c) If yes, who was the psychologist / agency who diagnosed the dyslexia?

_____

_____

_____

_____

(d) If no, please specify what it is that suggests this person has a reading / writing problem? Please give details.

_____

_____

_____

_____

Consent Form

Dyslexia Early Years Project

Dear Parent,

As part of our post-graduate doctoral degrees in psychology we (Ms. Elaine Smith and Ms. Erika Doyle) are conducting a long-term study of the motor (i.e. movement) development of children in relation to specific learning difficulties. We are inviting families to take part in our research who feel they are capable of making the commitment necessary for involvement in the study (see attached information sheet) and who meet some other necessary criteria.

The first part of this study will involve a forty minute assessment of your son's physical reflexes and balance skills. Your child will be videotaped whilst completing these elements, to enable later analysis.

If you wish to permit your son to take part in this phase of the study, please sign the consent form below and return to us as soon as possible. Our study satisfies the requirements of the Department of Psychology Ethics Committee and is consistent with Ethical Guidelines of the Psychological Society of Ireland.

Please note that if your child does become involved in the study he will remain anonymous in all reports and confidentiality of individual data is assured. Videotaped material will remain the property of the Department of Psychology and will not be released to any other researcher without your express permission.

Finally, you are at liberty to withdraw your child from the study at any point, should you so wish.

Elaine Smith, BSc (Psychology), Erika Doyle, BA (Psychology), Dr. Ray Fuller, MA, PhD, FPsSI, FTCD, MESI (Research Supervisor)
Department of Psychology
Trinity College
Dublin 2.
Tel: 608 2095/608 2426
Fax: 671 2006

I do wish my child to take part _____

I do not wish my child to take part _____

(Please tick one)

Signature of parent or guardian:

_____

Date _____

Dyslexia Early Years Project

This is to confirm that I agree to my child participating in the Dyslexia Early Years Project at his own risk and that I shall not hold Trinity College Dublin or any of its agents liable for any injury associated with that participation

Signed: _____

Date: _____

The Dyslexia Early Years Project satisfies the requirements of the Department of Psychology Ethics Committee and is consistent with Ethical Guidelines of the Psychological Society of Ireland.

DYSLEXIA

Reading / Writing difficulties?

Your participation in an experiment is needed!

The Dyslexia Research Group, located in the Department of Psychology, Trinity College, Dublin, has launched a 1 year experimental study into dyslexia and its treatment.

We are contacting families with children aged 3-6 years, where older brothers/sisters or parents suffer from either dyslexia or reading and spelling problems. Our study aims to recruit 400 **boys** between 3-6 years. However it is possible that in the near future boys aged 6+ and girls in the 3-6 year age range may be able to participate.

Our aim is to evaluate 3 different potential treatments for dyslexia, designed for young pre-school or early-school children. These treatments (versions of some of them cost well over 1000 Euro) may alleviate the problems associated with dyslexia and our aim is to determine which, if any, of these treatments will be effective. It is of course possible that none of them may be.

Participation in the study may involve a regular commitment of about 10 minutes each day over a period of approximately one year.

Contact Details

For further information or involvement in the study please contact:

Ms. Erika Doyle at edoyle4@tcd.ie or
Ms. Elaine Smith at esmith@tcd.ie or
telephone us during normal office hours on 01-6082095.

C

Retrospective Questionnaire

D.E.Y.P.: Retrospective Questionnaire

Child Name: _____ Date of Birth: _____

Section 1: Doing the Programme

Please answer the following questions as accurately and honestly as possible. There is no "right" answer; we are simply interested in how practical you found these programmes.

- Did your child participate in a movement programme?

  YES [ ] *Please continue this section*

  NO [ ] *Please skip to Section 2*

- On average, how many days per week did your child do the movements?

  Please indicate 1-7---------- [ ]

- Approximately, for how many minutes each day did your child engage in the movements?

  2-4 minutes [ ]

  4-6 minutes [ ]

  6-8 minutes [ ]

  8-10 minutes [ ]

- Regarding the quality of the movements, please tick the box which you feel applies most to the way you and your child did the movements.

  Usually rushed through them----------[ ]

  Sometimes rushed them / sometimes slow and controlled ----------[ ]

  Most of the time slow and controlled way, but occasionally rushed -----[ ]

  We usually did them in a slow and controlled way----------[ ]

- Child's motivation for the exercises?

  He / she was happy to do them----------[ ]

  He / she was not always happy about it----------[ ]

  It was difficult to get him / her to do them----------[ ]

- Were there any family or personal difficulties which interfered with participation in the programme? *Please state YES or NO; you may give reasons only if you wish to do so.*

  _____

D.E.Y.P.: Retrospective Questionnaire

- Were there any difficulties in learning / teaching the programme to the child? If so, what?

  _____

- Was the video helpful?

  _____

- Were the storylines helpful?

  _____

- Do you have any suggestions for making the programme more appealing to the child?

  _____

- How did you fit the movements into your child's daily routine?

  _____

- Please tick if you wish to avail of another programme used in this study. **YES [ ]**
  NO [ ]

Section 2: Other Activities

The following questions concern other activities your child might have been involved in over the last year. Please respond to those which apply.

- Sport: If your child has been involved in any sport (e.g. swimming, gymnastics, football, dancing), please list what they were and for how long they were involved in them.

Sport (e.g. tennis)	How long? (e.g. 1 month)	How often? (e.g. once a week)
1.		
2.		
3.		
4.		
5.		

- School / Academic Help: If your child was involved in any clubs or groups which focussed on school related work (e.g. remedial classes in school, private tutoring, language classes), please list what they were and for how long they were involved in them.

Group (e.g. remedial help)	How long (e.g. school year)	How often? (e.g. once a week)
1.		
2.		
3.		
4.		

- Other Specialised Help: If you child received any other help specifically to do with any developmental problems, please give details (e.g. Speech & Language therapy, DDAT, Primary Movement, Neuro-developmental Therapy (NDT)).

Help (e.g NDT)	How long (e.g. all year)	How often? (e.g. once a week)
1.		
2.		
3.		
4.		

- Other Extra-Curricular Activities: Please give details of any other *regular* extra-curricular activities your child might have engaged in (e.g. music lessons) and for how long they were involved in them.

Activity (e.g. music)	How long (e.g. all year)	How often? (e.g. once a week)
1.		
2.		
3.		
4.		

Section 3: School Attendance

- Has your child received any schooling, be it pre-school, primary school or otherwise?

  No schooling at all yet----------[ ] ***Skip to Section 4***

  Number of years child has spent in pre-school (e.g. Montessori)------[ ]

  Number of years child has spent in primary school----------[ ]

D.E.Y.P.: Retrospective Questionnaire

- In the past year, how regular has your child's attendance in school been? *Please tick box which applies.*

  Missed 0-2 days----------**[ ]**
  Missed 3-5 days----------**[ ]**
  Missed 6-20 days----------**[ ]**
  Missed more than 20 days----------**[ ]**

Section 4: Medical & Family

- Have there been any medical problems since the study started (in addition to anything mentioned in the first questionnaire)?

  _____

- Have there been any diagnoses of any of the following?

  Dyslexia [ ] **Dyspraxia [ ]** **ADHD [ ]**
  ADD [ ] **Autism [ ]** **Other [ ]** *Please specify* _____

- Any other speech/hearing problems?

  _____

- Is the child taking 'EyeQ'?_____

- Is the child taking other medication or supplement? _____

- Please comment on whether you think your child has progressed over the last year in terms of reading, balance or attention.

_____
_____
_____
_____

D.E.Y.P.: Retrospective Questionnaire

Are there any other comments you would like to make?

_____

_____

_____

_____

_____

_____

----------**END OF QUESTIONNAIRE-THANK YOU**----------

OFFICE USE

Child ID:_____

Initial Group [ ]
End Group [ ]

If changed group, how much of initial programme did they do (in weeks)? [ ]

Age child started study:_____ Finished:_____

Manual returned: ☐

Video returned: ☐

Cert.: ☐

T-shirt: ☐

Report: ☐

Further Programme: ☐

R-Questionnaire entered: ☐

D

Random Group Assignment

Random Group Assignment

(Start LH column, go downwards, then move to RH column)

3	3	2	2	3	1	3	3	3	2	2	2
	3	1	4								
4	3	1	3	1	1	3	1	3	4	3	4
	3	1	1								
3	1	4	2	3	2	2	4	3	1	4	4
	2	3	2								
3	2	2	3	4	2	4	2	2	3	1	1
	1	3	1								
1	3	2	1	3	4	2	1	4	1	4	3
	2	3	2								
1	1	2	3	4	1	2	4	3	1	4	3
	3	2	2								
1	1	2	2	4	3	1	2	3	2	1	4
	1	1	1								
4	4	1	1	3	3	2	2	4	4	2	4
	2	3	2								
1	3	3	2	2	2	4	2	1	2	4	2
	3	3	3								
2	3	4	1	2	4	1	4	1	2	4	3
	1	4	3								
2	2	2	4	2	1	4	1	4	2	2	2
	4	2	4								
2	2	1	2	1	3	3	4	2	4	3	2
	4	4	1								
3	4	2	3	2	2	4	3	1	2	3	2
	4	2	1								
2	2	1	1	4	1	4	3	3	4	2	2
	1	1	4								
3	3	1	4	3	1	1	2	3	4	3	4
	3	4	4								
2	4	2	2	2	3	1	2	1	3	1	2
	1	4	2								
4	3	1	4	1	2	2	2	3	3	4	3
	1	3	1								
4	1	2	1	2	1	2	3	3	1	3	2
	2	2	4								
2	3	4	3	4	2	4	2	4	1	1	1
	1	2	3								
4	2	4	3	2	1	2	1	1	1	2	3
	2	4	2								
4	2	2	1	2	2	3	4	3	3	1	3
	4	2	4								
1	4	4	2	3	2	2	2	3	2	2	4
	2	1	2								
3	2	3	3	2	2	1	4	4	1	3	3
	1	3	1								
3	2	1	4	2	1	3	1	4	3	4	1
	3	2	4								
4	3	4	2	1	2	4	2	2	3	3	3
	4	3	4								
4	2	3	4	4	2	2	1	4	2	1	3
	4	4	4								
1	1	3	1	4	3	2	1	3	2		

E

Test Battery

TEST PROCEDURE

A. Balance Tests: **Video**

Palm Pilot tones:		**End**
01	One Leg Balance	#
02	Advanced Romberg	#
03	Tandem Walk	#
04	Walking on Tiptoe	#
05	Slalom Walk	#
06	Hopping on the spot	#
07	March and about turn	#
08	Crawling on all fours	#

Errors: *

B. Reflex Tests: **Video**

Palm Pilot tones:		**End**
09	ATNR: Lying Down	#
10	ATNR: Table position – front view	#
11	STNR: Table position – side view	#
12	ATNR: Standing - front view	#
13	TLR: Standing - side view	#
14	MORO: Standing - side view	#

Errors: *

C. Oculo-Motor Functioning Tests:

15. Visual tracking
16. Hand-Eye Tracking
17. Fixation with Eyes
18. Near Point Convergence and Re-establishment of Binocular Vision

D. Motor/Adiadochokinesia Tests:

19. Fingers to nose
20. Heel to shin
21. Finger tapping (rapid alternate movement)
22. Palm reversal
23. Incy Wincy spider

E. Phonological Tests:

24. Letter Name Knowledge
25. Phoneme Deletion
26. Non-Word Repetition

Administration:

- Arrange next appointment.
- After 1st test session scoring in conjunction with video
- Randomize into groups
- Within 3 weeks send out video and manual if in treatment group, notification of new appointment

BALANCE TESTS

Dynamic Balance and Leg Dominance

Let the child choose the dominant leg by asking the child to run up to a small ball and kick it 5 times.

Note which leg is used to kick the most.

- ☐ Right
- ☐ Left

01 - #

ONE LEG BALANCE

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 seconds practice.

With eyes open bend the knee and lift the foot off the ground.
Count seconds.
Repeat for other leg.

Standardization for age groups:

3 year old:	Place arms out at shoulder height to balance, lift foot off floor in front of body.
4 year old:	Place arms out at shoulder height to balance, lift foot off floor in front of body.
5 year old:	Place hands on hips, lift foot off floor in front of body.

Scoring:

Time in seconds: Left foot _____

Right foot _____

1 Perfect rock solid – 5 seconds at 4 years, 6 seconds at 6 years
2 Slight wobble, 20% elevation of hands
3 Sway, hands moving
4 Puts foot down within 5 seconds
5 Unable

Kohen Raz: cites Bayley 1969:
75% of 3 years olds: 3 seconds

Goddard 2001: Developmental Test Battery for use with Pre-school children
Schrager, O. (need ref)
2 years: 3 seconds
3.5- 4 years: 8 seconds
6 years: 10 seconds

Holt, 1991: Mean duration of one leg stand:
3.5 years: 2 seconds
4 years: 4-8 seconds
5 years: over 8 seconds)

Folio & Fewell, 2000, Peabody Developmental Motor Scales:
37-42m: 5 seconds
55-60m: 10 seconds

Mann Test (Advanced Romberg)

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 seconds practice.

The child is to stand heel to toe with eyes open.
Repeat for eyes closed.

Standardization for age groups:

3 year olds:	Place arms out at shoulder height to balance
4-5 year olds:	Hands on hips

Scoring:

Eyes open	_____seconds
Eyes closed	_____seconds

1 Perfect rock solid (8 secs)
2 Feet wobbling
3 Sway, hands out
4 Steps out of position within 8 seconds
5 Unable

(Kohen Raz: cites Bayley 1969:
Eyes open
50% of 5 year olds: 15 seconds
75% of 6 year olds: 15 seconds

*Eyes closed (**Kohen Raz 1984**)*
25% of 6 year olds: 10 seconds

TANDEM WALK

Gross Muscle Co-ordination

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 practice steps.

The child is to walk heel to toe for 10 steps along a 4ft x 4 inch line.

Standardization for age groups:

Under 5: hands out and allowed to look down, not necessarily heel to toe, forwards only.

6 year olds: place hands on hips, walk heel to toe, forwards and backwards.

Stop counting steps immediately a foot comes off the line.

Scoring:

Forwards _____ steps
Backwards _____ steps

1 Perfect 10 steps
2 Cannot do heel to toe over 5 years despite correction
3 Major wobble
4 Under 10 steps/unable to keep foot on line
5 Foot down on first step/unable

Folio & Fewell, 2000, Peabody Developmental Motor Scales:
37-42m: with hands on hips and without heels touching toes walks forward 4ft on 4'' line without stepping off (8ft without swaying 20%).

49-54m: with hands on hips, toes touching heels walks backwards for 5 steps without stepping off.

04 - #

WALKING ON TIPTOE

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 practice steps.

Place coloured line on floor.
Child to walk up to 10 steps on tiptoe.
Allowed to look down.
Stop counting if child comes off line or heel goes down.
From 5 years try backwards aswell.

Standardization for age groups:

3 year old:	Place arms out at shoulder height to balance.
4 year old:	Place arms out at shoulder height to balance.
5 year old:	Place hands on hips.

Scoring:

Forwards _____ steps
Backwards _____ steps

1 Perfect (10 steps)
2 Cannot take small steps, large steps only/shuffle backwards
3 Sway 20%
4 Unable to stay on tiptoe (less than 10 steps)
5 Foot down on first step/Unable

Norms
Holt 1991: *Walking along line 25mm wide, 3m long*

2.5 years: not more than 3 steps off
3 years: no steps off

Folio & Fewell, 2000, Peabody Developmental Motor Scales:
25-30m: with hands on hips, without heels touching floor walks 5 steps.
31-36m: with hands on hips, without heels touching floor walks 8ft on 4'' line.
49-54: Arms overhead, without moving feet, stands on tiptoes.

Check Kohen-Raz for age of backwards

SLALOM WALK

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 practice steps.

Use diagonal line on floor
Child stands to left of line with hands on hips and lifts leg at knee and places foot on other side of line
Child to walk up to 10 steps
Allowed to look down
Make sure child understands instructions
Make sure testers steps are not too large
Stop counting if foot does not cross line, child overbalances and puts foot down

Scoring:

Forwards _____ steps

Backwards 6+? _____ steps

1 Perfect (min 10 steps)
2 Slight wobble & hesitance placing foot over line
3 Body sway
4 Less than 10 steps
5 Steps on line or puts foot down immediately

HOPPING ON THE SPOT

Demonstrate the test.
Ask children to watch and listen before attempting test.
Give 5 practice hops.

Valid from 4 years up
Place hands on hip
Hop on one leg
Score up to 10 hops
Repeat on other leg

From 8 years: hop forward on one leg.

Scoring no of hops: left foot_____

right foot_____

1 Perfect 10 hops
2 Wobble on landing/moving around
3 Quick hops not gaining any height/2nd foot resting on hopping leg
4 Less than 10 hops
5 Unable or not lifting hopping foot off floor

Holt (1991): Hopping on the spot

4 years: 5 times
5 years: 10 times
(McCaskill & Wellman 1938)

07 - #

MARCH AND ABOUT TURN

Demonstrate first using outline square of green material
Ask children to watch and listen before attempting test.
Give 5 practice steps.

Swinging arms first on the spot
Lifting the knees start to march on the spot
March around the square.

Scoring:

Observe pattern and tick box

- ☐ Homolateral
- ☐ Crosslateral

1. Perfect crosslateral
2. Loses crosslateral reverts to homolateral
3. Mixed cross and homolateral gait
4. Full homolateral
5. Having difficulty marching at all

CRAWLING ON ALL FOURS

Demonstrate first.
Ask children to watch and listen before attempting test.
Give 5 practice steps.

The child is to crawl along the diagonal.

Watch for:
1. homolateral/cross pattern
2. Head flick
3. or opposite knee flick

Scoring:

Observe pattern and tick box

☐ Homolateral
☐ Crosslateral

1 Perfect crosslateral
2 Loses crosslateral reverts to homolateral
3 Mixed cross and homolateral gait
4 Full homolateral
5 Cannnot manage any crawling

Folio & Fewell, 2000, Peabody Developmental Motor Scales:
5-11m: creeps on hands and knees with opposite arms and legs moving together.

Not all children crawl before walking.

REFLEX TESTS

SCORING 1-4 gives description in range

5 = UNABLE due to anxiety, muscle tone, unable to stay up on all fours, keep arms in position etc.

Dyslexia Early Years Project Reflex Tests

09 - #

Demonstrate First
Ask children to watch and listen before attempting tests

ATNR: LYING DOWN

Test to each side – eyes open and eyes closed

The tester kneels behind the subject lying on the floor. Arms placed at 45 degrees to the body with elbows bent. Hands loosely placed palm down and fingers spread and with tips touching floor. The tester places hands on subjects head taking care not to cover ears.

- Tester turns head to the left and counts 5 seconds
- Returns head to midline for 1 second
- Tester turns head to the right and counts 5 seconds
- Repeat with eyes closed.

Scoring:

N.B. only score side of body to which head is turned

Arms:

1 No movement on the side to which the head is turned
2 Tremor
3 Fingers move
4 Hand and arm move

Feet:

1 No movement
2 No score
3 No score
4 Feet move

Left arm:	eyes open	1 2 3 4
Left leg:	eyes open	1 4
Right arm:	eyes open	1 2 3 4
Right leg:	eyes open	1 4

Left arm:	eyes closed:	1 2 3 4
Left leg:	eyes closed:	1 4
Right arm:	eyes closed:	1 2 3 4
Right leg:	eyes closed:	1 4



ATNR LYING DOWN

Dyslexia Early Years Project Reflex Tests

10 - #

ATNR: AYRES TEST

Test to each side – eyes open and eyes closed

The tester kneels in front of the subject on the floor. The subject assumes table position on all fours with hands facing forward palms down, looking at the floor. Make sure arms are not locked or twisted. **Watch for twisting of body in compensation.** The tester places hands on subjects head taking care not to cover ears.

- Tester turns head to the left and counts 5 seconds
- Returns head to midline for 1 second
- Tester turns head to the right and counts 5 seconds
- Repeat with eyes closed.

Scoring:

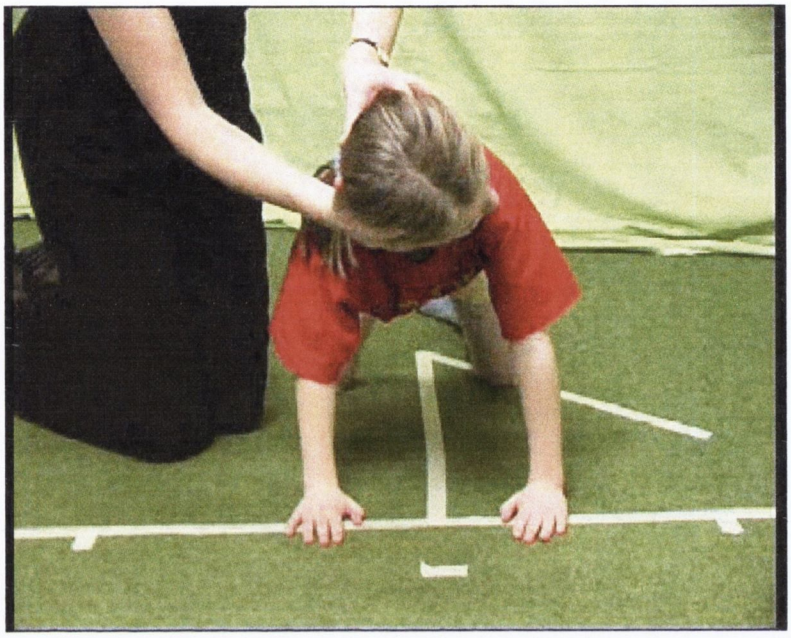
N.B. Score opposite arm in box on scoresheet and flag at front of sheet

Arms:

1 No movement on the side to which the head is turned
2 Tremor
3 Elbow flicks –trying to keep arm straight
4 Definite bend in the arm

Left arm:	eyes open	1 2 3 4
Right arm:	eyes open	1 2 3 4
Left arm:	eyes closed:	1 2 3 4
Right arm:	eyes closed:	1 2 3 4

Observe for twisting of body in compensation. Let subject relax and try again.



ATNR: Ayres

Dyslexia Early Years Project Reflex Tests

12 - #

ATNR: SCHILDER TEST

Test to each side – eyes open and eyes closed

The tester stands behind the subject. The subject stands with feet together, arms held out in front at shoulder height. Hands are relaxed and palms down. The tester places hands on subjects head taking care not to cover ears.

- Tester turns head to the left and counts 5 seconds
- Returns head to midline for 1 second
- Tester turns head to the right and counts 5 seconds
- Repeat
- Rest as arms will be tired
- Repeat as above with eyes closed.

Scoring:

N.B. Only score side of body to which head is turned

Arms:

Observe does the head pull the arms in its direction

1 No movement or 0-10^0 in children under 5 years
2 Movement 10-25^0 in direction of head movement
3 Movement 25 – 45^0
4 Arms move +45^0

Do not score drop (e.g. opt out of the task) as it may be fatigue at this age.

Arm movement

To left:	eyes open	1 2 3 4
To right:	eyes open	1 2 3 4

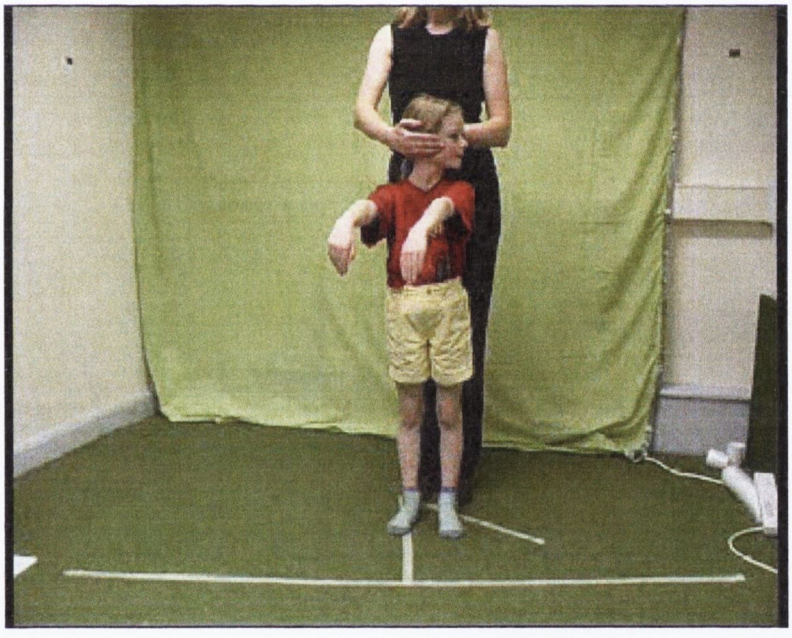
ATNR: STANDING

To left: eyes closed: 1 2 3 4
To right: eyes closed: 1 2 3 4

Drop
To left: eyes open 1 2 3 4
To right: eyes open 1 2 3 4

To left: eyes closed: 1 2 3 4
To right: eyes closed: 1 2 3 4

ATNR: STANDING



ATNR: Schilder

ATNR: SCHILDER TEST

Test to each side – eyes open and eyes closed

The tester stands behind the subject. The subject stands with feet together, arms held out in front at shoulder height. Hands are relaxed and palms down. The tester places hands on subjects head taking care not to cover ears.

- Tester turns head to the left and counts 5 seconds
- Returns head to midline for 1 second
- Tester turns head to the right and counts 5 seconds
- Repeat
- Rest as arms will be tired
- Repeat as above with eyes closed.

Scoring:

N.B. Only score side of body to which head is turned

Arms:

Observe does the head pull the arms in its direction

1 No movement or 0-10^0 in children under 5 years
2 Movement 10-25^0 in direction of head movement
3 Movement 25 – 45^0
4 Arms move +45^0

Score drop (e.g. opt out of the task)

1 Drop of 0-10^0 in children under 5 years
2 Drop of 10-25^0
3 Drop of 25 – 45^0
4 Drop of +45^0

Arm movement

To left: eyes open 1 2 3 4
To right: eyes open 1 2 3 4

To left:	eyes closed:	1 2 3 4
To right:	eyes closed:	1 2 3 4

Drop

To left:	eyes open	1 2 3 4
To right:	eyes open	1 2 3 4
To left:	eyes closed:	1 2 3 4
To right:	eyes closed:	1 2 3 4

14- #

MORO REFLEX - UPRIGHT TEST

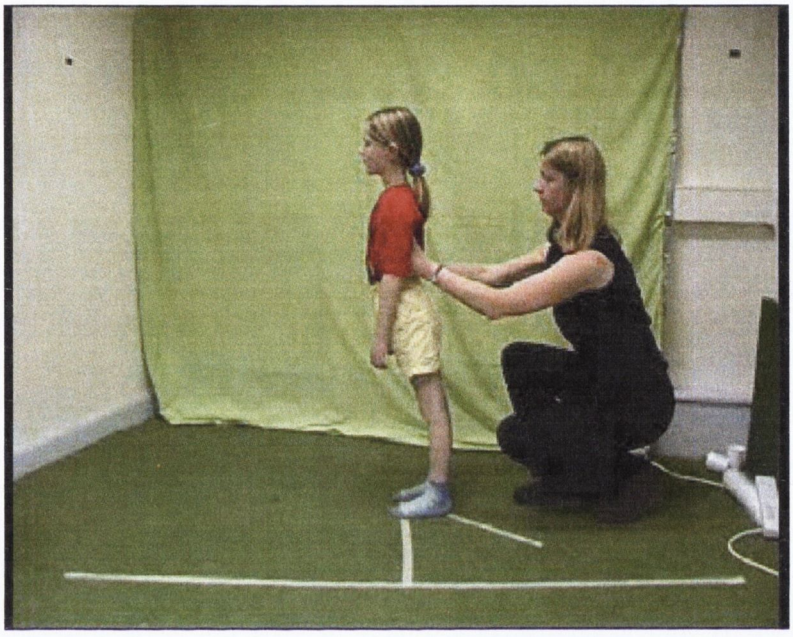
Do not use sudden noises this will upset child and you will loose their trust.

Talk through the test and then perform twice with eyes open and twice with eyes closed.

Stand with feet together like a tree
Keep the head in midline
The tester places hands on the child's waist
"the tree is going to blow gently in the wind"
Guide the child 2-3 inches forward feet remaining still
The back to neutral
The rock child gently back on heels for 2-3 inches
Observe when they opt out
Do they step out – can't stop themselves
Repeat with eyes closed

1 No problems with backwards and forwards
2 On backward movement arms come up
3 They go backwards but fall out of it
4 Opt out of forwards/backwards movement/clasping of arms across body
5 Unable due to muscle tone

Toes coming up is normal, listen for breathing on backwards movement – intake of breath.



MORO: STANDING

Dyslexia Early Years Project Reflex Tests

11 - #

STNR

The child does this themselves do not guide the head.

With the child in the table position, sideways to the camera, arms facing forward, ask the child to put their head down looking between the knees. Hold for 5 seconds.

Observe arms

1 No movement
2 Tremor in the arms
3 Flick in the arms
4 Definite bend

Then ask the child to bring the head up and look up at the ceiling

Observe trunk and legs

1 No movement
2 1 lurch backwards and corrects it
3 lurch backwards x 2
4 Goes backwards but does not correct it and sometimes sits on heels

Repeat for eyes closed.

Scoring:

Trunk involvement	1 2 3 4
Arm involvement	1 2 3 4
Evidence with creeping on all fours	1 2 3 4



STNR: TABLE

13 - #

TLR – UPRIGHT TEST

Stand behind the child in case of loss of balance no need to touch child.
Talk through movement with child

Child should stand with feet together facing forward, eyes open
Child should bring head down to look at toes
Pause for 5 seconds
Bring head to midline
Take head up to look at ceiling
Pause for 5 seconds
Bring head back to midline
Repeat with eyes closed

Head down

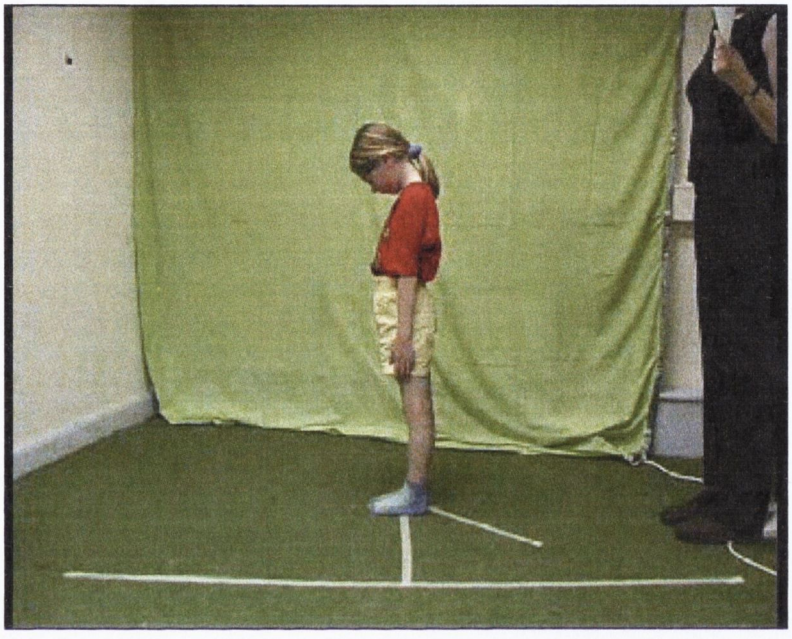
Look for flexor movement in the legs, do knees move, also note sway:

1 No movement
2 Tremor in the knees
3 Little flicks in the knee
4 Definite bend in knees

Head back

Look for extension in the arms

1 No movement
2 Definite sway in body
3 Sway with arms
4 Loss of balance



TLR: STANIDING

Neurological Dysfunction as a significant factor in children with Dyslexia
Blythe, S.G., BDA International Conference. Dyslexia: At the Dawn of the Century, April 2001.

Oculo-Motor Functioning Tests:

1. Visual Tracking

Test Position: Standing with feet together, arms by the sides.

The child is instructed to follow the coloured tip of a ballpoint pen with his/her eyes without moving the head. The pen is held at a distance from the face equivalent to the distance between the end of the child's fingertips and the elbow, three inches below eye level.
The tester moves the stimulus slowly from side to side for **10 movements**.
Eye movements are observed for:

Scoring: once they have the flow score for stable performance

Ability to follow the movements of the pen without anticipation	1
Jumping	2
Head movement.	3
Unable to focus on and follow pen	5

2. Hand-Eye Tracking

Test position: Standing feet together, arms by the sides.

The procedure is the same for test no. 1 except that the child holds the pen in his/her hand and is asked to move the pen from side to side without moving the head. Let the child choose which hand.

Scoring: once they have the flow score for stable performance

Ability to follow the movements of the pen without anticipation	1
Jumping	2
Head movement	3
Unable to focus on and follow pen	5

3. Fixation with Eyes

Test Position: Standing with feet together, arms by the sides.

The child is instructed to fixate on the coloured tip of a ballpoint pen with his/her eyes, and instructed to hold that fixation while moving the head from side to side **10 times.** The pen is held at a distance from the face equivalent to the distance between the end of the child's fingertips and the elbow, three inches below eye level. When the movement is stable the eyes are observed for any deviation from the fixation points the head moves – ocular-reflex.

Maintains fixation point **Yes 1**

No 5

4. Near Point Convergence and Re-establishment of Binocular Vision

The child is instructed to focus on the coloured point of the non-writing end of a ball point pen **held at eye level at a distance of arm's length from the face** and is instructed to follow the coloured dot as it is moved towards the subject until the eyes converge.

The child is then asked to say, "stop" when the image begins to blur/or they feel a strain on the eyes. The pen is then moved away and the child was asked to say, "stop" when the coloured point becomes clear again. The distance between the point going out of focus and returning to focus again is measured. If the distance exceeds **6 to 8 centimetres**, re-establishment of binocular vision is slow.

_____ cms

Convergence OK **1**

Convergence Slow **4**

Demonstrate First
Ask children to watch and listen before attempting test

Motor Control

1. **Finger-to-nose test**

Description:
Eyes open
Stand with feet together
Bring elbows out to shoulder height
Bring alternate **finger tips** to **tip of nose 10 times**

Try with eyes closed.

Scoring:
1 Perfect
2 Compensating, bringing head to nose, or **side** of finger to nose
3 Hitting side of nose
4 Hitting face
5 Unable

Eyes open	**1**	**2**	**3**	**4**	**5**
Eyes closed	**1**	**2**	**3**	**4**	**5**

Demonstrate First
Ask children to watch and listen before attempting test

Motor Control

2. Heel on Shin

Description:
Child sits on chair
The left heel is brought to rest at the top of the
right shin just below the knee.
Push the heel down the opposite shin and push out at the end.
Try once only.
Repeat with right heel.

Scoring:
1 Perfect
2 Heel goes to side of leg
3 Inside of foot goes down leg

5 Unable to do it.

Left	1 2 3 5
Right	1 2 3 5

Notes:

Autistic and Aspergers children will struggle with these tests – indicating problems with the cerebellum/brain stem and other balance regions of the brain

Ref:

McPhillips
Holt? neuro
Dow & Moruzzi (1958) in N&F test battery

Demonstrate First
Ask children to watch and listen before attempting test

Adiadochokinesia (rapid alternate movement)

3. Fingers

DEMONSTRATE FORWARDS AND BACKWARDS

Description:
Child sits on chair
Starting with the index finger on the left hand, the child brings finger and thumb together once and continues with the other fingers in a rhythmic tapping manner, forward and back.
Tester to count at least 10 consecutive taps.
Repeat with right hand.

Scoring:

- left hand
- right hand

1 Perfect, tapping has rhythmic ripple
2 Can do it but conscious of it
3 Can do it but slow and laboured
4 Can't do movement with one or more fingers
5 Unable to attempt it

Notes:
Usually the difficulty is with bringing little finger and thumb together.

Ref:
Folio & Fewell, 2000, Peabody Developmental Motor Scales

49-54m: Touches each finger to thumb.

Demonstrate First
Ask children to watch and listen before attempting test

Adiadochokinesia (rapid alternate movement)

4. Rapid reversal of hands

DEMONSTRATE SLOWLY – THERE MUST BE A DEFINITE UP AN DOWN MOVEMENT OF HANDS

Description:
Child sits on chair
Placing palms face down on knees, turn one palm up
Slowly reverse their orientation so palm up goes down and down goes up
Demonstrate and start slowly
There must be definite up/down rhythm
Child should attempt 10 rotations

Scoring:
1 Perfect, speed is fast and automatic
2 Slower rhythm
3 Really thinking about it but can do it
4 Cannot turn opposite hands
5 Unable to attempt it

Notes:

It is unusual that the child would fail on one test alone, there should be a pattern.

Demonstrate First
Ask children to watch and listen before attempting test

Adiadochokinesia (rapid alternate movement)

3. Finger and Thumb (Incy Wincy) (10 rotations)

Description:
Child sits on chair
Demonstrate slowly
Child places opposing index finger and thumb together
Twist hands release the lower two to meet on top
Give 5 practice goes
Time 10 rotations
Can break and continue

Scoring:

Time 10 rotations in _____ secs

Able 1 **Unable 5**

Notes:

Neuro test need refs
McPhillips

Dyslexia Early Years Project

Name_____
Child ID _____

In school ☐

Familiar with Letterland scheme ☐

Phonological Tests

Letter Name Knowledge

Using the plain lower case flashcards ask the child to randomly name the 26 letters of the alphabet. Hold up a card for 5 seconds asking them to name letter and then continue to the next letter. Place an X in the box for an error. Score correct letters out of 26.

A	B	C	D	E	F	G	H	I	J	K	L	M
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Total correct: _____/ **26**

Phoneme Deletion Test:

The child is required to remove the first phoneme (sound in itialics) of the words below. Say to the child *' in the word **bus** if I take out the ' /b/' I am left with .....**us**'* supplying the answer. Continue with the demonstration stimuli.

Demonstration stimuli: ***b*-us** ***s*-ad** ***p*-ie** ***c*-ow**

Now say to the child *' in the word **bear** if I take out the ' /b/' I am left with?...'* Do not supply the answer.

Test stimuli: ***b*-ear** ***s*-it** ***j*-am** ***t*-in** ***c*-ake** ***t*-oy** ***c*-up** ***m*-an**

Total correct: _____/ **8**

Dyslexia Early Years Project **Name**_____
Child ID _____

Non-Word Repetition Test:

Gathercole & Baddeley (1989)

The child is required to repeat non-words between one and four syllables in the following order:

1. ***Simple non-words:***

sa	zi	mo	cu
le	ka	ru	fa
te	fu		___ / **10**

2.

hond	grall	tull	clird
fot	nate	sep	bift
smip	thip		___ / **10**

3.

hampent	bannow	diller	pennel
ballop	sladding	prindle	rubid
glistow	tafflest	barrazon	bannifer
thickery	skiticult	commerine	dopelate
brasterer	glistering	trumpetine	finneriser
contranponist	stoppograttic	penneriful	loddenapish
perplisteronk	empliforvent	commerciate	blonterstaping
woogalamic	frescoveril		___ / **30**

Sourced from: Muter, V. & Snowling, M. (1998) Reading Research Quarterly, 33, 320-337



Conners' Short Form

Profile for Females: Conners' Parent Rating Scale - Revised (S)

Child's Name:_____ Gender: M F (Circle One)

Birthdate:____/____/____ (Month Day Year) Age:_____ School Grade:_____

Parent's Name:_____ Today's Date:____/____/____ (Month Day Year)

T	A. Oppositional 1	2	3	4	5	B. Cognitive Problems/ Inattention 1	2	3	4	5	C. Hyperactivity 1	2	3	4	5	D. Conners' ADHD Index 1	2	3	4	5
90			17	16	17			16				15				27	33	30		
89		18				12	15		10				8				32		26	28
88								15		16						28		29	27	26
87	14		16	16	16				15		12	14			9		31	23		
86		15					14							8		25	30		26	27
85						11		14		15								27		
84	13		15	14	15				14			13	8			26	29	28	25	26
83		14					14			14	11						28		24	25
82								13								23		25		
81			14	13	14	10			13			12				22	27	24	23	24
80	12	13					12			13				5	5		26			23
79								12			10		7			21		23	22	
78			13	12	13				12			11					25			22
77	11	12				9	11			12						20	24	22	21	
76			12		12			11			9						23	21	20	21
75				11					11			10				19				20
74		11				8	10			11			8				22	20	19	
73	10		11		11			10						4	4	18	21	19		19
72									10		8	9							18	
71		10		10			9			10						17	20	18	17	18
70	9		10		10	7		9	9								19			17
69										9		8	5			16		17	16	
68		9		9			6				7					15	18	16		16
67			9		9			8	8								17		15	
66	8					6				8		7		3	3	14		15	14	15
65				8			7										16	14		14
64		8	8		8			7	7		6		4			13	15		13	
63	7					5				7		6						13		13
62				7			6									12	14		12	12
61		7	7		7			6	6								13	12	11	
60										6	6	6	3			11		11		11
59	6			6		4	5	5						2	2		12		10	
58		6	6		6				5	5						10	11	10		10
57											4							9	9	9
56	5			5			4	4	4			4				9	10		8	
55		5	5		5	3				4			2			8	9	8		8
54																	8		7	
53				4			3	3	3		3	3				7		7		7
52	4	4	4		4					3				1	1		7	6	6	6
51						2										6	6		5	
50			3	3			2	2	2			2	1					5		5
49	3	3			3					2	2					5	5	4	4	4
48						1											4			
47			2	2			1	1	1	1		1				4		3	3	3
46		2			2									0			3		2	
45	2										1		0		0	3	2	2		2
44			1			0	0	0	0	0		0						1	1	1
43		1		1	1											2	1			
42	1										0					1	0	0	0	0
41			0																	
40		0		0	0											0				
39																				
38	0																			

Note:
For age-groups:

Column 1: ages 3 to 5

Column 2: ages 6 to 8

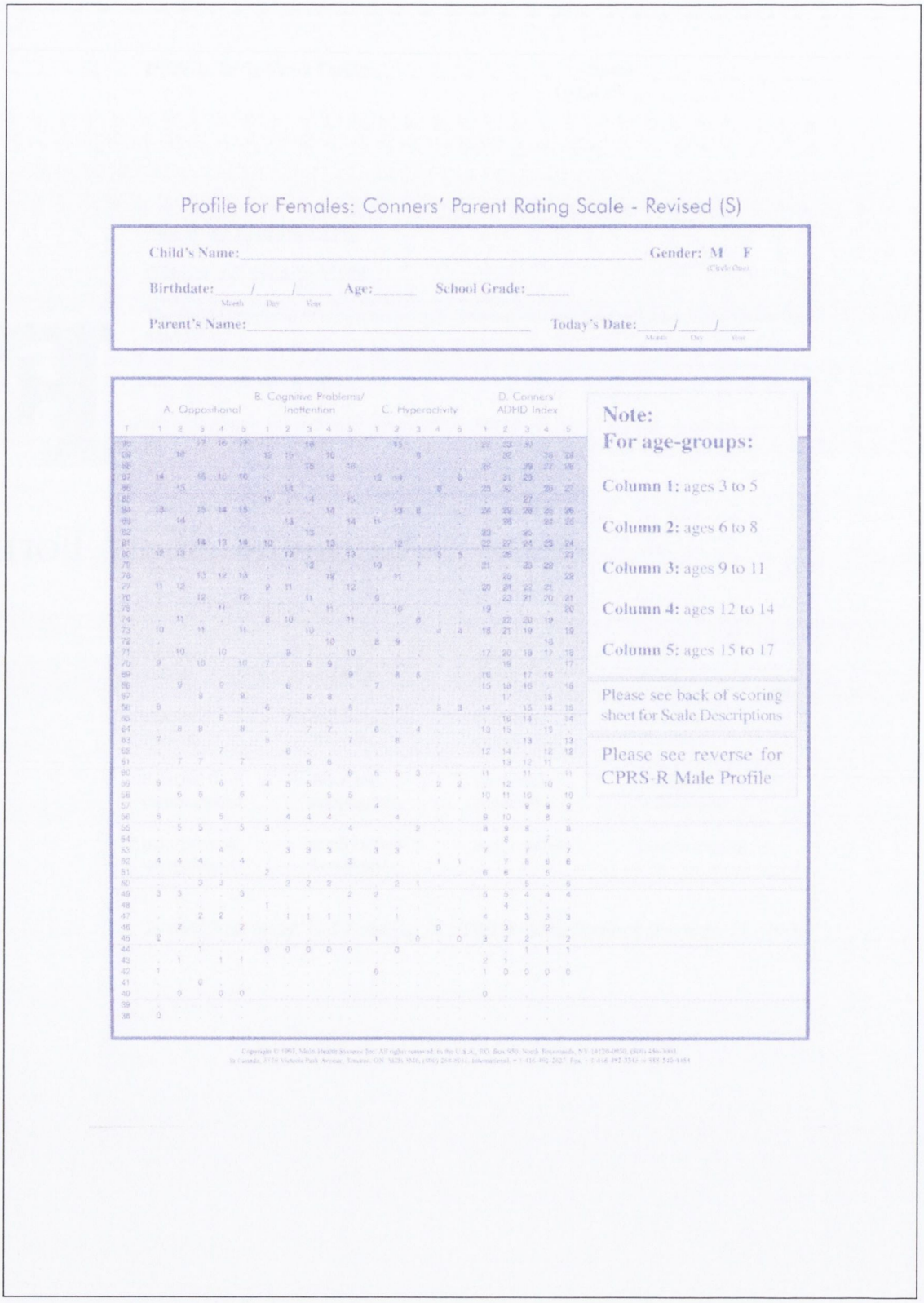
Column 3: ages 9 to 11

Column 4: ages 12 to 14

Column 5: ages 15 to 17

Please see back of scoring sheet for Scale Descriptions

Please see reverse for CPRS-R Male Profile



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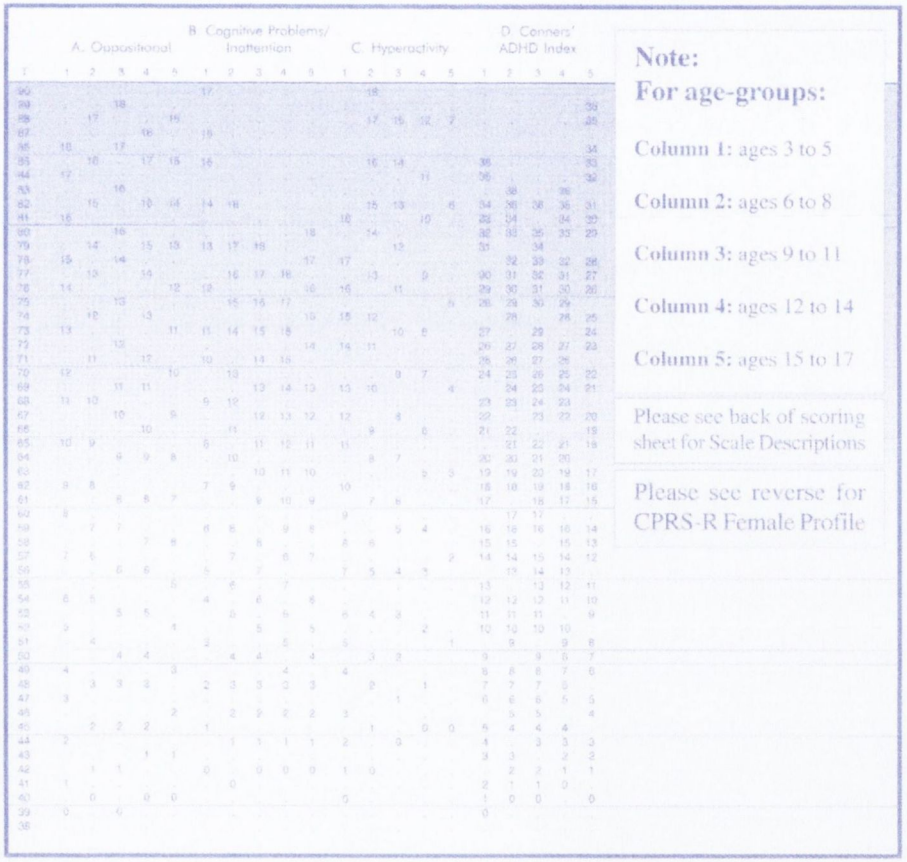
Profile for Males: Conners' Parent Rating Scale - Revised (S)

Child's Name:_____ Gender: M F
(Circle One)

Birthdate:____/____/____ Age:_____ School Grade:_____
Month Day Year

Parent's Name:_____ Today's Date:____/____/____
Month Day Year



Note:
For age-groups:

Column 1: ages 3 to 5

Column 2: ages 6 to 8

Column 3: ages 9 to 11

Column 4: ages 12 to 14

Column 5: ages 15 to 17

Please see back of scoring sheet for Scale Descriptions

Please see reverse for CPRS-R Female Profile

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Conners' Parent Rating Scale - Revised (S)

by C. Keith Conners, Ph.D.

Child's Name: _____ **Gender:** M F

Birthdate: ____/____/____ (Month / Day / Year) **Age:** _____ **School Grade:** _____

Parent's Name: _____ **Today's Date:** ____/____/____ (Month / Day / Year)

Instructions: Below are a number of common problems that children have. Please rate each item according to your child's behavior in the last month. For each item, ask yourself, "How much of a problem has this been in the last month?", and circle the best answer for each one. If none, not at all, seldom, or very infrequently, you would circle 0. If very much true, or it occurs very often or frequently, you would circle 3. You would circle 1 or 2 for ratings in between. Please respond to each item.

	NOT TRUE AT ALL (Never, Seldom)	JUST A LITTLE TRUE (Occasionally)	PRETTY MUCH TRUE (Often, Quite a Bit)	VERY MUCH TRUE (Very Often, Very Frequent)
1. Inattentive, easily distracted	0	1	2	3
2. Angry and resentful	0	1	2	3
3. Difficulty doing or completing homework	0	1	2	3
4. Is always "on the go" or acts as if driven by a motor	0	1	2	3
5. Short attention span	0	1	2	3
6. Argues with adults	0	1	2	3
7. Fidgets with hands or feet or squirms in seat	0	1	2	3
8. Fails to complete assignments	0	1	2	3
9. Hard to control in malls or while grocery shopping	0	1	2	3
10. Messy or disorganized at home or school	0	1	2	3
11. Loses temper	0	1	2	3
12. Needs close supervision to get through assignments	0	1	2	3
13. Only attends if it is something he/she is very interested in	0	1	2	3
14. Runs about or climbs excessively in situations where it is inappropriate	0	1	2	3
15. Distractibility or attention span a problem	0	1	2	3
16. Irritable	0	1	2	3
17. Avoids, expresses reluctance about, or has difficulties engaging in tasks that require sustained mental effort (such as schoolwork or homework)	0	1	2	3
18. Restless in the "squirmy" sense	0	1	2	3
19. Gets distracted when given instructions to do something	0	1	2	3
20. Actively defies or refuses to comply with adults' requests	0	1	2	3
21. Has trouble concentrating in class	0	1	2	3
22. Has difficulty waiting in lines or awaiting turn in games or group situations	0	1	2	3
23. Leaves seat in classroom or in other situations in which remaining seated is expected	0	1	2	3
24. Deliberately does things that annoy other people	0	1	2	3
25. Does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behavior or failure to understand instructions)	0	1	2	3
26. Has difficulty playing or engaging in leisure activities quietly	0	1	2	3
27. Easily frustrated in efforts	0	1	2	3

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Conners' Parent Rating Scale - Revised (S)

by C. Keith Conners, Ph.D.

Child's Name:_____ Gender: M F

Birthdate:____/____/____ (Month / Day / Year) Age:_____ School Grade:_____

Parent's Name:_____ Today's Date:____/____/____ (Month / Day / Year)

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For each item, transfer the circled number into each of the white boxes across the row. Sum each column and write the totals in the boxes labelled "TOTALS" at the bottom.

A: Oppositional	B: Cognitive Problems/ Inattention	C: Hyper-activity	D: ADHD Index				
				0	1	2	3
				0	1	2	3
				0	1	2	3

Scale Descriptions

A. Oppositional
Individuals scoring high on this scale are likely to break rules, have problems with persons in authority, and are more easily annoyed and angered than most individuals their age.

B. Cognitive Problems/Inattention
High scorers may be inattentive. They may have more academic difficulties than most individuals their age, have problems organizing their work, have difficulty completing tasks or schoolwork, and appear to have trouble concentrating on tasks that require sustained mental effort.

C. Hyperactivity
High scorers have difficulty sitting still or remaining at the same task for very long, feel more restless and impulsive than most individuals their age, and have the need to always be on the go.

D. Conners' ADHD Index
Identifies children/adolescents "at risk" for ADHD.

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Dyslexia Screening Tests

DEST-2 Score Sheet for _____

Entering Scores

Having written the test scores (from the response sheet) into the second column of the 'DEST-2 Score Sheet', check the Score Key is for the right age, then place it carefully on top of the Score Sheet. The cutaway allows you to enter the 'At Risk Index' scores in the third column of the score table. Look up the corresponding index (--, -, 0, +, ++) in the right hand columns of the Score Key, and enter it in the 'At Risk Index' column: e.g. for rapid naming for age 6:0 to 6:5, you would enter -- for a score of 70; - for a score of 60; 0 for a score of 55; + for a score of 32; and ++ for a score of 31. The norms on the Score Keys differ for each age, so make sure you use the right one. Note that some of the tests are at ceiling in the '0' or '+' category, and therefore the higher category has the same score in brackets. If the same score appears in two columns, select the lower category. The score in this category will not be in brackets.

	Test Score	At Risk Index	--	-	0	+	++
1. Rapid Naming							
2. Bead Threading							
3. Phon. Discrimination							
4. Postural Stability							
5. Rhyme/First Letter							
6. Forwards Digit Span							
7. Digit Naming							
8. Letter Naming							
9. Sound Order							
10. Shape Copying							
11. Corsi Frog							
12. Vocabulary							

Overlay the Score Keys for the appropriate age

Interpretation

Work out the numbers of -- and - scores. If 4 or more are --, or 7 or more are either -- or -, the diagnosis is 'at risk'. For a quantitative measure, score 2 for --, 1 for -, 0 for the remainder, and add up the scores. The 'At Risk Quotient' (ARQ) is then the sum divided by 12. An ARQ of 0.9 or greater is strong evidence of being at risk, and an ARQ of 0.6-0.8 is mild evidence of being at risk. Also complete the profile chart. At risk areas such as rhyming suggest areas for possible remediation work. Digit span weakness suggests possible memory difficulties. Discrimination weakness may suggest hearing acuity or processing problems.

Full Name _____

Class _____

School _____

Child's date of birth _____

Age at testing _____

Family history of reading difficulties

(from permission form)_____

Test behaviour: concentration _____

anxiety _____

Other _____

Number with - -_____(A)

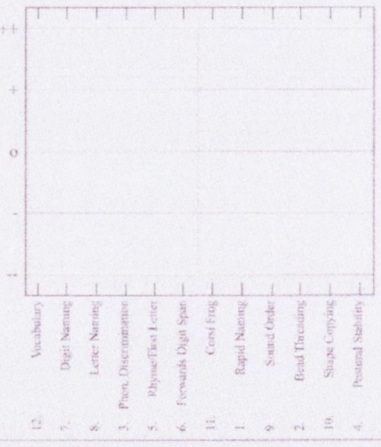
Number with - _____(B)

At risk score (2xA)+B_____(C)

At Risk Quotient (C)/12_____(D)

Screening diagnosis _____

Tester _____ Date _____



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DEST-2 Response Sheet for _____

1. Rapid Naming	2. Bead Threading	3. Phon. Discrimination	4. Postural Stability
Time (secs)	Total	bad dad	Arms by side
Errors	Less initial 3	cap cap	1
Time + (5 x errors)	Minus 1 if string dropped	day day	2
Add 10 if place card needed	more than once	pin thin	
		lip limp	Arms in front
		fat fat	1
		cub cup	2
		leg leg	
		fan van	
Total	Total	Total (max 9)	Total (max 24)

5. Rhyme	6. Forwards Digit Span	7. Digit Naming	8. Letter Naming
leg hen	5 1	4	t
pin win	3 9	8	s
cup pup	1 3 6	3	d
hop doll	4 9 5	9	c
toe toad	7 6 4 2	5	w
mud bud	5 8 4 7	7	o
peg pet	7 4 6 5 8	6	b
wing sing	8 6 1 3 9		q
First letter	7 5 4 3 1 6		n
dog	9 7 5 2 4 3		y
sack	1 3 4 7 9 6 2		
hat	2 1 3 4 8 7 5		
tap	1 7 2 9 6 3 5 8		
net	5 7 6 4 8 1 3 2		
Total (max 13)	Total (max 14)	Total (max 7)	Total (max 10)

9. Sound Order	10. Shape Copying	11. Corsi Frog	12. Vocabulary
mouse	Hand used	4 2	Seesaw
duck		5 1	Pineapple
mouse	‖	1 3 6	Camel
mouse	□	5 3 7	Lizard
duck	=	7 6 4 2	Volcano
mouse	O	6 1 3 4	Light bulb
duck	÷	2 4 7 3 5	Autumn
duck	Δ	4 6 1 3 7	Canoe
duck	◇	7 5 4 3 1 6	Jellyfish
mouse		1 7 5 2 4 3	Habit
mouse		1 3 4 7 5 6 2	
duck		2 1 3 4 6 7 5	
duck		1 7 2 4 6 3 5 2	
mouse		5 7 6 4 2 1 3 2	
mouse			
duck			
Total (max 16)	Total (max 21)	Total (max 14)	Total (max 10)

DST Record Form for _____

1. Rapid Naming	2. Bead Threading	4. Postural Stability	10. Verbal Fluency	11. Semantic Fluency
Time (sec)	Total	Arms by side	8	Animals
Errors	Less initial 3	1		
		2		
Time + 5 x errors		Arms in front		
		1		
		2		
Total	Total	Total (max 24)	Total	Total

3. One Minute Reading	5. Phonemic Segmentation	6. Two Minute Spelling	7. Back Span
Form (A or B)	1. Rainbow (rain)	Hand used	2 4
Errors	2. Wigwam (wam)	Handwriting quality	6 9
Passes	3. Marmalade (malade)	(good/ave/poor)	8 3 5
Last word read	4. Dog (d)		1 7 6
Words attempted (A)	5. boat (oat)	Number completed	6 9 3 4
Errors plus passes (B)	6. stake (ache)	Number of errors	3 8 1 7
Score (A–B) (C)	7. stake (take)	Number correct	4 1 6 2 3
Time	8. stake (stay)	Add 8 if used only the	2 7 4 6 8
Bonus (1 pt per sec under 60)	9. snail (snay)	8.5 spellings	8 7 1 5 6 9
_____ (D)	10. flag (fag)		4 1 5 2 7 8
Total (C+D)	11. glow (go)		3 8 6 4 1 7 5
	12. igloo (igoo)		5 8 2 3 9 6 1
			6 8 4 5 3 2 1 7
			4 1 5 3 8 7 6 2
Total	Score (max 12)	Total score	Total score

8. Nonsense Passage Reading		9. One Minute Writing
A. One day a snib fell into the fog. He was so sarp and nid that he cried. He said, "Chig." Then he ran back to his doot. She said "Oh stid," and gave him a ack-lint dtack.		Words _____ (A)
B. One day a snib fell into the fog. So grunty was he that he cried "Ober, give me a throld!" He climbed out, shook the water off, and ran back to his doot. She said "Oh stid," and gave him a ack-lint dtack.		Time Bonus (1 point for each 2s under 60) _____ (B) Lesser of 8 and 10 _____ (C)
C. Once upon a time a boy ran away from drang. He ran and ran until he fell into a loury greel. So grunty was he that he cried "Ober, give me a throld, remehtil me, shoosmo the wiidrifer. At last, he dragged himself out, shook the water off, and quickly went gobbsium.		Errors _____ Error penalty (1 point for each 2 errors) _____ (D)
D. In the olden days, a nrinaker set out to stratberg an enormous dolfilroy that threatened his country. It was a really grangwally illadonker and after killing it he was dungeriemely tired. But the very next day he set out to Oligonderyock, to graffil-antler his eleftiensh. On his arrival, he met his huntivaldam at the station. They were married and lived happily ever after.		Writing quality (good ave poor) Penalty if writing poor (1–3) _____ (E)
Real Words correct, (max: A = 28, B = 34, C = 42, D = 53)	(A)	Penalty if poor punctuation (0–2)
Nonsense words correct (max = 10)	(B)	(only for age 8:6 +) _____ (F)
Score = (A) + (2 x B)	(C)	Total:
Time		A + C – D – E – F
*Time Bonus (1 per 2 s less than 60 s) [Max 10] _____ or Time Penalty (1 per 2 s more than 60 s) [Max 60] _____ *bonus should only be given if 15 or more is scored.		
Score after penalty / bonus	(D)	
Half Score (= half of C)	(E)	
Total Score (greater of D and E)		Total Score

DST Record Form for _____

Entering Scores

Write the test scores in the 'Test Score' column of the score table below. Find the Score Key appropriate for the child's age. Place it carefully on top of this sheet. The cutaway allows you to enter the 'At Risk Index' scores in the third column of the record form. Look up the corresponding index (--, -, o, +) in the right hand column of the Score Key, using the instructions at the top of the Score Key, and enter it in the 'At Risk' column on this sheet. The score keys differ for each age, so make sure you use the right one.

	Test Score	'At Risk' Index	--	-	o	+
1. Rapid Naming						
2. Bead Threading						
3. One Minute Reading						
4. Postural Stability						
5. Phonic Segment						
6. Two Minute Spelling						
7. Backwards Span						
8. Nonsense Passage						
9. One Minute Writing						
10. Verbal Fluency						
11. Semantic Fluency						

Overlay the score keys for the appropriate age

Interpretation

Work out the numbers of --, -, o and + scores. If 3 or more are either -- or -, the diagnosis is 'At Risk'. For a quantitative measure, score 3 for --, 2 for -, 1 for o, 0 for the remainder, and add up the scores. The 'At Risk Quotient' is then the sum divided by 10. An ARQ of 1 or greater is strong evidence of being 'At Risk'. Also complete the profile graph. 'At Risk' areas such as Segmentation suggest possible reconstitution work. Digit Span weakness suggests possible memory difficulties. Areas of strength may provide the basis for a remedial strategy.

Full Name _____ Tester _____ Date _____

Class _____ School _____

Child's date of birth _____

Age at testing _____

Family history (permission form) ☐

Test behaviour: concentration _____

anxiety _____

Other info:

Number with -- _____ (A)

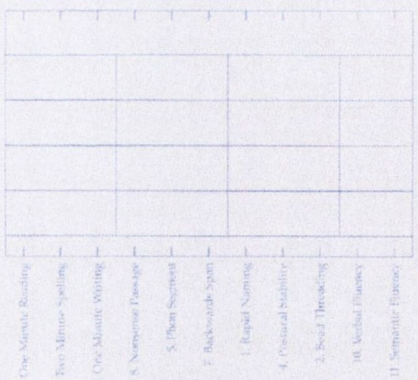
Number with - _____ (B)

Number with + _____ (C)

'At Risk' score (3xA) + (2xB) + C _____ (D)

'At Risk' quotient (D)/ 10 _____ (E)

Screening diagnosis _____



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H

Dyslexia Screening Test Reports

Dyslexia Early Years Project

Results from the Dyslexia Early Screening Test

Name :

Date:

The Dyslexia Early Screening Test (D.E.S.T.-2) is designed for children between the ages of 4:6 – 6:5 years. It consists of 12 different tests on which dyslexic children can perform poorly. The results provide a profile of strengths and weaknesses which may be used as a guide for the child's academic support in school.

Screening Tests

1. Rapid naming: This involves correctly naming different pictures as quickly as possible.
2. Bead threading: This represents a test of fine motor skill requiring hand-eye coordination.
3. Phonological Discrimination: This tests the child's ability to judge the sounds of a word.
4. Postural stability: This involves a gentle push in the back to determine whether the child has a problem with maintaining balance.
5. Rhyme: This assesses the child's ability to detect rhyme.
6. Forwards digit span: This is also a test of working memory, requiring the child to listen to a series of numbers then repeat them back in the same order.
7. Digit naming: This tests the child's knowledge of numbers.
8. Letter naming: This tests the child's knowledge of letters.

9. Sound order: This gives an indication of whether the child may have difficulty detecting rapid changes in consonants by testing whether they can determine the order in which 2 different tones are presented.
10. Shape copying: Writing neatly and fast can be difficult for dyslexic children.
11. The Frog test: This tests the child's spatial memory.
12. Vocabulary: This tests the child's reasoning abilities.

According to the scoring criteria, _____ scores were as follows.

TEST	RESULT
Rapid naming	Below average
Bead threading	Average
Phonological discrimination	Average
Postural stability	Well above average
Rhyme	Above average
Forwards digit span	Average
Digit naming	Average
Letter naming	Average
Sound order	Average
Shape copying	Well above average
Spatial memory	Average
Vocabulary	Well above average

An "At Risk Quotient" of 0.9 or greater is strong evidence that a child is "at risk" of developing dyslexia. However, _____ score was 1.05 , which suggests that the risk of _____ developing dyslexia is high.

The result suggests that _____ may be at risk of dyslexia; this combined with a family history of dyslexia means that his progress in school should be carefully monitored. Areas of particular weakness could be the focus of remediation work. You can seek to have him assessed, either through the school with the National Educational

Psychological Service (N.E.P.S.), or privately; information regarding private assessment can be sought from the Dyslexia Association of Ireland (D.A.I.). Please be aware that there are long waiting lists for such assessments regardless of whether you go through N.E.P.S. or privately; also, children are not usually eligible for testing before they are 6 years old.

Erika Doyle

Dyslexia Research Group
School of Psychology
Aras an Phiarsaigh
Trinity College
Dublin 2

Date:

Dear ,

I would like to express my deepest thanks to you and your family for participating in the Dyslexia Early Years Project. This project would not have been possible without the commitment shown by you and families like you. I am particularly grateful to _____ for her excellent behaviour and co-operation during the testing sessions.

I enclose the results of the Dyslexia Screening Test _____ completed when last tested here. This is not meant as a definitive statement or diagnosis regarding dyslexia, however, it is a fairly valid screening procedure.

The results for _____ show that his "at risk" score for developing dyslexia is low. A report detailing these results is enclosed.

Please feel free to contact us at any point should you have any questions. I wish you and _____ the best of luck for the future.

Yours sincerely,

Erika Doyle

University of Dublin, Trinity College. Dyslexia Early Years Project. Smith, E., Doyle, E. & Fuller, R.

Dyslexia Early Years Project

Results from the Dyslexia Screening Test

Name:

Date:

The Dyslexia Screening Test is designed for children between the ages of 6:6 – 16:5 years and provides an indication (an 'At Risk' Quotient) of whether a further, full psycho-educational assessment should be sought. It includes tests of attainment (reading, writing & spelling) as well as screening tests for dyslexia which cover a range of skills usually problematic for dyslexic children.

Attainment Tests

1. Reading test
2. Spelling test
3. Writing test

Screening Tests

4. Rapid naming: This involves correctly naming different pictures as quickly as possible.
5. Bead threading: This represents a test of fine motor skill requiring hand-eye coordination.
6. Postural stability: This involves a gentle push in the back to determine whether the child has a problem with maintaining balance.
7. Phonetic segmentation: This assesses the child's phonological skill, that is, their ability to break down the sounds of a word, as well as assessing their short-term memory.
8. Backwards digit span: This is a test of working memory, requiring the child to listen to a series of numbers then repeat them back in reverse order.

University of Dublin, Trinity College. Dyslexia Early Years Project. Smith, E., Doyle, E. & Fuller, R.

9. Nonsense passage reading: This tests the child's ability to read words with which they are not familiar, such that they must break down the word into chunks to work out how it sounds.
10. Semantic & Verbal fluency: These tests measure the ability to generate a list of words from some category, for example, food (semantic fluency) and the ability to generate a list of words beginning with the same sound (verbal fluency).

According to the scoring criteria, _____ scores were as follows.

TEST	**RESULT**
Reading	Average
Spelling	Average
Writing	Average
Rapid Naming	Average
Bead Threading	Well below average
Postural Stability	Above average
Phonetic Segmentation	Average
Backwards Digit Span	Average
Nonsense Passage Reading	Average
Semantic Fluency	Above average
Verbal Fluency	Average

An 'At Risk' Quotient of 1 or greater is strong evidence that a child is 'at risk' of developing dyslexia. However, _____ score was well under this risk quotient. His score was 0.2, which suggests that the risk of him developing dyslexia is low.

However given that there is a family history of dyslexia, if you are ever concerned about _____ subsequent progress in school and you suspect that the problems are related to dyslexia, you can seek to have him assessed, either through the school with the National Educational Psychological Service (N.E.P.S.), or privately. Information regarding private assessment can be sought from the Dyslexia Association of Ireland

University of Dublin, Trinity College. Dyslexia Early Years Project. Smith, E., Doyle, E. & Fuller, R.

(D.A.I.). Please be aware that there may be long waiting lists for such assessments regardless of whether you go through N.E.P.S. or privately. Children are not usually suitable for testing before they are 6 years old.

Erika Doyle

University of Dublin, Trinity College. Dyslexia Early Years Project. Smith, E., Doyle, E. & Fuller, R.

I

Scoresheet

Name: _____

Child ID: _____

Session no: _____

Date: _____ Age: Y: ____ M: ___

SCORE SHEET

COMMENT BOX

See individual test description sheets for scoring procedure

5 = Unable

Oculo-Motor Functioning Tests:

Visual Tracking **1 2 3 5**

Hand-Eye Tracking **1 2 3 5**

Fixation with Eyes **Yes 1 No 5**

Measure start of near Point Convergence and re-establishment of Binocular Vision (range 6-8 cms) _____ cms

Yes 1 Slow 4

Motor/Adiadochokinesia tests:

Fingers-to-nose - eyes open **1 2 3 4 5**
- eyes closed **1 2 3 4 5**

Heel on shin - left **1 2 3 4 5**
- right **1 2 3 4 5**

rapid alternate movement

Finger tapping (Birdie Song) - left hand **1 2 3 4 5**
- right hand **1 2 3 4 5**

Palm reversal **1 2 3 4 5**

Finger to thumb (Incy Wincy spider) _____ rotations in ____ secs
Child should attempt up to 10 rotations **Able 1** **Unable 5**

Name: _____

Child ID: _____

Session no: _____

Date: _____ Age: Y: ___ M: ___

Phonological Tests:

In School **Yes** ☐ **No** ☐

Letterland Scheme **Yes** ☐ **No** ☐

Letter Name Knowledge **/ 26**

Phoneme Deletion **/ 8**

Non-word Repetition **/ 10**

/ 10

/ 30

Video Data

Balance tests:

Dominant Leg — Right ☐

Left ☐

01 Standing on one leg *(5 secs @ 4yrs, 6 secs @ 6 years)* - right ____ secs

1 2 3 4 5

- left ____ secs

1 2 3 4 5

02 (Mann Test) Advanced Romberg *(min 8 secs)* - eyes open ____ secs

1 2 3 4 5

- eyes closed ____ secs

1 2 3 4 5

03 Tandem walk *(min 10 steps)* - forwards __ / 10 steps

1 2 3 4 5

5 yrs+ - backwards __ / 10 steps

Name: _____

Child ID: _____

Session no: _____

Date: _____ Age: Y: ___ M: ___

1 2 3 4 5 *

04	Walking on tiptoe ***(min 10 steps)***	- forwards	__ / 10 steps **1 2 3 4 5**
		5 yrs+ - backwards	__ / *10 steps* *1 2 3 4 5* *
05	Slalom Walk ***(min 10 steps)***	- forwards	__ / 10 steps **1 2 3 4 5**
		6 yrs+ - backwards	__ / *10 steps* *1 2 3 4 5* *
06	Hopping on the spot ***(min 10 hops)***	- right	___ / 10 hops **1 2 3 4 5**
		- left	___ / 10 hops **1 2 3 4 5**
07	March and about turn		**1 2 3 4 5**
08	Crawling on all fours		**1 2 3 4 5**

Name: _____

Child ID: _____

Session no: _____

Date: _____Age: Y: ____M:___

Balance Score Matrix

Scores	**x Amount**	**Total**
1		
2		
3		
4		
5 = Unable		
	Total : - 5 yrs / 11 +5 yrs / 13 + 6 yrs / 14	
	Average	

If average 2 or less = Low Risk ☐

Otherwise High Risk ☐

Name: _____

Child ID: _____

Session no: _____

Date: _____ Age: Y: ___ M: ___

Video Data

Reflex tests:

09 ATNR: Lying Down

Eyes open:	- left arm	1 2 3 4 5
	- left leg	1 4
	- right arm	1 2 3 4 5
	- right leg	1 4
Eyes closed:	- left arm	1 2 3 4 5
	- left leg	1 4
	- right arm	1 2 3 4 5
	- right leg	1 4

10 ATNR: (Ayres) Table position – front view

Opposite Arm

Open: head left: ❒ 1-5
head right ❒ 1-5

Closed: head left ❒ 1-5
head right ❒ 1-5

Eyes open:	- left arm	1 2 3 4 5
	- right arm	1 2 3 4 5
Eyes closed:	- left arm	1 2 3 4 5
	- right arm	1 2 3 4 5

11 STNR: Table position – side view

Eyes open:	- Trunk	1 2 3 4 5
	- Arms	1 2 3 4 5
Eyes closed:	-Trunk	1 2 3 4 5
	- Arms	1 2 3 4 5

12 ATNR: (Schilder) Standing position

Eyes open:	- left arm	1 2 3 4 5
	- right arm	1 2 3 4 5
Eyes closed:	- left arm	1 2 3 4 5
	- right arm	1 2 3 4 5

Name: _____

Child ID: _____

Session no: _____

Date: _____ Age: Y: ____ M: ___

13 TLR: Standing

Eyes open:	Head down:	**1 2 3 4 5**
	Head back:	**1 2 3 4 5**
Eyes closed:	Head down:	**1 2 3 4 5**
	Head back:	**1 2 3 4 5**

14 MORO: Standing

Eyes open:	**1 2 3 4 5**
Eyes closed:	**1 2 3 4 5**

Reflex Score Matrix

Scores	**x Amount**	**Total**
1		
2		
3		
4		
5 = Unable		
	Total /26	
	Average	

If average 2 or less = Low Risk ☐

Otherwise High Risk ☐

Group: _____

J

Ethics Approval

Department of Psychology
University of Dublin, Trinity College
Dublin 2, Ireland
Tel: +353 1 608 1886
Fax: +353 1 671 2006
Head of Department: Professor Ruth Byrne

Department of Psychology
Ethics Committee

20 November 2002

Dear Erika Doyle and Elaine Smith,

The Department of Psychology Ethics Committee met recently to consider your application entitled 'Retained primary reflexes and motor development: a longitudinal study of their relationship and of the effects of a remedial programme to stimulate normal primary reflex processes' for approval. I am pleased to tell you that the Committee has decided to approve your application.

Yours sincerely,

Chairperson, Department of Psychology Ethics Committee

K

Reflex Manual and Timetable



Early Years Project

INSTRUCTION MANUAL

Movement Programme 1

Dyslexia Early Years Project
Dept. of Psychology
TCD
Tel: 608 2095
www.dysvideo.org

Contents

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Exercise 2: Instructions for parents	Page 17
Exercise 2: Stories for the children	Page 22
Exercise 3: Instructions for parents	Page 24
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Exercise 4: Stories for the children	Page 39
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Dear Parent/Guardian,

Thank you for agreeing to allow your child take part in the Dyslexia Early Years Project.

This manual is to help guide you in the movement programme you will be doing with your child over the course of the next year. The video-tape illustrates each of the movements described in the manual. It would be useful to look at the video first to get an idea of the movements.

We would like your child to spend 10 minutes each day doing some movements. It may be useful to build them into your daily routine, using a quiet room, perhaps before bedtime.

Refer to the timetable at the back of this manual for the exercise for each particular day and tick the box when it is done, leave it blank if no exercise was done that day.

Please do not hesitate to contact us at the numbers/emails below if you have any questions about any aspect of the programme. We want you and your child to enjoy this programme and if we can help in that please ask for advice at any time.

This project could have an enormous influence in helping children at risk for dyslexia. Your family's commitment to participation is very much appreciated.

Yours faithfully,

Erika Doyle *edoyle4@tcd.ie* *087 9746032*
Elaine Smith *esmith@tcd.ie* *086 3845473*

Dyslexia Early Years Project
Rm 1.15
Dept. of Psychology
Aras an Phiarsaigh
Trinity College
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Tel: 608 2095
www.dysvideo.org

Getting Started

Once you have viewed the video please refer to the back of your manual for timetable of the exercises. Fill in the start date and tick the box when the exercise has been completed by your child each night. Try out your exercise and do not worry if your child does not complete the movements properly in the first few nights. Remember it is not a memory or learning game. The important thing is that the child concentrates on doing the movements competently for the required amount of time and eventually becomes accomplished at the movements after a few weeks. The stories are just to help keep your child's interest and keep the movements flowing.

The manual with your timetable filled in, and the video are to be returned to the Dyslexia Research Group at the end of your child's movement programme. They remain the property of Trinity College Dublin. These materials

are only to be used in the context of your child's participation in this study.

Programme 1

Instructions for Parents

Exercise 1: 12 weeks duration

Exercise 1 should be done by your child every night for 12 weeks. There are stories for each exercise to help make it fun. Sit the child in a low chair so that their feet are flat on the ground before they begin. You may find it comfortable to sit opposite the child and tell one of the stories on page 14 at a slow pace as you go through each stage of the exercise.

For Exercise 1 follow these steps:

Start Position:

1. Sit the child in a low chair crossing right arm over left placing the hands palms down at the shoulder.
2. Cross right foot over left.
3. Place the head at midline. This is where the head is in the centre position in relation to the body, not slightly up/down, left or right.



First Movement: Right Side

4. Keeping arms and feet in position, very slowly move the head to the right so that the chin is in line with shoulder. At first allow 5 seconds for this movement the first night. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



Encourage slow head movement lengthening the time each night until 30 seconds is reached.

Second Movement: Right Side

5. Holding the head in this position, extend the right hand slowly out to the right at shoulder height. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it too lasts for 30 seconds.



Do not worry if this time is not achieved within the first week. Encourage slow head movement and full arm extension until the full time is reached.

---

6. Right Hand

Keep the arm in this position for 10 seconds. One way of doing this is for the child to count to 10 on fingers and thumb ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back to thumb and forward again until you count to 10).***



Do not worry if your child cannot fully manage this at first, encourage them to continue.

Third Movement: Right Side

7. Holding the head in position with the forefinger of the left hand placed on the chin, bring the right arm back to starting position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



8. Removing the finger bring the head back to the midline. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



Encourage slow head movement lengthening the time each night until 30 seconds is reached.

Now change the child's sitting position and repeat the exercise with head and left arm:

Changing Start Position:

9. With the child sitting in the low chair, this time crossing left arm over right placing the hands palms down at the shoulder.
10. Cross left foot over right.
11. Place the head at midline.



First Movement: Left Side

12. Keeping arms and feet in position, very slowly move the head to the left so that the chin is in line with the shoulder. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



Second Movement: Left Side

13. Holding the head in this position, extend the left hand and arm slowly out to the left at shoulder height. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



Do not worry if this time is not achieved within the first week. Encourage slow head movement and full arm extension until the full time is reached.

Keep the arm in this position for 10 seconds. One way of doing this is for the child to count to 10 on fingers and thumb ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back to thumb and forward again until you count to 10.***



Do not worry if your child cannot fully manage this at first, encourage them to continue.

Third Movement: Left Side

14. Holding the head in position with the forefinger of the right hand placed on the chin, bring the right arm back to the start. position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



15. Removing the finger bring the head back to the midline. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds.



The full exercise can be done with eyes closed when mastered.

Goal: **After the first week this exercise should take about 4 minutes per night, moving head and arm out and back on each side.**

We do want your child to enjoy these exercises. Once your child is familiar with the movements you may wish to use some of the stories overleaf to maintain interest, or make up your own story, or you may prefer not to use a story at all.

Programme 1

Suggested stories for Exercise 1

A Dragon Fly in flight:

First Movement:
Move your head to follow the purple dragon fly as he flies from one flower to the next ***(slow head movement to the right/left).***

Second Movement:
Keeping your eyes on the dragon fly watch as he lands on the flower ***(hold head position).***
Slowly with your right/left hand, show what flower he flew to ***(right/left arm extension).*** Point to where he is ***(hold position).***
Count how long he stays on the flower ***(fingers to thumb).***

Third Movement:
Show him the way back to his flower ***(arm movement back to crossed over start position).***
Moving your head watch as the dragon fly flies back to his flower ***(move head back to midline start position).***

Repeat the story for head and left arm movement and legs crossed left over right as per instructions.

The Spaceship:

First Movement:
A little space ship flies across the night sky. Move your head to watch as it flies over to the moon ***(slow head movement to the right/left).***
Keeping your eyes on the spaceship, watch it land on the moon ***(hold head position).***

Second Movement:
With your arm trace the path it took across the night sky ***(right/left arm movement).***
Point to where it landed ***(hold head and arm position).***
Count how long it stays there ***(fingers to thumb).***

Third Movement:
Keep watching the spaceship but trace its way home with your arm ***(arm back to crossed over start position).***
Then move your head as you follow the spaceship on its way home to earth ***(head back to midline start position).***

Repeat the story for head and left arm movement and legs crossed left over right as per instructions.

A little bird flying:

First Movement:
Moving your head follow the little bird as he flies from his nest to the next tree ***(slow head movement to the right/left).***

Second Movement:
Watch as he lands on the branch ***(hold head position).***
Slowly with your right hand, show what tree he flew to ***(right/left arm extension- hold position).*** Pointing to where he is count how long he stays in that tree ***(fingers to thumb).***

Third Movement:
Show him the way back to his nest ***(arm movement back to start position).***
Moving your head watch as the bird flies back to his nest ***(head back to midline start position).***

Repeat the story for head and left arm movement and legs crossed left over right as per changing position instructions.

Programme 1

Instructions for Parents

Exercise 2: 4 weeks duration

Exercise 2 should be done by your child every night for 4 weeks. There are stories for each exercise to help make it fun. Sit the child in a low chair so that their feet are flat on the ground before they begin. You may find it comfortable to sit opposite the child and tell one of the stories on page 22 at a slow pace as you go through each stage of the exercise.

For Exercise 2 follow these steps:

Start Position:

1. Sit the child in a low chair crossing right arm over left placing the hands palms down at the shoulder.
2. Cross right foot over left
3. Place the head down on the chest



First Movement:

4. Keeping the arms and feet in position, very slowly lift the head so the chin is past the mid-line (but not so far back as to hurt the neck) and look at the ceiling. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute. Do not worry if this time is not achieved within the first week. Encourage slow head movement until the goal of 1 minute is reached.





Second Movement:

5. Keep the head in this position for 10 seconds.



Third Movement:

6. Bring head slowly back down to chest. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute.



Now change the child's sitting position and repeat exercise with the head:

Changing Start Position:

This is not shown in the video, however it is similar to above just follow the instructions below:

1. Still sitting in a low chair, the child now crosses left arm over right placing the hands palms down at the shoulder.
2. Cross left foot over right
3. Place the head down on the chest



First Movement: Changed position

4. As before keeping arms and feet in position, very slowly lift the head so the chin is past the mid-line (but not so far back as to hurt the neck) and look at the ceiling. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute. Do not worry if this time is not achieved within the first week. Encourage slow head movement until the goal of 1 minute is reached.

Second Movement: Changed Position

5. As before keep the head in this position for 10 seconds.

Third Movement: Changed Position

6. Bring head slowly back down to chest. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by end of week 1 it lasts for 30 seconds and by the end of week two it lasts for 1 minute. Again do not worry if this time is not achieved within the first week. Encourage slow head movement until the goal of 1 minute is reached.



This can be done with eyes closed when mastered.

Goal: **After the first week this exercise should take about 4 minutes per night, bringing the head up and down and then crossing arms and feet in the changed position to repeat head movement.**

We do want your child to enjoy these exercises. Once your child is familiar with the movements you may wish to use some of the stories overleaf to maintain interest, or make up your own story, or you may prefer not to use a story at all.

Programme 1

Suggested stories for Exercise 2

The Little Daisy:

First Movement:
A little plant in the ground lifts his head out of the soil slowly to look at the sun ***(lift head from chest slowly).***

Second Movement:
The sun helps him grow strong ***(hold head position looking at the ceiling).***

Third Movement:
The sun goes down, the little daisy brings his head down slowly and goes to sleep ***(bring head slowly back down to chest).***

Repeat story for exercise with legs crossed left over right as per instructions.

The Spaceship Lands:

First Movement:
A little spaceship pod lands in the garden. A small door on the top of the pod slowly opens up and back ***(lift head slowly from chest).***

Second Movement:
A spaceman looks out ***(hold head position looking at the ceiling).***

Third Movement:
The door slowly closes again ***(bring head slowly back down to chest).***

Repeat story for exercise with legs crossed left over right as per instructions.

The Bird Asleep:

First Movement:
A bird is asleep on a branch. She snores and lifts her head slowly ***(lift head slowly from chest).***

Second Movement:
She holds her head up ***(hold head position looking at the ceiling),***

Third Movement:
and snoozing again, drops her head slowly down to her chest. ***(Bring head slowly back down to chest).***

Repeat story for exercise with legs crossed left over right as per instructions.

Programme 1

Instructions for Parents

Exercise 3: 4 weeks duration

Exercise 3 should be done by your child every night for 4 weeks. There are stories for each exercise to help make it fun. Sit the child in a low chair so that their feet are flat on the ground before they begin. You might find it most comfortable to sit opposite the child and tell one of the stories on page 30 at a slow pace as you go through each stage of the exercise.

For Exercise 3 follow these steps:

Start Position:

1. Sit the child in a low chair crossing right arm over left placing the hands palms down at the shoulder.
2. Cross right foot over left
3. Place the head down on the chest



First Movement: Right Side

4. Keeping feet in position, slowly lift the head up and the right arm out simultaneously, so the chin is past the mid-line (but not so far back as to hurt the neck), and look at the ceiling, with the right arm in full extension. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by end of week 2 it lasts for 1 minute.

   Do not worry if this time is not achieved within 2 weeks. Encourage slow head movement and full arm extension until the goal of 1 minute is reached.





Second Movement: Right Side

5. Keep the arm and head extended for 10 seconds. One way of doing this is for the child to count to 10 on fingers and thumb ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back and forward again until you count to 10).***



Do not worry if your child cannot fully manage this, encourage them to continue.

Third Movement: Right Side

6. Simultaneously bring the head slowly back down to chest and the right arm back to start position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by end of week 1 it lasts for 30 seconds and by end of week 2 it lasts for 1 minute.



Now change the child's sitting position and repeat exercise with the head and left arm:

Changing Start Position:

1. Still sitting in the low chair, the child now crosses left arm over right placing the hands palms down at the shoulder.
2. Cross left foot over right
3. Place the head down on the chest



First Movement: Left Side

4. Keeping feet in position, slowly lift the head up and the left arm out simultaneously, so the chin is past the mid-line (but not so far back as to hurt the neck), and look at the ceiling, with the left arm in full extension. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute. Do not worry if this time is not achieved within the first two weeks. Encourage slow head and arm extension until the goal of 1 minute is reached.



Second Movement: Left Side

5. Keep the arm and head in this position for 10 seconds. One way of doing this is for the child to count to 10 on fingers and thumb ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back and forward again until you count to 10).***



Do not worry if your child cannot fully manage this at first, encourage them to continue.

Third Movement: Left Side

6. Simultaneously bring the head slowly back down to the chest and the left arm back to start position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute.



Do not worry if this time is not achieved within the first week. Encourage slow head and arm extension until the goal of 1 minute is reached.

This can be done with eyes closed when mastered.

Goal: **<u>After the first week this exercise should take about 4 minutes per night, moving head up and arm out and back on each side.</u>**

We do want your child to enjoy these exercises. Once your child is familiar with the movements you may wish to use some of the stories overleaf to maintain interest, or make up your own story, or you may prefer not to use a story at all.

Programme 1

Suggested stories for Exercise 3

The Little Daisy Begins to Grow:

First Movement:
The little daisy lifts his head and the petals on his right side at the same time, to warm in the sun. ***(Lift head and right arm slowly from chest).***

Second Movement:
The sun makes him strong ***(hold head position looking at the ceiling).***

Third Movement:
He folds his head and petals closed again. ***(Bring head and arm slowly back down to start position).***

Repeat story for the exercise with head/left arm and legs crossed left over right as per instructions.

The Little Spaceman is not too sure:

First Movement:
The little spaceman opens the door on the top and the door on the right side of his ship ***(lift head and right arm slowly from chest).***

Second Movement:
He checks to see if it is safe to come out ***(hold head and arm position looking at the ceiling).***

Third Movement:
He hears someone coming so he closes the top and side door slowly so as not to be heard ***(bring head and arm slowly back to start position).***

Repeat story for the exercise with head/left arm and legs crossed left over right as per instructions.

Little Bird Wet in the Rain:

First Movement:
The little bird got wet in the rain. She lifts her head and right wing to dry in the sun ***(lift head and right arm slowly from chest).***

Second Movement:
hold position.

Third Movement:
When she is dry she folds her wing and brings her head back down ***(bring head and arm slowly back to start position).***

Repeat story for the exercise with head/left arm and legs crossed left over right as per instructions.

Programme 1

Instructions for Parents

Exercise 4: 4 weeks duration

Exercise 4 should be done by your child every night for 4 weeks. There are stories for each exercise to help make it fun for the children. Sit the child in a low chair so that their feet are flat on the ground before they begin. You may find it comfortable to sit opposite the child and tell one of the stories on page 39 at a slow pace as you go through each stage of the exercise.

For Exercise 4 follow these steps:

Start Position:

1. Sit the child in low a chair crossing right arm over left placing the hands palms down at the shoulder.
2. Cross right foot over left
3. Place the head down on the chest



First Movement:

6. Keeping feet in position, slowly lift the head and two arms simultaneously, so the chin is past the mid-line (but not so far back as to hurt the neck), and look at the ceiling with both arms in full extension to shoulder height. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute.





Encourage the child to move head slowly and bring both arms slowly to full extension. Do not worry if it takes longer to achieve the 1 minute goal.



Second Movement:

6. Keep the arms and head in this position for 10 seconds. The child should count to 10 on both hands ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back and forward again until you count to 10).***

   Do not worry if your child cannot fully manage this at first, encourage them to continue.





Third Movement:

6. Bring head and arms slowly back down to start position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute.



Now change the child's sitting position and repeat exercise with the head and both arms:

Changing Start Position:

1. Still sitting in a low chair, the child crosses left arm over right placing the hands palms down at the shoulder.
2. Cross left foot over right
3. Place the head down on the chest



First Movement: Changed Position

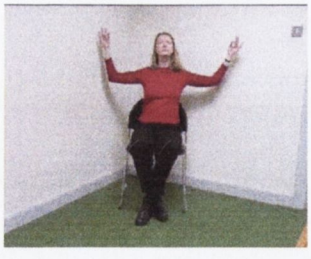
4. Keeping feet in position, slowly lift the head and two arms simultaneously, so the chin is past the mid-line (but not so fat back as to hurt the neck), and look at the ceiling with arms in full extension to shoulder height. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by the end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute.



Encourage the child to move head slowly and bring both arms slowly to full extension. Do not worry if it takes longer to achieve the 1 minute goal.

Second Movement: Changed Position

5. Keep the arms and head in this position for 10 seconds. The child should count to 10 on both hands ***(thumb to forefinger, then to middle finger, to ring finger and then little finger, then work from little finger back and forward again until you count to 10).***



Do not worry if your child cannot fully manage this at first, encourage them to continue.

Third Movement: Changed Position

6. Bring head and arms slowly back down to start position. At first allow 5 seconds for this movement. Gradually increase the time for this movement over the week so that by end of week 1 it lasts for 30 seconds and by the end of week 2 it lasts for 1 minute. Do not worry if this time is not achieved within the first week. Encourage slow head and arm retraction until the goal of 1 minute is reached.





Finish Position

This can be done with eyes closed when mastered.

Goal: Exercise 4 should take 4 minutes per night, moving head up and arms out to full extension and repeat with left foot over right

We do want your child to enjoy these exercises. Once your child is familiar with the movements you may wish to use some of the stories overleaf to maintain interest, or make up your own story, or you may prefer not to use a story at all.

Programme 1

Suggested stories for Exercise 4

The Little Daisy:

First Movement:
The little daisy lifts her head and all her petals to warm in the sun ***(lift head and extend both arms slowly).***

Second Movement:
The sun makes her strong ***(hold head position and arm extension, looking at the ceiling).***

Third Movement:
She drops her head and folds her petals closed again. ***(Bring head and arms slowly back to start position).***

Repeat story for exercise with legs crossed left over right as per instructions.

The Little Spaceship gets ready to fly home:

First Movement:
The little spaceman opens the top door and the side doors of his ship ***(lift head and extend both arms slowly).***

Second Movement:
He checks to see if there is anyone about ***(hold head position and arm extension, looking at the ceiling).***

Third Movement:
It is time to fly home so he closes the top and side doors slowly so as not to be heard ***(bring head and arms slowly back to start position).***

Repeat story for exercise with legs crossed left over right as per instructions.

The Little Bird sunning herself:

First Movement:
The little bird is sunning herself one afternoon. She lifts her head and stretches out both wings to the sun ***(lift head and extend both arms slowly.)***

Second Movement:
Hold position.

Third Movement:
When she is tired she folds her wings and brings her head back down to have a sleep ***(bring head and arms slowly back to start position).***

Repeat story for exercise with legs crossed left over right as per instructions.

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Timetable

Start Date: _____ Child Name: _____

Day	Exercise	Page	Tick
1	1	6	
2	1	6	
3	1	6	
4	1	6	
5	1	6	
6	1	6	
7	1	6	
8	1	6	
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11	1	6	
12	1	6	
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15	1	6	
16	1	6	
17	1	6	
18	1	6	
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20	1	6	
21	1	6	

Day	Exercise	Page	Tick
22	1	6	
23	1	6	
24	1	6	
25	1	6	
26	1	6	
27	1	6	
28	1	6	
29	1	6	
30	1	6	
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37	1	6	
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41	1	6	
42	1	6	

Day	Exercise	Page	Tick
43	1	6	
44	1	6	
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48	1	6	
49	1	6	
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63	1	6	

Day	Exercise	Page	Tick
64	1	6	
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Day	Exercise	Page	Tick
85	2	17	
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Day	Exercise	Page	Tick
106	2	17	
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112	2	17	
113	3	24	
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Day	Exercise	Page	Tick
127	3	24	
128	3	24	
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131	3	24	
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133	3	24	
134	3	24	
135	3	24	
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141	4	32	
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143	4	32	
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146	4	32	
147	4	32	

Day	Exercise	Page	Tick
148	4	32	
149	4	32	
150	4	32	
151	4	32	
152	4	32	
153	4	32	
154	4	32	
155	4	32	
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168	4	32	

Day	Exercise	Page	Tick
169	1	6	
170	1	6	
171	1	6	
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Day	Exercise	Page	Tick
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Day	Exercise	Page	Tick
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Day	Exercise	Page	Tick
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252	1	6	

Day	Exercise	Page	Tick
253	2	17	
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Day	Exercise	Page	Tick
274	2	17	
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Day	Exercise	Page	Tick
295	3	24	
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313	4	32	
314	4	32	
315	4	32	

Day	Exercise	Page	Tick
316	4	32	
317	4	32	
318	4	32	
319	4	32	
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322	4	32	
323	4	32	
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332	4	32	
333	4	32	
334	4	32	
335	4	32	
336	4	32	

Day	Exercise	Page	Tick
337	4	32	

End Date:_____

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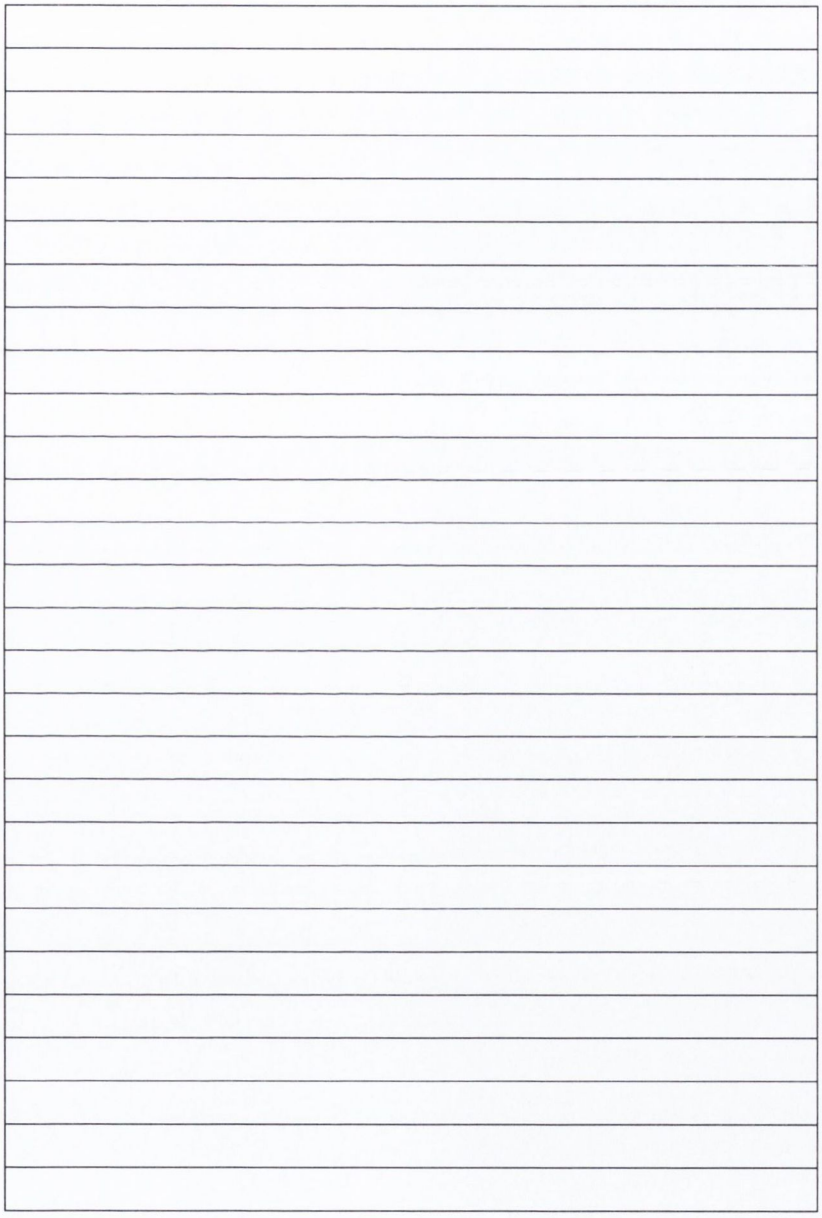
Comments

Please feel free to comment on any problems encountered on any particular dates of your programme. Please include the relevant date of your comment.



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Balance Manual and Timetable



Early Years
Project

INSTRUCTION MANUAL

Movement Programme 2

Dyslexia Early Years Project
Dept. of Psychology
TCD
Tel: 608 2095
www.dysvideo.org

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Dear Parent/Guardian,

Thank you for agreeing to allow your child to take part in the Dyslexia Early Years Project.

This manual is to help guide you in the movement programme you will be doing with your child over the course of the next year. The video-tape illustrates each of the movements described in the manual. It would be useful to look at the video first to get an idea of the movements.

We would like your child to spend 10 minutes each day doing some movements. It may be useful to build them into your daily routine, using a quiet room, perhaps before bedtime.

Refer to the back of your manual for timetable of the exercises. Tick the box once the exercise has been completed by your child each night. Try out your exercise and do not worry if your child does not complete the exercises properly in the first few nights. Remember it is not a memory or learning game. The important thing is that the child concentrates on doing the exercises competently for the required amount of time and eventually becomes accomplished at the movements after a few weeks. The stories are just to help keep your child's interest and keep the movements flowing.

The manual with your timetable filled in, and the video are to be returned to the Dyslexia Research Group at the end of your child's movement programme. They remain the property of Trinity College, Dublin. These materials are only to be used in the context of your child's participation in this study.

Please do not hesitate to contact us at the numbers/emails below if you have any questions about any aspect of the programme. We want you and your child to enjoy this programme and if we can help in that please ask for advice at any time.

This project could have an enormous influence in helping children at risk for dyslexia. Your family's commitment to participation is very much appreciated.

Yours faithfully,

Erika Doyle *edoyle4@tcd.ie* *087 9746062*
Elaine Smith *esmith@tcd.ie* *086 6845476*

Dyslexia Early Years Project
Rm 1.15
Dept. of Psychology
Aras an Phiarsaigh
Trinity College
Dublin 2.
Tel: (01) 608 2095

INSTRUCTIONS TO PARENTS

This movement programme lasts one week and is repeated again each week for 48 weeks. The programme is made up of 2 different sets of games one set called "John's Big Adventure" and one called "Traditional Stories."

You will need some area of the house that has a space at least 4 metres wide where the child can perform his movements. Each movement should be performed in as accurate a way as possible. Static movements (i.e. those that can be performed on the spot) should be continued for up to **10** seconds. Dynamic movements (i.e. those that involve movement along the 4 metre line) should be repeated up to **6** times. That is, up an imaginary line 6 times and down the line 6 times.

Please ensure that the area you use has plenty of protection (e.g. mats, carpets, cushions, pillows, blankets) so that the child does not hurt himself if he should lose his balance.

John's Big Adventure

This set of games is made up of 4 games, one for each day:

- Day 1: John in the jungle.
- Day 2: John and the giant.
- Day 3: John and the animals.
- Day 4: Simon Says.

Traditional Stories

This part of the programme consists of 3 games, one for each day. Unlike the previous section these do not form one continuous story. They are loosely based on traditional stories from other cultures but parts have been adapted to incorporate the necessary movements. The stories are:

- Day 5: The Goddess of Luck.
- Day 6: Lucky Hans
- Day 7: The Magic Doll

These movements should last about 10 minutes each night. If the game does not last that long then it should be extended or even repeated to bring the time up to 10 minutes.

Do not worry if 10 minutes seems too much for your child. Encourage him to do whatever he can without becoming exhausted. Do not worry either if it takes some weeks for him to become familiar with the movements.

For all stories you may, if you wish, use your own child's name instead of the one used here.

John in the Jungle

(Game 1 - day 1)

You may use your child's name instead of John in the story to keep him interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room or bedroom) where the child can perform these movements.

Each movement should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to 6 times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

Game 1: John in the Jungle

(Instructions)

Once upon a time there was a little boy called John who was in the middle of the jungle and he had to go home for his dinner. But first he had to do lots of things to get out of the jungle.

John sees a river and on the river there is a boat.

John runs down to the river to the boat.
(RUN to warm up – run up and down 6 times).

Carefully he puts one leg into the boat,
(STAND on one foot - 10 seconds).

Then he puts the other leg into the boat.
(STAND on two feet - 10 seconds).

He starts to row while standing, first on the left,
(LEAN to side and SIMULATE ROWING - 10 seconds).

then he rows on the other side.

(LEAN to other side SIMULATE ROWING - 10 seconds).

But then the boat wobbles and wobbles.

(WOBBLE - 10 seconds).

So John sits down in the boat and rows one side,

(KNEEL on knees and sit back on heels - SIMULATE ROWING - 10 seconds).

then the other.

(KNEEL on knees and sit back on heels - SIMULATE ROWING ON OTHER SIDE - 10 seconds).

Then John sees an airplane at the side of the river.

He paddles to the side of the river.

(**PADDLE** twice each side).

John gets out of the boat - first one leg,

(STAND on one foot - 10 seconds).

then the other leg.

(STAND on two feet - 10 seconds).

He runs to the airplane.

(RUN up and down 6 times).

First the airplane needs to be wound up. He winds up the airplane.

(ARM WHIRLS - 10 in one direction and 10 in the other. If your child cannot manage all of this just encourage them to do whatever they can).

Then he gets into the plane, first one foot,

(STAND on one foot - 10 seconds).

then the other.

(STAND two feet together - 10 seconds).

The plane starts to move,

(WALK SLOWLY with arms extended at 90 degrees - 2 lengths).

then it moves faster.

(WALK FASTER, arms still extended - 2 lengths).

then it moves really fast.

(POWER WALK with arms still extended - 2 lengths).

Then the bump, bump, bump and the plane takes off!

(JUMP with 2 feet together, arms still extended - 10 PACES, then RUN back to start).

The plane is flying through the sky.

(RUN with arms still extended – up and down 6 times).

John sees the edge of the forest and decides to land, he slows down.

(From RUN to WALK slow down gradually, with arms still extended).

John lands the plane, first one wheel come down.

(HOP on one foot, arms still extended – 6 paces).

then the other wheel.

(JUMP with 2 feet together, arms still extended - 6 paces).

The plane lands.

(WALK, with arms still extended up and down 6 times along path. Arms may then go down).

John gets out of the plane - first one leg,

(STAND on one foot - 10 seconds).

then the other leg.

(STAND on two feet together - 10 seconds).

John is still not home but now he is tired so he decides to have a rest and continue his journey tomorrow. So John lies down on the ground and goes to sleep.

Estimated time: 4 minutes. Repeat if necessary.

John and the Giant

(Game 2 - day 2)

You may use your child's name instead of John in the story to keep him interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to **6** times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

Game 2:John and the Giant

(Instructions)

John sees a giant at the bottom of the hill. The giant is so big maybe he can see John's house and tell him how to get home for his dinner.

John decides to roll down the hill
(ROLL on ground, at first very slow and controlled).

He starts to roll faster and faster
(ROLL faster).

When he gets to the bottom of the hill John sees 2 big fences. He runs at the first fence and takes a big jump and jumps right over the fence.
(JUMP over the fence).

Then he runs at the second fence and takes a big jump and jumps right over the fence.
(JUMP over second fence).

Then he walks up to the big giant.
John asks the giant if he will show him how to get home for his dinner and the giant says he will help John go home for his dinner but only if John shows him what a plane looks like because the giant has never seen a plane.

So John **runs** with arms outstretched to show the giant what a plane looks like.
(RUN up and down 6 times with arms outstretched).

But the giant enjoyed seeing what a plane looked like so much that he wanted John to show him what a train looks like because he has never seen a train either.

So John walks making "chew chew" movements with his arms to show the giant what a train looks like.
(WALK up and down 6 times making "chew chew" noises).

But the giant enjoyed that so much that he wants to know what it is like to ride a horse because he has never seen anyone riding a horse.
So John gallops to show the giant what a horse looks like.

(GALLOP up and down 6 times).

But the giant enjoyed that so much that he wants to know what a car looks like because he has never seen a car either.
So John jogs using his arms to make a steering wheel motion to show the giant what a car looks like.
(JOG up and down 6 times).

But the giant enjoyed that so much he wants to know what a helicopter looks like because he has never seen a helicopter either.
So John twirls to show the giant what a helicopter looks like.
(TWIRL along the path with arms outstretched, once forward in one direction and once back in the other direction).

But the giant enjoyed that so much he wants John to show him what a pogo stick looks like because he has never seen a pogo stick either.
So John bounces to show the giant what a pogo-stick looks like.
(BOUNCE up and down the path 6 times).

Then the giant tells John that he will help him go home for his dinner if he plays a game with him first.

The giant wants John to play a game with him called "Tug of War." The giant says if John wins the game he will help him go home

(PLAY tug of war – continue for a 10 tugs – let child win).

John wins the game.

The giant tells John the animals will help him get home and he will bring John to the animals in his wheelbarrow. John gets in the wheelbarrow.

(WHEELBARROW - 2 lengths)

But then John is so tired again that he has to lie down for another sleep. He decided to wait till tomorrow before letting the giant take him to the animals.

Estimated time: 4 minutes. Repeat if necessary

John and the Animals

(Game 3 – day 3)

You may use your child's name instead of John in the story to keep him interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to 6 times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of 10 seconds.

Game 6:John and the Animals

(Instructions)

First John meets a kangaroo. He asks the kangaroo if he knows how John can get home. The kangaroo doesn't know but he says the gorilla will know and he will help John get to the gorilla. But John must pretend to be a kangaroo if he wants help.

John and the kangaroo skip together to the gorilla's house.
(SKIP up and down 6 times).

They meet the gorilla. John asks if the gorilla knows how he can get home. The gorilla says he doesn't know but that the ants will know and he will help John get to the ants but John must pretend to be a gorilla.

John and the gorilla rock together to the ants' house.
(ROCK up and down from side to side, shifting weight from one leg to the other whilst making gorilla impressions with the arms curled under the armpits - up and down 6 times).

They meet the ants. The ants are very busy. John asks if they know how he can get home. They say they do not know but that the horse might know and they will bring him to the horse but he must pretend to be an ant.
John and the ants march together to the horse's house.
(MARCH up and down 6 times using opposite arm and leg).

They meet the horse. John asks the horse if he knows how John can get home and the horse says he doesn't know but that the frog might know. He will take John to the frog but John must pretend to be a horse.

John and the horse gallop together to the frog's house.
(GALLOP up and down 6 times – *Change leading leg half way*).

They meet the frog. John asks the frog if he knows how John can get home. The frog says he does not know but that the crab might know and he will bring John to the crab but John must pretend to be a frog.

John and the frog leap together to the crab's house.

(LEAP once then CRAWL along rest of path, turn and repeat. Do this up and down 6 times - *do not worry if your child finds this difficult. Encourage them to do only what they can manage*).

They meet the crab. John asks the crab if he knows how he can get home and the crab says that the only person who can help John is the ostrich. He will bring John to the ostrich but John must pretend to be a crab.

John and the crab crawl together to the ostrich's house.
(CRAWL on all 4s up and down 6 times).

They meet the ostrich. John asks the ostrich if he knows how he can get home and the ostrich says he does not know but that the eagle might know and he will bring John to the eagle but first John must pretend to be an ostrich.

John and the ostrich walk step towards the eagle's house.
(WALK up and down 6 times, making each 3rd step a BALANCE ON ONE FOOT - "step, step, hold on one foot, step, step,

hold on one foot etc." Ensure the foot balanced on changes each time).

They meet the eagle. John asks the eagle if he knows how he can get home and the eagle says he does not know but that the giraffe might know and he will bring John to the giraffe but first John must pretend to be an eagle.

John and the eagle fly to the giraffe's house.
(RUN up and down path 6 times, pretending to fly, arms out like wings flapping).

They meet the giraffe. John asks the giraffe if he knows how he can get home and the giraffe says he does not know but that the bat might know and he will bring John to the bat but first John must pretend to be a giraffe.

John and the giraffe walk to the bat's house.
(WALK up and down path 6 times, slowly, raising each leg high alternately).

They meet the bat. John asks the ostrich if he knows how he can get home and the bat says he does not know but that Simon might know and he will bring John to Simon tomorrow but first John must have a rest and go to sleep like a bat.

John and the bat sleep like bats do.

(BEND over and hang head upside-down for 10 seconds, FLAPPING arms like bat wings).

Estimated time: 4 minutes. Repeat if necessary.

Simon Says

(Game 4 – day 4)

You may use your child's name instead of John in the story to keep him interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to **6** times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

Game 4: Simon Says

(Instructions)

(To be done twice: first time with eyes open, second with eyes closed.)

John meets Simon. He asks Simon if he knows how John can get home. Simon says he can help John get home but only if he plays a game with him called "Simon Says" where John has to do everything Simon says. John thinks this sounds like a fun game so he agrees.

Simon says clap your hands and John claps his hands.
(STAND STILL & CLAP HANDS x 10).

Simon says do jumping jacks and John does jumping jacks.
(JUMPING JACKS x 10).

Simon says do windmills and John does windmills.

(WINDMILLS x 10. Spin left x 5, spin right x 5 - *if this causes too much dizziness for your child you may omit or reduce it).*

Simon says touch your toes and John touches his toes.
(TOUCH TOES - 10 times. Child is permitted to bend their knees).

Simon says stretch up and John stretches up.
(STRETCH UP - 10 seconds - *keep head in midline, looking straight ahead*).

Simon says stretch to the left and John stretches to the left.
(STRETCH TO LEFT - 5 seconds).

Simon says stretch to the right and John stretches to the right.
(STRETCH TO RIGHT - 5 seconds).

Simon says shake your left leg and John shakes his left leg.
(SHAKE LEG - 5 seconds).

Simon says shake your right leg and John shakes his right leg.

(SHAKE LEG - 5 seconds).

Simon says hang upside down and John hangs upside down.

(HANG HEAD AND UPPER BODY DOWN - 10 seconds).

Simon says sit down, cross legs and bounce one.

(DO BOTH LEGS - 5 seconds each).

Simon says sit on the ground, cross legs and rock.

(ROCK - side to side for 5 seconds, then forward and backward for 5 seconds).

Simon says pretend to be pop-corn.

(BUNNY HOP x 5).

Simon says do a tumble.

(TUMBLE x 2 - *help child if unable*).

Then Simon was so happy with John that he said he would take him home to his mummy and daddy for his dinner. He told John to shut his eyes and then he would find himself at home. So John

shut his eyes and when he opened them he was back at home. His mum had made him his favourite dinner. He sat down and told his mum and dad all about his big adventure in the jungle, with the giant, with the animals and with Simon.

Estimated time: 4 minutes. Repeat if necessary.

THE END

SECTION 2

TRADITIONAL STORIES

(Games 5-7)

The Goddess of Luck

(Game 5 - day 5)

This story is loosely based on a traditional Nepalese story.* Because the actions do not run for the entire length of the story the child may sit down when they are finished and listen to the rest of the story.

You may use your child's name instead of the one in the story if you feel it would help keep your child interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room or bedroom) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to **6** times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

* As retold by Josephine Evetts-Secker (1998) in "The Barefoot Book of Mother and Son Tales," Barefoot Books, Great Britain.

The Goddess of Luck

(Instructions)

Once upon a time high up in the mountains in Nepal there lived anwoman and her son who were very poor. They were so poor that sometimes they had to beg for food. One day the boy decided he did not like being poor and asked his mother why they were so poor. But she did not know why they were so poor so the little boy decided that he would set off to look for the Lord of the Universe to ask him why they were so poor.

So one day the boy set off looking for the Lord of the Universe. He walked for hours and hours and hours.
(Child should WALK up and down the line 6 times).

After walking a long time the boy reached a thick jungle. He was so tired from walking that he stopped and looked around.
(Child should MARCH on spot while the next part of the story is told).

While the boy was standing there along came the god and goddess Siva and Parvati and they saw the little boy standing all alone. The boy told them that he and his mother were very poor and he was trying to find the Lord on the Universe to ask him why they were so poor. Parvati felt sorry for the boy and wanted to give him something nice. But Siva said they could not give the boy anything unless he skipped up and down for them.

(Child should SKIP up and down 6 times along the line).

Then Siva said they could not give the boy anything unless he marched for them.

(Child should MARCH up and down 6 times along the line).

Then Siva said they could not give the boy anything unless he hopped for them.

(Child should HOP, on one foot then the other up and down 6 times along the line – or whatever they can manage).

Then the god and goddess were happy so they gave the boy a gold necklace. The boy was so happy he started to run all the way home to show his mother.

(Child should RUN up and down the line 6 times).

But then the boy got tired and slowed down. Soon he was walking he was so tired.

(Child should WALK up and down the line 6 times).

Then the boy got even more tired and soon he was crawling on the ground.

(Child should CRAWL up and down the line 6 times).

Finally the boy got so tired he decided to have a little sleep. He lay down on the ground and began to sleep.

(Child should lie on the ground and pretend to sleep).

But while the boy was asleep a big eagle flew by and saw the gold necklace sparkling. The eagle swooped down and flew off with the necklace. When the boy woke up he was so sad he cried all the way home.

(Child should WALK up and down line 6 times).

When he got home his mother did not believe his story and they were still really poor. So the boy decided that the next day he would try to find the Lord of the Universe again. When morning

came the boy left the house and marched off with much determination.

(Child should MARCH up and down the line 6 times).

Once again he met the god and goddess Siva and Parvati. He told them his sad story about losing the necklace. Parvati felt sorry for the boy and wanted to give him something else nice. But Siva said they could not give the boy anything unless he did jumping jacks for them.

(Child should do jumping jacks on the spot for 10 seconds).

Then Siva said they could not give the boy anything unless he did lots of stretches for them.

(Child should stretch to the left 10 times, then stretch to the right 10 times, then touch his toes 10 times - child is permitted to bend the knees).

Then the god and goddess gave the boy a diamond ring. The boy was so happy he started to run all the way home to show his mother.

(Child should RUN up and down the line 6 times).

After running for so long the boy was thirsty and so he stopped by a stream to drink the water. But while he was bending over the ring fell out of his pocket and into the stream where it was quickly swallowed by a big fish. The boy was so upset that he cried all the way home.

(Child should WALK up and down the line 6 times).

When he got home his mother did not believe his story and they were still really poor. So the boy decided that the next day he would try to find the Lord of the Universe again. When morning came the boy was feeling a bit better and again full of determination so he left the house and skipped off with much determination.

(Child should SKIP up and down the line 6 times).

Once again he met the god and goddess Siva and Parvati. He told them his sad story about losing the diamond ring. Parvati felt sorry for the boy and wanted to give him something else nice. But Siva said they could not give the boy anything unless he did a funny walk for them.

(Child should SWAY from side to side up and down the line 6 times).

Then Siva said they could not give the boy anything unless he did running jumps for them.

(Child should run then jump once (as if jumping over a fence) each time along the line. Run up and down the line 6 times).

Then Siva said they could not give the boy anything unless he did spins for them.

(Child should SPIN in one direction up and down the line 3 times then in the other direction 3 times – if they cannot manage this encourage them to do only what they can manage).

Then the god and goddess gave the boy some diamonds. The boy was so happy he started to run all the way home to show his mother.

(Child should RUN up and down line 6 times).

But when he got home his mother wasn't there. He left the diamonds in the house and went out looking for her. When he found her he brought her home only to find that a thief had broken into the house and stolen all the diamonds so his mother did not believe his story and they were still poor. So once again

the boy got up the next day determined to find the Lord of the Universe. He left his house and walked a long way.

(Child should WALK up and down line 6 times).

Once again he met the god and goddess Siva and Parvati. He told them his sad story about losing the diamonds. They felt so sorry for him that they decided this time to go to the Goddess of Luck to ask her to help the boy.

At this point the child may sit down and listen to the rest of the story.

The Goddess of Luck heard the story and thought the little boy's spirit was great. She came down to meet him and gave him a copper coin. The little boy was overjoyed and went straight home to show his mother. His mother was very happy. They saw a fisherman walking along the road selling fish so the little boy bought a fish. When he cut open the fish guess what he saw? He saw his diamond ring in the fish's belly! But that was only the first bit of luck because then the little boy needed some wood to stoke the fire to cook the fish so he went outside and climbed a tree. When he got to the top of the tree he saw an eagle's nest and guess what was inside the eagle's nest? His gold necklace! But that was only the second bit of luck because when he got back

home the thief was standing at his front door. The thief had felt so bad about stealing the diamonds that he had decided to give them back to the little boy. So then there were three bits of luck. The little boy now had food and a gold necklace and a diamond ring and lots of diamonds. This is how the Goddess of Luck helped the poor mother and her son to become rich!

Estimated time: 4 minutes. Repeat if necessary.

THE END

Lucky Hans

(Game 6 - day 6)

This story is loosely based on a traditional German story.*

You may use your child's name instead of the one in the story if you feel it would help keep your child interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to **6** times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

* As retold by Josephine Evetts-Secker (1998) in "The Barefoot Book of Mother and Son Tales," Barefoot Books, Great Britain.

Lucky Hans

(Instructions)

Once upon a time there was a young boy called Hans who had worked for his master faithfully for several years. One day Hans decided he had worked enough for his master and told him that he now wanted to go home to his mother. His master was sad to let him go but agreed to let him go home and as a reward for having been such a good worker gave him a huge lump of gold.

The lump of gold was so big that Hans could only carry it on his back. When he set off for home he had to carry it on his back. **(Child should WALK up and down the line 6 times pretending to hold the gold on their back, keeping the face forward at all times).**

While he was walking along Hans met a man on horseback. Hans thought it would be great to have a horse and not have to hurt his own feet on the road. So Hans decided to give his gold to the man in return for the horse.

Hans got up on to the horse slowly -first raising one leg over it then straddling it.

(Child should BALANCE on one leg of their choice for about 5 seconds then stand legs apart on both feet in a straddle position for 5 seconds).

When he was up on the horse Hans was delighted and started to canter on the horse.

(Child should GALLOP gently up and down line 6 times, pretending to ride the horse - ensure they change leading leg half way).

Then the horse started to go faster and faster and faster. Soon the horse was galloping along so fast that Hans was having trouble staying on top of the horse.

(Child should RUN fast up and down 6 times pretending to ride the horse).

But then the horse was running so fast that Hans got thrown off the horse. Just then a farmer passed by with a cow. He saw Hans was having problems with the horse and offered to swap the cow for the horse. Hans was happy to get rid of the horse. It was

hard to control it. But now he had a cow! Hans jumped up on the cow.

(Child should BALANCE, as before, on one leg of their choice for about 5 seconds then stand legs apart on both feet in a straddle position for 5 seconds).

The cow began to walk with Hans on top.

(Child should WADDLE from side to side up and down line 6 times).

Then Hans was very thirsty so he decided to milk the cow for a drink.

(Child should bend over and pretend to the milk the cow for 10 seconds).

But nothing would come out of the cow and finally she kicked Hans hard. Just as she kicked the boy a butcher passed by with a pig. The butcher told Hans that the cow was no good for milk but he would swap the pig for the boy's cow if the boy hopped on one foot for him.

(Child should hop on the spot for as long as they can manage).

Then the butcher said he would only swap the cow for the pig if Hans hopped on the other foot, so Hans hopped on the other foot.

(Child should hop on the other foot for as long as they can manage).

Then the butcher said he would only swap the cow for the pig if Hans promised to be kind to the pig and talk to it while crawling along with it. The boy agreed and so Hans and the pig went on their merry way with Hans crawling along side the pig and talking to it.

(Child should CRAWL up and down the line 6 times like the pig).

But then Hans's knees and hands began to get sore. He saw a boy with a goose and thought how much easier it would be to have a goose. So Hans offered to swap the pig for the goose. The boy said he would only swap the goose for the pig if the boy tried to keep the goose amused, because it was a very nice goose and liked to see funny things. So Hans agreed to keep the goose amused and swapped the pig for the goose. When Hans had the goose he did lots of things to make the goose laugh.

(Child should do jumping jacks 10 times).

The goose thought the jumping jacks were very funny but then wanted to see more funny things so Hans tried to walk like the goose to amuse him.
(Childs should WALK up and down the line 6 times flapping arms like wings).

The goose thought that was funny but then wanted to see more funny things so Hans rolled along the ground to try and make the goose laugh.
(Child should ROLL along the ground up and down the line 6 times).

But then Hans was tired of having to make the goose laugh. He saw a scissor-grinder walking along who was whistling merrily to himself. The scissor-grinder told Hans that his job made lots and lots of money. Hans thought it would be nice to have a grindstone so that he too could make lots and lots of money. He told the scissor-grinder that he would like a grindstone and the scissor-grinder told Hans that he would give him one in return for the goose. So Hans gave the scissor-grinder the goose and the

scissor-grinder gave Hans a large stone. So Hans went on his merry way carrying the stone on his back because it was so heavy. **(Child should WALK up and down the line with arms raised 6 times pretending to carry the stone on his back).**

But then the stone got so heavy that Hans couldn't carry it anymore. He stopped to take a drink from a well and as he was drinking he accidentally dropped the stone into the well. But Hans did not mind at all. He was so happy that now he didn't have to carry a heavy stone. So he jumped up and skipped all the way home to his mother thinking how lucky he was not to have anything now to carry.

(Child should JUMP as high as possible, CLAP their hands 5 times and SKIP up and down the line 6 times).

Estimated time: 4 minutes. Repeat if necessary.

THE END

The Magic Doll

(Game 7 - day 7)

This story is loosely based on a traditional Wabanaki story. *

You may use your child's name instead of the one in the story if you feel it would help keep your child interested.

Have an imaginary line inside the house about 4 metres long (perhaps the length of the sitting room) where the child can perform these activities.

Each activity should be performed in as accurate a way as possible. Dynamic movements (i.e. those that involve movement along a line) should be repeated up to **6** times. Static movements (i.e. those that can be performed on the spot) should be continued for a period of **10** seconds.

* As retold by Josephine Evetts-Secker (1998) in "The Barefoot Book of Mother and Son Tales," Barefoot Books, Great Britain.

The Magic Doll

(Instructions)

Once upon a time there was a very good boy called Kayak. One day, when he was old enough, he decided to leave home. His mother was very sad to let him go but knew that he had to grow up. The chief of the tribe saw Kayak leave home and wanted to test how good Kayak was. He hobbled along in front of Kayak and dropped a little box to see if Kayak would be an honest boy and give it back to him. Kayak saw the old man drop the box and was tempted to keep it but instead he picked it up and ran after the old man and gave it back to him. The old man knew then that Kayak was indeed a good boy and told him he could keep the box because it was a lucky box and inside was a magic doll who could grant wishes when Kayak needed them on his journey. Kayak said thank you to the man then went on his journey.

Kayak walked for days and days looking for a village where he might get some food and some rest.
(Child should WALK up and down line 6 times).

Eventually he got to the village of the Micmac people and Kayak went to meet the chief of the village. Because the chief was an important man, Kayak had to bow for a long time in front of him.
(Child should BOW and hold the position for 10 seconds).

The chief had a very beautiful daughter and Kayak immediately fell in love with her. He asked the chief if he could marry his daughter. But the chief said Kayak could only marry his daughter if Kayak could jump as high as the sky. Kayak knew that he could not jump as high as the sky so he got out the lucky box and opened it. He asked the magic doll to make him be able to jump as high as the sky.
(Child should JUMP as high as they can 10 times).

The chief was angry that Kayak was able to jump as high as the sky. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his

daughter if he could rock better than a boat. Kayak knew that he could not rock better than a boat so he got out the lucky box and opened it. He asked the magic doll to make him be able to rock better than a boat.

(Child should SIT on the floor knees bent and feet together and ROCK from side to side 10 times).

The chief was angry that Kayak was able to rock better than a boat. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if could fly better than a bird. Kayak knew that he could not fly better than a bird so he got out the lucky box and opened it. He asked the magic doll to make him be able to fly better than a bird.

(Child should hold out their arms at 90 degrees to body and RUN up and down line 6 times flapping their arms like a bird).

The chief was angry that Kayak was able to fly better than a bird. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he swims like a fish. Kayak knew that he could not swim better than a fish so he got out the lucky box and opened it.

He asked the magic doll to make him be able to swim better than a fish.

(Child should do either breast-stroke or front-crawl like movements with the arms – whichever is easier, as they RUN up and down line 6 times).

The chief was angry that Kayak was able to swim better than a fish. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could march better than the best soldier in the army. Kayak knew that he could not march better than the best soldier in the army so he got out the lucky box and opened it. He asked the magic doll to make him be able to march better than the best soldier in the army.

(Child should MARCH up and down line 6 times).

The chief was angry that Kayak was able to march better than the best soldier in the army. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could roll better than a ball. Kayak knew that he could not roll better than a ball so he got out

the lucky box and opened it. He asked the magic doll to make him be able to roll better than a ball.

(Child should ROLL on the ground up and down the line up to 6 times if they can manage but fewer if they cannot).

The chief was angry that Kayak was able to roll better than a ball. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could shake better than a leaf. Kayak knew that he could not shake better than a leaf so he got out the lucky box and opened it. He asked the magic doll to make him be able to shake better than a leaf.

(Child should SHAKE each limb for 10 seconds – fewer if they cannot manage it, first the arms and then the legs).

The chief was angry that Kayak was able to shake better than a leaf. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could hop for a mile. Kayak knew that he could not hop for a mile so he got out the lucky box and opened it. He asked the magic doll to make him be able to hop for a mile.

(Child should HOP up and down the line 6 times, switching feet half way. If the child cannot manage this much encourage them to do whatever they can).

The chief was angry that Kayak was able to hop for a mile. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could skip better than a kangaroo. Kayak knew that he could not skip better than a kangaroo so he got out the lucky box and opened it. He asked the magic doll to make him be able to skip better than a kangaroo.

(Child should SKIP up and down the line 6 times).

The chief was angry that Kayak was able to skip better than a kangaroo. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could crawl better than a spider. Kayak knew that he could not crawl better than a spider so he got out the lucky box and opened it. He asked the magic doll to make him be able to crawl better than a spider.

(Child should CRAWL on all fours up and down the line 6 times).

The chief was angry that Kayak was able to crawl better than a spider. Kayak thought that now he would be able to marry the chief's beautiful daughter but the chief said he could only marry his daughter if he could leap the length of 10 men. Kayak knew that he could not leap the length of 10 men so he got out the lucky box and opened it. He asked the magic doll to make him be able to leap the length of 10 men.

(Child should take a RUNNING LEAP along the line – run, leap – then turn around and repeat up and down 6 times).

Then the chief was no longer angry. He saw that Kayak obviously had the strength and courage of a great man and he knew this would be a good person for his beautiful daughter to marry. He told Kayak that he was a good boy and that he could now marry his beautiful daughter. Kayak was so happy he ran up and down shouting at the top of his voice and clapping hard.

(Child should RUN up and down line 6 times clapping their hands).

Kayak married the chief's beautiful daughter and they lived happily ever after.

Estimated time: 4 minutes.Repeat if necessary.

THE END

Start Date: _____

Day	Exercise	Page	Tick
1	1		
2	1		
3	1		
4	2		
5	2		
6	2		
7	3		
8	3		
9	3		
10	4		
11	4		
12	4		
13	5		
14	5		
15	5		
16	6		
17	6		
18	6		
19	7		
20	7		
21	7		

Day	Exercise	Page	Tick
22	8		
23	8		
24	8		
25	4		
26	3		
27	6		
28	7		
29	1		
30	2		
31	3		
32	8		
33	1		
34	3		
35	8		
36	2		
37	7		
38	8		
39	1		
40	3		
41	1		
42	8		

Day	Exercise	Page	Tick
43	4		
44	7		
45	7		
46	8		
47	7		
48	8		
49	3		
50	6		
51	5		
52	1		
53	4		
54	2		
55	1		
56	7		
57	6		
58	5		
59	1		
60	6		
61	5		
62	6		
63	1		

Day	Exercise	Page	Tick
64	2		
65	1		
66	1		
67	4		
68	3		
69	6		
70	6		
71	7		
72	2		
73	1		
74	7		
75	7		
76	6		
77	5		
78	4		
79	3		
80	1		
81	2		
82	6		
83	7		
84	3		

Day	Exercise	Page	Tick
85	6		
86	1		
87	4		
88	4		
89	1		
90	2		
91	6		
92	4		
93	7		
94	5		
95	1		
96	6		
97	1		
98	7		
99	4		
100	6		
101	6		
102	8		
103	5		
104	4		
105	6		

Day	Exercise	Page	Tick
106	3		
107	5		
108	4		
109	6		
110	7		
111	5		
112	7		
113	2		
114	7		
115	6		
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117	4		
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122	4		
123	7		
124	5		
125	7		
126	4		

Day	Exercise	Page	Tick
127	2		
128	2		
129	6		
130	7		
131	5		
132	4		
133	6		
134	5		
135	4		
136	2		
137	7		
138	1		
139	7		
140	3		
141	5		
142	6		
143	6		
144	8		
145	1		
146	6		
147	5		

Day	Exercise	Page	Tick
148	8		
149	2		
150	2		
151	8		
152	6		
153	1		
154	8		
155	1		
156	4		
157	1		
158	4		
159	8		
160	1		
161	3		
162	8		
163	2		
164	6		
165	1		
166	6		
167	5		
168	8		

Day	Exercise	Page	Tick
169	2		
170	1		
171	4		
172	3		
173	1		
174	4		
175	3		
176	4		
177	4		
178	7		
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181	3		
182	3		
183	6		
184	6		
185	7		
186	1		
187	2		
188	3		
189	7		

Day	Exercise	Page	Tick
190	5		
191	7		
192	4		
193	7		
194	4		
195	6		
196	6		
197	3		
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Day	Exercise	Page	Tick
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212	3		
213	2		
214	5		
215	6		
216	5		
217	7		
218	3		
219	5		
220	8		
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222	6		
223	7		
224	4		
225	8		
226	4		
227	7		
228	2		
229	8		
230	7		
231	7		

Day	Exercise	Page	Tick
232	6		
233	3		
234	7		
235	6		
236	5		
237	6		
238	6		
239	5		
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245	4		
246	2		
247	6		
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249	2		
250	4		
251	8		
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Day	Exercise	Page	Tick
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258	4		
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260	5		
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264	7		
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267	2		
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269	5		
270	7		
271	1		
272	3		
273	4		

Day	Exercise	Page	Tick
274	8		
275	6		
276	2		
277	7		
278	4		
279	3		
270	4		
281	3		
282	2		
283	7		
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Day	Exercise	Page	Tick
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299	7		
300	3		
301	3		
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303	6		
304	8		
305	8		
306	8		
307	1		
308	6		
309	1		
310	5		
311	3		
312	1		
313	5		
314	7		
315	3		

Day	Exercise	Page	Tick
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317	5		
318	8		
319	5		
320	4		
321	3		
322	6		
323	5		
324	4		
325	4		
326	7		
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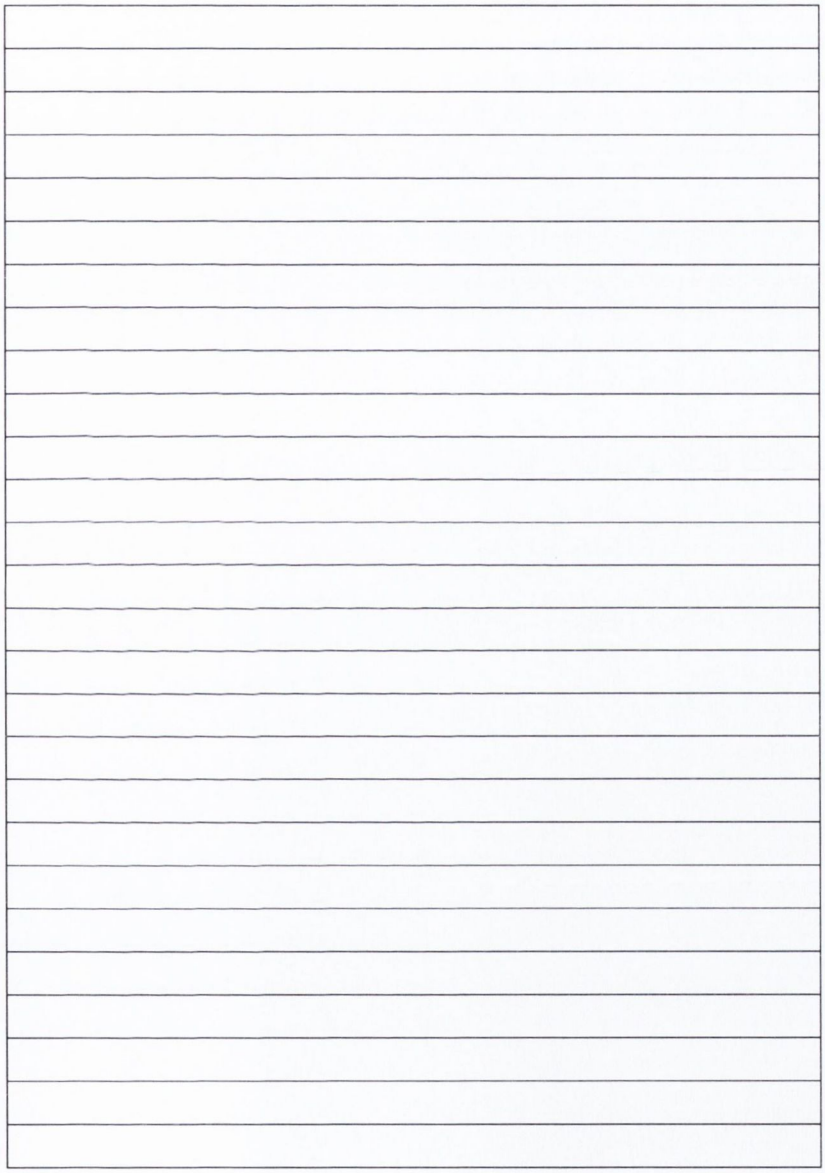
End Date: _____

Comments

Please feel free to comment on any problems encountered on any particular days of your programme. Please include the relevant date of your comment.



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Placebo Manual and Timetable



Early Years Project

INSTRUCTION MANUAL

Movement Programme 3

Dyslexia Early Years Project
Dept. of Psychology
TCD
Tel: 608 2095
www.dysvideo.org

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Dear Parent/Guardian,

Thank you for agreeing to allow your child to take part in the Dyslexia Early Years Project.

This manual is to help guide you in the movement programme that you will be doing with your child over the course of the next year. The video-tape illustrates each of the movements described in the manual. It would be useful to look at the video first to get an idea of the movements.

We would like your child to spend 10 minutes each day doing some movements. It may be useful to build them into your daily routine, using a quiet room, perhaps before bedtime.

Refer to the back of your manual for a timetable of the exercises. Tick the box once the exercise has been completed by your child each night. Try out your exercise and do not worry if your child does not complete the exercises properly in the first few nights. Remember it is not a memory or learning game. The important thing is that the child concentrates on doing the exercises competently for the required amount of time and eventually becomes accomplished at the movements after a few weeks. The stories are just to help keep your child's interest and keep the movements flowing.

The manual with your timetable filled in, and the video are to be returned to the Dyslexia Research Group at the end of your child's movement programme. They remain the property of Trinity College Dublin. These materials are only to be used in the context of your child's participation in this study.

Please do not hesitate to contact us at the numbers/emails below if you have any questions about any aspect of the programme. We want you and your child to enjoy this programme and if we can help in that please ask for advice at any time.

This project could have an enormous influence in helping children at risk for dyslexia. Your family's commitment to participation is very much appreciated.

Yours faithfully,

Erika Doyle *edoyle4@tcd.ie* *087 9746032*

Elaine Smith *esmith@tcd.ie* *086 3845473*

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Tel: 608 2095

DIRECTIONS TO PARENTS

This movement programme lasts a total of 12 months. There are 8 different exercises carried out through stories and games. The sequence of stories and games will be in a random order.

For 4 of the stories the parent must take responsibility for moving the child's limbs and for the 4 face movement games the child has to imitate the parent's face movement or expression.

Parental Help Stories

There are 4 different stories in which the parent is actively engaged.

- 1: The Teddy game
- 2: Mr. Jelly
- 3: Finding Santa
- 4: Walking in the jungle

Parental Help Stories: During these stories the child should lie comfortably on the ground on blanket or rug, or on a bed. Ask the child to let their body 'go floppy'. The parent must take full responsibility for the weight of every limb in every movement. Don't let the child control any movements. Each movement should be held for a

period of approximately 10 seconds. If the parent wishes they may count aloud to 10.

Face Games

There are 4 different games which involve face movements.

- 5: Simon Says
- 6: Party Food
- 7: Snap
- 8: The Slow-Fast Game

The child should sit comfortably in a high backed chair and only move the facial muscles. The parent demonstrates and asks the child to hold the expression for five seconds.

Finally, these exercises should last about 10 minutes each night. If the game does not last that long then it should be extended or even repeated to bring the time up to 10 minutes.

Parental Help Games

The Teddy Game

(Instructions)

This game makes use of 2 teddies or dolls. One teddy (or doll) is put on each side of the child. The game requires the child *to* guess which teddy/doll is where or, with the control of the parent, to exercise the arms and legs.

When in the lying position the child should lie comfortably on the ground on a blanket or rug. When in the sitting position the child should sit comfortably in a high backed chair or fully supported on a bed. The teddies should be placed on either side of the child, far enough away so the child can see both teddies by moving his eyes **but without having to move the head.**

Ask the child to let their body 'go floppy' and to allow the parent to move their limbs. Young children may find this difficult so you may have to demonstrate. The parent must take <u>full</u> responsibility for the weight of every limb in every movement. Don't let the child control <u>any</u> movements. The child's eyes should

be closed while the movement is in progress but can be opened once the child has guessed "which teddy." If the guess is right the parent is recommended to say "very good" in a positive and encouraging way and if wrong the parent should say "oops" or some other such child friendly word. It is very important that the child does not move their head when they open their eyes to look at the teddy. If the teddy is so close he cannot see it without moving his head then move the teddy further away from the child's body.

While the parent is manipulating the child's arms it is suggested that they locate themselves behind the child's head and when manipulating the child's feet and legs they may move to the front of the child. These, however, are only suggestions and if you find a method which is more comfortable (e.g. remaining at the child's feet throughout), it is acceptable to adopt that method.

All manipulations should be held for 10 seconds.

The process should last about 10 minutes. If it is shorter then repeat the game again. All movement of limbs must be done in a slow and deliberate manner.

The Teddy Game

(Story 1 of 4)

Ask the child to lie down and be very still: The parent is to manipulate the arms. Explain to the child that he must guess which teddy is where when asked and that he must practise his arm and legs exercises like teddy does.

Part 1

1. Kneel above the child's head to manipulate arms.
2. The child should shut his eyes.
3. Parent should lift the child's right arm, supporting all weight and point it towards the teddy on the right.
4. Ask the child to guess which teddy he is pointing towards, then allow him to open his eyes. Respond appropriately ("Very good" or "Oops!").
5. Child should shut eyes again and parent should lift the child's left arm, supporting all weight and point it towards the teddy on the left. Ask him to guess which teddy they are pointing at. Respond appropriately. (You may now begin to switch the teddies' positions for at least three times to make the game more fun).
6. Now put a teddy at the end of each foot.

7. Parent should raise the right leg, pointing it towards the

teddy on the right and ask the child to guess teddy.

8. Respond appropriately.
9. Parent should raise the child's left leg, pointing it toward the teddy on the left and ask the child to guess teddy.
10. Respond appropriately.
11. You may now switch the teddies' positions three times to make the game more fun.

Continue in this fashion, moving the teddies from arms to feet and asking the child to guess for as long as you wish or until child tires of game.

Part 2

1. Tell the child that he and teddy must practise their arm exercises so that they can climb trees properly.
2. Parent should hold up one of the child's arms and bend it forwards and backwards. (It is permitted to bend the arm at the elbow).
3. Repeat above with the other arm.
4. Now parent should hold up both the child's arms and bend them backwards and forwards as if climbing a tree.
5. Tell the child that teddy now has to practise his leg exercises so that he can run very fast.

6. Parent should hold up one of the child's legs and in a similar manner bend it at the knee forwards and backwards.
7. Repeat above with the other leg.
8. Now parent should hold up both the child's legs and bend them backwards and forwards as if running.

Part 3

1. Tell the child that teddy has to practise his arm exercises again so that he can swim properly.
2. Parent should hold up one of the child's arms move it up and back then outwards and return to the side, as if doing back-crawl.
3. Repeat above with the other arm.
4. Now parent should hold up both the child's arms and bend them backwards and forwards as climbing a tree.
5. Tell the child that teddy now has to practise his leg exercises again to help his swimming.
6. Parent should hold up one leg, bend it at the knee then move it in a circular motion as if doing the breast-stroke.
7. Repeat above with the child's other leg.

8. Now hold up both the child's legs and bend them backwards and forwards together.

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Mr. Jelly

(Instructions)

Child should begin by standing. A soft comfortable floor with blankets or rugs should be prepared.

The procedure involves enactment of a story, which is narrated by the Parent. The parent should read the script prompted by the word "parent," and should then move the child according to the directions as instructed in the bold type beneath.

Ask the child to let their body 'go floppy' and allow the parent to move their limbs. The parent must take full responsibility for the weight of the child's limbs when manipulating them, except for very beginning of story when child is standing (for purposes of story). All movement of limbs must be done in a slow and deliberate manner.

Mr. Jelly

(Story 2 of 4)

Child should stand while this introduction is being read.

Once upon a time there was a man called Mr. Jelly and his very good friend called Mrs. Nelly. Sometimes Mr. Jelly turns all wobbly and can't stand up!

1) Parent wobbles and gently pretends to fall to floor then encourages child to do the same and gently ensures he "falls" to the ground so he is now in a lying position.

2) **Parent:** "One day Mr. Jelly and Mrs. Nelly are at the seaside and Mr. Jelly wants to go for a swim but he can't stand up!"

3) **Parent:** "Mr. Jelly tries to lift one leg but it wobbles too much."
(Parent lifts child's right leg and gently shakes it from side to side before a gentle return to the ground).

4) **Parent:** "Mr. Jelly tries to lift the other leg but it wobbles too much."
(Parent lifts child's left leg and gently shakes it from side to side before a gentle return to the ground).

5) **Parent**: "Mr. Jelly then tries to lift both legs but that doesn't work either."

(Parent lifts both legs and shakes both of them together before a gentle return to ground.)

6) **Parent:** "But Mr. Jelly wanted to go for a swim so much that Mrs. Nelly decided to help him. She decided to drag him all the way to the sea."

(Parent lifts the child's arms and swings them from side to side, pretending to drag them. Ensure child stays firm and does not move any part of his own body).

7) **Parent:** "When he is in the sea Mrs. Nelly has to help Mr. Jelly to swim. She helps him do the breast-stroke with his arms."

(Parent holds both child's arms and moves them in a circular motion in front of body).

8) **Parent:** "Then she helps him to do the breast-stroke with his legs."

(Parent holds both legs and moves them in a circular motion).

9) **Parent:** "Then she helps him to do the front crawl."
(Parent holds both arms and brings them one at a time towards her in a front-crawl fashion).

10) **Parent:** "Then she helps him to kick his legs."
(Parent picks up legs and moves them in an up and down fashion slowly getting faster and faster).

11) **Parent:** "Then a BIG wave comes" and Mr. Jelly goes under the water."

12) **Parent:** "Under the water he sees lots of fish swimming around."
(Arms of child should be down along sides of body. Hold wrists and flap them outwards and inwards whilst referring to the fish).

13) **Parent:** " When he comes back to the top of the water Mrs. Nelly decides they should go back to the beach and have a picnic so she drags him back to the beach."
(Parent pretends to drag child using legs, as before).

14) **Parent:** "Mrs. Nelly helps Mr. Jelly to dry himself, first she dries his legs,"

(Parents takes one leg and gives it a gentle shake from left to right and then takes the other leg and gives it a gentle shake from left to right).

15) **Parent:** "then she dries his arms."

(Parents takes one arm and gives it a gentle shake from left to right and then takes the other arm and gives it a gentle shake from left to right).

16) **Parent:** "Mrs. Nelly has a picnic. She puts out sandwiches and cakes and lemonade."

17) **Parent:** "Mr. Jelly wants a sandwich so he tries to lift one arm but he can't. He tries once, then he tries again."

(Parent slowly lifts right arm high then drops it with a gentle return to the ground x 2 times).

18) **Parent:** "Mr. Jelly tries lifting his other arm but he can't, he tries once then he tries again."

(Parent slowly lifts left arm high then drops it with a gentle return to the ground x 2 times).

19) **Parent:** "Mrs. Nelly has to help Mr. Jelly. She puts a sandwich in his hand and helps him to eat it."

(Parent pretends to put food in child's hands and moves them alternately to the child's mouth making munching noises).

20) **Parent:** "Then Mr. Jelly tries to get a drink but he can't. He tries lifting his arm once and then again."

(Parent slowly lifts right arm again high then drops with a gentle thud x 2 times).

21) **Parent:** "Mr. Jelly tries with the other arm once then again."

(Parent repeats with the other arm x 2 times).

22) **Parent:** "Mrs. Nelly helps him get a drink."

(Parent pretends to put bottle in child's right hand and moves it towards the mouth, making glugging noises).

- This is end of session, rest is simply for closure).

23) **Parent:** "SUDDENLY Mr. Jelly finds he can move again! He moves one leg then the other."

(Parent encourages child to shake both legs)

24) **Parent:** "Then he moves his arms."

(Parent encourages child to move both arms).

25) **Parent:** "Mr. Jelly gets up. He says thank you to Mrs. Nelly for a lovely day at the sea-side and for being so nice to him and helping him to swim and to eat his lunch. Then he goes home."

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Finding Santa

(Instructions)

A soft comfortable floor with blankets or rugs should be prepared.

Procedure involves enactment of a story, which is narrated by the Parent. The parent should read the script prompted by the word "parent," and should then move the child according to the directions as instructed in the bold type beneath.

Ask the child to let their body 'go floppy' and allow the parent to move their limbs. The parent must take full responsibility for the weight of the child's limbs when manipulating them. All movement of limbs must be done in a slow and deliberate manner.

Finding Santa

(Story 3 of 4)

There once was a little toy soldier who fell out of Santa's sack on Christmas Eve. Santa was very busy rushing around to all the little boys' and girls' houses and so he didn't even notice the soldier fall out of the sack. The soldier didn't know which house he was meant to go to so he decided he should find Santa again as fast as possible. The soldier had to do lots of things before he could find Santa.

1) Child is lying on ground with arms down by sides.
(Parent positions herself above the head of the child).

2) **Parent:** "The soldier lay on the ground wondering where Santa was. He looks all around for Santa, first to the left and then to the right."
(Parent lifts left arm and points it to the left; then lifts the right arm and points it to right. Then lift and point either hand to the front).

3) **Parent:** "The soldier was sure Santa must be somewhere near so he had another good look. He looked, right, left and straight ahead."
(Repeat above a second time).

4) **Parent:** "The soldier couldn't see Santa but he did see a bicycle, so he decided to get on the bicycle and go looking for Santa. He climbs on the bike and puts one foot on the pedal and the other foot on the other pedal."
(Parent moves to end of child and lifts one foot then the other, pretending to put them on the pedals).

5) **Parent:** "Then the soldier began to cycle the bike."
(Holding the 2 feet the Parent begins to circle them in a pedalling motion).

6) **Parent:** "The soldier pedalled faster and faster looking for Santa. He looked everywhere, in gardens, in houses, in shops, he pedals up the hill, he pedals down the hill, but he couldn't find Santa."
(Parent begins to pedal faster, beginning slowly then gradually speeding up. Slow down gradually on cycling motion).

7) **Parent:** "The soldier sees a big river. He wonders if Santa in on the other side of the river. He walks to the river."
(Parent lifts feet and makes walking motion).

8) **Parent:** "At the river the soldier sees a boat. He gets into the boat and sails across the river. The boat is very rocky."

(Child must keep body still. Parent should lift the arms and move them up and down as if wobbling on a rocky boat. These start off gradually).

9) **Parent:** "There were lots of little waves and lots of BIG waves."
(Parent should move the arms gently for the little waves and more pronounced for the big ones).

10) **Parent:** "At the other side of the river the soldier gets out of the boat. He cannot see Santa. He looks all around; to the left, to the right and up and down."
(When speaking Parent again moves right arm to right; then repeats with left arm; then repeats with either arm forwards).

11) **Parent:** "But he cannot see Santa. However, he does see a helicopter. He gets in to the helicopter and it starts to fly. He can see all around."
(Parent holds both arms and raises them slowly along the floor up and down, up and down, above the head and back. Repeat several times while saying...)

12) **Parent:** "...the soldier sees lakes, the soldier sees forests, the soldier sees birds flying in the sky, the soldier sees lots of people, the

soldier sees houses and then do you know what the soldier sees? He sees SANTA!! He sees Santa on the other side of the river."
(All the while be moving the arms up and down).

13) **Parent:** "The soldier lands the helicopter and goes running back to the river."
(Parent simulates running by lifting the feet alternately in a hurried running motion).

14) **Parent:** "The soldier gets into the boat again and sails back through the waves to the other side."
(Parent does same as before, lifting arms and moving them up and down gently for small waves and more so for large ones).

15) **Parent:** "The soldier runs back to the bicycle."
(Parent again lifts feet making a running motion with them).

16) **Parent:** "The soldier gets on to the bike, first one foot and then the other. "
Again, lift first the left and then the right leg as if stepping on to a bicycle.

17) **Parent:** "Then the soldier starts to cycle very fast."

Simulate a cycling motion rotating the feet in a slow then faster cycling manner whilst saying...

18) **Parent:** "...the soldier cycled faster and faster, passed all the houses and passed all the gardens and passed all the shops, hoping he could find Santa.

19) **Parent:** "As the soldier came round a corner do you know who he saw?"
(Ask child. If they say "Santa" reply "Very good, he saw Santa." If they say nothing or get the answer wrong tell them he saw Santa.)

20) **Parent:** "The soldier jumped off the bike and went running up to Santa" (Parent again simulates running by lifting feet and doing an up-down motion). "Santa was very pleased to see him and gave him a big hug"(give child hug). "The soldier was very happy to be back with Santa again."

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Walking in the Jungle

(Instructions)

A soft comfortable floor with blankets or rugs should be prepared.

Procedure involves enactment of a story, which is narrated by the parent.

Ask the child to let their body 'go floppy' and allow the parent to move their limbs. The Parent must take all responsibility for the weight of the child's limbs when manipulating them. All movement of limbs must be done in a slow and deliberate manner.

Walking in the Jungle

(Story 4 of 4)

Once upon a time there was a little boy who wanted to go for a walk in the jungle. (Child is lying comfortably on the ground with arms straight down by sides).

1) **Parent:** "The little boy walked for ages to get to the jungle."
(Parent sits at child's feet and lifts them both alternating their movement up and down, up and down to simulate walking).

2) **Parent:** "Finally the little boy could see the jungle but first he had to walk through a lot of mud. It was very hard to walk through the mud and it took a long time."
(Very slowly the Parent takes the right leg and bending it at the knee moves it upwards then downwards as if it is treading down into mud, then very slowly she lifts the left leg and does the same).

3) **Parent:** "When the little boy got out of the mud he walked into the forest. He could lots and lots of trees. Suddenly it was VERY windy and the trees began to wave around and around."

(Parent lifts both arms together and holding them up, waves them from left to right).

4) **Parent:** "When the wind stopped there was a fairy standing in front of the little boy. The fairy told the little boy that if he clapped his legs 5 times and then clapped his hands 5 times he could see any animal he wanted in the jungle."

5) **Parent:** "The little boy was so excited he immediately clapped his hands and feet 5 times saying he wanted to see lots of birds."
(Parent picks up both feet together and claps them 5 times. Then she picks up both hands and claps them 5 times).

6) **Parent:** "SUDDENLY there were lots of birds in the jungle. The little boy could see birds with big wings flying around."
(Parent holds both of child's arms out straight at 90 degrees to body and very slowly waves arms up and down together 5 times).

7) **Parent:** "Then the little boy could see birds with small wings too."
(Parent bends child's arms at elbow and places hands on hips then moves them more quickly up and down by the elbows).
8) **Parent:** "The little boy then wanted to see monkeys so he clapped his legs then his hands and said that he wanted to see monkeys."

(Parent picks up both feet together and claps them 5 times. Then she picks up both hands and claps them 5 times).

9) **Parent:** "Suddenly the monkeys appeared in the trees and the little boy could see them swinging from tree to tree."
(Parent picks up boy's hands and swings simultaneously them in an exaggerated and slow manner from side to side).

10) **Parent:** "The boy saw a family of monkeys - there was the Daddy monkey **(make very large swinging movements),** then there was the Mummy monkey **(make slightly smaller swinging movements),** then there was a boy monkey **(make little swinging movements)** then there was a baby monkey **(make tiny little swinging movements).**

11) **Parent:** "Then the little boy wanted to see zebras, so he clapped his feet and he clapped his hands and said that he wanted to see zebras."
(Parent claps feet 5 times then hands 5 times).

12) **Parent:** "Suddenly the little boy lots of zebras. They were galloping along **(Parent lifts both legs and rotates them in a cyclical movement).** "He saw a family of zebras. He saw a Daddy zebra **(make big galloping movements with the legs),** then he saw a Mummy zebra **(make slightly smaller galloping movements with legs),** then he saw a

boy zebra **(make little galloping movements)** then he saw a little baby zebra **(make tiny galloping movements).**

13) **Parent:** "Then the little boy wanted to see elephants so he clapped his feet and clapped his hands and wished to see elephants." (Clap hands and feet x 5).

14) **Parent:** "Suddenly there were lots of elephants nearby. The boy could see a family of elephants all with long trunks. He could see a Daddy elephant **(Parent lifts child's right arm and holds it in front of child's face swinging it from side to side as much as possible),** then the little boy saw a Mummy elephant **(repeat as above with slightly smaller movements),** then the little boy saw a boy **elephant (repeat as above with smaller movements),** then the little boy saw a baby elephant **(repeat as above with tiny movements).**

15) **Parent:** "After that the fairy told the little boy that it was time to go home. The little boy was happy because he was very tired. He walked out of the jungle."
(Parent should make walking motions with feet alternately as before).

16) **Parent**: "Then the little boy had to wade back through all the mud" **(Parent should lift child's legs alternately as before making effortful strikes through the mud).**

17) **Parent**: "After that the boy had to walk a long way home again" **(Parent should make walking movements).**

18) **Parent**: "The little boy got home then just in time for bed."

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Face Games

Instructions

Simon Says

This game is very similar to the 'Simon Says' children's game but there is no 'catching out' of the child. The aim is to get the child to copy the faces you are making. Facial movements should be done slowly and should be held for at least 5 seconds.

Child sits in a chair with a high back so that the head is supported. Sit opposite him and ask him to **keep his head and body still** and to copy everything that Simon does. The parent demonstrates. If the child copies the movement properly congratulate him (e.g. saying "very good"). If the child copies it wrongly or ignores it persist until they do it right. Make sure the child can see exactly what you are doing. With the teeth licking exercises especially, open your mouth to allow the child to see what you are doing. The game may be played with the child giving the instructions once they know the particular movements.

Do not worry if it takes time for your child to be able to do each face game.

Simon Says

(Game 1 of 4)

1. **Parent:** "Simon says scrunch up your nose."

(Parent scrunches up nose – ensure that child copies action).

2. **Parent:** "Simon says smile."

(Using the orbital muscles round the mouth smile on both sides of the mouth i.e. smile normally)

3. **Parent:** "Simon says smile with this side of your mouth only."

(Parent smiles with one side of the mouth only. Encourage the child to copy).

4. **Parent:** "Simon says now smile with the other side of the mouth only."

(Parents smiles with the other side of the mouth only – Ensure child smiles on other side and holds for 5 seconds).

5. **Parent:** "Simon says puff out both cheeks and hold."

(Parent puffs out cheeks and holds for 5 seconds.

6. **Parent:** "Simon says puff out one cheek only and hold."

(Parent puffs out one cheek and holds for 5 seconds).

7. **Parent:** "Simon says puff out the other cheek only and hold."

(Parent puffs out the other cheek and holds for 5 seconds - Ensure child has puffed out different cheek).

8. **Parent:** "Simon says bite your lower lip."

(Parent bites lower lip bringing upper jaw over the lower one).

9. **Parent:** "Simon says bite your upper lip."

(Parent bites upper lip, bringing lower jaw up over the upper one).

10. **Parent:** "Simon says stick out your tongue."

(Parent sticks out tongue).

11. **Parent:** "Simon says wave your tongue around."

(Parent sticks out tongue and waves it around).

12. **Parent:** "Simon says lick your chin."

(Parent licks chin with tongue).

13. **Parent:** "Simon says try to reach your nose with your tongue."
(Parent tips nose with tongue if possible. Ask the child to try, do not worry if the child cannot manage it).

14. **Parent:** "Simon says lick your lips."
(Parent licks lips starting at the top and going the whole way around).

15. **Parent:** "Simon says lick your lips this way."
(Parent licks lips in the other direction).

16. **Parent:** "Simon says lick your top teeth."
(Parent licks upper teeth in one direction).

17. **Parent:** "Simon says lick your teeth the other way."
(Parent licks upper teeth in the other direction).

18. **Parent:** "Simon says lick your bottom teeth."
(Parent licks bottom teeth in one direction).

19. **Parent:** "Simon says lick your bottom teeth the other way."
(Parent licks along the lower teeth in the other direction).

20. **Parent:** "Simon says lick all your teeth."

(Parent places tongue between the upper teeth and lips and moves it in one direction and continues down onto the lower teeth and across until a circle has been completed).

Part 2

21. **Parent:** "Simon says lick your bottom teeth this way."

(Parent licks along the lower teeth in one direction).

22. **Parent:** "Simon says puff out this cheek only and hold."

(Parent puffs out one cheek and holds for 5 seconds)

23. **Parent:** "Simon says smile."

(Smile normally)

24. **Parent:** "Simon says try to reach your nose."

(Parent tips nose with tongue if possible).

25. **Parent:** "Simon says smile with this side of your mouth only."

(Parent smiles with one side of the mouth only).

26. **Parent:** "Simon says puff out both cheeks and hold."

(Parent puffs out cheeks and holds for 5 seconds.

27. **Parent:** "Simon says wave your tongue around."

(Parent sticks out tongue and waves it around).

28. **Parent:** "Simon says lick your lips this way."

(Parent licks lips in one direction).

29. **Parent:** "Simon says lick your bottom teeth."

(Parent licks bottom teeth in one direction).

30. **Parent:** "Simon says bite your lower lip."

(Parent bites lower lip bringing upper jaw over the lower one).

31. **Parent:** "Simon says scrunch up your nose."

(Parent scrunches up nose).

32. **Parent:** "Simon says stick out your tongue."

(Parent sticks out tongue).

33. **Parent:** "Simon says lick your lips."

(Parent licks lips starting at the top, going to the right and then the whole way around).

34. **Parent:** "Simon says lick your top teeth."

(Parent licks upper teeth in one direction).

35. **Parent:** "Simon says puff out one cheek only and hold."

(Parent puffs out one cheek and holds for 5 seconds).

36. **Parent:** "Simon says lick your teeth this way."

(Parent licks upper teeth in one direction).

37. **Parent:** "Simon says bite your upper lip."

(Parent bites upper lip, bringing lower jaw up over the upper one).

38. **Parent:** "Simon says lick all your teeth."

(Parent places tongue between the upper teeth and lips and moves it in one direction and continues onto the lower teeth until a circle has been completed).

39. **Parent:** "Simon says now smile with one side of the mouth only."

(Parents smiles with one side of the mouth only).

40. **Parent:** "Simon says lick your chin."

(Parent licks chin with tongue).

Part 3

41. **Parent:** "Simon says lick all your teeth."

(Parent places tongue between the upper teeth and lips and moves it in one direction and continues onto the lower teeth and across until a circle has been completed).

42. **Parent:** "Simon says puff out one only and hold."
(Parent puffs out one cheek and holds for 5 seconds – Ensure child has puffed out different cheek to previous).

43. **Parent:** "Simon says bite your upper lip."

(Parent bites upper lip, bringing lower jaw up over the upper one).

44. **Parent:** "Simon says try to reach your nose."

(Parent tips nose with tongue if she can or does her best).

45. Parent: "Simon says puff out both cheeks and hold."

(Parent puffs out cheeks and holds for 5 seconds).

46. **Parent:** "Simon says wave your tongue around."

(Parent sticks out tongue).

47. **Parent:** "Simon says smile."

(Parent smiles normally).

48. **Parent:** "Simon says lick your bottom teeth."

(Parent licks bottom teeth in one direction).

49. **Parent:** "Simon says scrunch up your nose."

(Parent scrunches up nose).

50. **Parent:** "Simon says lick your lips."

(Parent licks lips starting at the top and going the whole way around).

51. Parent: "Simon says lick your top teeth."

(Parent licks upper teeth in one direction).

52. **Parent:** "Simon says lick your teeth the other way."

(Parent licks upper teeth in the other direction).

53. **Parent:** "Simon says lick your chin."

(Parent licks chin with tongue).

54. **Parent:** "Simon says puff out one cheek only and hold."

(Parent puffs out one cheek and holds for 5 seconds).

55. **Parent:** "Simon says lick your lips this way."

(Parent licks lips in one direction).

56. **Parent:** "Simon says stick out your tongue."

(Parent sticks out tongue).

57. **Parent:** "Simon says lick your bottom teeth this way."

(Parent licks along the lower teeth in one direction).

58. **Parent:** "Simon says now smile with one side of the mouth only."

(Parent smiles with one side of the mouth only).

59. **Parent:** "Simon says smile with this side of your mouth only."

(Parent smiles with the other side of the mouth only).

60. **Parent:** "Simon says bite your lower lip."

(Parent bites lower lip bringing upper jaw over the lower one).

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

Face Games

Instructions

Party Food

Child sits in a chair with a high back so that the head is supported. Sit opposite him and ask him to keep **his head and body still**. Parent narrates the story and asks child to enact the facial movements as she is talking. For the first week Parent and child should do faces together while story is being narrated. All facial movements should be done slowly and should be held for at least 5 seconds. The child should only move the face muscles, not the head or body.

Do not worry if it takes time for your child to be able to do each face game.

Party Food

(Game 2 of 4)

1) **Parent narrates:** "Once there was a little girl called Suzie. It was Suzie's birthday and her mummy made lots of yummy food for Suzie's dessert. She made a big chocolate cake and lots of ice-cream and lots of sweets. They were all Suzie's favourite foods."

2) **Parent:** "Suzie ran into the kitchen. She could see all the lovely food on the table. She walked over to the chocolate cake. It looked SO good that she started to smile."

(Child should smile on one side of face only, hold for five seconds, then smile on the other side of the face only, hold for five seconds, then break into a proper full smile and hold for five seconds).

3) Parent: "Suzie wanted to smell the chocolate. She took a big sniff of the cake".

(Child should scrunch up the nose and hold for 5 seconds).

4) **Parent:** "Suzie thought the cake looked and smelled so good! She licked her lips."

(Child should lick the lips starting at the top, going in one direction to complete a circle. Then lick the lips in a circle in the other direction).

5) **Parent:** "Suzie picked up some cake and opened her mouth really wide **(child should open mouth, pretending to take a bite, child should not use hands).**
Suzie took such a big bite that it filled one side of her mouth **(child should puff out one cheek and hold it for 5 seconds).** Then she took another big bite and that filled the other side of her mouth **(child should puff other cheek and hold for 5 seconds).** Then Suzie took a REALLY big bite and her entire mouth was full of cake!" **(Child should puff out both cheeks and hold for 5 seconds then pretend to swallow).**

6) **Parent:** "Suzie could feel lots of bits of cake inside her mouth. She licked all around her mouth."

(Child should now lick the upper teeth, in one direction, then the other. Then along the bottom teeth, in one direction, then the other. Then he should place the tongue between the upper teeth and lips and move it in one direction then continue onto the lower teeth until a full circle is completed).

7) **Parent:** "Suzie knew she shouldn't eat ALL the cake. She wanted to save some for her mummy and daddy. But it was really hard not to eat more cake. She bit down on her lower lip to try to stop herself eating any more."

(Child should bite lower lip, bringing the upper jaw over the lower jaw, then he should bite upper lip, bringing lower jaw over upper jaw).

8) **Parent:** "Suzie knew there was cake all over her face. She stuck out her tongue and licked her chin and nose."

(Child should stick out tongue as far as possible, wave it around, reach down and try to lick the chin, then reach up and try to lick the nose).

9) **Parent:** "THEN Suzie saw the ice-cream. Suzie took a big sniff of the ice-cream."
(Child should scrunch up the nose and hold for 5 seconds.)

10) **Parent:** "Suzie thought the ice-cream looked and smelled so good! She licked her lips."

(Child should lick the lips starting at the top, going in one direction to complete a circle. Then lick the lips in a circle in the other direction).

11) **Parent:** "Suzie picked up a bowl of ice-cream and opened her mouth really wide **(child should open mouth, pretending to take a bite, child should not use hands).**

Suzie took such a big spoonful that it filled one side of her mouth **(child should puff out one cheek and hold it for 5 seconds).**

Then she took another big spoonful and that filled the other side of her mouth **(child should puff other cheek and hold for 5 seconds).**

Then Suzie took a REALLY big spoonful and her entire mouth was full of ice-cream! **(Child should puff out both cheeks and hold for 5 seconds then pretend to swallow).**

12) **Parent:** "Suzie could feel lots of ice-cream inside her mouth. She licked all around her mouth."

(Child should now lick the upper teeth, first in one direction, and then the other. Then along the bottom teeth, first in one direction and then the other. Then he should place the tongue between the upper teeth and lips and move it in one direction, then continue onto the lower teeth until a full circle is completed).

13) **Parent**: "Suzie knew she shouldn't eat ALL the ice-cream. She wanted to save some for her mummy and daddy. But it was really hard not to eat more ice-cream. She bit down on her lower lip to try to stop herself eating any more."

(Child should bite lower lip, bringing the upper jaw over the lower jaw, then he should bite upper lip, bringing lower jaw over upper jaw).

14) **Parent**: "Suzie knew there was ice-cream all over her face. She stuck out her tongue and licked her chin and nose."

(Child should stick out tongue as far as possible, wave it around, reach down and try to lick the chin, then reach up and try to lick the nose).

15) **Parent**: "THEN Suzie saw the sweets. Suzie took a big sniff of the sweets."

(Child should scrunch up the nose and hold for 5 seconds.)

16) **Parent:** "Suzie thought the sweets looked and smelled so good! She licked her lips."

(Child should lick the lips starting at the top, going in one direction to complete a circle. Then lick the lips in a circle in the other direction).

17) **Parent:** "Suzie picked up a handful of sweets and opened her mouth really wide **(child should open mouth, pretending to take a bite, child should not use hands).**
Suzie took so many sweets that they filled one side of her mouth **(child should puff out one cheek and hold it for 5 seconds).**
Then she took another big handful and that filled the other side of her mouth **(child should puff other cheek and hold for 5 seconds).**
Then Suzie took a REALLY big handful and her entire mouth was full of sweets! **(Child should puff out both cheeks and hold for 5 seconds then pretend to swallow).**

18) **Parent:** "Suzie could feel lots of bits of sweets inside her mouth. She licked all around her mouth."

(Child should now lick the upper teeth, first in one direction and then the other. Then along the bottom teeth, again in one direction and then the other. Then he should place the tongue between the upper teeth and lips and move it in one direction and then continue onto the lower teeth until a full circle is completed).

19) **Parent:** "Suzie knew she shouldn't eat ALL the sweets. She wanted to save some for her mummy and daddy. But it was really hard not to eat more sweets. She bit down on her lower lip to try to stop herself eating any more."

(Child should bite lower lip, bringing the upper jaw over the lower jaw, then he should bite upper lip, bringing lower jaw over upper jaw).

20) **Parent:** "Suzie knew there were bits of sweets all over her face. She stuck out her tongue and licked her chin and nose."

(Child should stick out tongue as far as possible, wave it around, reach down and try to lick the chin, then reach up and try to lick the nose).

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Face Games

(Game 3 of 4)

Snap/Copy Cat

Child sits in a chair with a high back so that the head is supported. Sit opposite him and ask him to keep **his head and body** still. This game involves both Parent and child making faces at the same time with the Parent going through the specified list of movements and the child attempting to do the same face. The parent counts out loud '1,2,3' and then each does a face.

If the child guesses the next face correctly the Parent should ensure it is performed properly. If the child guesses the wrong face allow them to finish it correctly but then ensure they do the correct face as well. This ensures that they perform all the facial movements

Because of the nature of the game the child should be familiar with the types of movements in this treatment. The Parent should ensure that the child performs each face properly and slowly – All facial movements should be done slowly and should be held for at least 5 seconds.

Do not worry if it takes time for your child to be able to do each face game.

Snap/Copy Cat

Instructions

1) **Parent:** "Can you guess which face I am going to do?"

2) Encourage child to say yes and to make a face from the list. The Parent should make the specific face at the same time as the child.

3) If the child gets the face wrong say "oops" but allow them to continue finishing it then ensure they copy the correct face.

4) If the child gets the face right say "well done."

5) Ask child "What's Next?"

6) Continue until all faces have been pulled.

7) In the first few weeks if the child is finding it difficult to remember the various faces, you can show them (as in the three types of smiles, or three types of puffing cheeks), and then ask which of the three you are going to do.

8) The whole procedure should be completed three times - Sessions 2 and 3 are the same exercises in a different order.

Snap/Copy Cat

(Game 3 of 4)

Faces: Session 1.

Warm up:

Parent: "Can you guess which face I am going to do...something with my nose?"

Parent demonstrates: Scrunch up nose.

Parent: "Snap! Well done!" if the child is right, and **"oops! try again if the child gets it wrong".**

Parent: "Can you guess which face I am going to do...something to do with smiling?"

In the first few weeks if the child is finding it difficult to remember the various faces, you can list them, as below, and ask which of the three you are going to do.

1) Smile a big smile.

2) Smile this side.

3) Smile the other side.

Parent: "Can you guess which face I am going to do...something to do with licking lips?"

4) Lick lips one way in a circle.

5) Lick lips the other way in a circle.

Parent: "Can you guess which face I am going to do...something to do with cheeks?"

6) Puff this cheek.

7) Puff the other cheek.

8) Puff both cheeks.

Parent: "Can you guess which face I am going to do...something to do with my tongue?"

9) Stick out tongue.

10) Wave tongue.

Parent: "Can you guess which face I am going to do...something to do with biting lips?"

11) Bite bottom lip.

12) Bite top lip.

Parent: "Can you guess which way I am going to do a circle?"

13) Place tongue between the upper teeth and lips and move it in a circle in one direction, then continue onto the lower teeth until you come full circle.

14) Place tongue between the upper teeth and lips and move it in a circle in the **other direction**, then continue onto the lower teeth until you come full circle.

Parent: "Can you guess whether I am going to lick chin or nose?"

15) Lick chin.

16) Lick nose.

Parent: "Can you guess which way I am going to lick my teeth?"

17) Lick top teeth.

18) Lick bottom teeth.

19) Lick all teeth in a circle.

Faces: Session 2

Repeat the same movements in your own or the suggested order:

Parent: "Can you guess which face I am going to do...something with my nose?"

Scrunch up nose.

Parent: "Can you guess which way I am going to lick my teeth?"

1) Lick top teeth.

2) Lick bottom teeth.

3) Lick all teeth in a circle.

Parent: "Can you guess whether I am going to lick chin or nose?"

4) Lick chin.

5) Lick nose.

Parent: "Can you guess which way I am going to do a circle?"

6) Place tongue between the upper teeth and lips and move it in a circle in one direction, then continue onto the lower teeth until you come full circle.

7) Place tongue between the upper teeth and lips and move it in a circle in the **other direction**, then continue onto the lower teeth until you come full circle.

Parent: "Can you guess which face I am going to do...something to do with biting lips?"

8) Bite bottom lip.

9) Bite top lip.

Parent: "Can you guess which face I am going to do...something to do with my tongue?"

10) Stick out tongue.

11) Wave tongue.

Parent: "Can you guess which face I am going to do...something to do with cheeks?"

12) Puff this cheek.

13) Puff the other cheek.

14) Puff both cheeks.

Parent: "Can you guess which face I am going to do...something to do with licking lips?"

15) Lick lips one way in a circle.

16) Lick lips the other way in a circle.

Parent: "Can you guess which face I am going to do...something to do with smiling?"

17) Smile a big smile.

18) Smile this side.

19) Smile the other side.

Faces: Session 3

Repeat the same movements in your own or the suggested order:

Parent: "Can you guess whether I am going to lick chin or nose?"

1) Lick chin.

2) Lick nose.

Parent: "Can you guess which face I am going to do...something to do with smiling?"

3) Smile a big smile.

4) Smile this side.

5) Smile the other side.

Parent: "Can you guess which face I am going to do...something to do with biting lips?"

6) Bite bottom lip.

7) Bite top lip.

Parent: "Can you guess which face I am going to do...something to do with cheeks?"

8) Puff this cheek.

9) Puff the other cheek.

10) Puff both cheeks

Parent: "Can you guess which way I am going to do a circle?"

11) Place tongue between the upper teeth and lips and move it in a circle in one direction, then continue onto the lower teeth until you come full circle.

12) Place tongue between the upper teeth and lips and move it in a circle in the **other direction**, then continue onto the lower teeth until you come full circle.

Parent: "Can you guess which face I am going to do...something to do with licking lips?"

13) Lick lips one way in a circle.

14) Lick lips the other way in a circle.

Parent: "Can you guess which face I am going to do...something with my nose?"

14) Scrunch up nose.

Parent: "Can you guess which face I am going to do...something to do with my tongue?"

15) Stick out tongue.

16) Wave tongue.

Parent: "Can you guess which way I am going to lick my teeth?"

17) Lick top teeth.

18) Lick bottom teeth.

19) Lick all teeth in a circle.

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

Face Games

Instructions

Slow-Fast

Child sits in a high back chair so his head is supported. Sit opposite him and ask him to keep his **head and body still**. The object of the game is the parent gives a prompt as to whether or not the face should be done slowly or fast, again competing to see who can finish doing it last or first depending on the prompt. The parent gives the prompt as to which face to pull and then both child and parent compete to see who can do it fastest or slowest. It is important that the child complete all exercises properly. The "winning" element is only for entertainment purposes and the parent can let the child win if they like. These can be slow or fast as long as they are repeated a second time with each movement subsequently getting the opposite treatment (i.e. slow or fast). Each movement is done twice. The child winning is at the discretion of the parent but is encouraged. Congratulate them if they "win" and congratulate yourself if you "win."

Do not worry if it takes time for your child to be able to do each face game.

Slow-Fast

(Game 4 of 4)

Prompts are as follows, ask the child to hold each face for 5 seconds.

1) "Can you... scrunch your nose slower than me?"

2) "Can you.. smile (both sides) faster than me?"

3) Smile this side faster?

4) Smile the other faster?

5) "Can you.. puff this cheek slower than me?"

6) Puff the other cheek slower?

7) Puff both cheeks slower

8) "Can you...bite bottom lip faster than me?"

9) Bite top lip faster?

10) "Can you...put tongue out slower?"

11) Wave tongue slower?

12) "Can you...lick chin faster?"

13) Lick nose faster?

14) "Can you...lick lips this way slower?"

15) Lick lips the other way slower

16) "Can you...lick top teeth this way faster?"

17) Lick top teeth the other way faster?

18) "Can you...lick bottom teeth this way slower?"

19) Lick bottom teeth the other way slower?

20) Lick all teeth (in a circle) slower ?

and then try:

1) "Can you ...scrunch your nose faster than me?"

2) "Can you.. smile (both sides) slower' than me?"

3) Smile this side slower?

4) Smile the other slower?

5) "Can you... puff this cheek faster than me?"

6) Puff the other cheek faster?

7) Puff both cheeks faster?

8) "Can you...bite bottom lip slower than me?"

9) Bite top lip slower?

10) "Can you...put tongue out faster?

11) Wave tongue faster?

12) "Can you...lick chin slower?"

13) Lick nose slower?

14) "Can you...lick lips this way faster?"

15) Lick lips the other way faster?

16) "Can you...lick top teeth this way slower than me?"

17) Lick top teeth the other way slower

18) "Can you...lick bottom teeth this way faster than me?"

19) Lick bottom teeth the other way faster?

20) Lick all teeth (in a circle) faster?

Estimated time: 4 minutes. Repeat if necessary to bring the time up to 10 minutes.

THE END

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LOG BOOK & TIME-TABLE

Start Date: _____

Day	Exercise	Page	Tick
1	1	6	
2	1	6	
3	1	6	
4	2	12	
5	2	12	
6	2	12	
7	3	19	
8	3	19	
9	3	19	
10	4	26	
11	4	26	
12	4	26	
13	5	32	
14	5	32	
15	5	32	
16	6	43	
17	6	43	
18	6	43	
19	7	53	
20	7	53	
21	7	53	

Day	Exercise	Page	Tick
22	8	64	
23	8	64	
24	8	64	
25	4	26	
26	3	19	
27	6	43	
28	7	53	
29	1	6	
30	2	12	
31	3	19	
32	8	64	
33	1	6	
34	3	19	
35	8	64	
36	2	12	
37	7	53	
38	8	64	
39	1	6	
40	3	19	
41	1	6	
42	8	64	

Day	Exercise	Page	Tick
43	4	26	
44	7	53	
45	7	53	
46	8	64	
47	7	53	
48	8	64	
49	3	19	
50	6	43	
51	5	32	
52	1	6	
53	4	26	
54	2	12	
55	1	6	
56	7	53	
57	6	43	
58	5	32	
59	1	6	
60	6	43	
61	5	32	
62	6	43	
63	1	6	

Day	Exercise	Page	Tick
64	2	12	
65	1	6	
66	1	6	
67	4	26	
68	3	19	
69	6	43	
70	6	43	
71	7	53	
72	2	12	
73	1	6	
74	7	53	
75	7	53	
76	6	43	
77	5	32	
78	4	26	
79	3	19	
80	1	6	
81	2	12	
82	6	43	
83	7	53	
84	3	19	

Day	Exercise	Page	Tick
85	6	43	
86	1	6	
87	4	26	
88	4	26	
89	1	6	
90	2	12	
91	6	43	
92	4	26	
93	7	53	
94	5	32	
95	1	6	
96	6	43	
97	1	6	
98	7	53	
99	4	26	
100	6	43	
101	6	43	
102	8	64	
103	5	32	
104	4	26	
105	6	43	

Day	Exercise	Page	Tick
106	3	19	
107	5	32	
108	4	26	
109	6	43	
110	7	53	
111	5	32	
112	7	53	
113	2	12	
114	7	53	
115	6	43	
116	2	12	
117	4	26	
118	5	32	
119	7	53	
120	5	32	
121	7	53	
122	4	26	
123	7	53	
124	5	32	
125	7	53	
126	4	26	

Day	Exercise	Page	Tick
127	2	12	
128	2	12	
129	6	43	
130	7	53	
131	5	32	
132	4	26	
133	6	43	
134	5	32	
135	4	26	
136	2	12	
137	7	53	
138	1	6	
139	7	53	
140	3	19	
141	5	32	
142	6	43	
143	6	43	
144	8	64	
145	1	6	
146	6	43	
147	5	32	

Day	Exercise	Page	Tick
148	8	64	
149	2	12	
150	2	12	
151	8	64	
152	6	43	
153	1	6	
154	8	64	
155	1	6	
156	4	26	
157	1	6	
158	4	26	
159	8	64	
160	1	6	
161	3	19	
162	8	64	
163	2	12	
164	6	43	
165	1	6	
166	6	43	
167	5	32	
168	8	64	

Day	Exercise	Page	Tick
169	2	12	
170	1	6	
171	4	26	
172	3	19	
173	1	6	
174	4	26	
175	3	19	
176	4	26	
177	4	26	
178	7	53	
179	5	32	
180	1	6	
181	3	19	
182	3	19	
183	6	43	
184	6	43	
185	7	53	
186	1	6	
187	2	12	
188	3	19	
189	7	53	

Day	Exercise	Page	Tick
190	5	32	
191	7	43	
192	4	26	
193	7	53	
194	4	26	
195	6	43	
196	6	43	
197	3	19	
198	8	64	
199	3	19	
200	3	19	
201	5	32	
202	3	19	
203	6	43	
24	5	32	
205	8	64	
206	4	26	
207	7	53	
208	4	26	
209	4	26	
210	5	32	

Day	Exercise	Page	Tick
211	7	53	
212	3	19	
213	2	12	
214	5	32	
215	6	43	
216	5	32	
217	7	53	
218	3	19	
219	5	32	
220	8	64	
221	4	26	
222	6	43	
223	7	53	
224	4	26	
225	8	64	
226	4	26	
227	7	53	
228	2	12	
229	8	64	
230	7	53	
231	7	53	

Day	Exercise	Page	Tick
232	6	43	
233	3	19	
234	7	53	
235	6	43	
236	5	32	
237	6	43	
238	6	43	
239	5	32	
240	4	26	
241	3	19	
242	3	19	
243	4	26	
244	2	12	
245	4	26	
246	2	12	
247	6	43	
248	3	19	
249	2	12	
250	4	26	
251	8	64	
252	7	53	

Day	Exercise	Page	Tick
253	2	12	
254	6	43	
255	8	64	
256	4	26	
257	2	12	
258	4	26	
259	3	19	
260	5	32	
261	4	26	
262	4	26	
263	4	26	
264	7	53	
265	7	53	
266	5	32	
267	2	12	
268	8	64	
269	5	32	
270	7	53	
271	1	6	
272	3	19	
273	4	26	

Day	Exercise	Page	Tick
274	8	64	
275	6	43	
276	2	12	
277	7	53	
278	4	26	
279	3	19	
270	4	26	
281	3	19	
282	2	12	
283	7	53	
284	8	64	
285	5	32	
286	4	26	
287	1	6	
288	2	12	
289	5	32	
290	8	64	
291	5	32	
292	5	32	
293	3	19	
294	2	12	

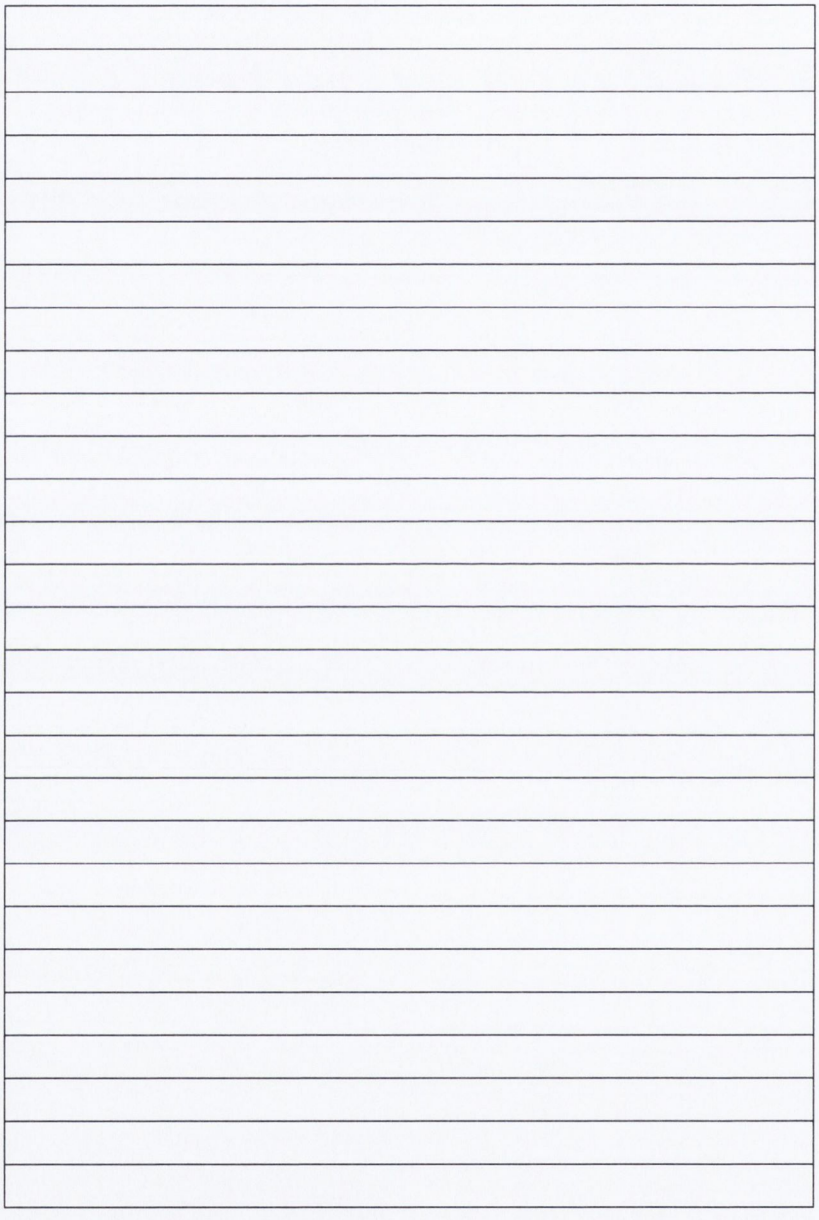
Day	Exercise	Page	Tick
295	6	43	
296	1	6	
297	5	32	
298	3	19	
299	7	53	
300	3	19	
301	3	19	
302	8	64	
303	6	43	
304	8	64	
305	8	64	
306	8	64	
307	1	6	
308	6	43	
309	1	6	
310	5	32	
311	3	19	
312	1	6	
313	5	32	
314	7	53	
315	3	19	

Day	Exercise	Page	Tick
316	6	43	
317	5	32	
318	8	64	
319	5	32	
320	4	26	
321	3	19	
322	6	43	
323	5	32	
324	4	26	
325	4	26	
326	7	53	
327	8	64	
328	6	43	
329	7	53	
330	6	43	
331	1	6	
332	5	32	
333	7	53	
334	2	12	
335	8	64	
336	3	19	

End Date: _____

Comments

Please feel free to comment on any problems encountered on any particular days of your programme. Please include the relevant date of your comment.



N

Video Procedure

Procedure: Video – Palm Pilot - Browser

1. If you are operating the camera, make sure that you get the full view of the balance tests when the children are moving around.

   In the reflex tests make sure the child fills the frame with a little space around him/her. Be careful of camera angles, these need to be right to aid computer measurement:

   ATNR Lying Down: Child is right angle to camera. Bring zoom in close to catch any tremors.

   ATNR Table Position: Child is facing camera, looking at the floor. Make sure head does not obscure view of arms.

   STNR: Child is side to camera but back from the wall so the child can look up at the ceiling. Make sure they move the head *slowly* up and down.

   Schilder: Child is facing camera.

   TLR: Child is side to the camera but facing other wall so knees can be viewed.

   Moro: Child is side to camera in centre of screen.

2. Tester no. 1 should not move in front of child obscuring view of camera. Always demonstrate from behind or to the side.

3. Be aware of hands on hips for the appropriate age groups, they vary slightly in tests.

4. On walking tests make sure child understands heel to toe, and small steps on tiptoe.

5. If the camera operator cannot see arms/knees make sure to roll up t-shirt/shorts.

6. Using the *palm pilot*:

   Make sure it is plugged into the camera - double wire goes into red socket – single wire goes into palm pilot.
   Turn on power at palm pilot top button.
   Using stylus or finger,
   Press 'child' button.
   Press '1' for session 1 and then enter id no. (6 digits)
   The 'del' button allows you to delete a number if you have made a mistake.
   Press 'child' button again.
   This allows tones to play directly into camera, the play panel will list the keys as they are played.
   Then press '1' and 'end' etc. for tests 1 to 14 as needed.
   If the wrong test number has been played press error and then the correct number.

   For the next child, start with pressing the 'child' no. as before.

7. *Browser*

After two days each child's video should be available through the browser. Before viewing you must enter the child's name and id in the contact data base and then log on to the browser using your password.

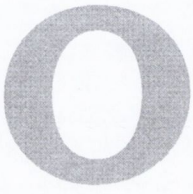
Note that each of us has an individual password to allow for individual scoring, either for cross scoring, practice for your individual 4th year project scoring or for objective scorers later on. So don't get these confused. If you are entering data check which way it is to be done.

Aisling:	tipperary
Elaine:	suitcase
Erika:	money
Stephanie:	dutch

Elaine and myself will use the admin password which allows us to view all scores. The admin score will be the score which is imported to SPSS for the main study results.

The browser will now allow us to enter scores as we view and to edit the video time if we need to see more/less of a test. Score entry is now to be done this way to avoid confusion and I will train A&S in on this. It is also proposed to have the browser up on Elaine's new pc when it is ordered so we have more access.

If the child id or name is not in the browser, check it has been entered in the contacts. In the unlikely event that this does not work it may have been an error in recording the tones. Select the date of testing instead and view the children. You may have to check the original tape (bottom drawer my desk) to see where the child came in that days tape. If there are two tapes for one day they are labelled a and b. Let me know if you are having a problem.



Certificate



Early Years Project

This is to confirm that _____

took part in the ***Dyslexia Early Years Project***

Signed _____ *Date*_____

Dyslexia Research Group
Department of Psychology
Trinity College
Dublin 2.

P

Tables

P.1 A Description of the 120 days compliant Sample S_{118}

Minutes per day per programme	Reflex	Balance	Placebo
2-4 minutes	13.9%	3.8%	0%
4-6 minutes	47.2%	26.9%	18.8%
6-8 minutes	19.5%	34.6%	25%
8-10 minutes	19.4%	34.6%	56.3%

Table P.1: *Average (estimated) time spent on programme per day, expressed as a percentage of group (Sample S_{118} minus control group, n=78).*

Quality of Programme	Reflex	Balance	Placebo
Usually Rushed	5.6 %	11.5%	6.3%
Sometimes Rushed	38.9%	30.8%	25%
Mostly slow and controlled	41.6%	42.3%	50%
Usually slow and controlled	13.9%	15.4%	18.7%

Table P.2: *Estimated quality of programme performed per day, expressed as a percentage of group (n=78).*

P.2 Percentage of Groups involved in other activities

Remedial Help by Programme	Reflex	Balance	Placebo	Control
Yes	41.7%	50%	62.5%	67.5%
No	58.3%	50%	37.5%	32.5%

Table P.3: *Percentage of group receiving remedial help of between 2-5 hours per week over the year of programme participation (n=118).*

Sport by Programme	Reflex	Balance	Placebo	Control
Yes	86.1%	92.3%	93.8%	87.5%
No	13.9%	7.7%	6.3%	12.5%

Table P.4: *Percentage of group participating in sport over the year of programme participation (n=118).*

Speech and Language	Reflex	Balance	Placebo	Control
Yes	19.4%	38.5%	31.3%	20%
No	80.6%	61.5%	68.7%	80%

Table P.5: *Percentage of group receiving speech and language therapy over the year of programme participation. In addition 1 child in Group 4 received physiotherapy once a month over the year (n=118).*

Extra Curricular Activities	Reflex	Balance	Placebo	Control
Yes	50%	26.9%	43.8%	25%
No	50%	73.1%	56.2%	75%

Table P.6: *Percentage of group attending extra curricular activities over the year of programme participation (n=118).*

P.3 Minutes per Day

	High Dyslexia Risk	
Minutes per Day	**Yes**	**No**
2-4 Mins	10.4%	6.1%
4-6 Mins	31%	36.7%
6-8 Mins	27.6%	24.5%
8-10 Mins	31%	32.7%

Table P.7: *Average (estimated) time spent on programmes expressed as a Percentage of Dyslexia Risk/Not at Risk at the higher risk level (DEST >=0.9 n=78).*

	Mild Dyslexia Risk	
Minutes per Day	**Yes**	**No**
2-4 Mins	8.8%	6.8%
4-6 Mins	32.4%	36.4%
6-8 Mins	26.5%	25%
8-10 Mins	32.3%	31.8%

Table P.8: *Average (estimated) time spent on programmes expressed as a Percentage of Dyslexia Risk/Not at Risk at the milder risk level (DEST >=0.6 n=78).*

	ADHD Risk	
Minutes per Day	**Yes**	**No**
2-4 Mins	22.2%	3.3%
4-6 Mins	27.8%	36.7%
6-8 Mins	22.2%	26.7%
8-10 Mins	27.8%	33.3%

Table P.9: *Average (estimated) time spent on programmes expressed as a Percentage of ADHD Risk/Not at Risk (n=78).*

P.4 Quality of Performance

	High Dyslexia Risk	
Movement Quality	**Yes**	**No**
Usually rushed	6.9%	8.2%
Sometimes rushed	31%	34.7%
Mostly slow & controlled	44.8%	42.9%
Usually slow & controlled	17.3%	14.3%

Table P.10: *Parental judgement of Movement Quality expressed as a Percentage of Dyslexia Risk/Not at Risk at higher risk level (DEST >=0.9 n=78).*

	Mild Dyslexia Risk	
Movement Quality	**Yes**	**No**
Usually rushed	8.8%	6.8%
Sometimes rushed	29.4%	36.4%
Mostly slow & controlled	47.1%	40.9%
Usually slow & controlled	14.7%	15.9%

Table P.11: *Parental judgement of Movement Quality expressed as a Percentage of Dyslexia Risk/Not at Risk at the milder risk level (DEST >=0.6 n=78).*

	ADHD Risk	
Movement Quality	**Yes**	**No**
Usually rushed	22.2%	3.4%
Sometimes rushed	50%	28.3%
Mostly slow & controlled	22.2%	50%
Usually slow & controlled	5.6%	18.3%

Table P.12: *Parental judgement of Movement Quality expressed as a Percentage of ADHD Risk/Not at Risk (n=78).*

P.5 Reflex and Balance Scores by Group

	Reflex	Balance	Placebo	Control
Low	72%	69%	81%	70%
High	28%	31%	19%	30%

Table P.13: *Percentage of children with low and high reflex scores by group (n=118).*

	Reflex	Balance	Placebo	Control
Low	25%	15%	25%	28%
High	75%	85%	75%	72%

Table P.14: *Percentage of children with low and high balance scores by group (n=118).*

P.6 120 days compliant sample minus 5 children undertaking school/private reflex programme Sample S_{113}

S_{118} - 5 school/private	**Group 1**	**Group 2**	**Group 3**	**Group 4**	
	Reflex	**Balance**	**Placebo**	**Control**	**Total**
Male	24	25	15	35	99
Female	7	1	1	5	14
Mean age in years	5,8	5,5	5,8	5,4	5,6
S.D. months	12	13	11	12	12
Risk of Dyslexia (High)	9	14	6	9	38
ADHD	6	5	5	9	25
Total Group	31	26	16	40	113

Table P.15: *Description of Sample S_{113}*

	Time 1		**Time 2**		**Time 3**	
Balance Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	2.584	0.619	2.344	0.684	2.289	0.610
Group 2	2.824	0.715	2.609	0.577	2.384	0.480
Group 3	2.792	0.787	2.385	0.624	2.355	0.691
Group 4	2.506	0.732	2.386	0.747	2.216	0.690
Total	2.641	0.710	2.426	0.676	2.294	0.620

Table P.16: *Mean of Balance scores at Time 1-3 by Group Sample S_{113}.*

	Time 1		**Time 2**		**Time 3**	
Reflex Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	1.830	0.314	1.750	0.273	1.815	0.286
Group 2	1.933	0.393	2.005	0.362	1.922	0.292
Group 3	1.704	0.319	1.858	0.354	1.797	0.208
Group 4	1.868	0.450	1.882	0.377	1.855	0.384
Total	1.846	0.387	1.871	0.351	1.852	0.316

Table P.17: *Mean of Reflex scores at Time 1-3 by Group Sample S_{113}.*

ANOVA Group × Time:

A repeated measures ANOVA was performed on Log10 transformed balance, reflex, motor, oculo-motor and phonological scores separately and no significance was found between groups over time. The results for the 5 minor dependent variables were as follows:

ANOVA	Group × Time
Balance Scores	$F_{(6,218)} = 0.531, P = 0.784$
Reflex Scores	$F_{(6,218)} = 1.019, P = 0.414$
Motor Scores	$F_{(6,218)} = 1.349, P = 0.237$
Oculo-Motor Scores	$F_{(6,218)} = 0.563, P = 0.759$
Phonological Scores	$F_{(6,218)} = 0.765, P = 0.598$

Table P.18: *ANOVA Group × Time for Sample* S_{113}

Initial Indicators and Risk of Dyslexia Sample S_{113}

Time 1: Bal/Reflex Scores × Dyslexia Risk	Chi-square
Balance Group 1	$\chi^2(1) = 0.552$, p = 0.642
Reflex Group 1	$\chi^2(1) = 0.839$, p = 0.639
Balance Group 2	$\chi^2(1) = 0.851$, p = 0.356
Reflex Group 2	$\chi^2(1) = 0.348$, p = 0.683
Balance Group 3	$\chi^2(1) = 3.200$, p = 0.074*
Reflex Group 3	$\chi^2(1) = 0.027$, p = 1.000
Balance Group 4	$\chi^2(1) = 1.672$ p = 0.196
Reflex Group 4	$\chi^2(1) = 0.335$, p = 0.697

Table P.19: *Time 1: Initial Risk Indicators × High Dyslexia Risk Sample* S_{113}

P.7 Non-ADHD '120 days' Compliant Sample S_{89}

Non-ADHD	**Group 1**	**Group 2**	**Group 3**	**Group 4**	
	Reflex	**Balance**	**Placebo**	**Control**	**Total**
Male	23	20	9	26	78
Female	6	1	1	3	11
Mean age in years	5,7	5,3	5,8	5,3	5,5
S.D. months	13	13	11	12	12
Risk of Dyslexia (High)	4	9	4	6	23
ADHD	-	-	-	-	-
Total Group	29	21	10	29	89

Table P.20: *Description of Sample* S_{89}

	Time 1		**Time 2**		**Time 3**	
Balance Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	2.541	0.730	2.315	0.724	2.238	0.649
Group 2	2.823	0.682	2.607	0.636	2.337	0.485
Group 3	2.576	0.652	2.184	0.501	2.169	0.621
Group 4	2.449	0.721	2.387	0.710	2.104	0.694
Total	2.852	0.710	2.393	0.680	2.210	0.623
Reflex Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	1.876	0.345	1.760	0.285	1.852	0.293
Group 2	1.894	0.288	1.970	0.369	1.884	0.302
Group 3	1.633	0.219	1.840	0.295	1.770	0.245
Group 4	1.833	0.411	1.905	0.382	1.815	0.363
Total	1.839	0.348	1.866	0.345	1.839	0.312

Table P.21: *Mean of Balance and Reflex scores at Time 1-3 by Group* S_{89}.

ANOVA Group × Time:

A repeated measures ANOVA was performed on Log10 transformed balance, reflex, motor, oculo-motor and phonological scores. The results for the 5 minor dependent variables were as follows:

ANOVA	Group × Time
Balance Scores	$F_{(6,170)} = 0.719$, p = 0.635
Reflex Scores	$F_{(6,170)} = 1.965$, p = 0.073*
Motor Scores	$F_{(6,170)} = 1.117$, P = 0.354
Oculo-Motor Scores	$F_{(6,170)} = 1.053$, P = 0.393
Phonological Scores	$F_{(6,170)} = 0.922$, P = 0.480

Table P.22: *Repeated Measures Anova Sample S_{89}*

Initial Indicators and Risk of Dyslexia:

Time 1: Bal/Reflex Scores × Dyslexia Risk	Chi-square
Balance Group 1	$\chi^2(1) = 1.768$, p = 0.304
Reflex Group 1	$\chi^2(1) = 1.167$, p = 0.552
Balance Group 2	$\chi^2(1) = 0.810$, p = 0.553
Reflex Group 2	$\chi^2(1) = 0.175$, p = 1.000
Balance Group 3	$\chi^2(1) = 2.857$, p = 0.200
Reflex Group 3	10 cases only
Balance Group 4	$\chi^2(1) = 0.125$, p = 1.000
Reflex Group 4	$\chi^2(1) = 0.730$, p = 0.633

Table P.23: *Time 1: Initial 'at risk' indicators × High Dyslexia Risk Sample S_{89}*

P.8 Children at Risk of ADHD Sample S_{29}

ADHD Risk	Group 1	Group 2	Group 3	Group 4	
	Reflex	Balance	Placebo	Control	Total
Male	4	5	5	9	23
Female	3	-	1	2	6
Mean age in years	5,8	5,5	5,8	5,4	5,6
S.D. months	12	13	11	12	12
Risk of Dyslexia (High)	5	5	2	3	15
ADHD Group	7	5	6	11	29

Table P.24: *Description of Sample S_{29}*

	Time 1		Time 2		Time 3	
Balance Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	2.588	0.551	2.524	0.516	2.391	0.551
Group 2	2.831	0.928	2.619	0.238	2.581	0.454
Group 3	3.152	0.913	2.721	0.706	2.668	0.742
Group 4	2.657	0.775	2.387	0.873	2.515	0.614
Total	2.773	0.772	2.529	0.666	2.528	0.580
Reflex Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	1.810	0.383	1.832	0.293	1.591	0.271
Group 2	2.100	0.712	2.153	0.321	2.080	0.198
Group 3	1.822	0.441	1.889	0.466	1.844	0.134
Group 4	1.925	0.559	1.821	0.373	1.964	0.434
Total	1.906	0.511	1.895	0.370	1.870	0.351

Table P.25: *Mean of Balance and Reflex scores at Time 1-3 by Group Sample* S_{29}.

ANOVA Group × Time:

A repeated measures ANOVA was performed on Log10 transformed balance, reflex, motor, oculo-motor and phonological scores. The results for the 5 minor dependent variables were as follows:

ANOVA	**Group × Time**
Balance Scores	$F_{(6,50)} = 0.448$, P = 0.843
Reflex Scores	$F_{(6,50)} = 0.753$, P = 0.610
Motor Scores	$F_{(6,50)} = 1.144$, P = 0.351
Oculo-Motor Scores	$F_{(6,50)} = 0.393$, P = 0.880
Phonological Scores	$F_{(6,50)} = 1.860$, P = 0.106

Table P.26: *Repeated Measures Anova Sample* S_{29}

Initial Indicators and Risk of Dyslexia

Time 1: Bal/Reflex Scores × Dyslexia Risk	Chi-square
Balance Group 1	$\chi^2(1) = 0.467$, p = 1.000
Reflex Group 1	$\chi^2(1) = 0.630$, p = 0.524
Balance Group 2	only 5 cases
Reflex Group 2	only 5 cases
Balance Group 3	$\chi^2(1) = 0.439$, p = 1.000
Reflex Group 3	$\chi^2(1) = 0.000$, p = 0.800
Balance Group 4	$\chi^2(1) = 3.227$, p = 0.152
Reflex Group 4	$\chi^2(1) = 0.076$, p = 0.661

Table P.27: *Time 1: Balance/Reflex Scores × High Dyslexia Risk Sample S_{29}*

P.9 Non-compliant (120 days) Sample S_{18}

120 Days non-compliant	Group 1	Group 2	Group 3	Group 4	
	Reflex	Balance	Placebo	Control	Total
Male	3	8	3	-	14
Female	2	2	-	-	4
Mean age in years	5,10	4,11	4,7	-	5,2
S.D. months	11	10	4	-	9
Risk of Dyslexia (High)	1	1	1	-	3
ADHD	-	2	-	-	-
Total Group	5	10	3	0	18

Table P.28: *Description of Sample S_{18}*

	Time 1		Time 2		Time 3	
Balance Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	2.253	0.649	2.399	0.997	2.484	0.498
Group 2	2.750	0.673	2.564	0.696	2.161	0.516
Group 3	2.433	0.395	2.771	0.587	2.310	0.834
Total	2.559	0.639	2.552	0.739	2.278	0.549
Reflex Scores	Mean	S.D	Mean	S.D	Mean	S.D
Group 1	1.700	0.303	1.721	0.171	1.880	0.344
Group 2	1.893	0.487	1.977	0.334	1.883	0.280
Group 3	2.211	0.699	1.967	0.0.393	1.822	0.659
Total	1.893	0.483	1.904	0.313	1.872	0.348

Table P.29: *Mean of Balance and Reflex scores at Time 1-3 by Group Sample* S_{18}.

ANOVA Group × Time:

A repeated measures ANOVA was performed on Log10 transformed balance, reflex, motor, oculo-motor and phonological scores. The results for the 5 minor dependent variables were as follows:

ANOVA	**Group × Time**
Balance Scores	$F_{(4,30)} = 1.170, P = 0.344$
Reflex Scores	$F_{(4,30)} = 1.088, P = 0.380$
Motor Scores	$F_{(4,30)} = 0.411, P = 0.799$
Oculo-Motor Scores	$F_{(4,30)} = 1.742, P = 0.167$
Phonological Scores	$F_{(4,30)} = 0.645, P = 0.635$

Table P.30: *Repeated Measures Anova Sample* S_{18}



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