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## The effect of a reflex replication program on retained primary reflexes, motor coordination, vocabulary, visual motor ability and rapid naming in preprimary aged children

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**THE EFFECT OF A REFLEX REPLICATION PROGRAM ON RETAINED  
PRIMARY REFLEXES, MOTOR COORDINATION, VOCABULARY, VISUAL  
MOTOR ABILITY AND RAPID NAMING IN PREPRIMARY AGED  
CHILDREN**

By

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**Date of submission:**

**15<sup>th</sup> December 2008**

## USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

## ABSTRACT

The link between movement and cognition is not new, but remains steeped in controversy in the educational community. One of the reasons for this controversy has been the lack of substantial research that supports the link between movement programs and observable academic benefits.

The results of recent research have indicated that the retention of primary reflexes, particularly the tonic neck reflexes in young children, can result in difficulties that affect the overall functioning of the child. The retainment of reflexes may lead to clumsiness, poor eye hand coordination, poor manipulative skills and consequently academic achievement may be compromised in some children (Sugden & Wright, 1998). This research is about determining the efficacy of *Primary Movement* program, a reflex replication program designed to reduce the effect of these inappropriately retained reflexes (McPhillips, Hepper, & Mulhern, 2000)

The research began by investigating the prevalence of retained Asymmetrical Tonic Neck Reflex (ATNR), the cause of significant motor difficulties, in a sample of approximately 200 preprimary children in metropolitan Perth, Western Australia using the Schilder Neurological Test which is one of the standard neurological tests to determine the presence of this reflex (McPhillips, Hepper, & Mulhern, 2000; Morrison, 1985). Baseline data was also established for all children in the following areas: motor skills (using Movement ABC Assessment Battery for Children (Henderson & Sugden, 1992); language skills (using Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); and visual motor integration (using the Developmental Test of Visual Motor Integration (Beery, 1989). Following the gathering of this data, an intervention based on the *Primary Movement* program was then conducted. The effect of the *Primary Movement* intervention was compared on the above variables, to the results of a gross motor intervention and a free play intervention (control).

As such this thesis investigates the efficacy of the *Primary Movement* program as an early intervention tool for preschool children in Australia displaying retained reflexes and associated issues such as motor difficulties, is evaluated.

## DECLARATION

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## **CHAPTER ONE: INTRODUCTION**

### **1.1 Context and background of the study**

The role of movement in relation to the physical, emotional and academic development of children is generally not well understood by educators. Gallahue and Ozmun (1998) maintain that although there has been a great deal of philosophical support for the relationship between the body and the mind, little had been done of an experimental or practical nature prior to the 1960s to confirm the importance of movement in educational situations. The developmental psychologists, Arnold Gesell and Myrtle McGraw, were among the first to recognize that the processes by which infants learned to control and coordinate their bodies set the stage for all further development. However, movement was seen as a "tool of developmental assessment" rather than "a topic for process-oriented research" (Lockman & Thelen, 1993, p.954). During the 1920s and 1930s, investigators described in detail the stages of change in posture and movement characterizing the early years of life although the links between motor development and cognition were not initiated until Piaget (1952) recognized the role that movement played in the developmental stages through which children progressed. Up until this time, educational and scientific communities believed that thinking and movement were unrelated and there was little support for early scientists who envisioned links between the two (Jensen, 1998).

A change in thought was instigated by Henrietta Leiner who suspected that the cerebellum, which was traditionally thought to simply process signals from the cerebrum and send them to the motor cortex area, may play a role in cognition as well (Jensen, 1998). Leiner had observed a thick cluster of fibres running through the cerebellum and up to the cerebral cortex during the dissection of a human brain in a neuroanatomy class. Of significant interest was the observation that these nerve fibres were coming from all over the brain, posing the question that if the cerebellum was only involved in movement, why did it need such substantial and diverse information from various parts of the brain. There was also interest in the role of the neocortex, an area within the cerebrum, which is present only in humans and considered to have a significant role in thinking. Dow, a neurologist, confirmed the accuracy of Leiner's assumptions when, in treating one

of his patients presenting with cerebellar damage, he noticed impaired cognitive function (Jensen, 1998).

The early reports on the role of the cerebellum recorded by Leiner were generally anecdotal and unable to be verified pathologically. It was another 30 years before functional magnetic resonance imaging (fMRI), would substantiate the findings of Leiner and Dow (A. L. Leiner, Leiner, & Dow, 1993). Recent studies based on fMRI research have confirmed that the cerebellum, the role of which was previously thought to be solely related to movement, does in fact play an important part in cognitive and language skills (Fawcett & Nicolson, 1995; Fawcett & Nicolson, 1999; Schmahmann & Sherman, 1998). Consideration therefore needs to be given to the importance of the relationship between movement and learning due to the fact that movement and learning appear to be in constant interplay (Greenfield, 1995). Simply put, one cannot separate movement from the learning process, a view shared by Halverson (1971) in stating that "movement is a means by which a child may learn more about himself, about his environment and about his world" (p. 18).

In order for motor skills to develop at age appropriate rates, there needs to be participation in experiences that involve movement. According to Portwood (2003), children need extensive opportunities to practice and refine movement skills. Limited opportunities to extend coordination, balance and motor skills, leaves development of these skills to chance. Espenschade and Eckert (1980) pointed out that infants and children have a capacity and a need for "spontaneous motor activity which will enable the child to practice neuromuscular coordination and will assist the child in the exploration of the environment" (p. 122). The age appropriate development of perceptual-motor skills requires the effective processing of sensory information in the form of tactile, visual and proprioceptive cues leading to efficient and coordinated movement. Low birth weight, prematurity, prenatal influences, cerebral palsy and neurodevelopmental factors involving the retainment of primary reflexes may also affect the development of these skills (Barnhart, Davenport, Epps, & Nordquist, 2003; Maldonado-Duran, Glinka, & Lubin, 2003; Sugden & Wright, 1998). Children with poor perceptual-motor skills, irrespective of the underlying causes, may be referred to as clumsy or motorically awkward and the terms



developmental apraxia and perceptual-motor difficulties have often been used to characterize the problem (Barnhart, Davenport, Epps, & Nordquist, 2003).

The nomenclature of motor difficulties is complex; however, the most recent classification of poor motor co-ordination was defined as 'Developmental Coordination Disorder' (DCD) by the American Psychiatric Association as follows:

Performance of daily activities that require motor coordination is substantially below that expected for the child's age and this motor delay interferes significantly with academic achievement or activities of daily living (Miller, Missiuna, Macnab, Malloy-Miller, & Polatajko, 2001 p. 5).

Younger children may display clumsiness or delays in achieving academic and motor milestones and even though the basic fundamental skills of reaching grasping, sitting and standing have emerged appropriately these fundamental movements have not developed sufficiently into skills that allow them to fully explore and learn from environmental experiences (Sugden & Wright, 1998).

The implications of DCD on learning are significant, particularly in areas requiring eye tracking and fine motor/manipulative skills such as reading and writing, and consequently academic performance, may be compromised. Jensen (1998) advocates that if movements are impaired then the cerebellum and its other connections to the brain may be compromised influencing language, reading and other activities requiring cognitive input. Children with DCD also tend not to be as popular with their peers as children with normal developmental movement skills, therefore putting self esteem and appropriate social skill development at risk (Miller, Missiuna, Macnab, Malloy-Miller, & Polatajko, 2001). According to Son and Meisels (2006, p.774) early motor assessment can be used as one of the indicators of future school achievement of young children thus emphasizing the important link between motor proficiency and later academic skills from an early age. DCD may persist into adult life and the presence of the symptoms of DCD in the early years carries an increased risk that without intervention, difficulties will continue beyond school age, a failure to address these problems leading to "academic, behavioral, physical and psychosocial consequences" (Missiuna, 1996, p.4). The occurrence rate worldwide of

DCD is approximately five percent with 10 percent of children considered to be 'at risk' and as such this constitutes a significant proportion of the population (Sugden & Wright, 1998).

While it is acknowledged that many factors in isolation or combination may contribute to the manifestation of movement difficulties, the persistence of primary reflexes which emerge during foetal life may have a significant effect on the development of motor and coordination skills (Morrison, 1985). The association between retained reflexes and developmental motor issues has a long and sometimes controversial history. Fay (1954), Bobath and Bobath (1975), Holle (1976) as well as current researchers such as Morrison (1985) and McPhillips, Hepper and Mulhern (2000) have identified that retainment of primary reflexes may be a major contributor to DCD. McPhillips, Hepper and Mulhern (2000) reported the results of a study in which 60 children aged eight to eleven years, from regular primary schools in Northern Ireland, presenting with reading difficulties, average verbal IQ and a persistent Asymmetrical Tonic Neck Reflex (ATNR), were involved in a randomized, double blind, placebo controlled trial. This research was an attempt to determine the effects of a specific movement program, *Primary Movement* (McPhillips, Hepper, & Mulhern, 2000), on the inhibition of primary reflexes and educational performance. Results indicated that participation in *Primary Movement* led to a significant decrease in the level of ATNR, and reading scores increased substantially in comparison to the control and placebo groups. The results of a further study by McPhillips and Sheehy (2004), led to the conclusion that "persistence of the ATNR plays a role, direct or indirect, in delaying the reading progress of a significant number of children attending ordinary primary schools" (p. 30).

## **1. 2 Significance of the study**

There has been a great deal of interest in the relationship between motor skills and cognition throughout the 20th century. One of the most significant reported relationships was a theory of cognitive development put forward by Piaget (1968) in which movement was emphasised as the primary agent leading to the acquisition of increased cognitive structures, especially in the early years. Piaget observed infants and children over an extended period and identified various behaviour cues as evidence of cognitive

development. Movement is emphasized by Piaget as being the 'primary agent in the acquisition of increased cognitive structures, particularly during infancy and preschool years' (Gallahue & Ozmun, 1998).

From early theories based on the role and importance of movement for learning there has been the development of perceptual-motor programs aimed at improving intellectual development. Programs developed by Kephart (1971), Delacato (1963) and Ayres (1972a; Ayres, 1972b) among others, were seen as panaceas for cognitive problems and were professed to improve performance in skills such as reading, language and comprehension. These programs placed a heavy emphasis upon the perceived need to remediate perceptual-motor functioning as a prerequisite to higher order cognitive functioning (Kavale & Mattson, 1983). All of these programs are based on the theory that the ability to generalize in higher mental processes is dependent on the ability to form motor generalizations and that underlying deficits in perceptual-motor skills are responsible for problems with cognition.

Unfortunately, the results of initial research into movement did not support the view of these theorists that academic skills would improve with extensive perceptual-motor training. Research outcomes were also plagued with criticisms of poor methodology and validity (Cummins, 1991; Kaplan, Polatajko, Wilson, & Faris, 1993; Kavale & Mattson, 1983). Consequently, any perceived links between motor-based intervention programs and cognitive skills have been met with skepticism and controversy. According to Kavale and Mattson (1983), the wide acceptance of perceptual-motor intervention techniques has been based "on informal, subjective evidence rather than formal, experimental investigations" (p.5). Even though there is little positive evidence to support the effectiveness of perceptual-motor based programs as cognitive interventions, many schools in Western Australia have provided expensive professional development for teachers to support program implementation. A survey by Western Australian researchers Blackmore and Corrie (1996) of schools in the Western Australian Perth Metropolitan area reported that 29 percent of those that responded conducted perceptual-motor programs and anecdotal responses indicated that teachers believed that they were beneficial to the academic achievements of children.

More recent approaches to research into the relationship between movement and cognition have been far more scientific and precise and have indicated evidence of a much deeper understanding of the parts of the brain linking both motor experiences and cognitive skills (Fawcett & Nicolson, 1999; A. L. Leiner, Leiner, & Dow, 1993). Parts of the brain thought initially to solely influence and control movement are now known to be linked to the effective performance of cognitive skills. Of particular interest has been the effect of neurodevelopmental concerns on the skills of reading and writing. According to McPhillips, Hepper and Mulhern (2000) the development of the nervous system including the brain stem, cerebral cortex and the cerebellum occurs at a fixed rate with lower brain anatomy responsible for early movement and higher brain structures taking over as development proceeds. They contend that if the lower brain structures do not relinquish control to higher structures, motor learning and consequently reading and writing skills may be compromised. If structures of the lower brain dominate, in particular the brain stem, there may be evidence of retained primary reflexes and there have been many studies including several recent studies linking retained primary reflexes to impaired performance on cognitive tasks (B. Bobath & Bobath, 1975; Jordan-Black, 2005; McPhillips, 2001; McPhillips, Hepper, & Mulhern, 2000; McPhillips & Jordan-Black, 2007; McPhillips & Sheehy, 2004). The conclusion drawn from this research indicates that if children retain primary reflexes (in particular the Asymmetrical Tonic Neck Reflex) then reading ability (McPhillips, 2001) as well as performance in mathematics and spelling (Jordan-Black, 2005) could be compromised.

This study is significant because:

- There are close links between the inhibition of primary reflexes and the reaching of motor milestones (Capute, Accardo, Vining, Rubenstein, & Harryman, 1978).
- Abnormalities with regard to the persistence or the degree of persistence may lead to issues in the development of motor functioning (Holt, 1991) and cognitive pursuits (Jordan-Black, 2005).
- There is a need to determine the prevalence and extent of retained reflexes in preprimary aged children.
- This research is the first of its kind in an Australian context. It is also the first time that research of this nature has been conducted with children of preprimary age.

This is significant as motor assessment is a useful tool when adequate assessment of an early cognitive achievement level is not easy, as is the case with children of this age that are developmentally below reading and writing age (Son & Meisels, 2006). Including motor skills in an early school assessment and providing an early intervention for children at risk for school failure ensures that the developmental needs of all children in all domains are purposefully addressed. Therefore, the evaluation of the success of the *Primary Movement* program on addressing the factors described above is integral to this research.

### **1.3 Purpose of the study**

The purpose of this research is:

- To determine the prevalence of and the severity of primary reflexes in the preprimary aged population.
- To determine whether a program designed to 'switch off' and integrate primary reflexes into higher order behaviour would enable the development of uncompromised motor coordination and lead to subsequent cognitive benefits.

### **1.4 Research questions**

1. What is the prevalence and severity of the ATNR reflex in the sample of preprimary children?
2. Does participation in the *Primary Movement* program have an effect on: the inhibition of the ATNR in those that present with ATNR in the sample population?
3. Does participation in the *Primary Movement* program have an effect on: motor abilities in the sample preprimary children?
  - 3(a) Does participation in the *Primary Movement* program have an effect on: the number of children classified as having DCD based on M-ABC results?

4. Does participation in the *Primary Movement* Program have an effect on: the drawing of an individual's self portrait?
5. Does participation in the *Primary Movement* program have an effect on: receptive vocabulary skills in the sample of preprimary children?
6. Does participation in the *Primary Movement* program have an effect on: visual motor integration in the sample of preprimary children?
7. Does participation in the *Primary Movement* program have an effect on: rapid naming ability in the sample of preprimary children?

### **1.5 Limitations of the study**

There are a number of potential and real limitations to a study such as this because it was conducted in real school settings where many variables were unable to be directly controlled but could be assumed to be the same for the three groups.

Variables related to the school setting such as the 'Hawthorne Effect' and the effect of teacher enthusiasm must be considered. While both the intervention teachers and the control teachers attended professional training in the *Primary Movement* program and the intervention teachers were randomly chosen, these factors must still be considered. Teacher's personalities and enthusiasm for participation were factors that were impossible to control precisely however to ensure fidelity of implementation, visits were made fortnightly to each classroom (experimental and control) and teachers were asked to keep a diary of participation.

The *Primary Movement* program itself is prescriptive and all attempts were made to ensure that teachers kept to the prescribed sequence of movements through visits and diary recording. This does not preclude the fact that some teachers may have included some of their own songs or movements during the intervention period. It is also possible that some teachers may have omitted some aspects of the prescribed program at some time due to illness or misadventure. This can also be said for the control groups. While teachers were

given strict guidelines in terms of the protocol to be followed during gross motor and free play activities, it is possible that other activities may have been pursued inadvertently without intention to deviate from the prescribed activity during the intervention period.

The research is action based in a school setting. It is impossible to ensure that all variables that contribute what is described as 'a normal pre-school curriculum' were included in all three schools over all nine classes. Choosing schools from similar socioeconomic areas (within a 10 kilometre) radius was the best that could be achieved with such a large population involved in this research. Another consideration is the effect of the home environment and the possibility of some students being exposed to opportunities for extension in variables such as language development, reading or tutoring and coaching that were not afforded to other students.

Measures were taken to address the 'Hawthorne Effect' including the provision of two control groups. On school visits the same attention including reward stickers and praise was given to the children and teachers in the control groups as was given to the children and teachers in the intervention group by the researcher.

## **CHAPTER TWO: CONCEPTUAL FRAMEWORK AND REVIEW OF ASSOCIATED LITERATURE**

### **Introduction**

This chapter provides the conceptual and theoretical framework underpinning this research. It is important to recognize the changing understandings of developmental and motor processes that have emerged since the early years of research in this area as these central tenets have made a significant contribution to contemporary theories and therapeutic approaches. The two main theories of motor development underpinning this research are: the maturational approach of Gesell and Armtruda (1945) and McGraw (McGraw, 1945) and the more contemporary dynamic systems theory of motor development (Bernstein, 1967) and Thelen (1995). Dynamic systems theory includes the constraints theory of Newell (1986), which is pivotal to this particular study. A third model that is considered in this chapter in terms of motor acquisition and interventional strategies is the cognitive – motor approach based on the information processing model which conceptualizes the acquisition of movement as a problem solving exercise and involves cognition, motor and affective elements. This and the other theories influencing the field will be explained and linked with the research that underpins them and consequent therapeutic practices emerging from these understandings will be outlined.

The role of movement in the overall development of the child including the development of sensory and perceptual processes and the link between perceptual-motor and cognitive development is also outlined in this chapter. The syndrome of Developmental Coordination Disorder and the impact this has on various areas of child development is also addressed. Of importance in the consideration of child development are the stages of motor competency which are explained with particular emphasis on the role of reflexes.

Over the years, substantial research has been reported on various interventions that have evolved due to the recognition of the significant role that movement plays in development and the identification of the effect that delayed motor development can have



on overall development including cognition. Significant attention is paid in this chapter to interventions based on neurodevelopmental or 'process' theories as these form the conceptual framework for investigation of the efficacy of the *Primary Movement* program as an intervention tool.

## **2.1 The significance of movement in infant development**

One of the most significant periods in the history of motor development is the maturational period which occurred from approximately 1928 to 1946, with the work of Gesell (1940), Gesell and Armatruda (1945) and McGraw (1945) dominating theoretical understanding. During this period, theories were based on the belief that each stage of the developmental process unfolds according to pre-programmed operations in the brain. Theories of development during this period placed significant emphasis on reflexive behaviour in the foetus and also on infant and neurogenic movements which are those generated by the Central Nervous System (CNS) (Piek, 2006). Another significant period was the process oriented period spanning 1970 to the present. Theories during this period were based on an understanding of the processes which are believed to underpin developmental change. The theories of motor development which dominate this period include those based on ecological approaches such as the dynamic systems model which focuses on factors external to the infant in initiating change and hence development. Irrespective of the numerous theories attempting to explain the primary initiators of movement development, whether they be maturational or environmental in nature, the fact that movement is significant in promoting infant development remains undisputed.

## **2.2 Neurodevelopmental overview**

To the layperson it may seem that the development of movement begins after birth, however the process of movement development actually starts in the uterus with sub-cortically controlled reflexive movements forming the basis for the future phases of motor development. At this stage of development, movement is driven by what is known as the primary reflex system (McPhillips, Hepper, & Mulhern, 2000; Morrison, 1985). This primary system remains active into the early months after birth, allowing the infant to respond to touch, light, sounds and changes in pressure, and provides critical survival

responses such as rooting and sucking. There are over 70 identified primary reflexes such as the Asymmetrical Tonic Neck Reflex, the Spinal Gallant Reflex and the Moro Reflex (Illingworth, 1987). At approximately six months of age, the maturation of the nervous system results in these reflexes being 'inhibited' or transformed into postural reflexes that lead to rolling, sitting, crawling and eventually walking. As children move through infancy, motor control progresses cephalocaudally, which is from head to feet and proximodistally, trunk to extremities, and the infantile gross motor patterns become more refined.

During these stages, there is increasing emphasis on the importance of participation in motor activity in order to develop perceptual-motor skills, the basis for early learning about one's immediate environment. According to Bowers (1988), by engaging in movement the child has an opportunity to receive and store sensory information from the external sensory receptors such as the eyes, ears and skin and also from the vestibular and kinaesthetic internal receptors. All children "benefit from experiencing a wide range of movements of their bodies in the early years for the development of control and coordination of the skills of work, play and daily living" (Bowers, 1988, p. 48). Perception involves the interpretation of incoming sensory data gathered by the sense organs and the organization of this new and incoming information with information that is already stored in memory. All conceptual and perceptual learning at this age such as body awareness, spatial awareness, directional awareness and temporal awareness is based on motor responses and therefore, the greater the exposure of the child to motor experiences, the greater the development of perception (Kephart, 1971).

Given that movement is considered vital to the overall development of children and central to the manner in which they gather information about, and interact with the environment (Piek, 2006), it is understandable that movement can also be linked to cognitive development, social activity and communication (Cech & Martin, 1995). These developmental periods providing an understanding of the role that movement plays during each stage will be discussed in more detail in the following sections.

## **2.3 Developmental stages of movement**

During the first year of life, there is a dramatic change in the movement abilities of infants due to the interaction of many different factors in motor development including the individual and the environment. Significant movement is observable prior to birth and also in the first six months after birth. This period is referred to as the primitive reflex period. These reflexes promote survival and also are the precursor movements or the building blocks for future movement.

### **2.3.1 Reflexive behaviour**

One of the earliest phases in movement development occurs in the foetal stage which according to Piek (2006) is the stage in development covering the period eight weeks post conception to birth. This is classed as the primitive reflex stage. While it is possible to generally describe the evolution of reflexive behaviour into voluntary motor control it is much more difficult to explain how and why these changes occur and this will be debated from several different viewpoints.

#### ***Primitive Reflexes***

According to Peiper (1963) primitive reflexes are involuntary and mediated by lower brain centres. Payne and Isaacs (1995) state that these reflexes occur sub-cortically, meaning below the level of the cortex of the brain, a view shared by Fiorentino (1981) reinforcing the belief that reflexive movements are produced without the direct involvement of higher brain centres. Many of these reflexes are present prenatally and are elicited in utero (Haywood, 1993; Piek, 2006, Wyke, 1975). Many of the initial reflexes are necessary for survival after birth, for example, the Moro reflex which assists with the first intake of breath and the rooting reflex which enables the newborn to feed (Haywood, 1993). The rooting reflex is activated when the area beside the infant's mouth is touched. Bly (1994) states that the turning of the head while in prone position, an aspect of the rooting reflex is also life saving, as it enables the infant to breath and prevents suffocation. The Asymmetrical Tonic Neck Reflex (ATNR) is one of the most widely researched primitive reflexes (Gallahue & Ozmun, 1998) and is elicited when the neck is rotated.

Others include the Moro and startle reflexes which may be elicited by placing the infant in a supine position and producing a feeling of insecurity of support. This causes a sudden extension of the arms and fingers and, to a lesser extent, extension of the legs and toes as well as a sharp intake of breath. The Moro reflex is one of the most widely used tools in the neurological examination of the infant as an asymmetrical response intended to elicit the reflex may indicate neurological dysfunction or injury to a limb (Gallahue & Ozmun, 2006)

Table 1

*Developmental Sequence and Approximate Rate for Appearance and Inhibition of Selected Primitive and Postural Reflexes*

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Moro	X	X	X	X	X	X	X	X				
Startle									X	X	X	X
Search	X	X	X	X	X	X	X	X	X	X	X	X
Sucking	X	X	X	X								
Palmer grasp	X	X	X	X	X							
Babinski	X	X	X	X								
Plantar grasp						X	X	X	X	X	X	X
Tonic neck	X	X	X	X	X	X						

Note: "X" indicates presence of reflex (Gallahue & Ozmun, 2006, p. 127)

Persistence of a primary reflex beyond the normal inhibition stage may be indicative of neurological dysfunction and is believed to be more significant in terms of indicating a possibility of neurological dysfunction, rather than if a reflex that is absent (Haywood, 1993; Morrison, 1985; Peiper, 1963). Over the years, a timetable has been developed for the appearance and inhibition of primitive reflexes. Table 1 above indicates this developmental sequence.

There is some conjecture regarding the use of the term 'primitive reflex' (Piek, 2006). Touwen (1984) argues that this term implies that the infant's brain is 'primitive' at birth and functions only at a reflexive level:

The responses are called primitive because the infant's brain is considered to be a primitive, underdeveloped, incompetent, deficient- edition of the adult brain. They are reflexes because the infant's brain is considered to function on a reflex basis- "reflex" being used to contrast with cortically controlled voluntary activity (p. 115).

Touwen (1984) maintains that infants have many reactions of which some are mediated by the Central Nervous System to stimulus, and the question is, whether the infant does more than respond to these stimuli in a reflex specific way. While reflexive behaviour is one property of the infant brain it is considered that the other main property is to generate activity (Touwen, 1984, p. 123). Gallahue and Ozmun (2006), propose that there are two important stages of the reflexive movement phase. These are the information encoding phase which occurs during the foetal period and continues until the fourth month of infancy and the information decoding stage which begins about the fourth month of infancy. In the first stage, the lower brain centres are dominant and cause involuntary reactions to a wide range of stimuli. In infancy, these reflexes assist with the gathering of information as well as seeking nourishment and protection. As the higher brain centres begin to develop, the lower brain relinquishes control and there is an inhibition of the reflexes. The skeletal movements are replaced by voluntary movement activity controlled by the motor area of the cerebral cortex. At this stage, the infant begins responding to sensory stimuli with perceptual motor functioning, that is, instead of merely reacting to

stimuli, the development of voluntary control involves reacting to sensory stimuli with stored information.

During the reflexive stage the newborn is considered to be an organism "which functions mainly on the basis of reflexes and reflex like reactions i.e. sub-cortically in a broad sense" (Touwen, 1984, p.117). Researchers including Capute, Accardo, Vining, Rubenstein, and Harryman (1978), Fiorentino (1981), Gallahue (1993), Holt (1975), Hottinger (1980) and to a certain extent Bobath (1980) refer to this period as a 'reflexive period' with Wyke (1975) explaining this as an understanding that "the neurological mechanisms that produce and control bodily movement throughout the first year of each individual's existence are entirely reflex" (p. 27).

There are however theorists, including Piek (2006) and Touwen (1976), who dispute this totally reflexive view of early motor development stating that the "emphasis on reflexes retarded early investigations into the development of the brain and in particular coordination" (Piek, 2006 p. 11). Touwen purports (1984) that the:

Infant's nervous system is recognized as being too complex to be explained merely on the basis of reflexes and reactions, however useful these may be for a neurological examination (p.119) and;

Purely stereotyped reflexes do not occur, although reflex mechanisms may be hidden by the variable responses of the infant's complex brain (p. 123).

According to Haywood (1993), the exact role of spontaneous or random movement and reflexive behaviour in motor development is still a subject of debate amongst developmentalists.

### **2.3.2 The role of reflexes in motor development**

In terms of the role that reflexes play in overall motor development, the most traditional view of reflexes is that those reflexes which resemble the later voluntary movements, such as locomotor reflexes, must disappear before voluntary behaviour can occur (Pontius, 1973). This view is shared to a certain extent by Robertson (1984) who contends that certain primitive reflexes need to appear and then disappear before the attainment of voluntary motor skills. Hence the role of reflexes in motor development is controversial. Touwen (1976) however questions the idea of sequential development in which reflexes appear and are then suppressed by the development of voluntary activity. Available evidence suggests that specific reflexes do play a part, or have an indirect role, in preparing the infant for later voluntary movement. According to Gabbard (1992) reflexes contribute significantly to the "regulation, strength, and distribution of infant muscularity" (p. 245). This can be applied to other elements of motor maturation such as balance, for which specific reflexes can provide practice.

While it is the belief of some theorists that reflexes merely reflect the developing structure of the nervous system, others take the view that reflexive movements provide practice for the infant in coordinated movements prior to the higher brain centres being ready to mediate the action (Peiper, 1963). In the past two decades researchers have gone beyond describing reflexive behaviour to studying the underlying causal mechanisms. The way in which reflexes are viewed is determined by the theoretical stance of the observer. The traditional views on reflexive movement reflect a neurodevelopmental perspective whereas developmentalists working from a dynamic systems perspective interpret reflexes as playing a different role in motor development.

Some of the primary reflexes elicited during early infancy resemble later voluntary movements and are sometimes called postural reflexes. Gallahue and Ozmun (2006) state that in the past few decades, it has been hypothesized by researchers such as Thelen and McGraw that these postural reflexes form the basis for later voluntary movement. It is believed that the gradual maturation of the cortex allows it to take over the control of the postural reflexes such as stepping, crawling and swimming. This ideology was challenged by Zelazo (1976) who is quoted by Gallahue and Ozmun (2006) as suggesting that:

Indeed, current behavioural and neurological research with infants challenges the validity and generality of the hypothesized independence between early reflexive and later instrumental movement. An alternative hypothesis holds that the newborn's reflexes do not disappear but retain their identity within a hierarchy of controlled behaviour (p.125).

Arguments against this hierarchical view were posited by anatomists who argued that there is a recognizable gap of up to several months occurring between the inhibition of a postural reflex and the onset of voluntary movement (Bower, 1976; Kessen, 1970; Wyke, 1975) and this time lag indicated that there was no direct link. It was also argued that the performance of reflexive and voluntary movements was controlled by different parts of the brain (Gallahue & Ozmun, 2006).

According to Coley (1978) the prevalent view is that reflexes provide "automatic movement that is a form of practice for aiding in the attainment of future movements" (p. 43). Fiorentino (1981) concurred that the reflexes play an important part in future movement by "regulating the degree, strength, balance and distribution of muscular tone" (p. 26).

Alternatively, although acknowledging that postural reflexes are essential for appropriate motor control, Piek (2006) suggests that there appears to be little support for the idea that primitive reflexes provide the basis for later movement abilities. This unpopular belief is based on the work of McDonnell, Corkum and Wilson (1989) who suggest that the two processes, primitive reflexes and voluntary control are both "neurologically and developmentally distinct" (Piek, 2006, p. 24). Rather than being linked to one another, reflexes and voluntary control develop at the same time. This idea forms the basis of a theory termed the "motor-genre" theory (McDonnell, Corkum, & Wilson, 1989).

Clearly, there are differing theoretical viewpoints concerning the relationship between reflexive behaviour and voluntary movement. However, there is no doubt that reflexes are



an essential aspect of early movement and according to Piek (2006) have been influential in understanding early and later motor development for a significant period of time.

#### **2.4 Significant theories of motor development**

Following the primary reflexive stage of development, a child progresses through key areas of development identified by Shirley (1963) as postural, locomotor and prehensile milestones. While it is acknowledged that there is often variance in the pattern of early responses, the order and age of occurrence of achievement of these milestones remains relevant today (Piek, 2006). The results of studies of large numbers of infants by Gesell (1940) made it possible to determine an 'average' sequence and rates of reflex development and inhibition and also developmental age norms for motor skill acquisition. In research leading to the publication of these developmental norms, Gesell and his associates examined more than 10,000 infants at various age periods and utilized these analyses to detect infants deviating from usual growth patterns, a process that has continued to the present day (Gallahue & Ozmun, 1998; Illingworth, 1987).

Research outlining the importance of achieving these developmental milestones is particularly significant because it has been reported that race, socioeconomic status and sex can influence the rate of achievement in motor development (Capute, Shapiro, Palmer, Ross, & Watchel, 1985). For example, infants with maternal participation in drugs and alcohol, who are premature or a low birth weight, may have a delay in the development of normal movement stages or motor milestones leading to a marked impairment of motor coordination. A factor receiving less attention is the influence of neurodevelopment yet this seemingly involuntary process that influences all aspects of human development may indeed delay or even inhibit achievement of motor milestones.

## **2.5 Maturation theories of motor development**

Early theories of motor development were primarily centred on a maturational view of development. Theorists who subscribe to maturational theory maintain that each stage of the developmental process unfolds according to preprogrammed operations encoded in the brain. According to Eckert (1987), as the cortex develops it inhibits the functions of the sub cortical layers, thus assuming an ongoing increase in neuromuscular control. Reflex behaviours are phased out and voluntary behaviour is assumed by the infant.

An important aspect of the theory of maturation is developmental direction or the order in which this development occurs. Gesell and Ames (1940) identified a cephalocaudal (head to feet) and proximal to distal (points close to the body centre to the body's periphery). Put simply, soon after birth infants control their head and at the end of the first year, they can stand. The upper arm and upper leg will develop control before the forearm, foreleg hand and foot (Piek, 2006). McGraw (1945) was another maturationist who linked the progression, from prone lying to creeping to upright locomotion, to cortical (cerebral cortex) control over muscle function.

Although this principle has been widely accepted, it has been challenged by recent findings, which suggest that the fetus has a large repertoire of movements from seven weeks onwards including a simultaneous onset of arm and leg movements at eight weeks (de Vries, Visser, & Prechtel, 1982). Piek (2006) reports that researchers Galloway and Thelen observed that infants can reach and interact with toys using their feet before they can reach with their hands. This leads to the suggestion that the principle of developmental direction may be task specific and there may be exceptions to the rule (Newell & van Emmerick, cited in Piek, 2006 p. 36).

The maturational view incorporates the notion that a significant diversion from the sequence or timing of motor milestones may be an indicator of abnormal development (Touwen, 1976). This has resulted in the emergence of various intervention programs including psychomotor patterning through the Doman-Delacato (1963) method. This method addresses the issues thought to arise from missing out on what are perceived to be essential aspects of the developmental sequence. Research into the efficacy of these

programs in addressing what is believed to be Central Nervous System disorganization has not necessarily been supportive of process interventions based on a maturational approach.

When one considers how similar motor sequences are across cultures, there is validity in the supposition that sequential phases of movement development are “endogenously generated through maturational processes” (Piek, 2006, p. 39). One of the criticisms of the maturational approach, according to Piek (2006), is that there is too much emphasis placed on the ‘norm’ and there are a significant number of studies that emphasize variability in development of individuals who ultimately achieve normal motor control. Further, even though children achieve motor milestones within the normal range, this does not exclude them from neurological damage.

## 2.6 Information-processing approach

The information- processing model is likened to the working of a computer in which the human is the information processor and is a distinctly top down approach Stelmach (1982). This implies that motor control is a series of processes that can be categorized as input, central, output and feedback (Piek, 2006). Each stage is a unique section which can be analysed separately.

The most popular of the information processing models used in the analysis of motor control is the closed loop model which is shown below.

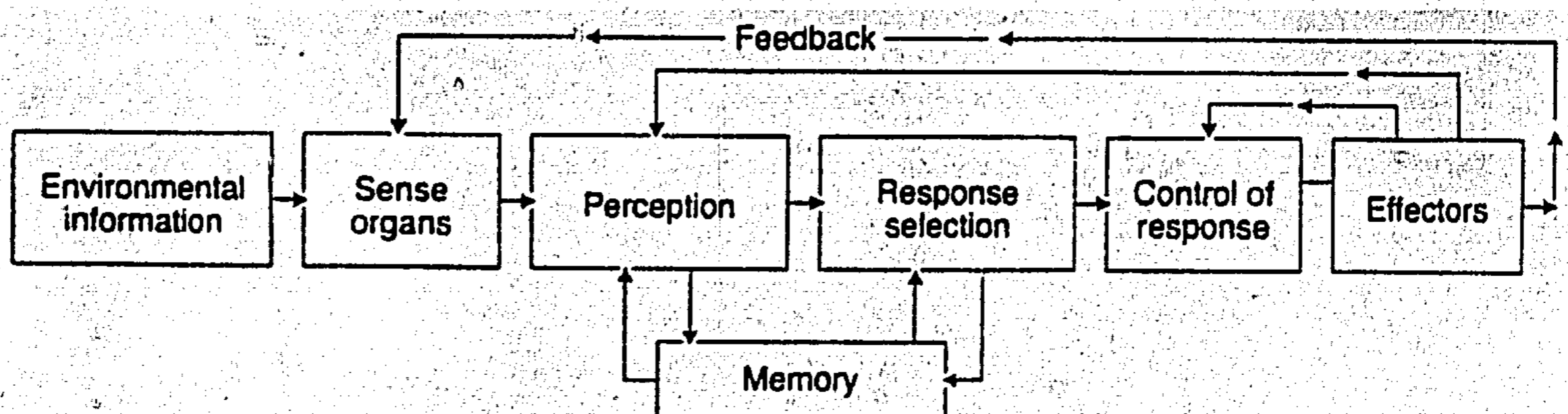


Figure 1. The information-processing model (Piek, 2006 p.45)

The information processing- processing approach allows the inference and measurement of cognitive aspects of motor functioning including such concepts as memory feedback and perception. This provides the participant, teacher or coach with information about the aspects of the skill performance which are often neglected (Kelso, 1982). This approach was dominant during the 60's and 70's, and according to Piek (2006) has been useful in analyzing developmental coordination disorders as it enables researchers to identify and investigate the stages affected by the disorder. There are however issues associated with the approach. One of the first to consider is that most of the research on motor development using the information from the information-processing approach was focused on older children and on a limited number of motor skills. There was little research on infant motor development using this approach (Piek, 2006). Further concerns are raised by (Kelso, 1982) who states "...despite the broad appeal of the information-processing framework its contribution has been somewhat narrow, focusing primarily on the analysis of specific experimental situations" (p.89). Kolt and Schnyder-Mackler (2003) purport that that there is some concern with the theory that the central control of movement by the CNS in the form of a motor program involves a memory based mechanism. Consequently a generalized motor program is stored as an abstract representation of movements. This motor program is retrieved when a movement is performed. The concern is that on this basis there is a requirement for a large retention of information in order that the full complements of movement possibilities are covered. This has led to arguments by Bernstein (1967) that this resulted in far too many components being controlled at the same time especially considering the vast numbers of muscles and joints required for movement. This led to the development of the dynamic pattern theory that will be discussed later in the chapter. In the dynamic pattern theory there is "no central representation of all components of the movement; instead the organisation of muscle contractions and joint movement is coordinated by environmental invariants and limb dynamics" (Kolt & Snyder-Mackler, 2003 p.111).

## **2.7 Cognitive- motor approach**

The cognitive-motor approach is adopted by Henderson and Sugden (1992) as part of the Movement Assessment Battery for Children and "serves a pragmatic function in providing a guiding framework for assessment and intervention" ( p.129). The cognitive

motor approach is a simple variant of the information - processing model and recognises the affective factors within the individual such as motivation and confidence, in its problem solving approach to movement tasks (Henderson & Sugden, 1992) . According to Georgopoulos (2002), cognitive motor control refers to processes that blend cognitive and motor functions seamlessly in an interwoven fashion. A model of the cognitive motor approach is shown in Figure 2.

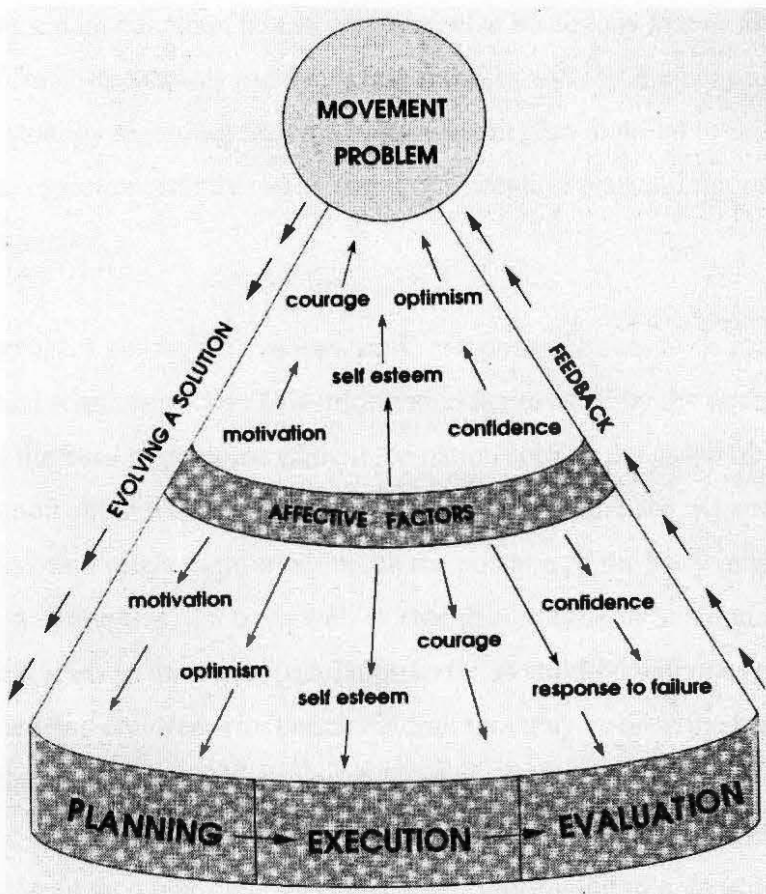


Figure 2. The cognitive motor approach (Henderson & Sugden, 1992, p.128)

Based on this model, the solution to a movement problem is seen as having three main components. The first of these components is the planning stage of the motor act, the second, the execution of the act and the third the evaluation. All of these factors are influenced by affective factors such as motivation, confidence and interest in learning the new task (Henderson & Sugden, 1992, p.129)

### ***Movement planning***

In this first step, the child would consider whether they are actually capable of the task as well as considering the conditions that prevail. Using the example of a child catching a ball, in planning the movement response, he must know about the task. This means he must know that the thrower is holding an object that can be thrown, know that the ball will come from the hand of the thrower and know information about the size and shape of the object as well as the speed and so on. If the child has had some past experience with catching, he can combine what he already knows about the task with the new information that this particular task requires and this memory allows him to apply the correct strategy regarding the type of movement plan required to this task. The sensory systems, most importantly vision and proprioception play an important role in the control of movement.

In terms of vision, the eye uses static and dynamic cues to determine all the properties of a visual scene correctly. This information is provided by the constant movement of the eye and the head to combine static information such as the shape of the object with information about whether the object is moving or stationary. Kinesthesia or proprioception refers to information on the position of the body in space and is gathered by receptors in muscles, joints, as well as receptors within the vestibular system. This is the sense that leads to the most speculation as far as children with movement difficulties are concerned and children with deficits in this area may be described as having poor vestibular functioning (Henderson & Sugden, 1992).

The brain then interprets this perceptual information into an action plan and dictates the roles of the muscles and joints in order to achieve the action. This involves not only the interpretation of the sensory information from the present task, but the utilization of information from past experience. Therefore the strategies used in a new motor problem will be similar to those used in previous situations so is therefore never completely unknown.

### ***Execution***

In order to catch the ball, the boy needs to have a plan of action that is organized and control such as determining the flight of the ball with his eyes, hand position, and absorb the force of the ball and so on. For an adult with a lot of experience in catching, this task is relatively easy with only minor new elements added to the task. However, young children have a limited repertoire of consistent movement patterns to consider.

### ***Evaluation***

This stage involves the assessment of success or failure and occurs during the task as well as at the end. During slow and continuous tasks then the movement can be adjusted concurrently however, this is not possible with faster actions. This stage is also known as feedback and this can be intrinsic, extrinsic or both. Intrinsic feedback occurs during the movement whereas extrinsic feedback is considered to be the knowledge of results. Extrinsic feedback can come for example from the teacher who may give verbal feedback on an action such as “you need to watch the ball into your hands next time”.

One objective of a cognitive-motor approach is to provide opportunities for children to participate in structured experiences enhancing fundamental movement skill learning at an early age with many opportunities to practice and refine skills in a meaningful context. The approach to intervention based on cognitive motor practices involves the task analysis, explicit teaching and adaptation of individual skills. In task analysis, skills are broken down, moving from the simple to the more complex, carefully built to a whole, and then practiced to an automatic level. Fundamentally, this approach conceptualises motor tasks as problems to be solved by the individual (Henderson & Sugden, 1992).

## **2.8 Dynamic systems theory of motor development**

One of the criticisms of the maturational model is that it cannot account for the tremendous variability in individuals and cultures as infant development can be “exquisite and individualized” (Kamm, Thelen, & Jensen, 1990 p.763). This variability in motor development was noted by Bernstein (1967) who proposed the ‘dynamic systems’ model as a means of understanding the contribution of factors external to the individual in motor development. Bernstein’s work was first published in Russian in 1947 and titled *The Coordination and Regulation of Movement* and was not published in English for another twenty years. Bernstein was the first to see movement as “the cooperative interaction of many body parts and processes to produce a unified outcome” (Thelen, 1995, p. 80). and recognized that movement control could not solely be attributed to muscular force but also must incorporate other factors such as reactive forces (Turvey, Fitch, & Tuller, 1982).

The premise for this theory of motor development is based in physics, chemistry and mathematics and is founded on the idea that when the elements of a system work together then the behaviour that emerges is such that it cannot be predicted from separate elements (Piper & Darrah, 1994). In this context, the word ‘dynamic’ refers to how a system or a particular variable evolves over time (Piek, 2006 p. 53) and from this perspective, motor development evolves as a consequence of not only the development of various body systems but also the task to be undertaken and the environmental context in which the task is done (Haywood, 1993). An example of this interaction between these three components is that a person may be able to move a particular limb in one body position, but not in another. Thus, it is possible to kick both legs at the same time while lying on your back but not while standing up. When these multiple systems are considered, developmentalists believe that this gives an opportunity to determine which of the many systems is important to the onset of the new skills (Haywood, 1993). The principle of this approach is that behaviour occurs as the result of many subsystems and the emergence of new movements occurs due to “natural laws” rather than a pattern inherent in the Central Nervous System (CNS) (Piek, 2006 p.51).

According to Newell (1996), factors that influence development can come from the organism, which includes factors such as body height and weight, the environment



including gravity and friction and the task. New skills cannot be attempted if one of the body's systems have developed but one or more systems are lagging behind. These slower systems must reach a critical point and are therefore referred to in this model as 'rate limiters' or 'rate controllers' (Haywood, 1993). Dynamic systems theorists consider many systems in determining the rate-controlling factors in development whereas maturationists consider the central nervous system to be the sole rate determiner. System theorists explain the various stages of motor development by stating that the factors that influence changes in behaviour do not all present at once with one of the factors for change becoming 'rate limiting' and preventing the system from generating a behaviour (Piper & Darrah, 1994). An example of this is infant stepping, a reflexive movement which disappears at around six months of age. From the perspective of a dynamic systems approach, the infant stepping reflex disappears due to the rapid weight gain which occurs during this period when limbs get heavier but not necessarily stronger, a combination of "increasingly heavy legs and a biomechanically demanding posture" (Thelen, 1995, p.80). When viewed in this way, developmental change is not planned; rather it comes about as the effect of multiple developing elements.

Piek (2006, p.60) describes how the interaction of four subsystems including sensory, cognitive and neuromuscular aspects of an individual leads to a new behaviour. It is only when all these subsystems have reached a certain level that the new behaviour emerges. Newell (1986) suggests however that the factors influencing motor development and more specifically coordination can come from three main sources. These are referred to as constraints as they are factors that restrict movement. These factors are the task, the organism and the environment. These constraints interact "to determine for a given organism the optimal pattern of coordination and control for any activity" (Newell, 1986 p.348).

Although traditionally the immaturity of the neurological system is proposed to be the limiting factor in motor development (organismic), Newell (1986) proposes that constraints theory should be more widely interpreted, particularly in terms of task constraints such as the consideration of the size and weight of an object to be manipulated in the development of grasping. This has resulted in the development of terminology such as 'developmental transitions' to replace the term 'stages of development' used by

maturationists. While viewing motor development from a stage perspective, there is little consideration given to understanding the actual processes that resulted in the transitions (Piek, 2006). This is important because an analysis of the developmental stages using the maturationist stage approach averages out development and “smooths developmental bumps and removes variability” (Piek, 2006 p.62) It is only by examining motor development through stage transitions that a true understanding of the nonlinear nature of development can be obtained.

## **2.9 Neuronal Group Selection Theory**

As theoretical frameworks for the processes involved in movement have evolved, so has a third theory, the Neuronal Group Selection Theory (NGST). This theory combines the two current but conflicting theories, Neuromaturationist and Dynamic Systems theory. According to Hadders-Algra (2000a) the NGST “combines the ‘nature’ part of the Neural-Maturationist theories with the ‘nurture’ part of the Dynamic Systems theory” (p.566). Proponents of NGST theory promote that during infancy, termed the Primary Variability stage (Hadders-Algra, 2000a) motor repertoires are primarily controlled by evolution and are not geared to external conditions. As the individual develops and the motor control centres become more capable of receptivity, motor performance can be adapted to specific situations. This theory could offer a balance between the other prominent but juxtaposed theories and according to Hadders-Algra (2000b) might promote effective intervention in children with motor dysfunction.

## **2.10 Comparison and description of the interaction between neuro maturational theory, dynamic systems theory and neuronal group selection theory**

In the dynamic systems model, maturation is rejected as the dominant explanation for developmental change and instead the roles of the individual, the environment and the task in shaping the development of the infant are emphasised. The following analogy by Gallahue and Ozmun (1998) assists in explaining the premise of the systems model: there is no recipe for a cloud, instead the organization arises from the flowing together of different components in an environmental context.

In order to comprehend more fully the different perspectives of these theories on motor behaviour, it may be helpful to look at an infant's motor behaviour such as reaching for and grasping a toy. According to the neurological model, this movement skill is explained by the inhibition of primary reflexes leading to the development of postural reflexes, which promote trunk and head control as well as postural stability. When the infant is neurologically ready, the central nervous system has matured to a necessary level to allow the infant to reach for the toy.

From a dynamic systems perspective, the maturation of the central nervous system is important, but other factors may influence the initiation of particular movements, such as motivation, biomechanical leverage, posture in reaching, while the properties of the toy, such as size and weight will determine the type of grasp that the infant will use as well as the position of the arm and the trajectory path of the reach (Piper & Darrah, 1994). All of these variables form the system required for reaching for the toy.

The maturational perspective of development (Gesell, 1940) purports to provide a comprehensive view of infant development from which parameters for measuring and assessing both normal and abnormal motor development have arisen. From this perspective, it is possible to identify children who deviate significantly from the normal continuum of development recognizing that motor development may be compromised by a lack of integrity in the developing Central Nervous System with the cerebral cortex viewed as the control centre. This is evidenced by retainment of primary reflexes which are initiated by the lower orders of the brain and indicating that control has not yet been passed on to the higher orders of the brain. The dynamic systems perspective identifies the influence of many subsystems in the development of movement and contextual factors are emphasized over neurodevelopmental factors. Although recognizing the influence of retained primary reflexes, interventions put forward by those aligned to the dynamic systems model are more task oriented. The retainment of primary reflexes may also be perceived as a task constraint (Newell, 1986) where specific maturational constraints place limitations on the organism to respond to the environment.

Bernstein (1967), who initiated the dynamic systems theory of motor development, postulated that the brain controls groups of muscles, not individual units and these groups

of muscles, tendons and bones can also initiate movement without receiving instructions from the cerebral cortex. In this context, the behaviour itself can affect and modify the resultant behaviour through a 'feed forward' system that self corrects rather than heeding direction from the cerebral cortex. This is in contrast to maturational theory and the information processing approach to movement acquisition in which instructions controlling movement are thought to exist before the motor behaviour emerges, encoded in the central nervous system. Here the central nervous system and higher centers of the brain control movement through a 'feedback' system with modifications to the movement coming from the cerebral cortex (Piper & Darrah, 1994).

While both dynamic systems and maturational perspectives acknowledge that movement problems exist, the identification of causes and therefore the interventions employed depend on the theory to which one ascribes. The maturational model provides the most well known structure of the processes of identification and intervention. However, there is increasing research into the effectiveness of the more contemporary dynamic systems approaches particularly in the area of Developmental Coordination Disorder (DCD). According to Newell (1991), traditional approaches to motor acquisition have failed to capture the impact of the dynamic stages of motor skill acquisition and the ecological approach of dynamic systems offers an opportunity to capture the "richness of the essence of skill and the fullness of the constraints that shape it" (p.233).

Consideration must be given to the theory which combines both Neuro maturational and Dynamic Systems approaches. Although a relatively new motor development theory, Neuronal Group Selection Theory (NGST) paves the way for novel approaches to treatment of developmental motor disorders including the provision of variable sensorimotor experience for younger children (Hadders-Algra, 2000b). It is suggested that older children need an emphasis on active practice.

### **2.11 Identification of motor difficulties during development**

The transformation of abilities in the first 12 months of an infant's life normally occurs without undue attention due to the predictable and orderly fashion in which these changes take place. It is only when delayed or aberrant motor patterns are observed that a

professional may be asked to intervene, however, normal motor skill development cannot be recognized without a solid understanding of normal motor development (Fiper & Darrah, 1994). The type of interventions that are utilized and the behaviour on which the interventions are based, depends ultimately on the model of motor development as the evolution of infant motor skills, the factors influencing rate, pattern and sequence lie embedded in the theories of motor development. In order to answer questions about interventions for students who deviate from the normal developmental curve, it is important to examine the theories of motor development that form the rationale for interventions.

In 1933, Shirley (1963) identified and outlined three key areas of developmental milestones. These include locomotor and postural milestones, such as unsupported sitting, as well as prehension milestones including reaching and grasping. While it is acknowledged that there is often variance in the pattern of early responses, the order and age of occurrence of achieving these milestones remains relevant today (Piek, 2006). Children who fail to reach these developmental milestones within a time period close to those outlined by Shirley (1963) are thought to be at risk of developmental delay or impairment in motor coordination.

One significant neurodevelopmental influence on motor development appears to be delayed maturation of the nervous system resulting in the dominance of lower order sections of the brain such as the brain stem, rather than the transition of motor control to higher order areas. This is evidenced by the retainment of primary reflexes, which ordinarily would be integrated into higher order movement control centres, contributing to delays in motor acquisition. While the majority of children move through developmental sequences in a predictable way others experience delays in movement acquisition resulting in compromised perceptual-motor functioning and coordination disorders.

According to Morrison (1985), the major task for the developing child is to gain adequate information about the environment therefore providing a basis for later evolving operational thought. Two of the major means by which the information gathering process takes place are through perceptual-motor exploration and visual perception. This period is a time of "primary, secondary and tertiary circular reactions" (Morrison, 1985), that is, a

period of development in which novelty attracts attention and maintains a child's interest until the child is familiar with the object or event at a sensory-motor level, contributing to a child's early schemas of "objects, space, time, motion and causal relationships" (p. 4). Following this stage, defined by Piaget (1954) as the sensorimotor stage of development, is the preoperational period that is characterised by important interactions between perception and cognition. During this stage, that begins at age two and continues to age seven, representational thought is developing and perceptions greatly influence adaptations to academic learning (Morrison, 1985).

Children experiencing difficulties with sensory and perceptual processes may use a variety of strategies to compensate for the resulting motor difficulties experienced during the preoperational period. Morrison (1985) suggested that one of these methods of compensation may be reliance on a more language-oriented operational system whereby young children may identify with adults and older children rather than their same age peers. A description of a child experiencing difficulties in sensory and perceptual processes may include the following criteria: the child dislikes school based physical education and avoids playing recreational sport, does poorly on tasks requiring visual motor skills but has strong verbal-social skills. While masking a motor difficulty, some compensatory strategies Morrison (1985) observed elicit a behavioural response that could be misconstrued in a classroom context.

When teachers are confronted by highly emotional and behavioural responses to a child's frustration and anxiety that is due, in part, to poorly developed motor skills, it is not surprising that such children are mislabeled as "hyperactive, with or without attention deficit disorder" (Morrison, 1985, p. 6). In fact, it is likely that as early as kindergarten or at a pre-academic level, the impact of poorly developed motor skills can lead to repeated failure to learn due to poorly developed automatised functions in motor skills, reading and writing (Morrison, 1985). When tasks become automatised, conscious attention can be shifted from the components of the act and attention can be focused on elaboration of the act or to perceive and process feedback received during the task. For example, a child who has mastered running can then shift conscious attention to variations such as running and kicking a ball. Reading requires motor input such as saccadic eye movements and is one

apparently unrelated 'motor' activity in which the perceptual component is performed automatically.

The influence of different intrinsic and extrinsic factors on motor development is significant and leads to a myriad of clearly observable and less obvious indicators of atypical motor skills. Put simply, in a classroom context educators may be less likely to attribute a motor deficit to a child's frustration at not being able to complete an academic task such as reading or writing. As the impact of neurodevelopmental factors is a central theme in this thesis, specifically the role of primary reflexes, this will be addressed further in subsequent sections.

Developmental clumsiness was referred to as early as 1911 by Dupre' (cited in Hulme & Lord, 1986) in which he described an awkwardness of voluntary movement, distinguishable from major motor disorders such as paralysis, due to the more subtle nature of its neuropathology and which affected motor functions supporting everyday life. Samuel Orton made the first major contribution to the study of clumsiness in 1937 (Hulme & Lord, 1986). He ascribed awkwardness of physical performance in children to disorders of praxis (motor planning) and gnosis (visuospatial ability), commenting that both gross motor movements such as running and also manual dexterity were affected. Interestingly, Orton also made significant contributions to the field of neurologically based learning disorders, such as Dyslexia and his interest in the relationship between motor and academic skills such as writing and reading is evident in contemporary research. Orton also noted the limiting effects of the condition on self esteem development, especially in school aged children.

Orton's observations are supported almost 70 years later by Hoare and Larkin (1991) who described the attributes of the disorder stating the effect on gross body movements such as running, jumping and hopping on fine motor dexterity such as writing, drawing and cutting. Also supported is the notion that social problems may arise as a result of isolation from sport and play, and as a result of these negative influences, the child can experience problems with self-esteem.

Descriptive clinical research during the 1960s, predominantly by Walton (cited in Hulme & Lord, 1986), identified many attributes associated with children with impaired movement control including great difficulty in writing, drawing and copying, defective articulation and articulatory dyspraxia, that is, incorrect pronunciation of words, inability to bare the teeth or put out the tongue on request, as well as an inability to carry out activities essential to everyday life independently such as feeding and/or dressing (p. 259). Research, including that of Gubbay (1975) and Dare and Gorden (1970) during the 70's emphasized the heterogeneous nature of the condition and described a range of characteristics that emphasized different features. The four core features of developmental clumsiness identified by Hulme and Lord (1986, p. 260) are:

- Impaired motor performance that is significant enough to interfere with activities essential to daily life including feeding and dressing, school tasks with a motor component such as writing and drawing and physical play activities;
- Absence of neurological signs indicating "pyramidal, extrapyramidal or cerebellar impairment" (p. 260);
- Normal intellectual capacity with the possibility of higher verbal than performance IQ on the WISC; and
- The ability to perform some motor tasks with ease but having great difficulties in others.

These identifying characteristics of developmental clumsiness have remained the basis of identification of motor difficulties, however the labels used to describe the condition have changed and at times have been used interchangeably leading to confusion in both research and practice. Some researchers have taken the view that different terms actually describe different groups of children. Some terms such as 'physical awkwardness' are quite subjective while others such as 'dyspraxia' or 'sensory-integrative dysfunction' carry some general assumptions about the underlying nature of the dysfunction (Missiuna & Polatajko, 1995). More recently, the condition previously described as 'clumsiness' has been defined as Developmental Coordination Disorder.



## 2.12 Developmental Coordination Disorder

The Fourth Edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM IV, APA, 1994) defines Developmental Coordination Disorder (DCD) as “a marked impairment in the development of motor coordination, which cannot be attributed to a general medical condition or mental retardation” (p.53). A recent addendum to the original definition contains an additional criterion that motor difficulties should have a negative impact on academic achievement or functional skills in daily life (Jongmans, Smits-Engelsman, & Schoemaker, 2003).

Jongmans et al. identified children with DCD as those who are:

Experiencing perceptual-motor problems that hinder them to such an extent that the quality of their academic performance or activities of daily living are affected in the absence of a medical explanation (p. 528).

Developmental Co-ordination Disorder (DCD) affects approximately five percent of children (Sugden & Chambers, 2003) . Maldonado-Duran and Glinka (2003) posited that this may be a conservative estimate and an additional 10 percent of children may have a minor form of the problem. Visser (2003) suggested that the diagnosis is normally based on the results of a standardised motor test such as the *Movement Assessment Battery for Children* (M-ABC) (Henderson & Sugden, 1992) where children diagnosed with DCD would score outside the normal range. Henderson and Sugden (1992) advise users of the *Movement Assessment Battery for Children* (M-ABC) that the cut off point for diagnosis of children with DCD are scores below the 5th percentile with those scoring between the 5th and 15th percentile classified as ‘at risk’ (p. 108).

There are numerous problems relating to the assessment of motor impairments in children (using the M-ABC described above), due to the absence of “a ‘gold standard’ equivalent to the role of the WISC in the cognitive domain” (Henderson & Barnett, 1998 p. 454). There is some conjecture regarding the appropriate quantitative criterion for the degree of impairment required for the child’s performance to be judged as abnormal and thus to warrant the application of the DCD label. This is probably due to the fact that there

have been few large scale studies to provide information on motor scores across the general population so there is no sound basis on which to judge the most valid cut-off scores (S. Henderson & Barnett, 1998). A further issue is determining what actually constitutes a comprehensive assessment of perceptual-motor impairment. Diagnostic criteria stated in the DSM IV (APA, 1994) refer to a range of everyday life skills broadly categorized as either gross motor or fine motor control. While these skills are relatively easy to assess, determining the level of children's self-help skills such as fastening buttons and tying laces, is far more challenging. Often these aspects of motor functioning are not included in standardised assessment instruments however, the M-ABC includes a non-standardised checklist comprised of items seen in everyday functioning to assist with assessment of these motor skills (Henderson & Sugden, 1992, p. 26).

### **2.13 Retained primary reflexes: The effect on normal development**

From a neurodevelopmental viewpoint, every child proceeds through a series of developmental stages beginning with a reflexive stage which transcends the prenatal and early infancy period. It is thought that the presence of these various reflexes is indicative of the level of neural maturation and hence Central Nervous System development. Should reflexes that are supposed to present in early stages still be retained at later stages of development, it is maintained that normal motor control will be affected due to sensory integration and perceptions being compromised (Morrison, 1985; Shumway-Cook & Woollacott, 1995). This may be a contributing factor in the diagnosis of DCD.

Research on the effect of retained reflexes on a child's motor development/coordination is not new. In the 1920's Magnus (cited in Shumway-Cook & Woollacott, 1995) explored the function of different reflexes finding that reflexes that are controlled by lower levels of the neural hierarchy are only present when the cortical centres are damaged and that higher centres of the brain normally inhibit these lower reflex centres. In the following years Schaltenbrand (cited in Shumway-Cook & Woollacott, 1995) described the development of human mobility in terms of the appearance and disappearance of primitive reflexes and went on to assert that the persistence of primary reflexes may result from pathology of the brain. Gesell and Armatruda (1947) and McGraw (1945) concurred and attributed normal motor development to the Central

Nervous System (CNS) becoming more cortically dominant resulting in the emergence of higher levels of control over lower level reflexes (Shumway-Cook & Woollacott, 1995 p. 9). Bobath (1965) recognised the importance of sub-cortical structures in explaining abnormal postural reflex activity in children with cerebral palsy and stated that "the release of motor responses integrated at lower levels from restraining influences of higher centres, especially that of the cortex, leads to abnormal postural reflex activity" (Bobath, 1965 p. 8). Based on a reflex/hierarchical theory of motor control and development, reflex assessment tests are often used to determine the level of neural maturation. Reflex profiles are used to record the presence of persisting and dominating primary reflexes which are believed to be "major deterrents to normal motor control" (Shumway-Cook & Woollacott, 1995, p. 11).

The prevailing thought of the time was that a complete understanding of the reflexes would allow the determination of the neural age of a child. This is referred to as a neurodevelopmental theory of development, also referred to as the sensory integration approach (Sherrill, 1993) and assumes that CNS maturation is the primary agent for change in development and minimizes the importance of factors such as musculoskeletal changes.

Morrison (1985) supported the hypothesis that should primary reflexes, particularly the tonic neck reflexes, be retained, a condition described by Morrison (1985) as "neurological dysfunction", then sensory integration and perceptions may be compromised (p. 2). The resulting perceptual dysfunction contributes to the difficulties that a child experiences in acquiring automatised perceptual skills such as those required for reading and writing (Fawcett & Nicolson, 1995). This is thought to be due to dysfunctions in visual tracking, pursuit and sequencing which are all functions of ocular-motor control, which itself is influenced by the vestibular system. This view is supported by Sugden and Wright (1998) who state that these motor impairments may also significantly interfere with academic achievement, strategic planning and visual-spatial performance which in turn affect the skills of reading and writing.

Evidence of this link between abnormal reflex responses and academic achievement is provided by the research of rider who, assessed the prevalence of abnormal reflex responses in normal second grade children compared to a group of learning disabled

children (Rider, 1972). The study revealed that significantly more abnormal reflex responses were detected in the learning disabled children than the normal children. It was also found that children with no reflex abnormalities scored more highly on WRAT achievement tests than the children who displayed abnormal reflex responses.

Impaired sensory and perceptual dysfunctions may result in a failure to learn prior to school experience, however, this is normally “not detected until the child must perceive and integrate visual auditory stimulus for academic learning and performance” (Morrison, 1985). This view is shared by Missiuna, Rivard and Bartlett (2003) who argue that many children with DCD do not display the full extent of their functional difficulties until they reach school age because coordination difficulties might not be easy to observe until the point at which the child learns and performs skills that require adaptation in the speed, timing, force or distance of the movement (p. 33).

The impact of experiencing perceptual-motor issues will affect the efficacy with which the child performs various motor tasks including gross motor activities such as running, catching and throwing and fine motor tasks such as doing up buttons (Gallahue & Ozmun, 1998) which itself affects self-esteem and withdrawal from physical activities (Missiuna et al., 2003). The further issues associated with the features of DCD however, in affecting cognition and academic progress, have far reaching implications on learning.

#### **2.14 The relationship between movement and cognition**

According to Sibley and Etnier (2003), numerous mechanisms can be used to explain the relationship between physical activity and cognition. There are two broad categories into which these mechanisms can be categorized: physiological mechanisms; and learning/developmental mechanisms. The physiological mechanisms are those physical changes that occur with exercise such as “increased cerebral blood flow, alterations in brain neurotransmitters, structural changes in the central nervous system and modified arousal levels” (Sibley & Etnier, 2003 p. 244). The learning/developmental aspect implies that movement and physical activity contribute to cognitive development particularly in very young children (Pica, 1997). This relationship between movement and cognition was initially promoted by Piagetian theory which claims that intellectual development is

influenced and determined by interactions with the environment primarily by movement (Yongue, 1998). Piaget (1968) postulated that the skills and relationships that one experiences during movement carry over to the learning of other relationships and concepts suggesting that more importance be placed on the movement involved in the activity rather than the actual physical exertion. Piaget also highlighted the importance of movement when he noted that movement was “the primary agent in the acquisition of increased cognitive functioning especially in infancy and preschool” (cited in Gallahue, 1976, p. 26). From a cognitive perspective, in order to solve a problem or to perform a particular skill, a series of mental operations must be performed (Stelmach, 1982). Piaget (1953) was one of the first theorists to relate early development to cognition and argues that all knowledge is related to us initially through our early motor actions (Piek, 2006).

Piaget (1953) outlined the importance of reflexes in early development not only in terms of motor development but in cognitive development as well. According to Piaget, action, either physical or mental results in knowledge. Although four stages of development were identified by Piaget in the development of cognition, it is the first of these stages, the sensorimotor stage, which occurs between birth and two years that is particularly relevant to the understanding of early infant development. During this stage, physical action is the main contributor to receiving new information. Cognitive abilities emerge as a result of sensorimotor experiences so in order to interpret the world and themselves, children need to be active in the environment. Piagetian theory is seen as closely aligned with a dynamic systems perspective due to the emphasis placed on the importance of the organism interacting with the environment and began a movement away from the prescriptive approaches such as the neurodevelopmental and cognitive perspectives, which involve top down processes relying on central control mechanisms.

The reason that Piaget’s input was significant was because this was the first time that it was argued that all knowledge was a result of movement or action and motor development took on a new relevance. It is important the educators working with young children have an understanding of how cognitive development relates to psychomotor development and the importance of developing appropriate lesson plans and instructional methods in order that child development is facilitated at every level. Piaget’s theories also led to the development of other theories which placed an emphasis on movement and adaptation to

the environment namely theories related to dynamic systems which explains how a movement is chosen as a result of interaction with the environment (Yongue, 1998). Actions are therefore seen as being self organized and softly assembled rather than hard wired to a particular system as in the neurodevelopmental approach (Ulrich, 1989).

According to Missiuna et al. (2003) children who are diagnosed with coordination disorders and motor dysfunction are likely to demonstrate comorbid conditions including learning disabilities supporting the notion of the interdependence of both movement and cognitive functions. The understanding of these comorbidities is important not only when considering the most appropriate intervention for children with learning disabilities, but also in accentuating the entwined nature of motor development and cognitive functioning.

#### **2.14.1 Comorbid effects of Developmental Coordination Disorder**

It is difficult to subtype children with DCD into homogenous groups (Hoare, 1994) and this raises a number of issues regarding the characteristics of children with DCD from a research and treatment point of view. Attention Deficit Hyperactivity Disorder (ADHD) and Learning Disabilities (LD) are two learning disorders that are presumed neurological in origin and are manifested differently and to varying degrees during the life span (NJCLD, 2006). It is not uncommon for LD and ADHD to accompany DCD with the three conditions often showing comorbidity (Dewey & Wilson, 2001; Jongmans, Smits-Engelsman, & Schoemaker, 2003). The rate of comorbidity between DCD and ADHD has been reported to be 50 percent (Landgren, Petterson, Kjellman, & Gillberg, 1996) and between DCD and LD of a similar magnitude (Kaplan et al., 1998). It is thought that DCD, ADHD, and LD do not exist independently but are all "reflections of heterogeneous atypical brain development" (Kaplan, Wilson, Dewey, & Crawford, 1998).

The variability in severity and comorbidity of neurologically based disorders was identified by Maldonado-Duran and Glinka (2003) who acknowledged that although varying grades of severity and comorbidity exist, some children have only a relatively minor form of motor dysfunction while others have associated comorbidities such as LD and ADHD. This position was also supported by Missiuna, Rivard and Bartlett (2003) who maintained that children diagnosed with DCD form a heterogeneous population with many

variations and acknowledging that there might be involvement of gross motor and postural functions or only of fine motor manipulative skills requiring eye-hand coordination (p. 33). The theory of comorbidity is also supported by Missiuna et al. (2003), in listing non-verbal Learning Disabilities, speech/articulation difficulties and Attention Deficit Disorder as conditions often present with DCD.

While the link between DCD, LD and ADHD has been established, the exact nature of the difficulties some children experience with academic pursuits that manifest in these disorders is less well understood. In referring to motor skills in the context of DCD, the emphasis is on perceptual-motor skills, as all movements require the coordination of motor information with perceptual information (Hulme & Lord, 1986). When a child is assessed as having DCD, their ability to perceive information from the environment, gathered through movement as well as their ability to interact with the environment is distorted. Perceptual-motor issues are most likely to be evident in skills requiring a significant degree of motor control including reading and writing. For this reason many studies on children with DCD have concentrated on remediating those perceptual deficits assumed to contribute to the development of motor skills, specifically vision and kinaesthesia (Hoare & Larkin, 1991).

#### **2.14.2 Perceptual-motor dysfunction and effects on cognitive development**

Perceptual processes are those involved in the detection and interpretation of sensory stimuli while motor processes are those involved in movement. The combination of the two, perceptual-motor processes, are those that coordinate perceptual and motor skills (Cole & Chan, 1990). It is thought that children who have DCD have dysfunction of perceptual-motor abilities resulting in neurological deficits and by remediating these deficits DCD and the comorbid components of the condition can be reduced or eliminated.

The development of movement and consequently of the sensory and perceptual-motor abilities of infants may be compromised for a variety of reasons. A child that experiences physiological damage to the parts of the brain that control movement, such as the brainstem or cerebral cortex, is unlikely to develop voluntary movement abilities, a stage beyond reflexive movement. This is most likely to occur in infants presenting with cerebral

palsy or neurological lesions (Barnhart, Davenport, Epps, & Nordquist, 2003; Maldonado-Duran et al., 2003; McPhillips et al., 2000).

Infants with maternal participation in drugs and alcohol, who are premature or a low birth weight may have a delay in the development of normal movement stages or motor milestones leading to a marked impairment of motor coordination. The development of perceptual-motor skills may also be affected by deficits in the cerebellum, the area of the brain thought to be vital in perceptual-motor functioning (Fawcett & Nicolson, 1995; Leiner, Leiner, & Dow, 1993). This thinking is not unlike that of McPhillips (2000) and Morrison (1985) who suggest that deficits in the movement related areas of the brain caused by retained primary reflexes affect perceptual-motor skills such as balance coordination and, in later years, associated activities such as reading and writing.

The proposed link between perceptual-motor development and cognitive development is not new, however attempts to apply this theory in an educational context have led to great controversy. Thirty years ago Gubbay (1975) described children with motor deficits as differing from their developmentally normal peers by having, amongst other issues, poor handwriting and poor academic performance. Recent research has indicated that brain sites that are involved in both thought and perceptual-motor processes are not as distinct as once thought (Rosenbaum, Carlson, & Gilmore, 2001) and Shumway-Cook and Woollacott (1995) profess that "since movement is not usually performed in the absence of intent, cognitive processes are essential to motor control" (p. 4). The assumption of a link between movement, perception and cognition has formed the basis of many process based movement intervention programs since the early 1900's. Orton (cited in Hulme & Lord, 1986) and Piaget (1952) were early theorists who established that there was a significant relationship between movement and cognition with Orton linking his early work to the study of Dyslexia in recent years.

This link has been further exemplified through the research on Developmental Coordination Disorder which has been associated with Attention Deficit Hyperactivity Disorder and Learning Disabilities (Dewey & Wilson, 2001). The results of research on this relationship between movement and cognition have indicated that it is indeed impossible to disassociate the role of movement in cognition. It is therefore reasonable to



assume, as have the theorists whose interventions follow, that if a child is demonstrating learning difficulties, remediation of underlying deficits in perceptual-motor processing will lead to cognitive gain.

The following section focuses on the theory behind perceptual-motor programs and provides examples of some of the most popular programs as well as evaluating the efficacy of perceptual-motor remediation for children with cognitive deficits.

## **2.15 Perceptual-motor based interventions**

The premise on which perceptual-motor interventions are based is that remediation of underlying deficits in sensory integration and ultimately perceptual-motor responses are negatively influencing the processes required for cognition. The foundations of these programs are firmly based on maturational theory. In order to remediate these perceptual deficits, students undergo training in sensory activities such as rocking, rolling and swinging as part of the program in order to retrain these processes and remediate the underlying deficit. This is the theory on which these programs are designed.

### **2.15.1 The theory underpinning perceptual-motor interventions**

In the 1960s, theorists such as Barsch, Ayres, Kephart, Cratty and Delacato (cited in Densem, A, Bushnell, & Horn, 1989) were instrumental in designing programs for students with learning difficulties based on sensory motor and perceptual-motor interventions. These programs were designed to remediate, or 'correct' perceptual and motor deficits that were believed to underlie and cause learning deficits. Programs were based on the following common assumptions: perception depends upon perceptual ability; academic performance is dependent on perceptual ability; and therefore, perceptual-motor performance can improve academic performance (Sherrill, 1993). These theorists carried out numerous studies using children with Learning Disabilities to determine the neurological and cognitive outcomes of participation in these intervention programs. Those who researched the effectiveness of these interventions were interested to determine whether participation in sensory activities aimed at stimulating primarily the vestibular and visual senses would lead to an improvement in skills such as reading.

Perceptual-motor programs based on the work of Ayres (1972) were one type of intervention program that was very popular during the 70s and 80s. Perceptual-motor is often referred to in the literature as 'Sensory Integration Therapy' or as 'Sensorimotor Integration' as it involves the stimulation of various senses seen as vital to a child's learning and denotes the CNS processing that occurs in both directions between sensory input and motor output (Sherrill, 1993). Ayres (1966) defined 'sensory integration' as the organization of sensory input for use in understanding the world. Kinesiologists also define sensory integration in the same terms (Williams, 1983). Sensory input important to motor learning are the vestibular, kinesthetic, visual and tactile systems where vestibular refers to the sense of balance, kinesthetic to the sense of position and movement of body parts and tactile to the sense of touch (Blackmore & Corrie, 1996; Sherrill, 1993). When these systems display abnormal functioning or delayed development, motor development and/or learning is affected (Sherrill, 1993). Ayres' approach involved activities such as balance beam walking, which provided the child with opportunities to integrate different sources of sensory information. To gain an understanding of the theory behind perceptual-motor programs, it is important to review the tactile, kinesthetic, vestibular and visual systems that the programs were presumed to influence.

The tactile system includes many skin receptors that provide sensory input for touch, pain, heat and cold. All individuals vary in their need for tactile stimulation: while some seem impulse driven to touch everything (tactile craving), there are those at the opposite end of the spectrum that are tactile defensive who dislike and avoid touch. Tactile defensiveness is commonly associated with "Learning Disabilities, Autistic-like behaviours, Mental Retardation and severe emotional disturbances" (Sherrill, 1993 p. 233).

The kinesthetic system works closely with the vestibular system to provide information about the position and movement of the body in space. There are many sensory receptors in the muscles and joints of the body that provide information to the CNS when the tension within the fibres changes. The kinaesthetic system is responsible for the ATNR and the Symmetrical Tonic Neck Reflex (STNR), in which head flexion causes the legs to extend and head extension causes the legs to flex, as well as other reflexes. According to Sherrill

(1993), as the kinesthetic system matures these reflexes are integrated leading to the coordination of movement.

Static and dynamic balance is maintained through information supplied to the brain by the vestibular system that originates in the inner ear of the temporal lobe. The vestibular system prevents falling, keeps the body parts properly aligned and contributes to coordinated movement. According to Sherrill (1993), the four sensory systems (kinaesthetic, vestibular, tactile and visual) combine to enable balance that requires both sensory and motor output.

The visual system is comprised of both reflex and voluntary subsystems that are important in postural control and motor performance. According to Sherrill (1993) there are two types of vision, orthoptic and refractive. Orthoptic vision refers to the six external muscles controlling the eyeball responsible for moving the eyeballs up, down, in, out and diagonally. Binocular coordination in which the two eyes work together is particularly important for balance and postural reactions. Eye muscle coordination problems are common among persons with disabilities including strabismus (squint or crossed eyes), which is commonly associated with Cerebral Palsy, Down Syndrome and Foetal Alcohol Syndrome (Sherrill, 1993). Refractive vision refers to visual acuity and problems may include myopia (nearsightedness) and hyperopia (farsightedness) as well as astigmatism (blurring and distortion) which are normally treated by glasses or surgery (Shumway-Cook & Woollacott, 1995).

The theory underpinning perceptual-motor programs is that most children with Learning Disabilities display a perceptual-motor dysfunction of neurological origin (Vellutino, Steger, Moyer, Harding, & Niles, 1977) and the emphasis is on remediating deficient perceptual-motor skills in order to facilitate higher order learning. The methods and techniques are strongly developmentally based and great emphasis is placed on early motor learning and visual-spatial development of the child. This reinforces the viewpoint underpinning Piagetian theory which claims that a child's intellectual development is influenced and determined by interactions with the environment (Yongue, 1998). The importance of motor learning in providing the foundations for higher order learning is

outlined by Piaget (1952) who observed that overt motor learning precedes the inner language method of problem solving, a trait that continues through adult life.

According to Myers and Hammill (1976) the motor system is the first neurological system to develop and begins when the human organism is still in an embryonic state. The perceptual system follows the motor system with the association system being the last neurological system to develop. Perception which allows us to make sense of the world is derived from early experiences with the environment. All of our early exploration of the environment is through movement. If developmental movement is dysfunctional then perceptual processes which are related to higher order thinking and cognition may be compromised (Leiner, Leiner and Dow, 1993). For this reason, it was surmised that motor programs that remediated these perceptual deficits would also improve cognitive performance.

### **2.15.2 An historical overview of perceptual and sensory deficit based interventions**

Temple Fay, a neurosurgeon (cited in Hopkins & Smith, 1978 p. 125) adopted one of the first sensorimotor neurodevelopmental approaches in the early 1940's called Neuromuscular Reflex Therapy. The application of Fay's work lies predominantly in the area of physical rehabilitation and occupational therapy and much of his work was completed prior to the present knowledge of the central nervous system. His basic premise was that the infant brain evolves through a series of developmental stages similar to a fish, a reptile, a mammal and finally a human. That is, as each individual organism matures, it passes through the same general phylogenetic stages as its ancestral species did in the course of evolution. Thus, human babies are at first able to make only gross bodily movements; later they crawl, then walk, and eventually perform highly skilled movements with their hands and mouths. Central to this theory is the view that the attainment of each stage is presumed to be dependent on the previous. Fay's description of the developing infant brain paralleling the evolution of the human species from its earliest origins is encapsulated as "ontology recapitulates phylogeny" (cited in Hopkins & Smith, 1978 p. 125) and this developmental approach formed the theoretical basis of a number of motor interventions, one of which remains popular today, in spite of very limited empirical support.

Delacato and Doman (cited in Doman, Spitz, Zucman, Delacato, & Doman, 1960) drew heavily on these ontological parallels with Fay's work developing the same patterns of movement into what is known as the Delacato and Doman program. As directors of the Institute for the Achievement of Human Potential, Delacato and Doman (cited in Doman et al., 1960) worked with children with brain injuries using a program based on a theoretical principle referred to as 'Neurological Organisation'.

Delacato (1963) suggested that brain development followed a consistent pattern and that neurological functions develop vertically from spinal cord to cortex with increasing levels of myelination. Myelin is a fatty cell which wraps itself around the axon or 'transmission fibre' that connects one nerve cell to another. It is the fatty myelin sheath which prevents information leakage as data is transmitted from one neuron to the next, however the process of myelination or 'insulation' takes time to develop and Delacato maintained that it is only at the age of eight years that a child is said to have reached a state of Neurological Organisation. Accordingly, Delacato claimed that if damage to the brain occurs or if environmental factors restrict a child's development, then evidence of neurological dysfunction will be observed including disorganisation in language or motor ability. According to the theory of Neurological Organisation, if there is damage to cells in the brain, those cells that remain intact can take over the functions of the ones that have been destroyed through a process called "patterning" (Myers & Hammill, 1976). Patterning involves manipulating the limbs of brain-injured children to produce movements that would normally be the responsibility of the damaged area. Delacato (1957) defines this method as "treating a central problem where it exists, in the central nervous system, not in the peripheral areas" (p. 8). It is believed that by frequently repeating the patterning, the brain will receive sensory messages.

Robbins (1966) (cited in Steadward, Watkinson, & Wheeler, 2003) carried out a study using the methodology similar to that adopted in this study, in which three second grade classes were assigned to the Delacato treatment, a no treatment control group, or activities opposed to Delacato treatment. Over a three-month period, the Delacato group received thirty minutes instruction in creeping, walking and a specified writing position. The negative group received 30 minutes of dancing and games and 'reverse' patterning. Both

groups received written instructions to be followed at home regarding sleep posturing, music and emphasizing sidedness. The outcomes showed no relationship between creeping and reading or type of treatment and reading and offer little support for the notion that the Delacato program is a general treatment for reading improvement. This view was shared by Freeman (1967) (cited in Steadward, Watkinson, & Wheeler, 2003) who, along with other concerns regarding the program, outlined statistical defects in reported studies and criticised the policy that makes parents therapists. Cohen, Birch and Taft (1970) concluded from an analyses of both the theories on which the method is based, and the applications of the method, that there is insufficient evidence from data to support the system of treatment and that the changes obtained in individuals may in fact be a result of normal growth and maturation. A further study by O'Donnell (cited in Balow, 1971, p. 522) focused on participants with reading difficulties. Results showed that the Delacato programme had no significant effect on oral reading, reading comprehension, vocabulary or phonics skills. There were also no significant differences on tests of visual motor integration or lateral dominance.

The American Academy of Pediatrics (AAP) had issued warnings regarding the use of patterning as early as 1968. These warnings were updated and repeated in 1982 with the latest cautionary policy statement being in 1999 (Ruppert & Sander, 1999):

This statement reviews patterning as a treatment for children with neurological impairments. This treatment is based on an outmoded and oversimplified theory of brain development. Current information does not support the claims of proponents that this treatment is efficacious and its use continues to be unwarranted (p. 1151).

In conclusion, on the potential of the Doman-Delacato program, Scherzer and Tscharnuter (1990) stated that "positive results are considered by many to be questionable; harmful effects likely to be common and extensive" (p.73). There is no recent research on the methods of Delacato and Doman indicating declining popularity of the technique, however, there are numerous case histories and testimonials of a non-scientific nature which support the idea of "patterning" (Berg, 2005; Mills, 2000) that are implemented from time to time in educative and therapeutic settings.

Another treatment approach also gaining popularity during the 1940's was a Neurodevelopmental Treatment (NDT) approach developed by Karel Bobath, a neuropsychiatrist, and Berta Bobath, a physical therapist (B Bobath, 1963). According to Hopkins & Smith (1978), the concept of neurodevelopmental treatment is based on two fundamental principles regarding the nature of the central nervous system dysfunction. First, that retardation of normal movement is caused by interference of normal brain maturation due to a lesion and second, this results in abnormal patterns of posture and movement due to abnormal or immature postural reflex activity. The treatment was primarily initiated to assist children with cerebral palsy and according to the Bobath's (Scrutton, 1984) the motor problems associated with cerebral palsy arise from Central Nervous System (CNS) dysfunction interfering with the development of normal postural control against gravity. Their approach focused on the "sensorimotor components of muscle tone, abnormal reflexes, abnormal movement patterns, postural control, sensation, perception and memory (components likely to be impaired through CNS damage)" (Butler & Darrah, 2001, p. 2) with the normal developmental sequence advocated as a framework for treatment. The therapy consisted of direct handling techniques, parental education, home or classroom programming and a positional programme for functional activities (Royeen & DeGangi, 1992). The physical handling is aimed at developing the movement components underlying functional motor skills such as "neuromotor maturation", balance, mobility and postural alignment and stability (p. 175).

It is difficult to determine the effectiveness of this type of motor therapy approach due to the fact that these are not specific treatments delivered in a standardised manner. The techniques depend on the skill of the therapist and the specific aims set for each child and children often progress in domains that are not measured by the dependent variables. According to Royeen and De Gangi (1992) many of the intervention studies based on the efficacy of NDT have been based on subjective clinical observations with only "48 percent yielding statistical evidence of effectiveness" (p. 193) and statistical significance is often not evident due mostly to small sample sizes.

A meta-analysis by Butler and Darrah (2001) of studies based on Neuro Developmental Treatment (NDT) determined that there as little evidence supporting the value of NDT

other than a change in range of motion. The authors concluded that there was not consistent evidence that NDT changed abnormal motoric responses, slowed or prevented contractures, or that it facilitated more normal motor development or functional motor activities. More intensive therapy did not seem to confer a greater benefit:

There was also no clear evidence that NDT produced any other potential benefits such as enhancement of social emotional, language or cognitive domains of development, better home environments, improved parent-child interactions, or greater parent satisfaction (Butler & Darrah, 2001 p. 789).

It is evident that further studies addressing the efficacy of NDT are necessary. Royeen and DeGangi (1992) advocated that studies need to investigate the efficacy of specific sensorimotor interventions to determine whether one treatment approach is of more benefit for specific clinical populations. Olney (1990) stipulated that the first step in this research is to investigate the following features: What is the treatment? When should it be initiated and ended? What frequency and duration of therapy provides the most positive effects? Who should be the therapy providers? In what setting should the therapy be provided? (Roussounis, Gaussen, & Stratton, 1987; Royeen & De Gangi, 1992). It is important to provide answers to these questions through empirically based research if NDT is to be recognized as an effective intervention for children with perceptual-motor difficulties.

### **2.15.3 Analysis of popular sensory motor and perceptual-motor interventions**

The programs advocated by Fay, Delcato, and Bobath are all examples of early process based (though not necessarily well known) approaches aimed at remediating underlying perceptual-motor deficits. The following programs are examples of some of the most popular and familiar process intervention strategies for children with Learning Disabilities. The premise is that by addressing the underlying deficits or processes, learning disabilities will be remediated. According to Cole and Chan (1990) perceptual-motor programs are an approach to special education that attempts to diagnose the underlying problems perceived as related to processing and then to provide an intervention to remediate those processes.



One of the most identifiable motor intervention programs is that developed by Ayres (1966) known as Sensory Integration (SI). Hoehn and Baumeister (1994) describe (SI) therapy as:

A controversial, though popular treatment for the remediation of motor and academic problems. It has been applied primarily to children with learning disabilities, under the assumption that such children (or at least a sub group of them) have problems in sensory integration to which some or all of their learning problems can be ascribed (p. 338).

Although Ayres' work is the most well known, there are many other theorists who have contributed to the development of perceptual-motor based programs including Frostig (1967), and Kephart (1971). According to Myers and Hammill (1976) the "basic sensory-perceptual – motor orientation and the suggested remedial activities are very much the same" (p. 314). Some examples of research on early movement programs based on the development of appropriate neurodevelopmental processes follow.

### ***Marianne Frostig's Visual Perception Program***

Marianne Frostig developed a theory of visual perception based on a neurodevelopmental approach primarily to assist students with Learning Disabilities in academic pursuits. Frostig's major area of interest was visual perception and in 1947 she founded the Marianne Frostig Centre of Educational Development in Los Angeles, California. Frostig recognized that perceptual adequacy is vital for academic success and therefore her main area of interest focused on developing these perceptual skills rather than instruction specifically in reading and writing. Even in teaching academic subjects, there is an emphasis on their perceptual aspects. Although Frostig does not disregard the knowledge of subject matter, she does not believe that just knowledge is sufficient to formulate optimal educational programs for children with Learning Disabilities and learning styles, preferred sensory channels and areas of perceptual or cognitive strengths and weaknesses, must be determined for each child for effective learning (Frostig, 1961). Research assessing the efficacy of instruction based on this concept of sensory preference has provided little support for this idea (Vellutino, Steger, Moyer, Harding, & Niles, 1977).

Although there has not been any specific causative factor for inadequate perceptual development, Frostig and Horne (1964) have identified that a disability in visual perception may result from delayed maturation, cerebral injury or genetic and environmental factors. According to Myers and Hammill (1976), the Frostig and Horne (1964) materials provided a well structured developmental program which can be used for remediation or developmental learning in specific areas of perceptual weakness.

The Frostig technique (Frostig & Horne, 1964) was investigated by Olsen in 1966 (cited in Balow, 1971) in which 120 students were tested for reading skill and then administered the Frostig Test of Visual Perception (Frostig & Horne, 1964). According to Balow (1971), correlations between the achievement measures and the Frostig tests were "low and non-specific to reading" (p. 520). These results are similar to those found by Olsen (1966) and raise serious questions about the validity of the Frostig tests in relation to reading.

Vellutino, Steger, Moyer, Harding, and Niles (1977) also raised questions regarding the use of diagnostic tests which are designed to isolate inferred disorders in sensory-cognitive processes and then provide direction for remediation. Vellutino et al (1977) states that these type of instruments including the Frostig Developmental Test of Visual Perception (Frostig, 1961) have weak theoretical foundations and do not have "sufficient factorial validity to be employed as diagnostic measures" (p. 380). While the Frostig materials may in fact lead to improved perceptual skills, there is no evidence that this translates to improved reading skills.

### ***Kephart: Perceptual-motor program***

Kephart's theory of perceptual-motor development and remediation represents a true process oriented teaching approach in that, according to this theory, children with Learning Disabilities should be treated in terms of remediating impairments of the basic skills and generalisations on which the act of reading and therefore cognitive pursuits depend. Kephart believed that perception and cognition develop from a motor base and a child must establish motor generalizations to reach full intellectual growth. In this treatment, there is emphasis on three main areas of perceptual-motor ability; sensorimotor learning; ocular

control and form perception. Administration of the Perceptual-Motor Rating Scale (Kephart, 1971) indicates the stages of learning that are inadequate and need to be treated. Sensorimotor deficiencies are addressed through activities involving walking on beams, balance boards, trampolines, dot-to-dot drawing and bilateral and unilateral exercises including rhythmical activities. Ocular control or control of the eyes is developed through monocular training and rotary pursuit such as tracking a pencil or a torchlight and form perception through blackboard activities, puzzles and pegboards (Myers & Hammill, 1976).

Kephart places a strong emphasis on the sensorimotor basis of all learning at all ages which he considers consists of generalizations rather than specific skills, for example, reading writing and mathematics involve many perceptual and motor skills. Even a basic skill such as drawing a square requires many basic perceptual-motor skills including manual dexterity, gross motor abilities, ocular control, eye hand coordination and laterality to name a few. Rather than basing remediation simply on the drawing of a square, Kephart believes the skill needs to be taught as a process. Further, it is believed that no training technique should be considered a goal in itself, rather a means by which a child can be taught generalized skills and abilities (Myers & Hammill, 1976). According to Myers and Hammill (1976) "teachers of various groups of children- mentally retarded, learning disordered and developmentally delayed- have reported positive results from the use of materials and activities recommended by Kephart" (p. 325).

### ***Ayres and sensory integration***

The theories and programs of both Kephart (1971) and Ayres (Ayres, 1966, 1972a, 1974, 1978, 1979) are quite similar in their emphasis on remediation of perceived underlying deficits in sensorimotor skills and abilities construed as contributing to the learning disability. Both approaches are classified as being perceptual-motor/sensorimotor specific. Cruikshank (1972) was a strong supporter of the view expressed by both Kephart and Ayres that children with disabilities manifest perceptual-motor dysfunction of neurological origin.

Ayres conceived and advanced the theory of Sensory Integration (SI) during the late 1960's and early 70's. According to Hoehn and Baumeister (1994), SI is a popular although controversial treatment for remediation of motor and academic problems as it is seen as "requisite for all perceptual-motor activity" (p. 338). SI therapy was originally intended as a treatment for children with Cerebral Palsy however, its scope of application has been extended to many different populations. The main area of application has been children with Learning Disabilities of which Ayres hypothesized that at least a subgroup have problems in sensory integration (Ayres, 1972).

Ayres (1979) recognizes hierarchical levels of brain function leading to sequential stages in neurological development and stresses the importance of the sub cortical levels of the brain, particularly the brain stem due to the fact that it can be categorized as 'early developing' both "phylogenetically and ontogenetically" (Hoehn & Baumeister, 1994 p. 338). Ayres' theory is underpinned by the belief that sensory processing takes place primarily in these sub cortical levels of the brain and not only motor acts but also cognitive abilities requiring higher order levels of the brain such as reading and writing are considered to be dependent on sensory integration.

The five main senses are touch (tactile), sound (auditory), sight (visual), taste (gustatory) and smell (olfactory). In addition, there are two other senses: vestibular, a movement and balance sense which provides information about where the head and body are in space, and proprioception, which is a joint/muscle sense that provides information about where body parts are and what they are doing (Bundy, Lane, & Murray, 2002). The integration of these systems, in particular the tactile, proprioceptive and vestibular systems, are considered of primary importance because these systems mature the earliest and due to their contribution to "generalized neurological integration and to enhanced perception in other areas" (Hopkins & Smith, 1978 p. 137). These systems contribute to the development of perceptual-motor ability including "body scheme, motor planning, motor and academic skill development and psychosocial development" (p. 136).

According to Ayres (1979) Sensory Integration is defined as the organization of sensory input for use.

The 'use' may be a perception of the body, or the world or an adaptive response, or a learning process, or the development of some neural function (p. 184).

Ayres observed that the cognitive approach to the treatment of children with learning disabilities had led to dissatisfaction of skill training as an entity as it did not lead to the development of the ability to generalize or to respond adaptively to the environment (Hopkins & Smith, 1978).

Learning Disabilities in this view, are suggested to be superficial symptoms that are attributable to an underlying neurological deficit, which is discoverable through diagnostic evaluation – a 'process' approach as opposed to 'content' approach to remediation (Hoehn & Baumeister, 1994). While motor programs or academic skills instruction programs are designed to precisely and directly influence specific motor and academic skills such as throwing a ball or subtracting figures for mastery, the experience is not expected to be generalized beyond those skills. In contrast:

Sensory Integration therapy is thought of as acting to remedy (or ameliorate the effect of) certain general sensorimotor disorders responsible for individual motor or academic difficulties, and to lay a sensory processing foundation for the successful development of such skills (Hoehn & Baumeister, 1994, p. 339).

Ayres (1972) suggests that this foundation is not sufficient in itself and that traditional teaching methods need to be maintained in conjunction with Sensory Integration therapy.

Ayres published eight papers between 1965 and 1987 (Cummins, 1991). These papers contain ten multivariate analyses concerned with the relationships between sensory and motor skills and in some studies, the relationship between sensory and academic skills. From these studies, some of which involved children with academic difficulties and others that did not, Ayres isolated five main factors that were understood to relate to, or were correlated with, patterns of neurological dysfunction. It is believed that these perceptual-motor factors emerge from the scores of children with Learning Disabilities but not from

the scores of children who learn normally. The five factors identified by Ayres as being the most common in children with learning disabilities are:

- Disorder in postural, ocular and bilateral integration;
- Apraxia (difficulty planning and executing motor acts);
- Disorder in form and space perception;
- Auditory language problems; and,
- Tactile defensiveness (Cummins, 1991 p. 160).

According to Cummins (1991) the presence of these factors has been “used to provide both the format and the rationale for diagnostic and remedial programs (p. 160). The problem with this approach is the diversity among the reviewers of Ayres’ studies with regard to the precise nature and nomenclature of these factors. This has led to factor labels being seen as “arbitrary devices that do not necessarily reflect true factor content” (Cummins, 1991, p. 167). Cummins (1991) concludes that there was in fact no core group of variables that could be accurately and consistently identified as discriminating between learning disabled and normal learning children. This is a view shared by Vellutino et al (1977) who state that the “sub-tests in these test batteries are so highly intercorrelated that it is almost impossible to uncover deficiencies in the variety of functions that they are intended to measure” (p. 380).

The culmination of the research based on the efficacy of Ayres’ sensory integration based programs in terms of diagnosing and providing adequate intervention for specific motor deficits has led to the conclusion that these multivariate studies provided no validity for either the diagnostic procedures or remedial programs advocated by Ayres for children with Learning Disabilities (Cummins, 1991; Vellutino, Steger, Moyer, Harding, & Niles, 1977).

#### **2.15.4 Efficacy of perceptual-motor and sensorimotor approaches in academic remediation**

There are a significant number of motor programs that are intended as potential panaceas for treatment of Learning Disabilities, albeit the efficacy of many of these programs remains controversial and unproven. Hatcher (2003) provides evidence that supports conventional phonological awareness training and letter knowledge as a preferred intervention for these children. Research on the efficacy of both the traditional approach to reading remediation that is the phonological, code emphasis approach, and the neurological deficit remediation approaches will be discussed in this section.

According to Fawcett and Nicolson (1995), reading difficulties associated with Dyslexia are not only characterized by problems with phonological performance but also by problems with balance and other motor skills indicating deficits in cerebral functioning. As the cerebellum is involved in not only motor but cognitive tasks as well, interventions solely based on a cognitive model such as a purely code emphasis approach may be insufficient for some children requiring a neurologically based intervention (Schmahmann & Sherman, 1998).

The use of perceptual-motor programs to remediate literacy associated deficits is based on the belief that perceptual-motor experiences underpin early learning and that children who have underdeveloped perceptual-motor processing will have difficulties with academic skills (Stephenson, Carter, & Wheldall, 2007). Perceptual-Motor Programs (PMP) are designed to train these underlying processes in order to facilitate academic learning and include programs such as *Brain Gym* (2006) and *Smart Starters* ("Smart Start with PMP", 2002) which are both popular in Australian schools.

The validity and type of methodology utilized in research authenticating the efficacy of the perceptual-motor and sensorimotor programs has often been questioned, with numerous reports that results were not positive in terms of the effects of the intervention (Carte, Morrison, Sublett, Uemura, & Satrakian, 1984; Cummins, 1991; Kaplan, Polatajko, Wilson, & Faris, 1993; Kavale & Mattson, 1983). A meta-analysis of 180 intervention programs carried out by Kavale and Mattson (1983), reported that almost half the treatment

effects for these perceptual-motor and sensory motor based intervention programs were negative including the effects of the interventions on academic achievement, particularly reading. They noted that the evidence for the efficacy of perceptual-motor programs depended mainly on narratives and case studies. When reviewing the abilities related to reading Hammill (2004) found that the correlation between motor skills and reading abilities was weak (0.17) and that training in perceptual-motor programs would have no benefit for reading. Hyatt (2007) reviewed four published studies on the effects of *Brain Gym* and concluded that none of the studies were sound and that there was no evidence of any positive effects from the program. The results of the research on the effectiveness of these interventions was so disappointing that Brown, Brown, Burke, Cronin, & Evers, (1986) as part of the Board of Trustees of the Council for Learning Disabilities in the United States, instructed schools to view participation and resource allocation to these programs as wasteful. Further, the Board perceived these programs to be an obstruction to the provision of appropriate services stating:

There is little or no empirical support for claims that the training of perceptual and perceptual-motor functions improves either the academic performance or the perceptual or perceptual-motor functions of the learning-disabled individual. Therefore, such training must be characterized at best as experimental and non-validated (Brown, Burke, Cronin, & Evers, 1986 p. 350).

More recent research by Kaplan, Polatajko, Wilson and Faris (1993) concluded that perceptual-motor programs made no significant difference to gross and fine motor skills, reading and mathematics and that for children presenting with Learning Disabilities, traditional methods were just as, and in some cases, more effective.

A critical analysis by Nolan (2004) questioned the conclusions made by Kavale and Mattson (1983) which were based on a meta-analysis of 180 studies which focused on the efficacy of perceptual-motor programs. Kavale and Matson (1983) stated in conclusion that perceptual-motor training was not an effective intervention for children with disabilities. Nolan (2004) disagreed with the conclusions of this meta-analysis on the basis of the method by which the studies in the meta-analysis were chosen thus questioning the validity



of the meta-analysis. According to Nolan's (2004) critical analysis, methodological flaws including study selection, completeness of data and analysis value in Kavale and Mattson's (1983) meta analysis "form a mosaic of uncertainty about the outcome" (Nolan, 2004, p. 71) and there is a distinct need for a newer meta-analysis to be completed based on current research.

One of the main points that Nolan (2004) makes is that one should not dismiss the possible value of perceptual-motor programs based solely on the meta-analysis of Kavale and Matson (1983). Nolan states in conclusion: 'One thing is certain; the debate on the efficacy of perceptual-motor training will and should continue' (p.72). One of the reasons for Nolan's considerations may be that there is a great deal of research that indicates a motor link to learning problems. Jongmans, Smits-Engelsman and Schoemaker (2003) indicate that children with extensive perceptual-motor problems are also likely to have minor neurological signs and cognitive issues. Kaplan, Wilson, Dewey and Crawford (1998) found high levels of comorbidity between Developmental Coordination Disorder (DCD) and reading disorders and Barnett, Kooistra, and Henderson (1998) established that children that present with specific problems such as Dyslexia or hyperactivity often have additional problems with motor coordination.

The great debate centres on two question; whether defective motor processing causes or contributes to academic learning problems and whether perceptual-motor training has a remedial effect on these issues. Although the academic efficacy of motor programs has been challenged in the past, the most damaging effect on the role of perceptual-motor programs was achieved by the Kavale and Mattson (1983) meta-analysis (Nolan, 2004). The conclusion of the meta-analysis ascertained that perceptual-motor training had no significant positive effect on a child's cognitive or motor skills. Subsequent more recent research has shown that when sensory input and integration processing deficits are minimised through motor intervention there is an improvement in motor performance and in some cases, academic performance increases. During longitudinal research, Jung (cited in Nolan, 2004, p.65 ) found that individuals with Dyslexia and individuals with autism showed positive changes in behaviour after intense sensorimotor training. Similarly, Portwood (2000) found significant positive results for handwriting, self-esteem, motor skills and behaviour. The question remains whether the theoretical analysis of the causal

factors for learning disabilities, viewed from a process (neurodevelopmental) perspective, generate effective interventions to improve the educational outcomes of students.

Based on current empirical research, there is limited evidence that a process based approach is a successful intervention for children with reading difficulties caused by neurological deficits as suggested by, for example, Kephart and Ayres. Consensus on research into reading instruction methods favours a code-emphasis, product oriented approach in which the ability to detect, rhyme, segment and blend sounds is considered to be the foundation for developing reading skills and has provided the basis for intervention programs for children with Learning Disabilities (Carnine, Silbert, & Kameenui, 1997; Snow, Burns, & Griffin, 1998). This view was reinforced through a meta-analysis of 52 experiments that compared groups of children being instructed using phonics to control groups who received alternative instruction. The analysis performed by The National Reading Panel (2000) and convened by the National Institute of Child Health and Human Development (USA) was subsequently replicated by similar investigations into best practice in Australia (Rowe, 2005) and the United Kingdom (Rose, 2006). All reports gave strong support to the teaching of phonological awareness and letter sound correspondences with *The National Inquiry into the Teaching of Literacy* concluding that in Australia, “systematic, direct and explicit phonics instruction” in conjunction with an integrated teaching approach is recommended to prevent reading difficulties (Rowe, 2005). However, according to Nolan (2004), research into the efficacy of process based neurological approaches in treating cognitive deficits should well and truly be continued and these approaches should not necessarily be dismissed solely on the basis of the poor research methodology that has frequented its past.

## **2.16 Contemporary process based interventions**

Innovations in technology during the 1990s have allowed for a more detailed analysis of what actually occurs in the brain during the performance of movement, language and cognitive skills. This has become possible using functional Magnetic Resonance Imaging (fMRI). This development has generated great interest about the cerebellum and the links between this, the movement centre of the brain, and other structures involved with cognition and language, in particular the cerebral cortex.

In recent times a great deal of interest has been shown in the cerebellum and the role that it plays not just in movement but in cognition as well. The human cerebellum has long been regarded as purely a motor mechanism however, there is a growing body of data focusing on the non-motor functions of the cerebellum. Thach (1996) highlights the important role of the cerebellum in perceptual-motor actions by stating that the cerebellum receives sensory input from muscles, skin and joint receptors and from vestibular, acoustic and visual organs. Due to the cerebellum's two way connections with most parts of the cortex, both cognitive and motor, there is strong support for the belief that the cerebellum is involved in the acquisition of cognitive, language and motor skills (A. L. Leiner, Leiner, & Dow, 1993).

Fawcett and Nicolson (1995) and Fawcett, Nicolson and Dean (1996) established through research, in the area of reading difficulties and Dyslexia, that those children with postural stability issues and muscle tone weakness displayed deficits in these areas comparable in magnitude to their reading and writing and language deficits. According to Nicolson et al., (1999), developmental Dyslexia is characterized by deficits in "phonological processing, motor skills, automatic balance and information processing speed" (p. 1662). Support for the theory that the cerebellum, an area thought to be solely involved in movement, is involved in language as well as cognition comes from Fawcett, Nicolson and Dean (1996) who, from their research, concluded that "it is now thought that the cerebellum is involved in the acquisition of 'language dexterity' in addition to its established role in motor skill acquisition and execution" (p. 259). It was once thought that the cerebellum could not have been a causal factor in Dyslexia due to its supposed lack of involvement in language. Nicolson et al., (1999) state that recent research has indicated a link between the cerebellum and prefrontal areas of the brain including Broca's language area and fMRI scans have revealed cerebellar involvement in language related activities as well as motor activities. Based on this evidence, Nicolson et al. (1999) postulate that cerebellar impairment may account for a range of the major difficulties faced by children with Dyslexia including phonological skill deficits, processing skill deficits and issues with motor skills (Fawcett & Nicolson, 1996, p.280). Recent behavioural and neuroimaging tests have shown that Dyslexia is associated with cerebellar impairment in 80 percent of cases (Nicolson, Fawcett, & Dean, 2001).

The Cerebellar Deficit Theory (Nicolson & Fawcett, 1990) introduced the concept of 'automaticity': the ability to perform a task automatically without conscious monitoring a process which depends ultimately on the cerebellum. "Automaticity is the final stage in learning any skill where performance becomes expert and less demanding in terms of resources"(Fawcett & Nicolson, 1995 p.236 ). If skills are not automatic, the brain struggles to maintain control over balance, posture and involuntary movements (Portwood, 2003).

Issues of automatization were first shown by Nicolson and Fawcett (1990) when using a dual task technique such as counting while balancing, it was revealed that performance deteriorated in children with Dyslexia. A further study in 1992 resulted in the conclusion that children with Dyslexia have problems with both motor and cognitive skills but mask this incomplete automatization with "conscious compensation" so that their performance appears normal but requires greater effort (Fawcett & Nicolson, 1992 p.159 ). There are problems associated with skills that require fast performance or with activities that require a fluent interplay of a range of skills. These deficits may lead to reading difficulties and general learning problems (Ramus, Pidgeon, & Frith, 2003).

O'Hare and Khalid ("Smart Start with PMP", 2002) found that children with developmental coordination disorder (DCD) are at high risk of reading and writing delay. It is reported that many of these children demonstrate "features of poor cerebellar function, reflected in problems with posture, balance and fast accurate control of movement" (p. 234). Recognition of the role of the cerebellum in reading and the implications of the cerebellar deficit theory in reading difficulties has led to the development of a variety of process based interventions emphasising remediation of cerebellar function.

### **2.16.1 Interventions based on the role of the cerebellum**

Studies similar to this and including those by Fawcett, Nicolson, and Dean (Fawcett, Nicolson, & Dean, 2001) has led to the assumption that a malfunction of the cerebellum and the consequent defects in movement coordination and eye tracking is the crucial cause of the disruption of learning. Therefore, a physiological improvement in the structure of

the cerebellum through a movement based program of some description, could serve as a cure. According to Stephenson and Wheldall (2008) it was not only the cerebellum that was of interest but also the vestibular system. Reynolds, Nicolson, and Hambly (2003) analysed the effect of a movement program designed to 'train' the cerebellum to respond normally to information from the vestibular system. This study involved 35 children aged between seven and ten years of age that all scored at a significant level on standard Dyslexia screening tests. Half of the sample completed an individually prescribed exercise program at home over a six-month period, while the other half did not. According to this research, the children that showed significant improvements in reading and verbal fluency were those on the exercise program.

The treatment regime was established as part of the Dyslexia, Dyspraxia and Attention Treatment (DDAT) centre (currently Dore Program) which was initially used in the United Kingdom in the late 1990's and began in Australia in 2002. The founder of the Dore program was a Welsh businessman, Wynford Dore, who while in search of a cure for dyslexia, became interested in the work of Levinson (2004) who linked Dyslexia, ADHD and phobias to malfunctions in the inner ear, the cerebellum or in both. The program was run through 21 centres around Australia and more than 10,000 Australians have been participants in the Dore program since 2002 (Hall, 2007; Stephenson & Wheldall, 2008). The intervention programs at the Dore centres were claimed to benefit those with Dyslexia, ADHD, dyspraxia and Aspergers syndrome (Dore, 2006). Although there is no research stating the exact nature of the exercises in the program, Whiteley and Pope (2003; Whiteley & Pope, 2003) conclude that this particular treatment "exerts direct effects on balance dexterity and eye movement control" (p. 165). The program claims to build new neural pathways to the cerebellum to improve cognitive and motor skills (Hall, 2007). Woods (2003) states that the treatment involves balancing on wobble boards, walking downstairs backwards, and beanbag juggling. The fact that the full details of the program are not given in the research, makes replication of this study impossible. The Dore Group (Australasia) has currently gone into liquidation ("Dore Groups (Australasia)", 2008) making further research on this particular program very difficult.

This particular intervention program has attracted controversy due to the claims made by Reynolds et al (2003) that this program is "effective in improving cognitive skills and

literary performance" (p. 48). In his commentary on behalf of the British Dyslexia Association, Rack (2003) asserted that the research by Reynolds et al. (2003) was not convincing and should never have been published. Hack (2003) writes:

The paper by Reynolds et al provides no evidence that the DDAT program has any specific effect on reading, spelling or language performance for people with Dyslexia, dyspraxia or ADD (p. 139).

Further criticism of the DDAT program was provided by Hatcher (2003) who concluded, when referring to the research by Reynolds et al (2003) that:

There are flaws in the methodology, analyses and interpretation of the results that are so great as to negate the study's internal validity, rendering the results at best uninterpretable with respect to the efficacy of the treatment (p. 147).

Woods (2003) reports that the cost of this treatment is around £ UK1500 while Collins (2005) reports that the treatment ranges up to £1900. Snowling, from York University (cited in Woods, 2003 p. 10), argued that the only obvious result was an increase in confidence in the participants and this amount is a lot of money to spend on increasing confidence. Collins (2005) writes that Dore claims the program is "effectively a workout for the brain that aims to provide the essential physiological fitness for learning to take place" and further claims that the program corrects the cerebellum in 90 percent of those who undergo the program (p. 36).

According to Stephenson and Wheldall (2008) the Dore program is unable to provide a credible claim for a cure or even for improvement. There have only been two published studies and both were funded by the Dore organisation with a "commercial interest in the product" (p.79).

### **2.16.2 The *Primary Movement* program**

McPhillips (2001), whose research focus is on the neurodevelopmental aspects of the brain, is specific about the area of the cerebellum that can be influenced through particular types of movement, namely the vestibulocerebellum which is phylogenetically the oldest part of the cerebellum, and is the first cerebellar structure to differentiate in the human foetus. According to Lundy-Eckman (1998) this specific area of the brain receives input from the vestibular and visual systems and in conjunction with other parts of the cerebellum is responsible for controlling body balance, posture and coordinating head and eye movements. The cerebellum is also responsible for the release and control of primary reflexes in the developing foetus and newborn. The outcomes of recent studies, McPhillips (McPhillips, 2001; McPhillips, Hepper, & Mulhern, 2000; McPhillips & Sheehy, 2004) have established a link between retained primary reflexes and the performance of skills required for successful reading and writing. The association of retained primary reflexes and developmental delay has a long history. Bobath and Bobath (1975) recognized the relationship between retained primary reflexes in causing abnormal motor coordination patterns in children with cerebral palsy as early as 1940. Fay (1954) and Holle (1976) were early developers of movement programs aimed at 'switching off' and integrating primary reflexes into higher order reflex behaviour. Other researchers have noted the effect of retained primary reflexes on developmental motor progress including eye tracking and manipulative skills and general developmental coordination skills (Barnhart et al., 2003; Sugden & Wright, 1998).

McPhillips, Hepper and Mulhern (2000) carried out a randomised, double blind, controlled trial to establish the effects of replicating primary-reflex movements on specific reading difficulties in children aged eight to eleven years of age. They suggested "that the rehearsal and repetition of primary-reflex movements may have a part in the inhibition process itself" (McPhillips et al., 2000, p.538) and that by inhibiting these reflexes controlled by lower brain structures, particularly the Asymmetrical Tonic Neck Reflex (ATNR), higher brain structures responsible for higher level voluntary movement would take over, assisting children with reading skills.

Sixty children attending mainstream primary schools in Northern Ireland were chosen to participate in the study. These children presented with substantial reading difficulties and were "at least 24 months behind on the Neale Analysis of Reading Ability (1999), at least 18 months behind on WORD and also had a persistent ATNR" (McPhillips et al. , 2000, p. 538). Sets of three children were matched on age, verbal I.Q., reading ability and persistent ATNR and the children were randomly assigned in blocks of 20 children to the control group, the experimental group or the placebo-control group. The control group carried out their normal daily life for the duration of the study while the experimental group received a movement sequence based on the Moro Reflex, the Tonic Labyrinthine Reflex, the ATNR and the Symmetrical Tonic Neck Reflex. Children in the placebo control group also received a movement program that was similar in style but not based on the replication of the primary reflexes. The experimental and placebo-control groups were assigned a new movement every two months.

The results of this research after a 12 month period were significant with the children in the experimental group showing a "significant decrease" in the levels of persistent ATNR whereas the changes in the other two groups were "not significant" with the (McPhillips et al. , 2000, p. 539). All groups showed improvement over time in the Neale Analysis of Reading Ability (Neale, 1999) and WORD. However, there was a substantially greater increase in reading scores for the children in the experimental group that led to a significant difference between the groups after the intervention. According to McPhillips et al (2000), the results of this research supports the view advanced by Morrison (1985) that the effects of persistent primary reflexes (particularly the ATNR) extend beyond the obvious disruption of motor development into cognitive areas.

More recently McPhillips and Sheehy (2004), provide an analysis of the prevalence of persistent primary reflexes amongst nine to eleven year olds in the general school population of a total of 11 primary schools in Northern Ireland. Results showed that children who were poor readers were much more likely to have a significantly higher level of retained ATNR and were more likely to have poorer motor skills than their peers in higher reading groups. This study further highlights the high levels of persistent ATNR found in students with reading difficulties and, according to McPhillips and Sheehy (2004) provide further evidence of the association between reading difficulties and motor



difficulties in young children. This is of particular interest as Fawcett and Nicolson (1995) found in their research that children presenting with Dyslexia have also been found to have significant difficulties in motor skills, further highlighting the proposed link between motor and reading.

### **2.16.3 Intervention approaches in Australian schools**

In an Australian context, the most often used motor interventions at a school level are perceptual-motor programs (PMP) (Stephenson, Carter, & Wheldall, 2007) These consist of commercially produced packages that require special equipment facilitating spinning, balance, rocking and rolling (Blackmore & Corrie, 1996). The teacher is required to follow the outline supplied in the program manual and to implement activities in a set sequence. Other adults are required for the successful running of the program and this responsibility normally falls on parents who attend on a roster system. Activities may include balloon batting with a rolled up newspaper, scooter boards on which the child lies and pulls themselves around obstacles and using a "hopper" to negotiate witches hats. According to Blackmore and Corrie (1996) these programs appeal to teachers because they seem "intuitively as though they should help children" and the activities were enjoyable (p. 10).

A report by Rohl, Milton and Brady (2000) analyses the PMP intervention practices for students with difficulty in literacy and numeracy in a sample of 377 schools across Australia. In Australia, 30 percent of schools reported using perceptual-motor programs with only eight percent in NSW and over 30 percent of schools in the other three states reporting such use. These results are similar to a survey by Blackmore and Corrie (1996) in which 29 percent of schools in the Perth metropolitan area indicated that perceptual-motor programs were conducted in their school and a number of teachers wrote comments indicating that, in their opinion, these programs were beneficial for children.

At an Australian level, the journal *Curriculum Leadership* published an article which described a literacy program funded by the Commonwealth Disadvantaged Schools Project that utilized a perceptual-motor program and prescribed activities for specific delays. This program received a national Literacy and Numeracy Award (Stephenson, Carter, &

Wheldall, 2007). This indicates that although there is a lack of evidence for the efficacy of these programs, they are still being implemented in Australian schools.

Given the availability of Professional Learning in perceptual motor programs currently available to teachers in Western Australia and anecdotal reports of equipment purchases by schools, it is reasonable to assume that teachers in Western Australia are continuing to conduct perceptual-motor programs. This indicates that there is a need to ensure that all Australian schools and teachers are well informed of relevant recent research and effective practice in relation to perceptual-motor programs.

It is presumed that teachers and schools continue to use these interventions accepting the claims made about them by commercial ventures at face value as they are either unwilling or as is most likely the case, unable, to research into the efficacy of these programs.

## **2.17 Summary of the conceptual framework and associated literature**

The interrelationship between movement and development was outlined in this chapter. It is impossible to consider one without the influence of the other and the best example of this relationship is demonstrated by the comorbidity between Developmental Coordination Disorder and Learning Disabilities. It is the identification of this relationship or comorbidity that has led to the development of intervention programs for children with Learning Disabilities based on the remediation of perceived underlying deficits in sensory integration and perceptual-motor functioning. These are considered to be process based neurological interventions as they are intended to address problems occurring in the processing of information at a neurological level. The efficacy of these programs as interventions for Learning Disabilities has been debated on numerous occasions with the most influential research being a meta analysis by Kavale and Matson (1983). The authors concluded that almost half the treatment effects for these perceptual-motor programs were negative including the effects of the interventions on academic achievement particularly reading (Kavale & Matson, 1983).

Not surprisingly, these negative results led many people to the conclusion that all intervention programs based on addressing motor deficits that purported to support individuals with Learning Disabilities were worthless.

In current times, with technological innovations such as functional Magnetic Resonance Imaging, there has been renewed interest in the links between motor (particularly the cerebellum) and cognition. This has led to resurgence in the development of process based neurological programs intended to address underlying deficits in neural processing. These programs are movement based with the premise of activating the cerebellum for example the *DDAT* program (currently Dore program) (Reynolds, Nicolson, & Hambly, 2003). This intervention is based on the research findings of Fawcett, Nicolson and Dean (2001) linking the cerebellum to Dyslexia. Another contemporary program is the *Primary Movement* program (McPhillips, 2001) which is based on research linking retained primary reflexes to Learning Disabilities.

While available research on the efficacy of perceptual-motor programs have somewhat tarnished the reputation of process oriented motor intervention programs, there is definitely evidence to suggest that children with motor difficulties are more at risk of reading, writing and spelling difficulties than children without difficulties (Dewey, Kaplan, Crawford, & Wilson, 2002), and intervention at an early age is vital to ongoing development. New research in the area of retained reflexes and the development of the *Primary Movement* program may provide an alternative to the reported limited efficacy and poor research design issues associated with a lack of confidence in perceptual-motor programs and motor programs in general and provide a solid research base on which to determine the efficacy of this program.

The *Primary Movement* program as an intervention emphasizes the interaction between the organism and the environment in the emergence of increasingly complex motor skills in young children. Although a process based approach to remediation, the persistence of reflexes is viewed within the constraints model (Newell, 1986). In this model, specific maturational constraints are viewed as placing limitations on the ability of the organism to respond to the environment and therefore a specific aspect of maturation

(persistence of primary reflexes) plays a critical role in the development of motor skills and consequently cognitive development.

According to Barnett ("Dore Groups (Australasia) ") there are multiple systems that place constraints on the child as an result of their interaction with the task and the environment in which they are performed. These restraints ultimately affect the extent and the rate of development of an individual in terms of motor skills. Process based interventions aim to affect the individuals development through reinforcing the developmental processes such as perceptual motor ability, however, the effectiveness of these interventions needs to be considered from the perspective of the other multiple and dynamic systems that have influence on the motor ability and other outcomes of the developing organism. The model adopted for this research is most comparable to the Neuronal Group Selection Theory model in which there is recognition of both the nature and nurture elements of motor development. It is assumed that neither the Neuro-maturational nor the Dynamic Systems theories can be adopted in totality in the research of the efficacy of motor based intervention programs. Rather, it is the interaction of the individual, in a genetic sense, the environment and the task which must be addressed when considering intervention processes. The interaction of the individual, the task and the environment is displayed in Figure 3, providing a summary of this Chapter.

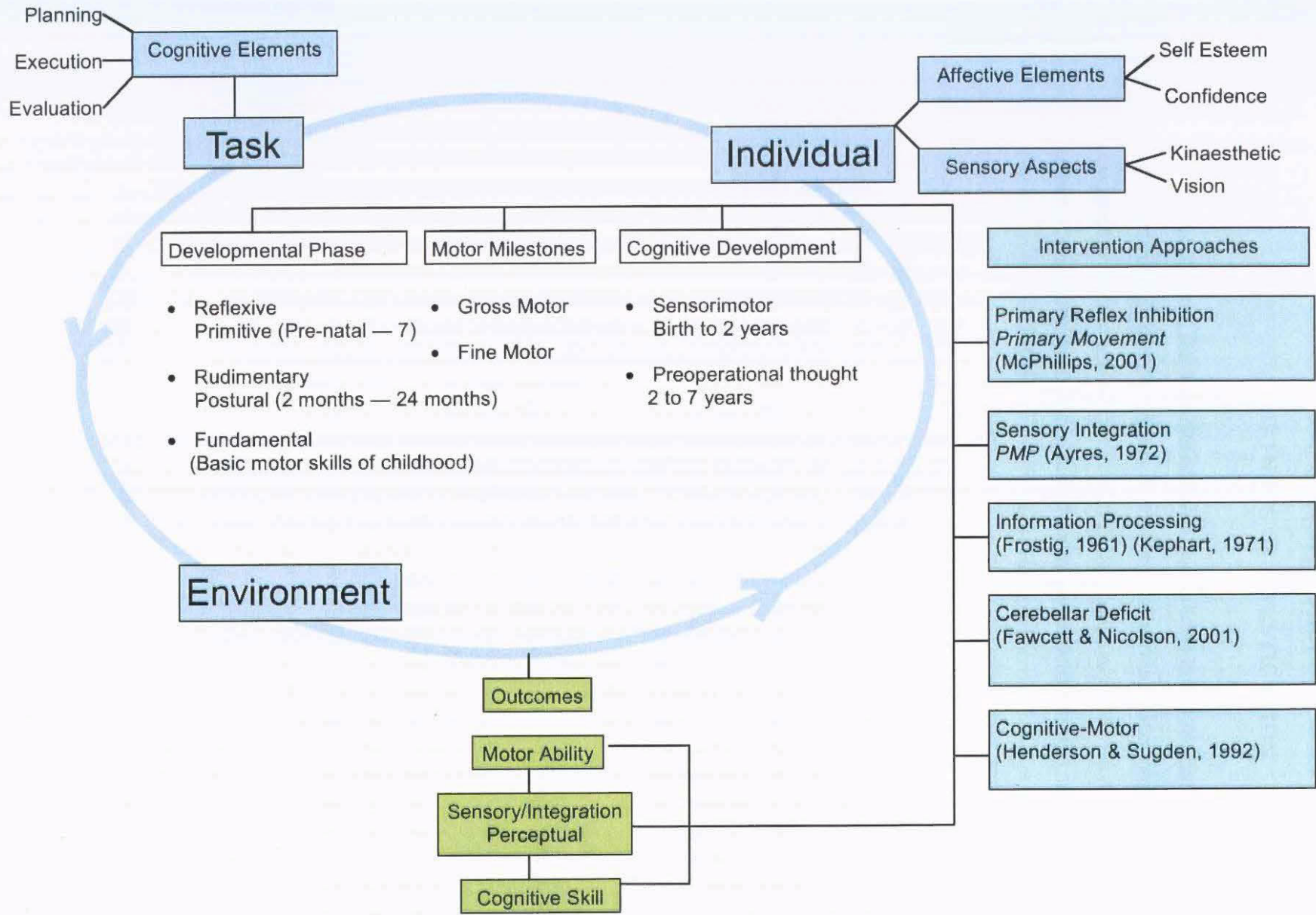


Figure 3. Relationship between theories of motor development and interventions incorporating the review of the literature

### CHAPTER THREE: METHODS OF INVESTIGATION

In this Chapter, the methods of investigation used in this research will be outlined and explained. This study investigates the effect of the *Primary Movement* program on the Asymmetrical tonic neck reflex, motor skills, vocabulary and visual motor ability in a cohort of preprimary children. Changes in the asymmetrical tonic neck reflex, motor skills, vocabulary and visual motor ability were compared across three groups: *Primary Movement* (intervention group) and two control groups, gross motor and free play. Three single individual student studies are conducted in order to exemplify the effect of each intervention on individual student studies. These children were matched as closely as possible on gender, age, ATNR level and results in the M-ABC Test.

Both quantitative and qualitative methods of data gathering were utilised for this research including the collection of work samples for the comparison of individual student studies. The work samples of the individual student studies consisted of a self portrait drawing completed at the pretest and posttest periods. Both standardised and non-standardised tests were used for the collection of quantitative data.

This main part of the study evaluated the effectiveness of a specific intervention by comparing posttest measures to baseline measures established at the outset. The three groups (experimental or *Primary Movement* group, gross motor activity control group and free play control group) from each of the three schools were combined for analysis.

All teachers involved in the research were introduced to the general principles of the *Primary Movement* program, the gross motor program and the free play program in the year prior to the commencement of the research project. The specific content of the interventions were not presented at this meeting.

Teachers who wished to withdraw from participating in the *Primary Movement* intervention for any reason were offered the other interventions on a random basis. The specific programs for each intervention were prescriptive in terms of content (except for the free play group) and fortnightly visits by the researcher to each school ensured that all

teachers involved in each intervention were adhering strictly to the requirements of each intervention program.

Allocation of classes to each intervention was random. The researcher had attended the foundation training course for primary teachers working with 3-7 year olds in Belfast, Northern Ireland in 2004 and teachers chosen to participate in the *Primary Movement* intervention were given similar training in the program by the researcher prior to and during the intervention.

All teachers were required to keep a daily diary to record participation in the intervention and to keep brief anecdotal records regarding any perceived changes in the children. Teachers were interviewed three times during the study and their responses to questions were recorded, transcribed and maintained as anecdotal records.

### **3.1 Standardised Tests**

#### **3.1.1 Motor**

Motor difficulties were assessed using Movement Assessment Battery for Children (M-ABC) (Henderson & Sugden, 1992) a comprehensive standardised assessment battery consisting of the M-ABC checklist and the M-ABC test. The M-ABC test gives an overall motor impairment score in which the higher the score, the greater the level of motor difficulties. There are four age bands which cover the ages 4-6, 7-8, 9-10 and 11-12 years. The level 4-6 was used in both pre and posttests in this research. The test gives sub scores for each activity area of manual dexterity, ball skills and balance as well as sub scores within these areas. The test consists of eight different test items yielding ordinal data from 0 to 5 with 5 indicating a severe motor problem and 0 indicating no problems. Items 1-3 measure manual dexterity, items 4 -5 measure ball skills and, items 6-8 measure (Table 2).

**Table 2**

*The components of the Motor ABC Test (Henderson & Sugden, 1992)*

<b>Manual dexterity</b>	<b>Ball skills</b>	<b>Balance</b>
1. Speed and precision with left and right hand	4. Accuracy in throwing	6. Static balance
2. Coordination of two hands	5. Catching an object	7. Fast explosive movement
3. Eye hand coordination		8. Slow controlled movements

According to the M-ABC test manual the most important score from the test is the total impairment score which summarizes the performance of the child on the test as a whole. It is calculated by adding the scores achieved by the child on the eight items during assessment. The test then provides percentile norms which indicate the percentage of children falling above or below a particular raw score. In this particular test, a high score indicates poor performance so a score which lies at the 2nd percentile will be higher than a score at the 10th percentile. A child scoring 20 out of a possible 40 on the test is much less competent than a child scoring 10. Total impairment scores which fall below the 5th percentile are indicative of a definite motor problem. Scores between the 5th and 15th percentile suggest a borderline degree of difficulty.

The second part of the M-ABC package is the checklist. Items were chosen for the M-ABC Checklist for completion by the teacher and the parent. These items give feedback on motor performance in everyday situations in the classroom and home environment. Performance on the parent's checklist is rated on a four point scale (zero is performs skill well, three is 'not close to achieving') by an adult familiar with the child's day to day motor functioning. The teachers checklist has a rating on a three point scale (zero is rarely, two is often). In both checklists, the lower the rating is, the better the performance. As the checklist is quite lengthy only two sections were used in this particular research with parents scoring motor performance in the home environment (24 questions) and teachers



scoring behaviour and motor functioning in the classroom (12 questions). The parent section is divided into two sections each consisting of 12 questions. The first section included questions on functional skills such as dressing and tying shoelaces. This section is classified as child stationary/environment stable. The second section includes questions on general gross motor skills that may be observed in play and is classified as child moving/environment changing. The teachers section requested information based on motor performance during tasks in the classroom including the level of over activity, impulsiveness and levels of persistence.

### **3.1.2 Visual Motor**

The Developmental Test of Visual Motor Integration (VMI), (Beery, 1989) consists of a developmental sequence of 24 geometric forms that the children will be asked to copy. According to Beery (1989) the main purpose of the administration of the VMI is to identify individuals who may be encountering difficulties in visual motor integration. The VMI was standardised on a United States sample of 2512 individuals aged 2-18 years and has proven reliability and validity. For the purposes of this research, the Short Format of the VMI test will be used.

### **3.1.3 Vocabulary**

Vocabulary skills (receptive vocabulary) are assessed using the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997). This is an individually administered, untimed, norm referenced test in which items are arranged in increasing difficulty. Each item consists of four black and white pictures arranged on a page. The child is instructed to select the picture that best represents the meaning of a "stimulus word" presented by the examiner (Dunn & Dunn, 1997). The test was standardised on a sample of 2725 persons of which 2000 were children and adolescents and 725 were adults. The test is used for the purpose of testing receptive vocabulary and for screening of verbal ability.

### **3.1.4 Rapid Naming**

The Dyslexia Early Screening Test (DEST) (Fawcett & Nicolson, 1996) is a screening instrument designed for children from four years and six months, to six years and five months of age (p. xi). There are ten tests in the battery and only one, the Rapid Naming Test was used in this research. This test measures the speed at which children could correctly name a page of outline drawings and was chosen in order to give an indication of the child's ability in one aspect of pre reading, automatising.

Percentile ranks have been allocated to raw scores in the Rapid Naming Test. For the purpose of this study, these have been awarded a score between 1-5. A child who completed the Rapid Naming Test very quickly would score a 1, a child who was very slow would score 5. These scores correlate to the DEST score key in which percentile ranks are given for each age group considering the score that the child achieved. For example, a child aged five years and six months scores a time of 65 seconds in the Rapid Naming test. This score places the child in the below average category (bottom 10-25 percent) and scores a 4. Scores are allocated as follows 5 = well below average (bottom 10 percent), 4 = below average (bottom 10-25 percent), 3 = average (26-75 percent), 2 = above average (76-90 percent), 1 = Well above average (top 10 percent).

### **3.2 Non-standardised test materials**

The level of persistent ATNR was assessed using the Schilder Neurological Test as described in McPhillips et al (2000) and Ayres (1972a). The Schilder Neurological test is performed in an upright position and involves the child holding and maintaining both arms out to the front at shoulder height, while the tester turns the head to both the left and right side. A child that is unable to maintain the arms in the front position is judged as having a positive ATNR and is judged on a zero to three point evaluation scale (left and right). The highest individual score that can be recorded is six which indicates a high level of ATNR, the lowest 0 which indicates no observable ATNR. Although this neurological test is behavioural in nature, the described method of testing in the standing position is acceptable in clinical contexts and, with practice, judgment is relatively uncomplicated (Morrison, 1985).

Anecdotal records and work samples form an important basis for the case studies. All teachers involved in the research were instructed to keep a diary in which they recorded daily participation in the intervention program and monthly anecdotal records. Work samples for children who had recorded a high (>4) ATNR score or a low (< 15th percentile) M-ABC score were also collected from all intervention groups with parental permission. Every month teachers were interviewed and their responses recorded and transcribed. Questions asked related to general comments about the intervention that they were involved in, the children's performance during the intervention, any skill transfer that may be occurring and any observable behaviour changes in individual children.

### **3.2.1 Self portrait by individual student studies**

All children participating in the research were required to draw a self-portrait prior to and after the period of intervention to examine perception of body image. The most frequently used test in the analysis of children's drawings is the Goodenough Draw a Man Test (Harris, 1963) which links children's drawing to their general intelligence. However, for the purpose of this research the completion of a self portrait was simply to compare the portrayal of self image at the start of the intervention period to the end.

A comparison was made between the drawings (work samples) of the three students identified as individual student studies at pretest and posttest in order to explore the possible effect of retained ATNR on the portrayal of body image in a self portrait.

### **3.3 Reliability and validity of standardised tests**

Reliability of a study is defined as the extent to which it consistently measures what it intends to measure and can be measured in various ways. A test is valid to the extent that it succeeds in measuring what it intends to measure and again there are many different ways of measuring a test's validity. Test validity is prerequisite to test reliability. If a test is not valid then there is no point in discussing reliability as test validity is required before reliability can be meaningful (Tzivinikou, 2003).

The standardised tests used in this research, the M-ABC (Henderson & Sugden, 1992), Peabody Picture Vocabulary Test (Dunn & Dunn, 1997), VMI Developmental Test of Motor Integration (Beery, 1989) and the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) all have information concerning validity and reliability included in the publication manual which is included in each test package. This information is reproduced below.

### ***M-ABC***

The M-ABC is one of the most popular instruments in the assessment of children with movement coordination problems (Ruiz, Graupera, Gutierrez, & Miyahara, 2003). The M-ABC can be used by a variety of professionals including teachers, therapists and pediatricians. According to the M-ABC test manual (Henderson & Sugden, 1992) studies have provided evidence that this test "measures motor difficulties in a way that is meaningful to other professionals involved in the same exercise and is related to the measures they use"(p.193).

The reliability of the test was established in the UK using 360 children randomly selected from a total population of 3000 examining test retest and intertester reliability. In test retest reliability the minimum value at any age was 0.75 and intertester 0.70.

### ***Peabody Picture Vocabulary Test- Third Edition (PPVT-III)***

The PPVT-III is an individually administered, norm referenced, wide range measure of listening comprehension for spoken words in standard English. The test was standardised on a USA population of 3,725 individuals for item analysis. Of that total, 2,725 were used for norms development. Special populations such as learning disabled, hearing impaired, and gifted and talented were included in the standardization sample.

To establish validity, the PPVT-III was conormed with the Expressive Vocabulary Test which is a companion assessment of expressive vocabulary. The median correlation between the two tests was 0.79. Criterion related reliability showed a correlation with measures of cognitive ability using the WISC-III Verbal IQ of 0.91.

In terms of reliability, internal reliability for this form of the test was determined to be alpha 0.92 to 0.98 with median 0.95 and test retest 0.91 to 0.94.

### *Developmental Test of Visual Motor Integration (VMI)*

The VMI consists of a developmental sequence of 24 geometric forms to be copied with paper and pencil. For the purposes of this research, the VMI was administered in a class group and were marked by a single individual. Test norms were derived from a sample of 5,824 in the USA from urban, rural and suburban areas between the ages of two years and six months and 19 years.

The VMI correlates highly with chronological age (0.89) and with academic achievement. Correlations between the VMI and school readiness tests overall, have averaged around 0.50. Correlations with reading and other achievement tests were higher for the primary grades than the upper grades. There is a tendency for the VMI to correlate more highly with arithmetic than with reading (Beery, 1989 p.15).

Test retest reliability scores range from 0.63 (over a seven month period) to 0.92 (over a two week period) with a median of 0.81. Split half reliability ranged from 0.76 to 0.91 with a median value of 0.85.

### *The Dyslexia Early Screening Test (DEST)-Rapid Naming Subtest*

The DEST is a 30 minute test designed for use in the early years (ages four years six months to six years six months). It involves 11 two minute sub tests, one of which is rapid naming. The rapid naming section is one of the sub-tests and requires each student to name as quickly as possible a page full of outline drawings of familiar objects. This test is based on the 'Rapid Automised Naming Test' devised by Denkla in the 1970s as an indicator of Dyslexia (Fawcett & Nicholson, 1996, p. 6). Norms have been derived for each test in the battery and these relate to the child's age at the time of testing. To establish the norms in the test manual, at least 100 children in each age group: 4:6 to 4: 11, 5:0 to 5:5, 5:6 to 5: 11 and 6:0 to 6:11, were involved in each test and overall 1000 children were involved in the

establishment of these norms. Test Retest reliability for the Rapid Naming Test is a high 0.751. As the DEST was developed to fill a need for a Dyslexia screening test, construct validity has not been established, as there are no other tests to compare this test to.

### **3.4 Data Collection**

The three schools for this research were of similar socio-economic status, all being in the southern suburbs of metropolitan Perth within a radius of ten kilometres of each other. Nine classes of preprimary students of similar size plus one split class of 11 pre primary children (total of ten) were involved in the study. Three classes from each school were involved in the research with the exception of School One in which four classes (three preprimary and a split preprimary/year one) were involved. Only the children of preprimary age were tested at School One however, all of the children in the class participated in the intervention. This was done for ethical reasons in that it was felt that it was unfair that one small group of preprimary students ( $n = 11$ ) should miss out on participation due to them being in a split class. Permission for all schools, teachers and parents was ascertained as part of the ethics application and permission for this project.

Each class at each school was randomly allocated an intervention, one *Primary Movement* class (School One, two *Primary Movement* classes), one gross motor activity class and one free play class. A total of 206 students were initially involved in the study. All preprimary children enrolled at these schools for the year 2005 were included. The mean age of the preprimary students at pretest who participated in the study was 61 months (5 years and 1 month) and at posttest 69 months (5 years and 9 months).

One class at each of the participating schools was randomly allocated an intervention either *Primary Movement*, gross motor or free play. For ethical reasons, all children at all schools had a chance to participate in some form of physical activity, *Primary Movement*, gross motor or free play, for 15 minutes each day. This was in addition to the 'normal' pre primary curriculum based activity program common to all schools. The fact that three schools and 10 different classes were involved ensured that a broad range of 'normal' pre primary activities would be represented in the study.

The *Primary Movement* group participated in the *Primary Movement* program, a reflex replication program which was devised by McPhillips (2000). This program involves the daily repetition of movement sequences that replicate the early reflexive foetal movement and includes specific exercises which are thought to stimulate not only the cerebellum but other areas of the brain involved in movement. The majority of the program is presented using nursery rhymes and other child friendly action songs and rhythmic movements. All teachers followed a prescribed sequence of presentation throughout the program for 15 minutes each day after lunch. A typical period of Primary Movement would consist of seated and standing songs in which movements which are known to stimulate the occurrence of reflexive behaviour are performed. This is followed by the slow movement which is a direct replication of either the ATNR or Moro reflex.

The gross motor group teachers were allocated a list of activities from which to choose daily activities. All teachers were instructed that each activity needed to be aerobic in nature, to involve large muscle groups such as the legs and to be teacher directed. Playground equipment such as monkey bars and climbing frames could be used for obstacle courses but no equipment other than the fixed playground equipment was to be used. This activity was carried out after lunch (with the exception of one class that had their session in the morning) for 15 minutes each day

The free play group had 15 minutes of free play after lunch with teacher supervision but no teacher direction. Equipment other than fixed playground equipment was to be made available if convenient. In most schools, this was packed up after lunch and therefore was not available.

The intervention period was 8 months (March 2004 to October 2004).

**Table 3*****Results of random allocation of students to intervention groups***

School Name	Groups	Number Per Group	Males	Females	Total
School One	Primary Movement	33	14	19	72
	Gross motor	21	7	14	
	Free Play	18	9	9	
School Two	Primary Movement	22	11	11	60
	Gross motor	21	13	8	
	Free Play	17	9	8	
School Three	Primary Movement	22	13	9	63
	Gross motor	22	7	15	
	Free Play	19	13	6	

**3.5 Testing Procedure**

All children were pretested in the ABC Test of Motor Ability (M-ABC) (Henderson & Sugden, 1992) and the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) and the Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) in the first weeks of the school term, (February) 2005, and posttested in November 2005. Testing for the presence of ATNR was also completed at these times. Testing was carried out by research assistant/s under the supervision of the researcher. Written instructions were given to the research assistant/s along with prior practice sessions to ensure that each test was administered correctly. One research assistant was specifically trained in testing for ATNR and was responsible for testing children in pre and posttest phases under the supervision of the researcher. Testing was carried out in a 'wet area' adjacent to the classrooms in each school. Teachers were given a copy of the VMI Developmental Test of Visual Motor Integration (Beery, 1989) along with the instructions for completing the test with their class. This was completed in the first week of school for pretest, (February) 2005, and during November 2005 for posttest, in class time. Schools that were pretested first and commenced the intervention earlier were posttested last to ensure that all classes spent an equitable amount of time on the intervention.



Two sections of the M-ABC Checklist, an optional section of the Motor ABC Test (Henderson and Sugden, 1992), were distributed to parents. Section One and Section Four were distributed for completion in the first two weeks of February 2005, and again in November 2005. Teachers were required to complete Section 5 of the M-ABC checklist in the same time period. Parents were also required to complete an activity schedule recording the activities outside of school hours that their child participated in. This was primarily for the purpose of determining whether participation in outside activities may have influenced results if the child was selected for the individual case phase. All children were asked to complete a human figure drawing of themselves on a plain piece of A4 paper using a pencil at pretest stage and again at posttest stage in order to ascertain any changes in perception of body image that may occur.

### **3.6 Data Analysis**

#### **3.6.1 Prevalence of ATNR**

In order to address research question one descriptive statistics from the three groups were combined to report on the prevalence of ATNR in the cohort of preprimary children as well as any differences between males and females.

#### **3.6.2 Inhibition of ATNR**

To address research question two, the effect of the Primary Movement program on ATNR, median scores were calculated and differences between groups determined using the Wilcoxon Signed Ranks Test. This is a non-parametric test used to test the median difference in paired data and is the non-parametric equivalent of the paired *t*-test. Research question three, the effect of the Primary Movement program on motor development is addressed using the non parametric equivalent of the one way ANOVA, the Kruskal Wallis test due to the non- parametric nature of the data. A comparison of pre and posttest data was made using the Wilcoxon Signed Ranks Test.

### **3.6.3 Effect of the *Primary Movement* program on receptive vocabulary and visual motor development**

Data to determine the effect of the Primary Movement program on vocabulary and visual motor ability (research questions 5 and 6) was analysed using a one way ANOVA at pretest and posttest to determine the similarity of the groups prior to the intervention. This was followed by a repeated measure ANOVA on standardised scores with test time as the repeated measure.

### **3.6.4 Effect of the *Primary Movement* program on rapid naming.**

Data examining this variable were analysed using the Wilcoxon Signed Ranks Test on each of the treatment groups at pre and posttest due to the non parametric nature of the data.

Table 4 provides a summary of data collection, procedures and analysis that will be performed on the data in order to address the respective research questions.

**Table 4**

*Proposed analyses of standardised and non-standardised test results*

Effect	Test	Scale	Analysis
Asymmetrical Tonic Neck Reflex	Schilder Neurological Test	0-6*	Descriptive analysis to show frequency and severity Wilcoxon Signed Ranks Test Comparison of mean scores at pretest and posttest for each group
Motor skills	Movement Assessment Battery for Children (Total impairment score)		Repeated measures ANOVA on standardised scores with test time as repeated measure
Motor skills	Movement Assessment Battery for Children (Sub-tests)		Kruskal-Wallis Test Comparison of mean impairment scores at pretest and posttest for each group
Motor skills	Movement Assessment Battery for Children (Parent Checklist Teacher Checklist)	0-3 0-2	Wilcoxon Signed Ranks Test
Visual Motor Integration	Developmental test of Visual Motor Integration		One way ANOVA (pretest and posttest) Repeated measures ANOVA on standardised scores with test time as repeated measure
Receptive Vocabulary	Peabody Picture Vocabulary Test		One way ANOVA (pretest and posttest) Repeated measures ANOVA on standardised scores with test time as repeated measure
Rapid Naming	Dyslexia Early Screening Test (Sub-test)	1-5	Wilcoxon Signed Ranks Test

\* data will be plotted to examine normalcy.

## CHAPTER 4

### RESULTS

In this chapter, data collected to answer the research questions will be presented. The data, collected from 195 preprimary children, formed the basis for the results of this research. Although 206 pre primary children took part in the pretest of this research, nine of the original cohort of children was unable to be posttested due to attrition. Results are also presented from individual student studies.

Results are presented for the intervention study first, followed by the results for the individual student studies in order to answer the following research questions:

1. What is the prevalence and severity of the ATNR reflex in the sample of preprimary children?
2. Does participation in the *Primary Movement* program have an effect on the inhibition of the ATNR in those that present with ATNR in the sample population?
3. Does participation in the *Primary Movement* program have an effect on: the development of motor in the sample preprimary children?
  - (a) Does participation in the primary Movement Program have an effect on the number of children classified as having DCD based on M-ABC results?
4. Does participation in the Primary movement program have an effect on the drawing of an individual's self portrait?
5. Does participation in the *Primary Movement* program have an effect on: the development of receptive vocabulary skills in the sample of preprimary children?
6. Does participation in the *Primary Movement* program have an effect on: the development of visual motor integration in the sample of preprimary children?

7. Does participation in the *Primary Movement* program have an effect on: rapid naming ability in the sample of preprimary children?

These questions represent a natural organizing structure for this Chapter.

#### 4.1 Research Question 1: What is the prevalence and severity of the ATNR reflex in the sample of preprimary children in Perth, Western Australia?

For the purpose of this study an ATNR score of 0 = ATNR not detectable, 1- 2 will be classified as mild, 3-4 moderate and 5-6 high. This is accepted practice using this instrument (Jordan-Black, 2005; McPhillips, 2001).

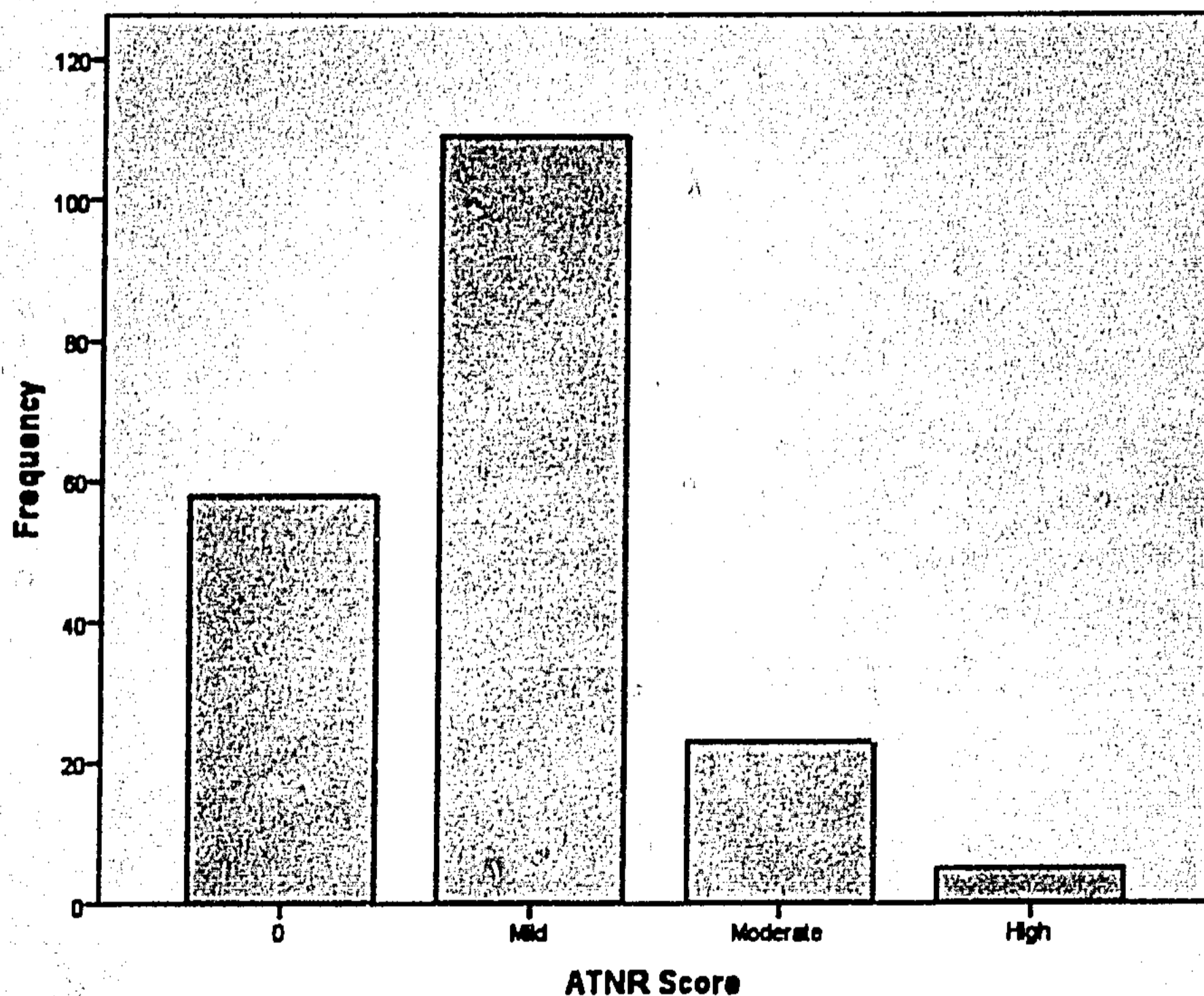


Figure 4. Frequency of ATNR scores for all children at pretest

Results indicate that 30 percent of children (n=58) presented with no observable ATNR, 56 percent (n=109) were adjudged to have an ATNR level of 1-2 (mild), 12 percent (n=23) presented with an ATNR in the moderate range and 2 percent (n=5) of scores were in the high range (Fig. 4). The median ATNR score of the sample group

(n=195) was 1. The median will be used for the comparison of pre and post ATNR test results using the Wilcoxon Signed Ranks test in the following section.

#### 4.1.1 ATNR score according to gender

The median score for male participants (n= 96) was 1.0 and for females (n=99) 1.0 Table 5 shows the percentage score for each group. The largest percentage of both males and females were represented in the lowest groups with 84 percent of males and 87 percent of females having an ATNR score below 2. Four percent of males and only one percent of females scored in the high range of retained ATNR.

Table 5

*Asymmetrical Tonic Neck Reflex Score and Gender Expressed as Percentages.*

ATNR Score	0	1-2 (mild)	3-4 (moderate)	5-6 (high)
Male	28	56	12	4
Female	32	55	12	1

#### 4.1.2 ATNR score and intervention group

The students were randomly allocated to intervention groups prior to the testing of ATNR. The median ATNR score for all three groups at pretest was 1.0. The *Primary Movement* group had 84 percent of students scoring an ATNR of 0 or in the mild range the gross motor group having 89 percent and free play 83 percent. The free play group had the highest percentage of students recording moderate and high scores for ATNR (17 percent), closely followed by the *Primary Movement* group (16 percent) and the gross motor group (12 percent). A Kruskal Wallis test performed on the groups showed no significant difference in ATNR between the three groups at the start of the project (Table 6)

Table 6

*Percentage of children in each Randomly Allocated Intervention Group based on Asymmetrical Tonic Neck Reflex Score*

ATNR Score	0	1-2 (mild)	3-4 (moderate)	5-6 (high)
<i>Primary Movement</i>	36	48	12	4
Gross motor	28	61	10	2
Free play	22	61	15	2

**4.2 Research Question 2. Does participation in the *Primary Movement* program have an effect on the inhibition of the ATNR in those that present with ATNR in the sample population?**

The median ATNR score for all intervention groups at pretest was 1. At posttest, the median score for ATNR had reduced to 0 for the *Primary Movement* group. All other intervention groups retained a median score of 1 indicating no overall reduction in ATNR for these groups. Table 7 indicates the number of students above and below the median ATNR score at pretest and posttest.

Table 7

*Percentage of Students Above and Below Pretest and Posttest Median ATNR Score in Each Intervention Group*

	<i>Primary Movement</i>		Gross motor		Free play	
	Pre (n=77)	Post (n=77)	Pre (n=64)	Post (n=64)	Pre (n=54)	Post (n=54)
Median	1.0	0	1.0	1.0	1.0	1.0
Scores above median	43	14	34	33	44	37
Scores below median	57	86	66	67	56	63

Pre and posttest results were compared using the Wilcoxon Signed Ranks Test (Table 8). A significant difference was found only in the *Primary Movement* group for before and after results. In the *Primary Movement* group, the mean rank decreased from 20 to 11 ( $p < 0.001$ ) and there are significantly fewer students above the median score: 43 percent in the pretest and 14 percent at posttest. There were no significant improvements for the other 2 intervention groups (gross motor  $p = 0.418$  and free play  $p = 0.098$ ).

Table 8

*Comparison of Pre and Post ATNR Test Results for the Primary Movement, Gross motor and Free play Group Using the Wilcoxon Signed Ranks Test.*

Treatment		N	Mean Rank	Sum of Ranks	Asymp.Sig. (2-tailed)
<i>Primary Movement</i>	Negative Ranks	38	20.22	768.50	
	Positive Ranks	1	11.50	11.50	
	Ties	38			
	Total	77			<0.001
Gross motor	Negative Ranks	14	13.64	191.00	
	Positive Ranks	11	12.18	134.00	
	Ties	39			
	Total	64			0.418
Free play	Negative Ranks	8	8.56	68.50	
	Positive Ranks	5	4.50	22.50	
	Ties	41			
	Total	54			0.098

#### 4.3 Research Question 3: Does participation in the *Primary Movement* program have an effect on the development of motor skills in the sample of preprimary children?

Motor skills were measured using the *Motor Assessment Battery for Children (M-ABC)* (Henderson & Sugden, 1992). There are three sub-tests in the practical test, manual dexterity, ball skills and balance. Sections of the parent and teacher checklist were also used. A child's overall score on the M-ABC is called the total impairment score. This score is then converted to a standardised score. This conversion to a standardised score allowed an analysis using ANOVA. A repeated measures ANOVA was performed on the standardised score based on overall performance (total impairment score) in the M-ABC for the three intervention groups with test time as the repeated measure.



There was a main effect of time ( $F(1,192) = 9.334, p = 0.003$ ) but not of treatment ( $F(1,192) = 0.607, p = 0.546$ ). There was however, a significant interaction between time and treatment ( $F(2,192) = 4.045, p = 0.019$ ). Post hoc analyses revealed that there was a significant difference between the *Primary Movement* group and the gross motor group ( $p = 0.015$ ). The means for the gross motor and free play groups did not increase significantly, however the *Primary Movement* intervention group mean significantly increased from a 93.8 at pretest to 99.9 at posttest. This indicates that although there was improvement in performance in all groups, the *Primary Movement* group was the only intervention group to demonstrate statistically significant improvement between pretest and posttest (Fig. 5).

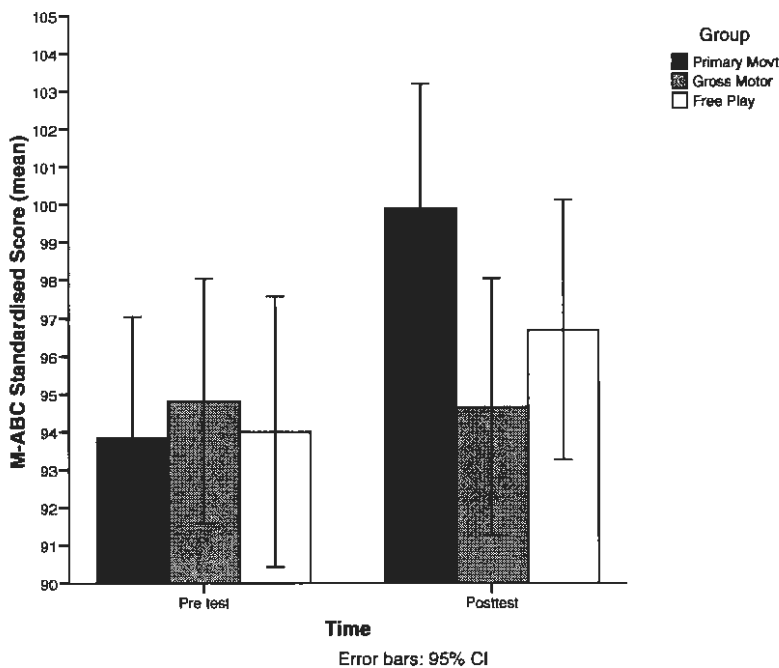


Figure 5. Effect of three movement interventions on M-ABC standardised scores at two test periods

### 4.3.1 Research Question 3 (a) Number of children classified as having Developmental Coordination Disorder or at risk of Developmental Coordination Disorder based on scores in M-ABC in three groups at pretest and posttest.

The relationship between the level of retained ATNR and performance in the M-ABC is shown in Figure 6. These results show that the higher the level of retained ATNR, the lower the performances in the M-ABC test. This is particularly the case for males.

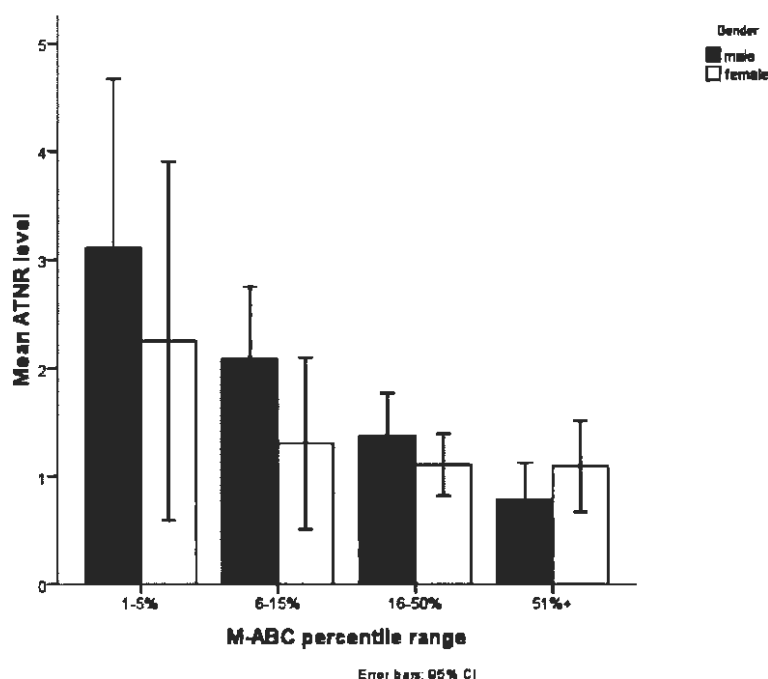


Figure 6. The relationship between persistence of the ATNR (mean ATNR level) and impairment scores on the M-ABC (M-ABC percentile range).

Henderson and Sugden (1992) state that children falling at or below the 5<sup>th</sup> percentile in total impairment score are classed as having the attributes of Developmental Coordination Disorder, while students scoring between the 5<sup>th</sup> and 15<sup>th</sup> percentile need to be closely monitored as they are at risk of coordination difficulties. Students above the 15<sup>th</sup> percentile band are considered to be demonstrating adequate motor skills according to the M-ABC.

The number of students below the 5<sup>th</sup> percentile increased in both the gross motor and free play groups. Only the *Primary Movement* group showed a reduction in the number of children below the 5<sup>th</sup> percentile (Table 9). While there was a decrease in the number of children in what is considered the 'at risk' group (5-15 percent) (Henderson & Sugden, 1992) the decrease is greatest for both the *Primary Movement* group in which 17 percent of children were considered at risk in pretest but only 1 percent in posttest and the free play group 30 percent to 7 percent. Numbers of students over the 15 percent threshold increased in the *Primary Movement* group from 73 percent to 91 percent. This was the highest percentage increase amongst the three groups. The free play group also improved with 65 percent of students being over the threshold at pretest compared to 86 percent at posttest.

Table 9

*Percentage of Students in each M-ABC Percentile Band at Pretest and Posttest*

M-ABC %	Primary Movement (n=77)		Gross motor (n=64)		Free play (n=54)	
	% Pretest	% Posttest	% Pretest	% Posttest	% Pretest	% Posttest
<5%	10	8	9	14	5	7
6-15%	17	1	14	6	30	7
>15%	73	91	77	80	65	86

#### 4.4 Results of M-ABC sub-tests

The M-ABC test is made up of three sub-tests – manual dexterity, ball skills and balance. Each of these sub-tests was analysed independently to determine the effect of the *Primary Movement* intervention. Pretest and posttest results of each sub-test are presented below. These tests unlike the total impairment score are not standardised and therefore, non-parametric measures are used.

#### 4.4.1 Manual dexterity sub-test

Data were compared for the three groups using the Kruskal-Wallis test. There was no significant difference between the three groups on the sub test of manual dexterity M-ABC Test at pretest ( $H(2) = 0.67, p = 0.716$ ) (Table 10).

Table 10

##### *Manual Dexterity at Pretest Showing Mean Ranks of Three Groups*

Treatment	N	Mean Rank
<i>Primary Movement</i>	77	101.20
Gross motor	63	93.52
Free play	55	98.75
Total	195	

As the groups were established to be the same at pretest, scores can be compared between pre and posttest stages allowing for covariance. Results are shown below in Table 11. Data for the manual dexterity test were compared for the three groups between pre test and posttest scores using the Wilcoxon Signed Ranks Test. Significant differences were found for the *Primary Movement* and gross motor groups. For the *Primary Movement* group, there was a significant *improvement* in performance on manual dexterity from pre test to posttest,  $T = 799.0, p = 0.022$ . In contrast there was a significant *decrease* in performance on manual dexterity for the gross motor group from pre test to posttest,  $T = 621.5, p = 0.046$ . There was no significant difference in performance on manual dexterity for the Free play group from pre test to posttest,  $T = 582.0, p = 0.955$ .

**Table 11**

*Comparison of Pre and Posttest Manual dexterity Results for the Primary Movement, Gross motor and Free play group using the Wilcoxon Signed Ranks Test.*

Treatment		n	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
<i>Primary Movement</i>	Negative Ranks	44	35.16	1547.00	0.002
	Positive Ranks	24	33.29	799.00	
	Ties	9			
	Total	77			
Gross motor	Negative Ranks	25	24.86	621.50	0.046
	Positive Ranks	34	33.78	1148.50	
	Ties	5			
	Total	64			
Free play	Negative Ranks	23	25.33	582.50	0.955
	Positive Ranks	25	23.74	593.50	
	Ties	6			
	Total	54			

#### 4.4.2 Ball skills sub-test

Data were compared for the three groups using the Kruskal-Wallis test at pretest. There was no significant difference between the three groups on the sub test of ball skills at pretest ( $H(2) = 0.69, p = 0.707$ ) (Table 12).

**Table 12**

*Ball skills at Pretest Showing Mean Ranks for Three Groups*

Treatment	N	Mean Rank
<i>Primary Movement</i>	77	101.56
Gross motor	63	96.69
Free play	55	94.48
Total	195	

Data were compared for the three groups on pre test and posttest scores using the Wilcoxon Signed Ranks Test (Table 13).

There was a significant difference for the gross motor group only. For the gross motor group, there was a significant *decrease* in performance on ball skills from pre test to posttest,  $T = 157.0, p = 0.042$ . There was also a decrease in performance on ball skills for the Free play group which just failed to reach significance from pre test to posttest,  $T = 112.0, p = 0.062$ ). In contrast there was little change in performance on ball skills for the *Primary Movement* group from pre test to posttest,  $T = 474.0, p = 0.616$

Table 13

*Comparison of Pre and Posttest Ball skills Results for the Primary Movement, Gross motor and Free Play group using the Wilcoxon Signed Ranks Test.*

Treatment		n	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
<i>Primary Movement</i>	Negative Ranks	22	21.55	474.00	0.616
	Positive Ranks	23	24.39	561.00	
	Ties	32			
	Total	77			
Gross motor	Negative Ranks	12	13.08	157.00	0.042
	Positive Ranks	20	18.55	371.00	
	Ties	32			
	Total	64			
Free play	Negative Ranks	11	10.18	112.00	0.062
	Positive Ranks	16	16.63	266.00	
	Ties	27			
	Total	54			

#### 4.4.3 Balance sub-test

Data were compared for the three groups using the Kruskal-Wallis test. There was no significant difference between the three intervention groups in the pretest of M-ABC balance skills ( $H(2) = 0.636, p = 0.728$ ) (Table 14).

**Table 14**

***Balance at Pretest Showing Mean Ranks for Three Groups***

Treatment	N	Mean Rank
<i>Primary Movement</i>	77	96.72
Gross motor	63	95.36
Free play	55	102.95
Total	195	

Data were compared for the three groups on pretest and posttest scores using the Wilcoxon Signed Ranks Test. There were significant improvements for all three groups. For the *Primary Movement* group there was a significant improvement in performance on balance from pretest to posttest,  $T = 131.0, p < 0.001$ . For the gross motor group there was a significant improvement in performance on balance from pretest to posttest,  $T = 161.5, p < 0.001$ . For the free play group there was a significant improvement in performance on balance from pretest to posttest,  $T = 158.5, p < 0.001$  (Table 15).

**Table 15**

***Comparison of Pre and Posttest Balance Results for the Primary Movement, Gross Motor and Free Play groups using the Wilcoxon Signed Ranks Test.***

Treatment		n	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
<i>Primary Movement</i>	Negative Ranks	38	23.79	904.00	<0.001
	Positive Ranks	7	18.71	131.00	
	Ties	32			
	Total	77			
Gross motor	Negative Ranks	33	22.47	741.50	<0.001
	Positive Ranks	9	17.94	161.50	
	Ties	22			
	Total	64			
Free play	Negative Ranks	31	19.60	607.50	<0.001
	Positive Ranks	5	11.70	58.50	
	Ties	18			
	Total	54			

## 4.5 M-ABC Checklist

The checklists form the second section of the M-ABC assessment (Dunn & Dunn, 1997) as outlined in materials and methods. A lower score indicates improvement in the skills or abilities described in the checklist.

### 4.5.1 Parent Checklist Section 1 – Child Stationary/Environment Stable

For each of the treatment groups, a Wilcoxon Signed Ranks Test was performed on the pre and posttest scores. A significant difference was found between pretest and posttest scores for all three intervention groups (Table 16). An analysis of the z score indicates that while all children improved significantly in terms of the parent's perception of motor skills in this section, there was slightly greater improvement in the children in the *Primary Movement* group. A decrease in impairment score is indicative of improvement.

Table 16

*Mean Ranks, z score and Significance of Parent Checklist Section 1 at Pretest and Posttest for Each Treatment Group*

	<i>Primary Movement</i>		Gross motor		Free play	
	Pre (n=70)	Post	Pre (n=54)	Post	Pre (n=41)	Post
Mean Rank	33.80	20.82	24.45	17.17	21.17	11.13
z score	-5.26		-4.81		-3.98	
Probability	<0.001		<0.001		<0.001	

### 4.5.2 Parent Checklist Section 4 – Child Moving / Environment Changing

For each of the treatment groups, a Wilcoxon Signed Ranks Test was performed on the pre and posttest scores. A significant difference was found between pretest and posttest for all three groups (Table 17). An analysis of the z score indicates that while all children improved significantly in terms of the parent's perception of motor skills in this section, there was slightly greater improvement in the children in the *Primary Movement* group. A decrease in impairment score is indicative of improvement.



Table 17

*Mean Ranks, z score and Significance of Parent Checklist Section 4 at Pretest and Posttest for each Treatment Group*

	<i>Primary Movement</i>		Gross motor		Free play	
	Pre (n=70)	Post	Pre (n=54)	Post	Pre (n=44)	Post
Mean Rank	33.72	23.89	24.06	18.78	18.93	12.55
z score	-4.51		-3.95		-2.78	
Probability	<0.001		<0.001		0.005	

#### 4.5.3 Teacher Checklist Section 5 – Behavioural Problems Related to Motor Difficulties

For each of the treatment groups, a Wilcoxon Signed Ranks Test was performed on the pre and posttest scores. A significant difference was found between pretest and posttest scores only for the gross motor group (Table 18).

Table 18

*Mean Ranks, z score and Significance of Teacher Checklist Section 5 at Pretest and Posttest for each Treatment Group*

	<i>Primary Movement</i>		Gross motor		Free play	
	Pre (n=77)	Post	Pre (n=64)	Post	Pre (n=54)	Post
Mean Rank	34.31	25.23	20.44	25.84	14.11	13.78
z Score	-1.35		-2.52		-1.57	
Probability	0.177		0.012		0.116	

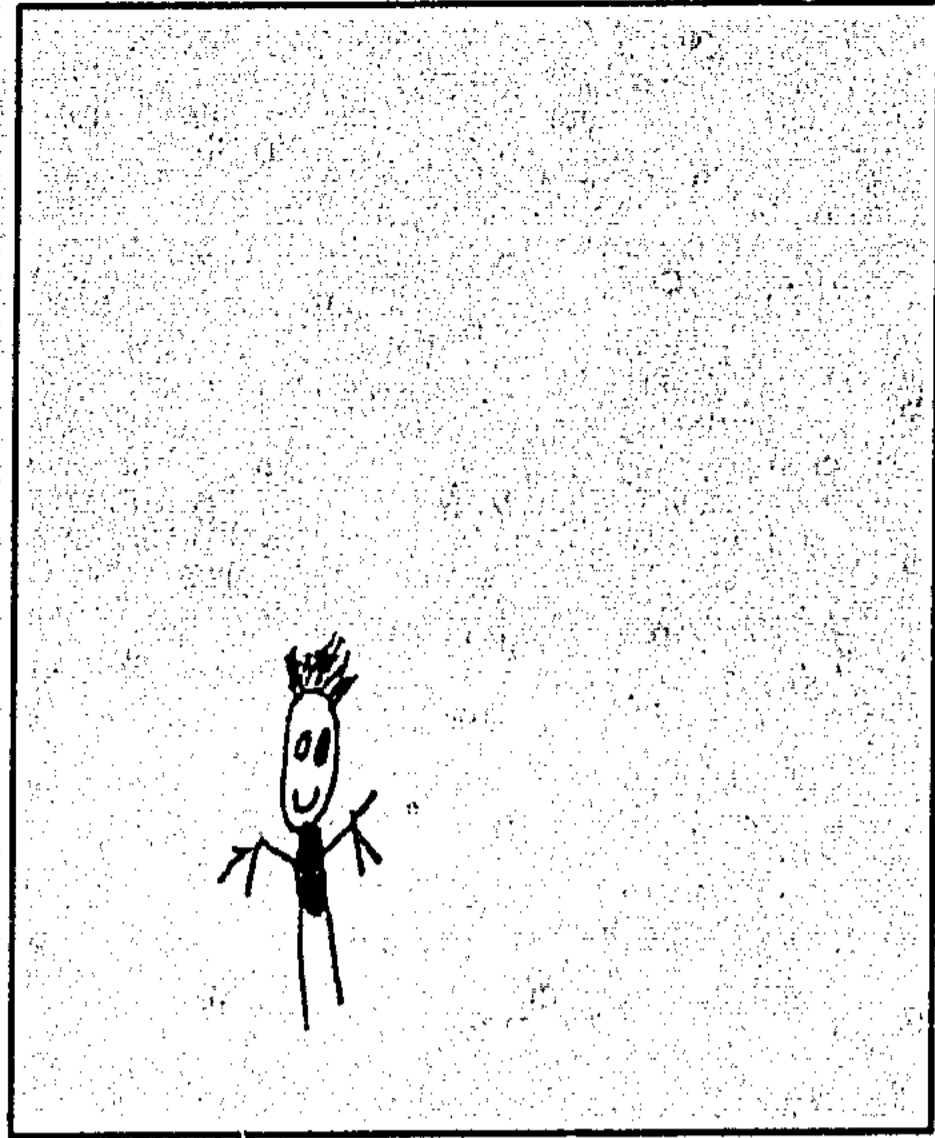
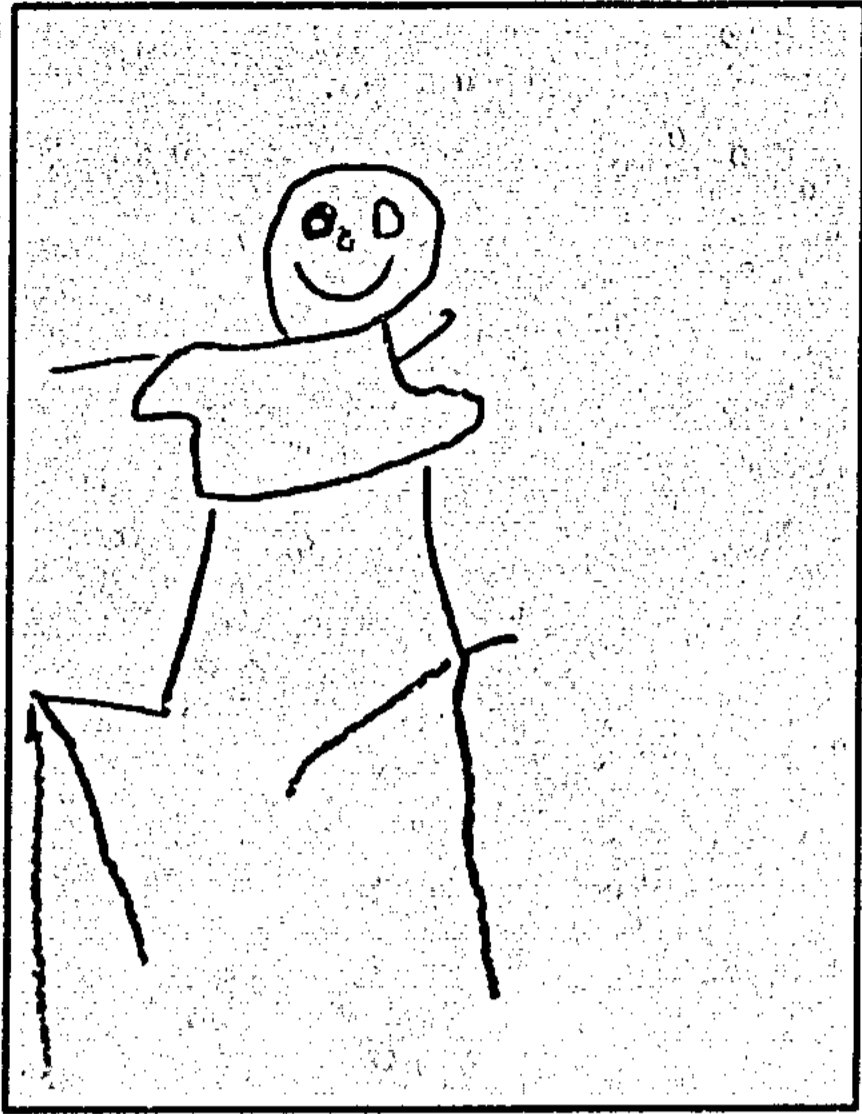
It is now possible to conclude in answer to research question three, that the students in the *Primary Movement* group were the only ones to improve significantly in the total impairment score of the M-ABC. While scores for both the free play and the gross motor groups increased between pre and posttest (indicating a decrease in ability), scores for the students in the *Primary Movement* group remained at the pretest level.

Of particular interest was the significant improvement in the manual dexterity sub-test by only the children in the *Primary Movement* group. In the ball skills subtest, students in the *Primary Movement* group maintained their level of ball skills throughout the test period while students in the gross motor and free play groups decreased in performance.

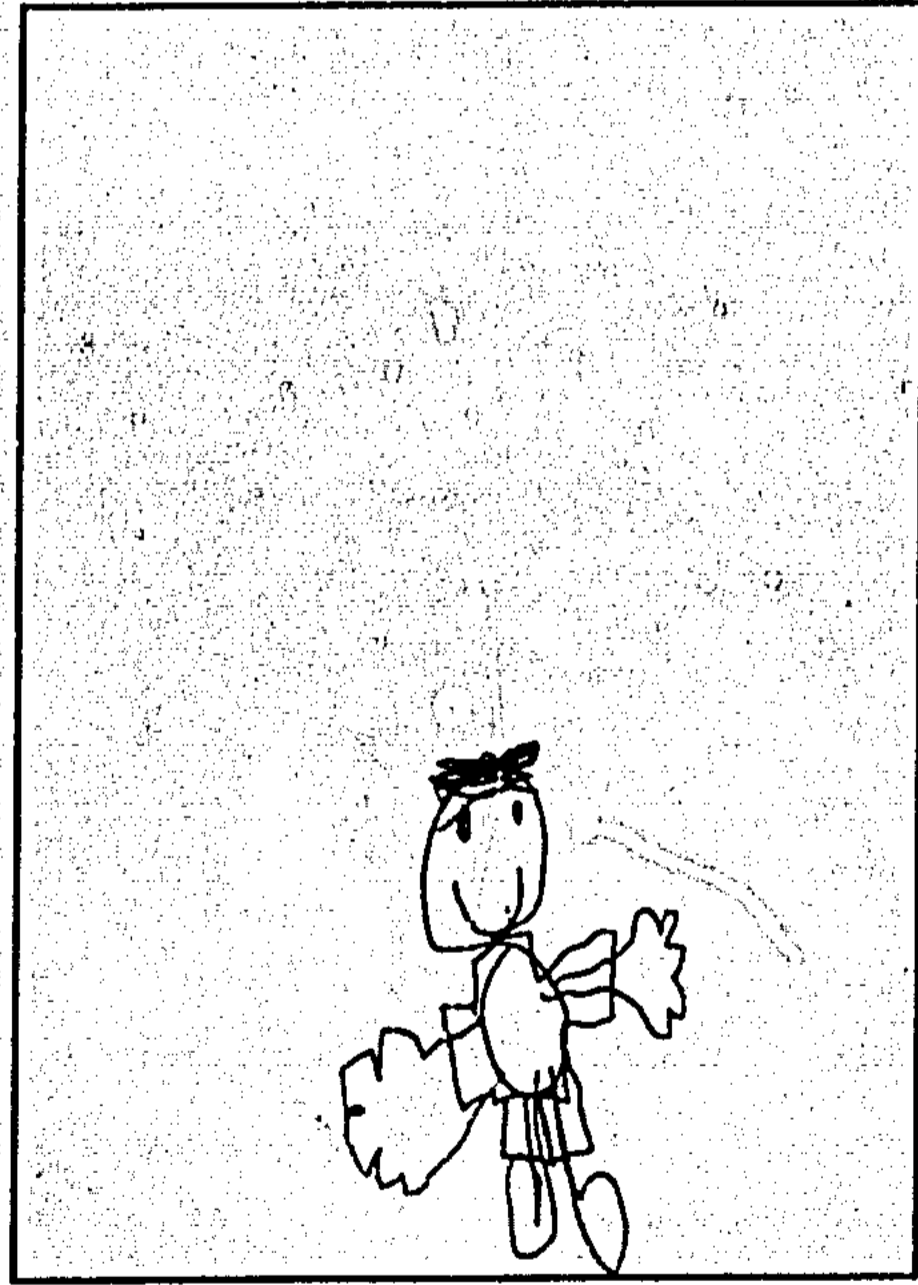
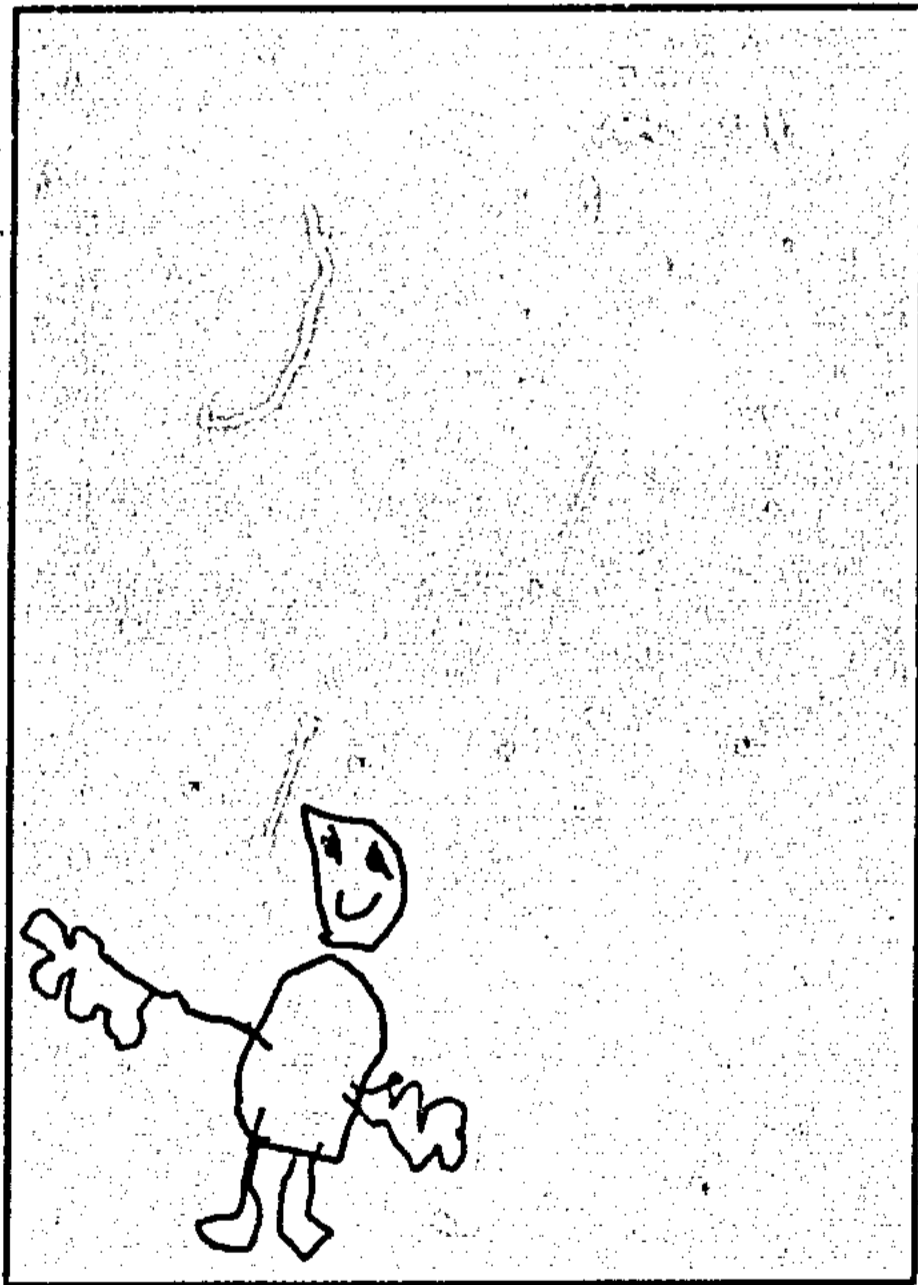
Finally, while all students improved significantly according to parents' perceptions of motor skills using the M-ABC checklist, an analysis of z scores indicates that the students in the *Primary Movement* group demonstrated a higher level of improvement than the other two groups. However, the results of the checklist need to be viewed with caution giving consideration to the possibility of influence of both placebo and 'Hawthorne Effects' on parent's perception.

#### **4.6 Research Question 4: Does participation in the *Primary Movement* program have an effect on individual figure drawing?**

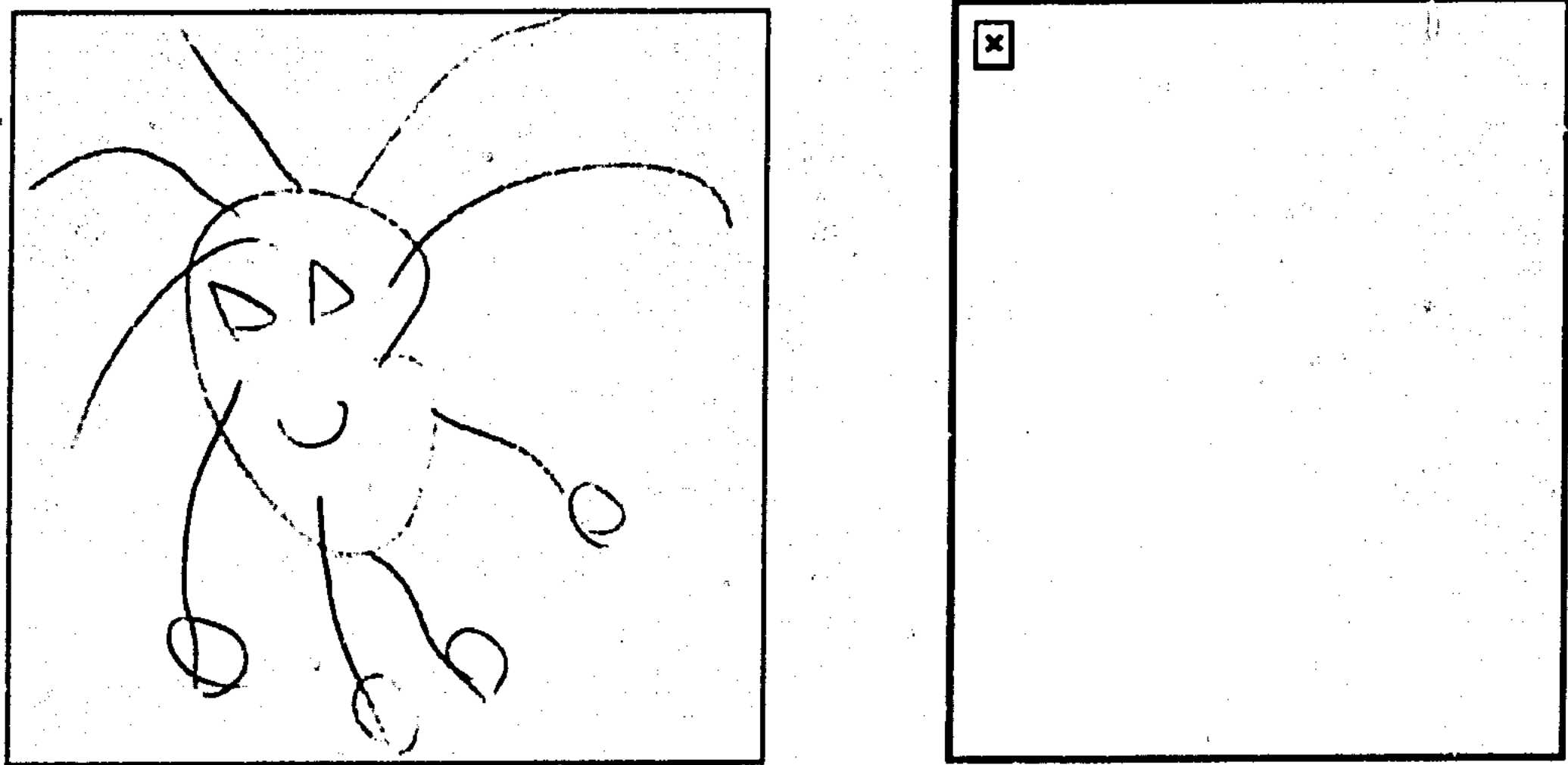
Below are the human figure drawings of the three individual student studies. In each individual case the three children present with an ATNR in the moderate to high range at pretest stage (4-6). The child with the highest level of pretest ATNR (6) was 'Jon'. In his drawings (Fig. 8) he has omitted the body at both pretest and posttest (ATNR score 4). Similarly 'Jed' (Fig. 9) has produced a pretest drawing (when ATNR was 4) that may be interpreted as grotesque with a misshapen body and legs drawn out of proportion.



**Figure 7.** Individual sample 'Jed' (*Primary Movement*) self portrait at pretest (left) and posttest (right).



**Figure 8.** Individual sample 'Jack' (*Gross Motor*) self portrait at pretest (left) and posttest (right).



*Figure 9.* Individual sample 'Jon (Free Play) self portrait at pretest (left) and posttest (right).

**4.7 Research Question 5: Does participation in the *Primary Movement* program have an effect on receptive vocabulary ability in the sample of preprimary children?**

Receptive vocabulary ability was tested using the *Peabody Picture Vocabulary Test* (Dunn & Dunn, 1997). As this test is standardised, a repeated measures ANOVA was performed on the standardised score based on overall performance for the three intervention groups with test time as the repeated measure. There was a main effect of time ( $F(1,188) = 21.595, P < 0.001$ ) but not of treatment ( $F(2,188) = 0.746, P = 0.476$ ) or interaction between time and treatment ( $F(2,188) = 0.365, P = 0.694$ ). This demonstrates that all groups increased standardised scores over time and that there were no significant differences between treatment groups (Fig. 10).

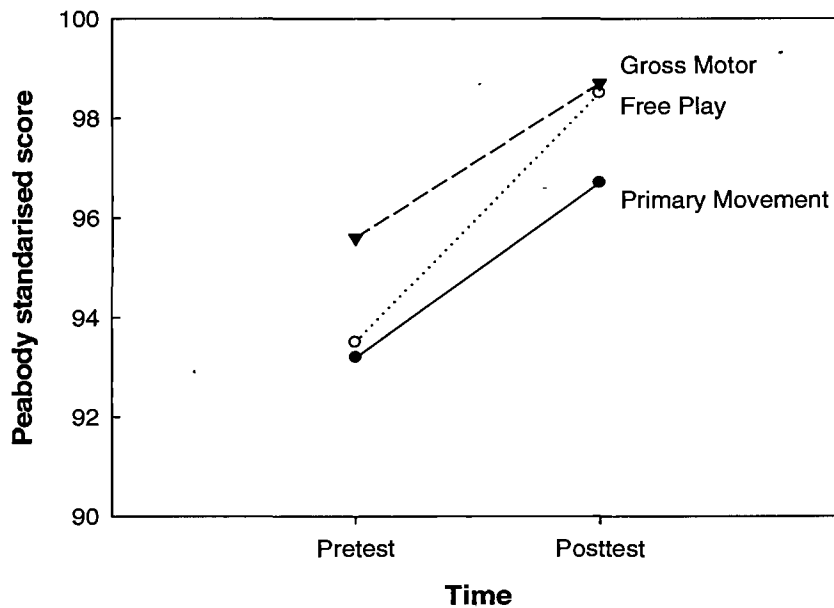
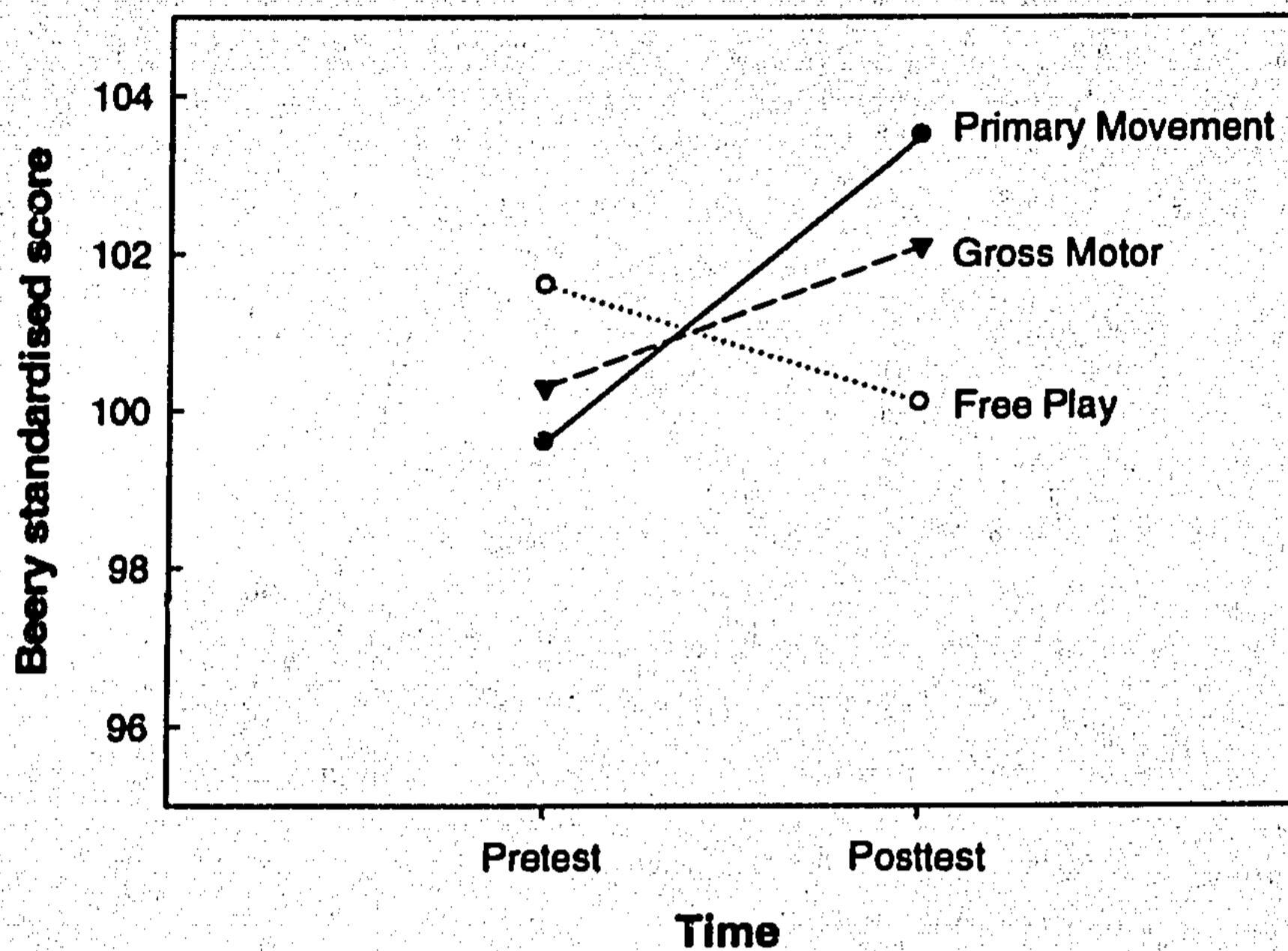


Figure 10. Effect of three movement interventions on mean standardised Peabody Picture Vocabulary Test Scores at two test periods

It is now possible to conclude that participation in the *Primary Movement* program does not have an effect on receptive language skills in the sample of preprimary children.

#### 4.8 Research Question 6: Does participation in the *Primary Movement* program have an effect on visual motor ability in the sample of preprimary children?

Visual motor ability was tested using the *VMI Developmental Test of Visual Motor Integration* (Beery, 1989). Mean standardised data were analysed using a one-way ANOVA at pretest and posttest. A repeated measures ANOVA was performed on the pre and posttest standardised scores on the Beery VMI with test time as the repeated measure. There were no significant main effects but there was, however, a significant interaction between time and treatment ( $F(2,192) = 3.194, p = 0.043$ ). Post hoc analyses revealed that there was a significant difference between the *Primary Movement* group and the gross motor group ( $p = 0.044$ ) (Fig. 11).



*Figure 11.* Effect of three movement interventions on mean standardised visual motor scores at two test periods.

It is now possible to conclude that participation in the *Primary Movement* program did have an effect on visual motor ability in the sample of preprimary children however this was not significant in comparison to the other two groups. While the gross motor group also showed an effect on visual motor ability, the *Primary Movement* group was significantly better than this group at posttest.

**4.9 Research Question 7: Does participation in the *Primary Movement* program have an effect on the development of rapid naming ability in the sample of preprimary children?**

The Rapid Naming Test is a sub-test of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) in which students are required to rapidly name a series of pictured objects. For the purposes of this study a lower score (<5) indicates a faster rapid naming time. Table 19 shows the comparisons for each intervention group in terms of the percentage of students above and below the median score at pretest.

**Table 19**

*Percentage of students above and below median DEST Rapid Naming sub-test score at pretest for three groups*

	<i>Primary Movement</i> Pre (n=77)	Gross motor Pre (n=64)	Free play Pre (n=54)
<b>Median</b>	3	3	3
Scores above median	31	23	35
Scores below median	69	77	65

For each of the treatment groups, a Wilcoxon Signed Ranks Test was performed on pre and posttest scores. A significant difference was found only for the *Primary Movement* group. In the *Primary Movement* group, the mean rank decreased from 19 to 18 ( $p = 0.018$ ). There were no significant improvements for the other 2 intervention groups (Table 20).

**Table 20**

*Comparison of Pre and Posttest DEST Rapid Naming Sub-test Results for the Primary Movement, Gross motor and Free play groups using the Wilcoxon Signed Ranks Test*

Treatment		n	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
<i>Primary Movement</i>	Negative Ranks	26	19.21	499.50	0.018
	Positive Ranks	11	18.50	203.50	
	Ties	40			
	Total	77			
Gross motor	Negative Ranks	14	20.68	289.50	0.132
	Positive Ranks	25	19.62	490.50	
	Ties	25			
	Total	64			
Free play	Negative Ranks	13	15.65	203.50	0.507
	Positive Ranks	17	15.38	261.50	
	Ties	24			
	Total	54			

#### **4.10 Results of individual student studies**

Individual students were selected on the basis of meeting the criteria of having a significant level of retained ATNR and/or achieving a low result in the M-ABC test. Three children with similar ages of the same gender were chosen at random for case studies from the pre primary cohort, one from each intervention group. These children were assigned the pseudonyms Jed (*Primary Movement* group), Jack (Gross Motor group) and Jon (Free Play group). The results of each individual case at pretest and posttest are presented in this section in order to demonstrate the changes in performance in motor skills, visual motor ability, receptive language and rapid naming on an individual from each of the three groups.

##### **4.10.1 Individual student study one 'Jed': *Primary Movement* program**

A single student from one of the schools involved in the research, in his first term of Preprimary was given the pseudonym 'Jed'. Jed was assessed for presence and severity of ATNR using the Schilder Test, for motor skills using a standardised motor skills test Movement Assessment Battery for Children (Henderson & Sugden, 1992), for receptive vocabulary the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) and the Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) in the first weeks of the school term (February) 2005. Jed's teacher was given a copy of The VMI Developmental Test of Visual Motor Integration (Beery, 1989) along with the instructions for completing the test with Jed. This was completed in the first week of school in class time at pretest in February 2005 and at posttest during November 2005. Jed participated in the *Primary Movement* intervention with the rest of his class over the eight-month period. The pretest and posttest results for Jed are shown in Table 21.

When first tested for the presence of the ATNR, Jed recorded a score of 4 (2 on the left and 2 on the right) that indicates a movement of the arms or marked dropping of the arms of up to 45 degrees as the head is turned to each side. Jed participated in the *Primary Movement* program with his classmates over the eight-month period. At the conclusion of the intervention period, Jed recorded an ATNR of 0 indicative of no response in the arms when head is turned to the side and therefore no indication of the ATNR reflex.



Jed improved in all areas of the M-ABC (Henderson & Sugden, 1992), manual dexterity (impairment score down from 6.5 to 4), ball skills (impairment score down from 5 to 2) and static/dynamic balance (impairment score down from 2 to 0). This overall improvement in scores improved his percentile norm for total impairment score by age in years, from a percentile equivalent of 9 to a percentile equivalent of 36 and increased his standardised score from 80 to 95.

In the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) initially completed when Jed was 5 years 3 months (63 months), he scored a raw score of 61 which equated to a standardised score of 95 and an age equivalent of 4 years 9 months (57 months). After eight months participating in the *Primary Movement* program, Jed at retest and aged 6 years (72 months) achieved a total raw score of 80, which equated to a standardised score of 100 and an age equivalent of 6 years 1 month (73 months).

Jed at pretest in The VMI Developmental Test of Visual Motor Integration (Beery, 1989) gained a raw score of 7 equating to a standardised score of 92 and an age equivalent of 4 years 10 months (58 months). After eight months participating in the *Primary Movement* program, Jed scored a raw score of 9 that equated to a standardised score of 86 and an age equivalent of 5 years 2 months (62 months).

The Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) was administered to Jed in February, 2005. This is a timed test requiring the child to name a series of familiar pictures as quickly as possible. Scores (in seconds) equate to an allocation of scores between 1 and 5 related to performance and age. Errors attract a 5 second penalty. In pretest Jed scored a time of 68 seconds and gained an extra 15 seconds for 3 errors giving a total time of 83 seconds. Based on his age of 5 years 3 months this equaled a score of 4 (Below average bottom 10-25 percent). At posttest Jed scored a time of 45 seconds with no additional time for errors. Based on his age of 6 years this equaled a score of 3 (average 26-75 percent).

Table 21

*Pretest and Posttest Performance of Jed (Primary Movement Intervention) on ATNR, M-ABC, Visual Motor and Rapid Naming Tests*

	Pretest (February)	Posttest (November)
Age (months)	63	72
ATNR	4	0
Manual dexterity (Impairment score)	6.5	4
Ball skills (Impairment score)	5	2
Static balance (Impairment score)	2	0
M-ABC total impairment score	13.5	6
M-ABC percentile	9	36
M-ABC Standardised score	80	95
Visual Motor Standardised score	92	91
Visual Motor age Equivalent score (months)	58	66
Peabody Vocabulary Standardised score	95	100
Peabody Vocabulary Age equivalent (months)	57	73
DEST Category Score	4	3
M-ABC Checklist Teacher	9	5
M-ABC Checklist 1 Parent	12	8
M-ABC Checklist 2 Parent	10	7

**4.10.2 Individual student study two 'Jack': gross motor group**

A single student from the gross motor group, in his first term of preprimary was given the pseudonym 'Jack'. Jack was assessed for presence and severity of ATNR using the Schilder Test, for motor skills using a standardised motor skills test Movement Assessment Battery for Children (Henderson & Sugden, 1992), for receptive vocabulary the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) and the Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) in the first weeks of the school term (February), 2005. Jed's teacher was given a copy of The VMI Developmental Test of Visual Motor Integration (Beery, 1989) along with the instructions for completing the test with Jack. This was completed in the first week of school for pretest (February), 2005 and during November 2005 for posttest, in class time. Jack participated in the gross motor intervention with the rest of his class over the period March 2005 to October 2005 inclusive. Table 22 shows the results of these tests in February and again in November.

When first tested for the presence of the ATNR, Jack recorded a score of 4 (2 on the left and 2 on the right), which indicates a movement of the arms, or marked dropping of the arms of up to 45 degrees as the head is turned to each side. Jack participated in the

gross motor program with his classmates over the eight-month period. At the conclusion of the intervention period, Jack recorded an ATNR of 2 (1 on the right and 1 on the left) indicative of a slight arm movement to the same side as the head is turned-up to 20 degrees therefore the ATNR reflex has reduced but not disappeared.

In some areas of the M-ABC (Henderson & Sugden, 1992), Jack's performance improved while in others performance levels decreased: manual dexterity (impairment score increased from 4 to 5), ball skills (impairment score increased from 0 to 2) and static/dynamic balance (impairment score decreased from 4 to 0). His percentile norm for total impairment score by age in years changed from a percentile equivalent of 22 to a percentile equivalent of 26 and increased his standardised score from 89 to 91.

In the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) initially completed when Jack was 4 years 10 months (58 months), Jack scored a raw score of 67 which equated to a standardised score of 101 and an age equivalent of 5 years 2 months (62 months). After eight months participating in the gross motor program, Jack aged 5 years 8 months (68 months) scored a total raw score of 91, which equated to a standardised score of 101 and an age equivalent of 6 years 10 months (82 months).

Jack at pretest in the VMI Developmental Test of Visual Motor Integration (Beery, 1989) gained a raw score of 8 equating to a standardised score of 107 and an age equivalent of 5 years 2 months (62 months). After eight months participating in the gross motor group, Jack scored a raw score of 14 that equated to a standardised score of 112 and an age equivalent of 6 years 8 months (80 months).

The Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) was administered to Jack in February, 2005. This is a timed test requiring the child to name a series of familiar pictures as quickly as possible. Scores (in seconds) equate to the following allocation of scores related to performance and age. Errors attract a 5 second penalty. In pretest Jack scored a time of 57 seconds and gained an extra 5 seconds for 1 error giving a total time of 62 seconds. Based on his age of 4 years 10 months this equaled a score of 3 (Average 26-75 percent). At posttest Jack scored a time of 44 seconds with no

additional time for errors. Based on his age of 5 years nine months this equaled a score of 3 (Average 26-75 percent).

**Table 22**

***Pretest and Posttest Performance of Jack (Gross motor Group) on ATNR, M-ABC, Visual Motor and DEST Rapid Naming Tests***

	Pretest (February)	Posttest (November)
Age (months)	59	68
ATNR	4	2
Manual dexterity (Impairment score)	4	5
Ball skills (Impairment score)	0	2
Static balance (Impairment score)	4	0
M-ABC total impairment score	8	7
M-ABC percentile	22	26
M-ABC Standardised score	89	91
Visual Motor Standardised score	107	112
Visual Motor age Equivalent score (months)	62	80
Peabody Vocabulary Standardised score	101	112
Peabody Vocabulary Age equivalent (months)	62	82
DEST Category Score	3	3
M-ABC Checklist Teacher	0	0
M-ABC Checklist 1 Parent	15	8
M-ABC Checklist 2 Parent	10	8

**4.10.3 Individual student study three 'Jon': free play group**

A single student from the free play group, in his first term of Preprimary was given the pseudonym 'Jon'. Jon was assessed for presence and severity of ATNR using the Schilder Test, for motor skills using a standardised motor skills test Movement Assessment Battery for Children (Henderson & Sugden, 1992), for receptive vocabulary, the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) and the Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) in the first weeks of the school term (February), 2005. Jon's teacher was given a copy of The VMI Developmental Test of Visual Motor Integration (Beery, 1989) along with the instructions for completing the test with Jon. This was completed in the first week of school for pretest (February), 2005 and during November 2005 for posttest, in class time. Jon participated in the free play intervention with the rest of his class over the eight-month period. Table 23 shows the results of these tests at pretest in February and at posttest in November.

When first tested for the presence of the ATNR, Jon recorded a score of 6 (3 on the left and 3 on the right) that indicates arm movement of greater than or equal to 45 degrees to

the side or down, swaying or loss of balance as the head is turned to each side. Jon participated in the free play group with his classmates over the eight-month period. At the conclusion of the intervention period, Jon recorded an ATNR of 4 (2 on the left and 2 on the right) indicative of movement of the arms or marked dropping of the arms as the head is turned.

Jon's impairment score only decreased for one sub-test in the M-ABC (Henderson & Sugden, 1992) manual dexterity (impairment score increased from 8.5 to 11), ball skills (impairment score increased from 2 to 6) and static/dynamic balance (impairment score decreased from 12 to 3.5). His percentile norm for total impairment score by age in years did not change from a percentile equivalent of 3 to a percentile equivalent of 3 and his standardised score decreased from 112 to 103.

In the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) initially completed when Jon was 4 years 9 months (57 months), Jon scored a raw score of 25 which equated to a standardised score of 69 and an age equivalent of 1 year 11 months (23 months). After eight months participating in the free play program, Jon aged 5 years 6 months (66 months) scored a total raw score of 45, which equated to a standardised score of 75 and an age equivalent of 3 years 7 months (43 months).

Jon at pretest in The VMI Developmental Test of Visual Motor Integration (Beery, 1989) achieved a raw score of 9 equating to a standardised score of 112 and an age equivalent of 5 years 6 months (66 months). After eight months participating in the gross motor program, Jon achieved a raw score of 10 that equated to a standardised score of 103 and an age equivalent of 5 years 10 months (70 months).

The Rapid Naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) was administered to Jon in February, 2005. This is a timed test requiring the child to name a series of familiar pictures as quickly as possible. Scores (in seconds) equate to an allocation of scores between 1 and 5 related to performance and age. Errors attract a 5 second penalty. In pretest Jon scored a time of 89 seconds and gained an extra 35 seconds for 7 errors giving a total time of 124 seconds. Based on his age of 4 years 9 months this equaled a score of 5 (Well below average, bottom 10 percent, strongly at risk). At posttest

Jon scored a time of 69 seconds with 5 seconds additional time for one error, a total of 74 seconds. Based on his age of 5 years 6 months this equaled a score of 4 (Below average, bottom 10-25 percent).

Table 23

*Pretest and Posttest Performance of 'Jon' (Free play Group) on ATNR, M-ABC, Visual Motor and DEST Rapid Naming Tests*

	Pretest (February)	Posttest (November)
Age (months)	57	66
ATNR	6	4
Manual dexterity (Impairment score)	8.5	11
Ball skills (Impairment score)	2	6
Static balance (Impairment score)	12	3.5
M-ABC total impairment score	22.5	20.5
M-ABC percentile	3	3
M-ABC Standardised score	72	72
Visual Motor Standardised score	112	103
Visual Motor age Equivalent score (months)	66	70
Peabody Vocabulary Standardised score	69	75
Peabody Vocabulary Age equivalent (months)	23	43
DEST Category Score	5	4
M-ABC Checklist Teacher	7	4
M-ABC Checklist 1 Parent	6	2
M-ABC Checklist 2 Parent	5	3

The student in the *Primary Movement* group (Jed) was the only student to display an absence of the ATNR at posttest while students from the gross motor and fine motor groups still displayed evidence of mild ATNR at posttest. The student in the *Primary Movement* group more than halved his total M-ABC impairment score while students in the other two groups showed only a small reduction in impairment score.

The students in the gross motor and the free play groups increased their impairment score (decreased performance) in the M-ABC manual dexterity sub-test. The student in the *Primary Movement* group was the only student to show a decreased impairment score (increased performance) in this sub-test. The individual student results of the receptive vocabulary and visual motor tests were typical of the main intervention study with all three students showing improvement. In the rapid naming test, all students showed improvement with the students in the *Primary Movement* and fine motor group moving up in classification.

In conclusion, the results of the individual student studies are typical of those in the main intervention study.

#### **4.11 Answers to the research questions based on results analysis**

The results of data analyses make it possible to answer the research questions posed in the beginning of this research. Discussion of these answers providing a conclusion to this thesis will then follow in the final chapter.

##### **1. What is the prevalence and severity of the ATNR reflex in the sample of preprimary children?**

Approximately one third, (30 percent) of the 195 students, presented without any observable sign of ATNR at pretest. Seventy percent of the cohort presented with an ATNR which was scored between one and six with scores of one to two classed as mild (56 percent), three to four as moderate (12 percent) and five to six as high (2 percent). On the basis of these results, the number of children who possess signs of a retained reflex at a considerable level (moderate to high) is around 14 percent of the research population.

##### **2. Does participation in the *Primary Movement* program have an effect on the inhibition of the ATNR in those that present with ATNR in the sample population?**

The *Primary Movement* program was the only intervention that resulted in a significant reduction in the persistence of the ATNR (Table 7).

##### **3. Does participation in the *Primary Movement* program have an effect on the development of motor abilities in the sample of preprimary children?**

Children in the *Primary Movement* group made significant gains in standardised scores on the M-ABC relative to the gross motor group and were in advance of the free play

group at the end of the intervention period (see Figure 3). Furthermore, in the M-ABC sub-tests, children in the *Primary Movement* group made significant gains relative to the gross motor group on the manual dexterity subscale and were in advance of the free play group at the end of the intervention period. The manual dexterity impairment scores of children participating in both the gross motor and free play intervention groups did not improve over the intervention period whereas the *Primary Movement* group showed a significant improvement.

There was also evidence that in the ball skills sub-tests, the ball skills of the *Primary Movement* group were significantly better than the gross motor group and almost significantly better than the free play group in pre- and posttest comparisons. There was, however, no evidence of a differential effect in the sub-tests measuring balance, with all three groups making similar progress (Table 15).

Based on these results, participation in the primary Movement program had an effect on the motor skills of the children in this sample. Children in the *Primary Movement* group showed a significant improvement in impairment scores on the M-ABC test compared to the other groups. The *Primary Movement* group was the only group to show significant improvement in the M-ABC sub-test Manual Dexterity.

In the M-ABC Parent checklists (Sections 1 and 4), all groups showed improvement however, students in the *Primary Movement* group demonstrated a statistically higher level of improvement than the other two groups. In the M-ABC Teacher checklist (Section 5), students in the *Primary Movement* group demonstrated a statistically higher level of improvement than the other two groups.

### **3 (a) Does participation in the Primary Movement program have an effect on the number of children classified as having DCD based on M-ABC results?**

The *Primary Movement* group had more children in the lowest percentile range ( $\leq 5$  percent) at pretest and that it was the only group to show a decrease in the number of children in this category at posttest (Table 9). Children in the bottom 5 percentiles on the M-ABC are considered to be at serious risk of significant motor difficulties



(Developmental Coordination Disorder) and are particularly difficult to remediate (Henderson & Sugden, 1992). The fact that so many children moved out of this percentile range after participating in the *Primary Movement* program indicates the efficacy of this particular program in remediating children with attributes of DCD. The lower number of children in the bottom (5th percentile) range in the free play group (5 percent), in comparison to the *Primary Movement* (10 percent) and gross motor (8 percent) groups may have given the free play group an overall advantage. This may explain the relatively poorer performance of the gross motor group in relation to the free play group although the apparent differences on some of the M-ABC scores were not significant.

Based on these results, participation in the *Primary Movement* program has an effect of the number of children classified as having DCD based on M-ABC results. The *Primary Movement* group was the *only* group to show a *decrease* in the number of children considered to have DCD based on M-ABC results at posttest.

#### **4. Does participation in the *Primary Movement* program have an effect on the drawing of an individual's self portrait?**

Vane and Kessler in (1964) identified that there were four indicators in children's drawings that were considered to be 'indicative of maladjustment'. These four indicators are no body, no arms, no mouth and grotesque features (p. 488).

Jon's drawings (free play group) (Fig. 7) demonstrate that he has omitted the body in pretest and this has repeated at posttest. There are some observable changes between his self portraits at pre and posttest in terms of body features. There appears to be an improvement in perception of proportion and manual dexterity. The figure has become smaller with attention to eye detail and positioning of limbs.

Jack (gross motor group) has produced a similar self portrait at pre test and posttest with minimal differences between pre and posttest (Fig. 6).

Jed (*Primary Movement* group) at pretest (Fig. 5) has produced a pretest drawing that may be interpreted as grotesque with a misshapen body and legs drawn out of proportion.

A comparison of Jed's (*Primary Movement* group) human figure drawing at pretest and posttest indicates that his self portrait became much better proportionally and more sophisticated with the addition of fingers and hair. There appears to be evidence of improved manual dexterity demonstrated by the detail exhibited in the smaller figure.

In answer to the research question, participation in the *Primary Movement* program has had some effect on the drawing of an individuals' self portrait.

**5. Does participation in the *Primary Movement* program have an effect on the receptive vocabulary skills in the sample of preprimary children?**

Although all three groups improved significantly on the vocabulary measure over the course of the study, there was no evidence of a differential improvement for any of the three groups. This suggests that all of the children received the same educational input over the course of the study and that the significant reflex and motor improvements of the reflex replication group were due to the intervention and not other language related factors.

In answer to the research question, there is no evidence that any of the interventions including *Primary Movement* had any direct effect on receptive vocabulary.

The results of the individual student studies were typical of the main intervention study.

**6. Does participation in the *Primary Movement* program have an effect on visual motor integration in the sample of preprimary children?**

There were no significant differences between the three groups at posttest in standardised visual motor scores however there was a significant difference between the *Primary Movement* group and the gross motor group with the *Primary Movement* group achieving higher standardised scores than the gross motor group.

The results of the individual student studies showed improvements in standardised visual motor score for the student in the Primary Movement group and for the student in the gross motor group and a decrease in standardised score for the student in the free play group.

**7. Does participation in the *Primary Movement* program have an effect on rapid naming ability in the sample of preprimary children?**

The *Primary Movement* intervention was the only program to have a significant influence on rapid naming ability (Table 19).

In the individual student studies, all students improved in rapid naming ability.

In conclusion it can be stated that, those students who participated in the *Primary Movement* program:

- Demonstrated significantly inhibited levels of ATNR
- Demonstrated significantly improved performance in overall motor skills (M-ABC)
- Demonstrated a significant improvement in manual dexterity (M-ABC sub-test)
- Demonstrated statistically higher levels of improvement in both the M-ABC Parent as well as Teacher checklists
- Demonstrated a significant improvement in rapid naming scores.

These results are based on comparison to the gross motor and free play groups in this sample of children.

## CHAPTER 5

### CONCLUSION TO THESIS

The main focus of this research was to investigate the relationship between retained primary reflexes and development in children of preprimary age. A significant emphasis was placed on the relationship between the Asymmetrical Tonic Neck Reflex (ATNR) and motor development and the relationship between ATNR and vocabulary and visual-motor development. This thesis also focused on the efficacy of the *Primary Movement* program in reducing ATNR levels and on improving performance in the physical and cognitive domains of preprimary aged children.

This chapter includes both discussion of the results of this research and a conclusion based on these findings.

#### **5.1 Evidence of prevalence and severity of ATNR reflex in the sample of preprimary children in Perth, Western Australia**

There is a paucity of research findings based on the prevalence and severity of the ATNR in preprimary children. An extensive review of the literature was undertaken and although there is acknowledgment that retained reflexes can be elicited in this age group (Morrison, 1985, p.107), limited scientific data is available. Fylan and Grunfel (2004, p.101) found that 35 percent of a total of 674 year two and year five children (aged five years to nine years) from schools in Northern Ireland, displayed evidence of retained reflexes. These children were tested using a series of eight neurological tests to identify abnormally retained reflexes, including a test for ATNR.

The results of this research to determine the prevalence of just one retained reflex, the ATNR, in preprimary aged children indicated that 14 percent of the 195 children who took part in the research presented with an ATNR score greater than three which for the purpose of this study indicates a score above what is considered to be mild. According to McPhillips, Hepper and Mulhern (2000), the level of ATNR identified by using the Schilder neurological test as was done in this research, gives a good overall picture of total reflex persistence and, although behavioural in nature, the described method of testing in

the standing position, is acceptable in clinical contexts (Morrison, 1985). It is surmised that if it had been practicable to perform a more extensive series of neurological tests in the present research, as described by Fylan and Grunfel (2004) in their research, this percentage may well have been comparable.

It should be considered that there are close links between the inhibition of primary reflexes and the reaching of motor milestones. Abnormalities with regard to the persistence of these primary reflexes, may lead to issues in the development of motor functioning. This indicates that there is a significant need for early intervention for those children displaying evidence of reflex retainment.

The persistence of the ATNR may be used as a clinical indicator of developmental delay and research suggests that the higher levels of persistence of the ATNR in boys "may place them at risk of potential difficulties relative to girls" (Jordan-Black, 2005 p.109) and there is considerable evidence of boys being more 'at risk' than girls in terms of a range of developmental problems (Frith, 2003). This relationship between retained ATNR and signs of Central Nervous System pathology is strengthened by the observation reported by Gesell (1940), that normal infants of four weeks display the ATNR spontaneously but by twenty weeks the reflex is difficult to elicit. This suggests that the ATNR is a normal occurrence during infancy however "persistence, or recurrence, in later development is indicative of retardation, and/or a prognostic indicator of future problems in motor development" (Morrison, 1985, p.50).

This understanding is vital to the relevance of this study in that it is assumed that children who demonstrate evidence of retainment of the ATNR, beyond the window of acceptable disappearance, are at risk of compromised motor development at a later stage. By screening children at a pre school age for the ATNR reflex which by all means should have disappeared, it becomes possible to identify students who may be at risk.

Morrison (1985) suggests that the persistence of the tonic neck reflexes "contributes to the development of learning failure as a result of related problems in attention and automatised perceptual processing skills" (p. 61). An example of this is the development of body image that occurs with the retainment of ATNR. In the postnatal period, a child will

automatically assume the “fencer position” in the prone position when the head is rotated and the child’s attention will be drawn to the hand on that side. As this reflex becomes inhibited, the child’s exploratory approach becomes symmetrical and objects can be brought to midline. According to Sherick, Greeniman and Legg (1976) this ability to explore across the midline stimulates the development of sensorimotor intelligence and contributes to body image and self observation. Therefore, a child who retains the ATNR reflex will not have this experience to the same degree as a normally developing child and according to Morrison (1985) “will demonstrate basic and chronic information processing failure seen as catching a ball at midline, inadequate visual motor coordination, as well as other problems related to midline development and body image” (p. 62).

In each of the three individual student studies, the three children present with an ATNR in the moderate to high range at pretest. It is proposed by Sherick, Geeniman and Legg (1976) that an inability to cross the midline restricts the development of body image and self observation and hence the representation of the body in self portraits. It is proposed that the retained ATNR present in all three individual students at pretest may have contributed to the deficiencies in self portraits at pretest particularly in the case of Jed and Jon (Figs. 5 and 7). Although interpretations of these drawings are quite subjective, the effect of the ATNR and issues with body image should not be overlooked, as they may be indicative of the types of conceptual issues described by Sherick, Geeniman and Legg (1976).

These pictorial indicators may offer some early insight into the possibility of issues in later years as a study by Woodard & Surburg (1999) found that children with Learning Disabilities are far more likely to display difficulties in crossing the midline with both upper and lower extremities “hindering motor learning skill and performance”(p.164). this is supported by research by Vane and Kessler (1964) who state that 42 percent of the children who had any of the four signs described previously in their kindergarten drawings, had been rated as ‘poor’ by their third grade teachers and in addition 71 percent of the children who had shown these signs in the kindergarten drawings were achieving below third grade level (p. 488). According to Pollak (1986), the figure drawings of children with Learning Disabilities may reflect a distorted or faulty body image attributed to weaknesses in visual perceptual and or visual motor integrative skills (p. 176). Although research in

this area has “significant methodological shortcomings”, Pollak (1986) insists that figure drawings remain a popular child assessment tool despite continued controversy over their clinical use.

Another consideration in terms of the prevalence and severity of the ATNR reflex in this sample of preprimary children is that the results of this current research replicate the findings of Morrison (1985), Woodard, and Surburg (1999) in indicating that children with evidence of a retained ATNR, have more difficulty with fine motor tasks especially those which require crossing of the midline, for example coin posting. In this current research, scores on manual dexterity tasks improved significantly at posttest for the *Primary Movement* group which corresponded to a significant decrease in the level of ATNR for this group.

In conclusion, the results of this research indicate that a retained ATNR is present at a moderate to high severity in a considerable number of children (14 percent of this population). A higher percentage of males were found to have the highest retainment of ATNR. Therefore, it is proposed that the retention of primary reflexes should be considered as a possible retardant of normal development and every effort should be made to assess children for the retention of particularly the ATNR at an early stage of schooling. Indicators such as limitations in motor functioning according to motor milestones especially in fine motor activities and age inappropriate figure drawing in the early years should not be dismissed as something that the child will ‘grow out of’ as without appropriate early intervention, a child’s ability to function in a school environment now, and in the future may be compromised. This is supported by McPhillips and Jordan-Black (2007) who concluded that ATNR persistence is a more powerful predictor of reading skills than motor skills (as measured by the M-ABC) in eight year old children.

## **5.2 Evidence of the influence of the *Primary Movement* program on the ATNR.**

The understanding underpinning this research question is the premise in accordance with the theoretical framework, that there is a need to ‘switch off’ or integrate primary reflexes into higher order reflexive behaviour to enable the development of uncompromised motor coordination. The *Primary Movement* program involves a series of

movements designed to replicate primary reflex patterns. In replicating these patterns it is suggested that primary reflexes, particularly the ATNR will diminish allowing higher brain structures to become more dominant. Thus, the rehearsal and repetition of primary reflex movements, as done by the foetus and the neonate, may have a part in the inhibition process.

In the main intervention study, the median intervention score for the *Primary Movement* group decreased from one to zero. The *Primary Movement* group was the only group to display a significant level of reduction in the ATNR. There were no significant improvements indicated by a reduction in ATNR scores in the other two groups who maintained the median score of one at the end of the intervention period. This replicates the findings of McPhillips, Hepper and Mulhern (2000) and Jordan-Black (2005). However, in both of these previous studies, the results were based on children aged between seven and eleven years. The results of the present study confirm the effectiveness of reflex replication in reducing the prevalence of the ATNR in younger children, and suggest that specific movements, based on replicating the primary reflex movement, are particularly powerful in reducing primary reflex persistence.

It is unknown whether inhibition of primary reflexes is solely a maturational process or whether external behavioural factors may contribute to or interact with the process of inhibition. However, this study eliminates the effect of short term maturation on the ATNR by having all children experiencing the interventions in the same eight month time frame.

It is generally assumed that the inhibition process occurs in the earliest months of life and not after early childhood (McPhillips, Hepper, & Mulhern, 2000). What is known is that failure to adequately inhibit tonic neck reflexes, for example the ATNR, may affect not only the coordination of movements of the head neck and arms but also vestibular function through the ocular motor system (Morrison, 1985). While severe persistence of the primary reflexes may be indicative of severe "predominantly intractable organic problems as seen in children with cerebral palsy", milder persistence may be associated with less severe disorders particularly in cognitive areas (McPhillips, Hepper, & Mulhern, 2000 p.538). According to Henderson, French and McCarty (1993), retention of the ATNR



reflex even at low levels of severity can contribute to or interfere with movement efficiency contributing to failure when participating in Physical Education activities.

It needs to be stated however, that the implication that the interpretation of the occurrence of the ATNR after the first year of life as possible neuropathology, needs to be treated with caution. According to Morrison (1985), the concurrent validity of interpreting the ATNR as a sign of Central Nervous System dysfunction is questioned by research that demonstrates that the reflex can also be elicited in children who have no academic problems.

The three individual student studies all displayed an ATNR score of four or more indicative of scores in the moderate to high range. After eight months participating in *Primary Movement* program, 'Jed' displayed a decrease in ATNR severity, scoring four in February and zero in November. The two other children, 'Jack' who participated in the gross motor program and 'Jon' who participated in the free play program, also displayed a decrease in ATNR severity scoring four in February and two in November and six in February and four in November respectively. It is suggested that the *Primary Movement* program was influential in the reduction of ATNR in Jed to undetectable levels using the Schilder Test. While the other two children did display a decrease in ATNR, the ATNR was still present to a certain degree as evidenced in posttest results.

### **5.3 Evidence of the effect of the *Primary Movement* program on the development of motor skills**

The results of the intervention study showed that children who participated in the *Primary Movement* program in this study were the only cohort to show statistically significant overall improvement in the Movement Assessment Battery for Children (M-ABC) (Henderson, 1992). In the M-ABC sub-test of manual dexterity, children in the *Primary Movement* group were the only group to improve statistically significantly. Importantly, the manual dexterity scores of children participating in the gross motor intervention actually increased indicating a decrease in manual dexterity over the intervention period.

These results are very important, as it has been suggested that there is a link between such skills, as measured in the manual dexterity subscale, especially the 'tracing activity', and early writing and possibly reading skills. Iversen, Berg, Ellertsen and Tønnessen (2005) assessed children, who were poor readers, on the M-ABC and reported that this group performed poorly on the manual dexterity tasks. The authors stated, "...all children with reading difficulties should be screened for possible motor difficulties" (p.217) and concluded that:

If motor problems are detected at an early age, teachers and other professional should be prepared for the possibility of the gradual occurrence of other developmental difficulties as well (p. 228).

An analysis of the handwriting of 125 children in year four and five in the Netherlands carried out by Smits-Englesman, Niemeijer and Van Galen (2001) led to the conclusion by the authors that poor handwriting was part of a wider neuromotor condition linked to, amongst other factors, poor coordination of fine motor skills. The study concluded that serious handwriting problems are accompanied by fine motor deficits and it is suggested that this may be due to an enhanced level of neuromotor noise causing a stiffening of the limb system.

It is postulated that the results of research associated with this thesis, indicate that retained ATNR may be a contributing factor to neuromotor noise for many children. This hypothesis is based on the suggestion made by Morrison (1995) that a child with neurobehavioral dysfunction associated with retained tonic neck reflexes is likely to elicit inadequate visual-motor coordination and difficulties crossing the midline: both factors required in writing. This is evidenced by the improvement in tasks such as coin posting and bead threading at posttest when overall ATNR had reduced.

The cerebellum plays an important role in the vestibular system. The vestibular apparatus, which is the sensory organ of the vestibular system, consists of the semicircular canal and otoliths (utricle and saccule). This apparatus emerges in utero projecting to the brain stem and to the cerebellum. The vestibulocerebellum is the first cerebellar structure to differentiate in the human foetus and this structure receives vestibular and visual signals

which assist with body balance, posture and to control head-eye movements (McPhillips, 2001). The persistence of the ATNR past the first year of life is associated with sensory, motor and cognitive problems due to a compromise in the integrity of the developing Central Nervous System particularly affecting the vestibular system including the cerebellum (McPhillips, 2001). The importance of the role of the cerebellum must be considered further to that of being solely involved in motor tasks. There is also evidence of the importance of the cerebellum in language (Ackermann & Hertrich, 2000; H. C. Leiner, Leiner, & Dow, 1989) and in reading (Fulbright et al., 1999).

In this research, when the magnitude and occurrence of the ATNR decreased (as it did in the *Primary Movement* intervention group) there was a corresponding significant improvement in fine motor skill. In groups in which the ATNR remained constant (gross motor and free play) there was no such improvement, in fact, in the gross motor group, there was an increase in impairment scores for fine motor skill. It is therefore proposed that the improvement in motor skill, specifically in the area of fine motor occurring in the *Primary Movement* group, could be attributed to the reduction in the occurrence and magnitude of the retained ATNR. The “neuromotor noise” as described by Smits-Englesman, Niemeijer and Van Galen (2001) may be attributed to the retained ATNR compromising the stability of the developing central nervous system particularly the cerebellum. This is referred to by Morrison (1985) as “neurobehavioural dysfunction”.

The *Primary Movement* intervention was the only movement intervention in this study to significantly improve overall performance in the M-ABC. Motor difficulties at an early age, especially in the fine motor area, may be indicative of neurobehavioural dysfunction that without remediation may affect learning and cognitive pursuits as the child progresses in school. Studies by Silva and Ross (1980) and Losse et. al., (1991) amongst others, provided results demonstrating that motor problems in the preschool period were predictive of later school problems providing a strong argument for early intervention for these children.

The results in other motor skill sub-tests eye indicated that the ball skills of the *Primary Movement* intervention were significantly better than the gross motor group and almost significantly better than the free play group in pre and posttest comparisons. It may

be interesting to note that the reflex replication program did not involve any training of fine motor control or specific fine motor task-oriented activities. Similarly, the *Primary Movement* program did not include any activities that involved catching or throwing. This suggests that reducing ATNR persistence may lead to improved fine motor control and ball skills without task oriented training.

There was no evidence of a differential effect in the sub-tests measuring balance. All three intervention groups made similar progress. This result was surprising in that it was expected that balance would improve with the *Primary Movement* intervention. Geuze (2003) states with regard to static balance "children with a developmental coordination disorder often fail this item"(p. 527).

Possible explanations should be considered for the lack of significant improvement in balance, including the fact that the children participating in this research were tested on the first day of preprimary education and retested eight months later. During this period there is a significant amount of growth and development occurring for all children irrespective of intervention. Also, the M-ABC sub-test consists of three items requiring both dynamic balance and static balance: jumping over a cord, walking along a line with heels raised and a one-leg balance. It is suggested that the combination of these scores to give a total balance impairment score may mask poor performance specifically in the static balance item.

Two of the three case studies presented at pretest with quite significant movement difficulties as reflected in their scores in the Movement Assessment Battery for Children (Henderson, 1992). Jon's total impairment score of 22.5 (Table 5) which places him below the 5th percentile is of major concern as "scores below the 5th percentile should be considered as indicative of a definite motor problem"(Henderson & Sugden, 1992, p.108). At the end of the free play intervention period, there is no change in the percentile norm even though his total impairment score has decreased. This is due to the M-ABC being a standardised test and Jon having increased in age from 4.9 years to 5.6 years. Participation in the free play intervention had no impact on Jon's overall motor performance in fact performance in both manual dexterity and ball skills decreased.

Jack who participated in the gross motor intervention showed a slight improvement in total impairment score but a poorer score in manual dexterity although balance and ball skills improved.

Jed, the *Primary Movement* intervention participant, showed improvement in all areas manual dexterity, ball skills and balance and consequently his total impairment score (TIS) was reduced. Jed's pretest TIS placed him at the 9th percentile, which suggests 'a degree of difficulty that is 'borderline' (Henderson and Sugden, 1995 p. 108). After eight months of participation in the *Primary Movement* program, Jed's improved TIS placed him at the 36th percentile for his age, classified as 'adequate or better' by Henderson and Sugden (1995).

In conclusion, Jed, the child that participated in the *Primary Movement* intervention was the only child to significantly improve in motor skills over the eight month period, moving from an at risk category of motor performance to adequate or better. He was also the only child to improve in the area of manual dexterity.

### **5.3.1 Behavioural problems related to Motor Difficulties (Teacher Section 5 M-ABC Checklist)**

Teachers were required to complete this section of the M-ABC checklist which focuses on observed classroom behavior at pretest and at posttest for all children involved in this research. The results show that all intervention groups improved in terms of perceived motor skills and related behavior in the classroom. The *Primary Movement* group, although improving, did not show a significant improvement. The only group that showed a significant improvement was the gross motor group.

Although the use of a checklist is less objective than using a standardised motor test, checklists provide a relatively fast impression of a child's level of motor competence and in this case, teachers may be able to identify children with motor problems as they are able to observe them in both the classroom and in the playground (Jongmans, Smits-Engelsman, & Schoemaker, 2003). In this research, the teachers were only required to complete one section of the checklist which related to the classroom. The checklist is primarily designed

for use in its entirety by teachers and in this form “meets standards for reliability and most aspects of validity” (Jongmans, Srnits-Engelsman, & Schoemaker, 2003, p.426). The reason for presenting the checklist in this abbreviated form (only Section 5) is that being the first week of school and the teacher’s first contact with these particular children, it would be difficult for teachers to provide specific information regarding the children’s motoric abilities.

The information gained from the completion of only these 12 questions was extremely limited in terms of generalizing the findings to other populations and the degree of validity and reliability in using the checklist in this way would be contentious issues. Other factors such as teachers not really being familiar with the children’s abilities due to the checklist being conducted in the first week of school is also a factor that must be considered in the interpretation of these results. The ‘Hawthorne Effect’, that is the impact of the participants knowing that they are part of a research undertaking (F. Hill, Le Grange, & Newmark, 2003), must also be considered when interpreting the results of the teacher checklist.

In conclusion, the Teacher Checklist, in the abbreviated format in which it was used in this research, is not a valid and reliable source of information regarding the children’s motor behaviour in the classroom however, the information remains useful in the case studies where attention can be paid to the skills of each individual to determine the effect of each intervention on specific skills.

### **5.3.2 Child Stationary/Environment Stable and Child Moving/Environment Moving M-ABC Checklist (Parent Sections One and Four)**

Parents of all children involved in the study were asked to complete sections one and four of the M-ABC checklist at pretest and posttest. Section one required parents to report on their child’s motor skills when the child was stationary and the environment stable and Section four when the child was moving and the environment changing. While all intervention groups showed a significant improvement over the test period, the z score of the *Primary Movement* group in both sections one and four indicates this to be the most effective intervention ( Tables 16 and 17).

These results must be interpreted with caution due to the possibility of response bias, that is, the tendency of the participants to answer according to what they feel is required by the researcher. Parents who had children participating in the *Primary Movement* intervention may have perceived that there was a requirement to record improvements in their child's ability to maintain the integrity of the research even if the improvements had not actually occurred. Also, parents are likely to be biased when reporting on the progress of their children as there is a social desirability for all children to be proficient in motor skills (F. Hill, Le Grange, & Newmark, 2003). The placebo effect and 'Hawthorne Effect' must also be considered in the interpretation of these results.

In conclusion, the results indicated that all students significantly improved in motor skills in their parent's estimation over the research period. The *Primary Movement* intervention group shows a greater improvement than the other two intervention groups on examination of the Z scores. However, these results are to be viewed with caution taking into account the stated shortcomings of the use of the checklist in the format in which it was presented, the possibility of response bias and the reactivity of research.

In the teacher section of the checklist related to classroom behaviour two students improved in the teacher's perception of motor skills and one remained the same (scoring 0 at both pretest and posttest). Again one must consider the limitations of using the checklist in this abbreviated format in the first week of school.

Based on the responses of his parents, Jed has improved in dressing skills and fine motor tasks including forming letters and picking up small objects, but still has difficulty in differentiating between right and left and holding scissors, paper and pens with the right tension. This information coincides with the improvement demonstrated by Jed in the fine motor section of the M-ABC. Although improving from an impairment score of 6.5 to 4, this score indicates that there are still issues with Jed's fine motor skills which are restricting him in efficient functional motor tasks. As Jed's ATNR score was four initially and was reduced to 0 at posttest, it can be assumed that there are other factors contributing to his fine motor difficulties other than retention of the ATNR. It is understandable that Jed is still encountering difficulties in motor skills in a home environment when one considers that he is still only achieving a score in the 36<sup>th</sup> percentile for his age at posttest however,

the improvement in his checklist score may be due to his improvement in overall motor skills reflected in his improvement from achieving a score in the 9<sup>th</sup> percentile at pretest.

Jack has also shown improvement in fine motor skills in the checklist even though in posttest his impairment score for manual dexterity increased from 4 to 5. He is still finding it difficult to stand on one leg when dressing and tying his shoelaces. Jack is still displaying difficulty with movement in a changing environment with scores in the checklist being very similar from pretest to posttest for this section. Although there has been an improvement in Jack's overall motor performance, as indicated by the checklist based on parent perception, his score in the M-ABC which only increased from the 22<sup>nd</sup> percentile to the 26<sup>th</sup> percentile remains a concern. Another factor that must be considered is that Jack still displays evidence of a retained ATNR which may be influencing motor performance and inhibiting potential.

Although Jon's parents have adjudged that he has improved in checklist section 1 there is now concern over Jon's ability to cope when the environment is not stable and Jon is moving. He is also still unable to tie his shoelaces or to do up buttons. These issues may be related to the retention of ATNR which at pretest was still 4. Jon did not improve in his percentile score related to age in the M-ABC which remained in the 3<sup>rd</sup> percentile at posttest.

In the case of Jed and Jack there appears to be some relationship between perceptions of parents of the child's motor performance at home and the results of the M-ABC. It is interesting to note the disparity in the case of Jon and this emphasizes the possibility of influences on the validity and reliability of the checklist in asking parents to complete it.

When analyzing the results of individual student studies on the checklist, it does not appear that the *Primary Movement* program has made any significant difference to Jed's performance when compared to the other two students. In fact, if one was to solely consider the checklist results in this research it appears that Jon has made the most progress although this contradicts his performance in the M-ABC practical test. When used in this abbreviated form conjunction with the M-ABC practical assessment, the checklist could be a useful way of establishing areas of concern in motor skills. However, one must



be cautious in using the results of this checklist used in this abbreviated format as anything more than guidelines for intervention as suggested by Henderson and Sugden (1992) who suggested that the checklist can be used for intervention planning as it may be helpful to know which cluster of skills or underlying motor skills in which the child is experiencing difficulties.

#### **5.4 The effect of the *Primary Movement* program on vocabulary skills**

The early development of speech, language and motor skills are related and are believed to occur simultaneously, and it is well documented that children with motor development problems may also have difficulty with speech and language development (Hammond & Warner, 1996).

The *Primary Movement* program did not have a significant effect on performance on the Peabody Picture Vocabulary Test (Dunn, 1995), which measures receptive vocabulary (a function of verbal IQ) compared to the gross motor and free play groups. Vocabulary is knowledge of words and word meanings and receptive vocabulary includes words that we recognize when we hear or see them. All groups showed an improvement in receptive vocabulary scores. This suggests that all of the children received the same educational input over the course of the study and that the significant reflex and motor improvements of the reflex replication group were due to the intervention and not other language related factors.

An analysis of articulation and speech production using the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy, & Kirk, 1968) may have yielded a different result due its focus on the measurement of psycholinguistic, articulation and speech production abilities which, according to Capute, Shapiro, Palmer, Accardo, and Watchel (1981), are more likely to be affected by motor impairment than receptive vocabulary. Estil, Whiting, Sigmundsson and Ingvaldson (2003) explored the relationship between language and motor impairments in 15, five to ten year old children with predetermined language impairment using the ITPA and M-ABC . It was found that there was a significant correlation between motor impairment and poor psycholinguistic skills in this group of students reflecting the findings of others such as Preis, Bartke, Willers and

Müller (1995). Of significance in this study was the finding that the motor problems of the language impaired children were restricted to fine motor and static balance. In these two sub-tests on the M-ABC participants were considerably below the norm. While Preis et. al (1995) caution against making generalizations to an individual on the basis of group data, this research highlights the relationship between motor and language development with emerging suggestions that language and motor deficits may co-occur (E. Hill, 2001).

One of the hypotheses as to why this comorbidity exists is based on the cerebellar deficit theory (Fawcett & Nicolson, 1999; Fawcett, Nicolson, & Dean, 1996) a theory based on research in which the cerebellar functions of children aged from 10 to 18 years of age with Dyslexia were compared to children without Dyslexia. Some of the tests involved speed of manual movement, bimanual coordination and static balance. These tests are similar to those used in the study by Estil et al., (2003) and were found to identify similar categories of motor skill critical to language and motor impairments. Diamond (2000) purports that language/motor impaired children exhibit similar deficiencies in motor skills to those of people with Dyslexia and suggests that there might be a common mechanism mediating these deficiencies, namely the cerebellum in relationship with the pre-frontal cortex.

In terms of the effect of primary reflex retainment and the effect on language development Capute, Shapiro, Palmer, Accardo and Watchel (1981) state that some retained reflexes have been associated with inappropriate tongue movements affecting suckling and swallowing and ultimately speech production in children with cerebral palsy.

The aim of the present study was to determine the effect of the *Primary Movement* program on receptive vocabulary or verbal IQ. As expected, results show that there were no significant gains in vocabulary development for the group participating in the *Primary Movement* program over the eight month period compared to the two other movement based interventions. Several reasons have been suggested for this result, the sensitivity and appropriateness of the test and the significant influence of other factors on vocabulary in the pre-school years. In Western Australia, participation in a Kindergarten program is optional. While some children participate in a Kindergarten programme under the jurisdiction of a school, others may be involved in community based Kindergarten

program, while others may not attend any formal program until pre primary. Therefore there are a great many variables which may affect the results of a test of receptive language in this age group over the eight month period. It is proposed that the choice of instrument of measurement, namely the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy, & Kirk, 1968) may have been better placed to measure psycholinguistic ability, rather than measuring vocabulary development. However, the relationship between motor and language development should not be overlooked especially in the pre-school years.

Viholainen, Ahonen, Cantell, Lyytinen and Lyytinen (2002) conclude from their research that:

Motor and language problems are often interconnected. Therefore, interventions supporting motor skills early in a child's life might also be beneficial for language development (p. 767).

All three individual student studies have improved in their performance on receptive vocabulary in the PPVT. There are many factors that may contribute to vocabulary development including environmental and social elements. These include the participation in structured schooling and socialization with others occurring within the school environment. As all three boys improved over the period of intervention, it is surmised that the improvement in scores on the PPVT is a function of participation in a preschool environment rich in language rather than a direct product of any particular intervention. Anecdotal records collected during the course of the study did not indicate that any of the three subjects had an obvious articulation or speech production difficulties that may be attributable to their higher than average ATNR scores.

### **5.5 The effect of the *Primary Movement* program on visual motor skills**

Analysis of the pre and posttest visual motor test data revealed a significant interaction between time and treatment ( $p = 0.043$ ) and a significant difference between the *Primary Movement* group and the gross motor group ( $p = 0.044$ ) however there were no significant differences in terms of main effects. Visual motor integration relies on many interrelated processes including a combination of visual perception and eye-hand coordination.

Performance of visual motor skills requires the ability to translate visual perception into motor functioning involving “motor control, motor accuracy, motor coordination and psychomotor speed”(Sanghavi & Kelkar, 2005, p.33). In order to break skill performance down and subsequently improve the clinical value of the Beery VMI (1989), supplemental tests of motor coordination and visual perception have been developed to discretely measure visual perception and motor control (Kulp & Sortor, 2003). The Beery VMI used in this research may have assessed very broad parameters of visual motor ability and consequently the test was not sensitive enough to provide evidence of specific improvements in the many variables present in visual motor performance. The evidence of a significant difference between the *Primary Movement* and gross motor groups may in fact be quite a significant result when viewed in this light.

This is supported by the evidence that two of the individual student studies actually decreased in standardised score for their performance in the Beery Test of Visual Motor Ability (Beery, 1989). The only individual study to show improvement was the participant in the gross motor program. There are many factors that may influence the outcomes of this test at a pre primary level. A study by Son and Meisels (2006) suggest that the use of visual motor screening in this age group should provide just one element of a larger profile or battery and there are many influences that may affect the outcome of this particular test and attributes, such as holding a pencil and drawing a line which are key components of this test, may be influenced by external factors such as self-control and social, emotional skills (p. 773).

#### **5.6 The Effect of the *Primary Movement* program on DEST rapid naming ability**

According to Fawcett and Nicolson (1996), there is strong evidence that dyslexic children are slower than their peers in naming pictures when there is a series of stimuli to be named. One of the causal factors is thought to be cerebellar impairment accounting for the deficits in speed of processing and motor skill in children with Dyslexia (Fawcett, Nicolson, & Dean, 1996).

This test was included in this research to determine if there was an effect of reduction of ATNR on rapid naming speed. According to Nicolson et al. (1999) cerebellar

dysfunction may “provide a unified account” (p. 1662) of a range of major difficulties experienced by children with Dyslexia. It is proposed that a major contributing factor to cerebellar dysfunction is persistent reflexes particularly the ATNR (Holt, 1991; McPhillips, 2001; Morrison, 1985).

This proposal is supported by the results of this research in which the *Primary Movement* intervention group significantly improved (decreased) their times for the rapid naming section of the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996) This is attributed to the significant inhibition of the ATNR reflex which occurred between pretest and posttest in the experimental group. The results suggest that for some children, the effect of a retained ATNR may result in cerebellar dysfunction contributing to difficulties in acquiring core literacy skills. According to McPhillips and Jordan-Black (2007):

Reflex persistence, therefore may be viewed as an early developmental risk factor for some children where subsequent effects are dependent on the interplay of a range of cognitive, environmental and biological factors (p. 753).

All three case studies showed improvement in scores for the Rapid Naming Test. In the case studies, the *Primary Movement* program did not have a more significant effect on improving speed in the rapid naming test than the gross motor or free play groups. However, the test procedure requires 5 seconds to be added to the total time for each naming error, for example, if a child says fish for dog. In two of these three individual student studies, errors contributed significantly to their overall time (Tables 21, 22 and 23). According to de Jong and Vrielink (2004), there are common processes involved in reading and rapid naming as both abilities depend partly on the same cognitive processes.

In these cases, participation in the skills required for reading through the normal preschool program such as left to right eye tracking over the 8 month period may explain the improvement especially in reduced error count for all three subjects. McPhillips and Jordan-Black (2007) stress that although reflex persistence can have a detrimental effect on literacy, effects are also dependent on the interplay of a wide variety of factors including

biological such as maturation and environmental factors, such as participation in print and reading components, as well as cognitive factors.

## **5.7 General conclusions**

### **Conclusion 1: Preschool aged children who retain primary reflexes are at risk of compromised performance in motor skills**

The *Primary Movement* program is designed to replicate or mimic the primary reflex system of the foetus. It is thought that the replication of the primary reflexes plays a major role in their inhibition and that this inhibition can be brought about at a much later stage in development than had previously been assumed (McPhillips, Hepper, & Mulhern, 2000). It is thought that the early movements of the foetus and the newborn, which were once thought of as passive byproducts of neural wiring, are now perceived to be interactive and as having a reciprocal effect on underlying CNS structure and function (Precht, 1984).

The results of this study indicate that the *Primary Movement* program significantly reduced the level of ATNR in the experimental group. Although previous research (Jordan-Black, 2005; McPhillips, Hepper, & Mulhern, 2000; McPhillips & Sheehy, 2004) had demonstrated similar results, this was the first piece of scientific research demonstrating the effect of the program on preschool aged children. As ATNR decreased for the experimental group, there was a reciprocal significant improvement in motor skills for this group. This improvement was most significant in the sub test of the M-ABC testing fine motor skills.

A recent study by Taylor, Houghton and Chapman (2004) has determined that boys aged seven to ten years with diagnosed AD/HD had significantly higher levels of retained reflex than non-diagnosed boys. The four primary reflexes were the Moro, Tonic Labyrinthine Reflex (TLR), Symmetrical Tonic Neck Reflex (STNR) and the Asymmetrical Tonic Neck Reflex (ATNR). This is important as the *Primary Movement* program significantly decreased the level of at least one of these reflexes in this thesis research.

It can be concluded that the *Primary Movement* program decreased the prevalence of retained reflex activity for the intervention group. In this research, the motor skills of children in the *Primary Movement* program improved significantly in comparison to the children in the gross motor and free play groups. This decrease in retained reflexes is important when one considers the research into the association of retained reflexes with other possible comorbidities of compromised motor skills such as Learning Disabilities, ADHD and Dyslexia. While the research base on the effect of retained reflexes is not presently large, future research into the effect of the *Primary Movement* program on children with these syndromes needs to be encouraged.

### **Conclusion 2: *Primary Movement* is an effective early intervention tool**

In the view of Morrison (1985) sensory and perceptual dysfunctions although present and resulting in a failure to learn prior to school experience, are often not detected until the child begins formal academic training in reading and writing; when the child must “perceive and integrate visual and auditory stimulus for academic learning and performance” (p.9). McPhillips and Jordan-Black (2007) concur especially in the area of literacy stressing that although not all children with spelling or reading difficulties have persistent reflexes, “testing for persistent reflexes at the earliest opportunity could compliment other methods that seek to identify children at risk for later literacy difficulties (such as phonological delays and possible visual and auditory processing problems)” (p. 753).

In terms of this research, the *Primary Movement* program can assist children at risk of motor difficulties at an age prior to the dysfunction attributable to retained reflexes has a detrimental effect on future motor learning and performance. Missiuna, Rivard and Bartlett (Missiuna, Rivard, & Bartlett, 2003) state that many children do not display the full extent of their functional difficulties until they reach school age. While motoric impairment will affect gross motor activities and fine motor tasks (Gallahue and Ozmun, 1998) there are also the well documented issues of poor self esteem and withdrawal from physical activities associated with coordination disorders. Early identification and remediation of underlying perceptual difficulties through addressing reflex persistence issues may complement other methods that assist with addressing coordination difficulties.

## 5.8 Future research

Given the changes that occurred in the human figure drawing of Jed, it would be valuable to investigate the effect of retained reflexes on self image. This investigation may include an analysis of the observable changes in children's drawings of themselves after participation in the *Primary Movement* program.

A second area of future research is the relationship between poor results in motor skills, particularly manual dexterity tasks and reading acquisition. As the children who participated in this research were of pre reading age, it was not possible to test this relationship that is, whether children who performed poorly in the M-ABC also performed poorly in tests of reading proficiency. This research would replicate studies by McPhillips (2001) and Jordan-Black (2005) however, could be based on children aged 6 to 7 years (Year 1), as opposed to the older children used in their studies (seven-eleven years). Although this research has been pursued by others (Son & Meisels, 2006), in terms of establishing the predictive validity of motor skills assessments for later cognitive achievement, the current climate of curriculum change with emphasis on cognitive outcomes in Western Australia warrants scientific research expounding the value of ensuring the proficient motor development of young children. This includes a significant focus on the benefits that a firm motor foundation can provide not only to the integrity of the CNS but in future academic pursuits.

Further study could also be done on the possible effect of retained reflexes and involvement in the *Primary Movement* program on the articulation and speech abilities of children at preprimary age. Anecdotal records, provided by class teachers in transcripts during school visits over the intervention period, indicated that some children had particularly improved in speech articulation during participation in the *Primary Movement* program. This research could involve the use of the Illinois test of Psycholinguistic Abilities (Kirk, McCarty & Kirk, 1968) or similar.

Finally, a longitudinal study to determining the carryover of the effects of *Primary Movement* program in terms of reduction in retained reflexes and improved motor



performance. This would examine whether the benefits of the program are still evident in the later years irrespective of the program being discontinued after early childhood years (K-3).

## 5.9 Final Conclusion

While the results show strong evidence of the positive effect of Primary movement on reflex inhibition on a cohort of pre-primary students in Western Australia, further research is necessary to generalize these results to a broader population. The children who received the *Primary Movement* intervention recorded a significant reduction in retained reflexes and a consequent improvement in motor skills particularly in the area of fine motor and manipulative skills. These children also showed significant improvement in rapid naming in the Dyslexia Early Screening Test (Fawcett & Nicolson, 1996). *Primary Movement* did not significantly improve receptive vocabulary in this research.

The premise underpinning this study is that the persistence of primary reflexes may be viewed as an early developmental risk factor for some children. While historically motor programs have addressed the 'product' of the perceptual deficit, more recent approaches such as the *Primary Movement* program addresses the 'process deficits' or the underlying prospective deficits related to the difficulties, in this case the retention of primary reflexes. While these are early days for the *Primary Movement* program, Stephenson and Wheldall (2008) report that the positive results shown by the program were part of a well designed studies which has been a problem with perceptual-motor programs in the past and although the results should be viewed with caution until a strong research base is established, prove quite promising (p.74).

*Primary Movement* or the replication of retained reflexes reflects the attributes of Neuronal Group Selection theory in that there is a recognition of the need to pay attention to the condition of the CNS as according to Hadders-Algra (2000b) the condition of the brain has a substantial effect on motor development (p.708). According to Hadders-Algra (2000b) clumsy children have dysfunctions in the nervous system. It is proposed that retained primary reflexes particularly the ATNR contribute significantly to functioning of the central nervous system (Morrison, 1985). Therefore the premise behind a reflex

replication program such as *Primary Movement* addresses one of the causes of central nervous system dysfunction allowing the individual to obtain more accurate sensory input which is important in adapting to the environment.

The results reported here provide a strong case for the introduction of the *Primary Movement* program in the preschool years as the first years of schooling provide the foundations for long term educational success and differences that emerge in the early years are likely to remain or to increase throughout the child's school life (Sammons, 1994). Testing for abnormal primary and postural reflexes should be more widely used in order to assess and identify children who are underachieving. These assessments can be combined with motor assessment at an early age prior to exposure to more advanced academic tasks such as reading and writing due to the fact that abnormalities in early patterns of motor development do affect acquisition and automisation of higher and more complex skills (Goddard Blythe, 2001). In this way children who have an underlying neurological dysfunction which may significantly affect performance may be identified, reflex inhibition programs and specialist teaching can be implemented.

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