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Motor Proficiency and Preacademic Learning  
in the Young Child  
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## Abstract

Children with learning difficulties often demonstrate a decreased level of motor proficiency. Researchers have identified learning disability subtypes and discovered a link between math-related learning difficulties and perceptual-motor, spatial and organizational deficits. Learning difficulties are typically not diagnosed until the middle primary grades following repeated academic failure, however clumsiness, which has also been linked to difficulties with academic learning, can often be detected earlier. The purpose of this study was to examine the relationship between motor proficiency and preacademic difficulties in the young child; specifically the relationship between early development of visual spatial skills, sequencing and arithmetic ability. Fifty children, ages 4 years 3 months to 5 years 8 months, were tested during two 30 - 40 minute sessions using: (1) the Miller Assessment for Preschoolers (MAP), a screening test designed to identify children at-risk for learning difficulties; (2) a pursuit tracking task (Buck, Leonardo & Hyde, 1981); (3) number/counting concept items (Miller, 1990). Subjects were divided into high and low performance groups based on total MAP score, specified MAP spatial items and number/counting concept items, and their performance on the pursuit tracking task examined.

The results of this study indicate that the low performance number/counting concept group demonstrated a significantly slower average response time, overshoot movement time and reaction time as compared to the control group. These findings offer support for the concept of an underlying perceptual-motor difficulty in children exhibiting problems in arithmetic. The low MAP and spatial groups demonstrated a significantly higher rate of overshoots, suggesting difficulty in processing of visual spatial information.

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## Chapter I

### Introduction

The importance of exploration and movement in the intellectual development of children was demonstrated by Piaget (1952). He believed that a child must interact and experience the environment in order to build the foundation for cognitive development; it is primarily through these interactions with the environment that learning takes place. In accordance with this theory, Ayres (1975) stated that "the most obvious and easily understandable relationship between motor activity and perceptual-cognitive development is the opportunity that mobility affords in exploring and learning about the environment" (p. 303). This early exploration, object manipulation and movement during periods of infancy and childhood are also critical in the development of spatial skills (Eckert, 1982; Harris, 1978; Skolnick, Langbort & Day, 1982).

Sensorimotor exploration is paramount to a child's overall development and is strongly associated with later academic achievement in school, according to Ayres (1975). Rarick (1980) is even more emphatic in his assertion that "few would challenge the concept that sensorimotor experiences play a prominent role in the intellectual development of the young child" (p. 185).

The relationship between motor proficiency and academic achievement has been investigated by numerous researchers over the years, and includes studies of both clumsy and learning disabled children. As early as 1937, Orton is credited with

documenting problems in the motor performance of children with learning disabilities. Children with learning difficulties typically have varying degrees of associated movement deficits. In fact, they are often described as clumsy in their movements with poor spatial organization and an overall decreased level of motor skill proficiency (Hulme & Lord, 1986; Keogh, Sugden, Reynard & Calkins, 1979; O'Brien, Cermak, & Murray, 1988; Roussounis, Gaussen, & Stratton, 1987; Sovik & Maeland, 1986). The fact that clumsiness has been observed in greater numbers of learning disabled children as compared to age-matched controls has been well documented (Ayres, 1975; Haubenstricker, 1982; O'Brien, Cermak, & Murray, 1988; Sovik & Maeland, 1986).

Researchers have found that children identified as clumsy have a significantly greater preponderance of learning difficulties than their peer group (Gordon & McKinlay, 1980; Henderson & Hall, 1982; Roussounis, Gaussen, & Stratton, 1987; Sovik & Maeland, 1986). A study by Sovik and Maeland (1986) revealed a considerably higher frequency of learning difficulties, particularly in spelling and writing, but also in reading and mathematics, in the children identified as clumsy as compared to control groups. Sovik and Maeland (1986) pointed out that not only do motor abilities play a predominant role in drawing, copying, writing and gymnastics, but "motor control and coordination are also required to some extent in related subject matters" such as reading, spelling and arithmetic. In support of this theory, Hulme and Lord (1986) stated that "methodologically

it has been argued that there are clear parallels between the problems encountered in studies of reading problems...and studies of clumsiness" (p. 268). Wall, McClements, Bouffard, Findlay, and Taylor (1985) also supported these findings by identifying a significantly greater number of reading-disabled children as compared to regular achievers who were physically awkward.

In an effort to resolve the question of why clumsy children have a higher rate of learning problems particularly in mathematics and reading, researchers have attempted to examine the processes involved in the early learning of these skills. The implication of visual perception, particularly spatial ability in learning mathematics has been well documented in the literature (Greenes, 1979; Guay & McDaniel, 1977; Ozols & Rourke, 1988; Skolnick, Langbort, & Day, 1982; Smith, 1964). Greenes (1979) has asserted that the perceptual skill most closely associated with the learning of mathematics is visual spatial perception and that spatial abilities are critical to a child's success in arithmetic. Skolnick, Langbort, and Day (1982) believed that spatial abilities are essential in children's scientific and mathematical understanding. Ozols and Rourke (1988) also concluded that "certain visual perceptual and visual spatial skills may be essential for the mastery of very basic arithmetic concepts for this subtype of learning disabled children" (p. 49).

The role of visual perception in learning to read has been recognized by many researchers (Baker, Decker & DeFries, 1984;

Goldberg, Shiffman & Bender, 1983; Gordon & McKinlay, 1980; Karnes & Stoneburner, 1983). Early research on reading disabilities points to language and verbal deficits as primarily responsible, however, Baker et al. (1984) concluded that "visual perception may be more important in the early stages of reading, while linguistic competencies may have a greater influence in the later stages" (p. 111). According to Goldberg, Shiffman, and Bender (1983), reading difficulties often result from "a marked difficulty with perception of shape, form, and spatial relationships" (p. 45).

The importance of spatial sequencing in learning to read has been discussed in the literature over the years (West, Morris, & Nichol, 1985). The complex task of learning to read involves attending to spatial relationships, particularly the spatial sequencing of letters, while decoding graphic symbols of different shapes and sizes into verbal meaning (West, Morris, & Nichol, 1985). Studies analyzing the performance of children with reading disabilities on the Wechsler Intelligence Scale for Children (WISC), suggested a deficit in sequencing ability (Rugel, 1974; Symmes & Rapoport, 1972). Similarly, results of neuropsychological testing of 108 children referred to a reading clinic indicated below average performance in verbosequential skills and above average performance on visuospatial skills (Harness, Epstein, & Gordon, 1984). This conclusion was later supported by Gordon (1988) in his study of academic achievement test performance and specialized cognitive functioning in 1,042

fourth and fifth grade children. He found that those children who performed poorly on measures of verbosequential skills demonstrated deficient reading and language achievement; these children showed above average performance on visuospatial skills. This study provides further evidence for the role of sequencing in learning to read, while implicating visual spatial skills in children with reading difficulty. However, there are numerous studies which point to the role of visual spatial skills in the early learning of arithmetic.

The results of studies investigating the motor proficiency of clumsy children with learning difficulties have suggested that visual perceptual and visual motor difficulties underlie the motor deficits seen in some of these children (Henderson & Hall, 1982; Hulme, Biggerstaff, Moran, & McKinlay, 1982; Hulme, Smart, & Moran, 1982; Lord & Hulme, 1987; O'Brien, Cermak, & Murray, 1988). In particular, a study by Lord and Hulme (1987) found that clumsy children performed worse than a control group on spatial judgements. The researchers concluded that "clumsy children's motor problems are a result, at least to some extent, of imperfect visuo-spatial perception" (Lord & Hulme, 1987, p. 255). The deficit in visual spatial perception seen in clumsy children may be a contributing factor to the child's difficulty manoeuvring around objects in the environment as well as in academic performance.

There are a growing number of studies linking clumsiness to potential learning difficulties in young children (Henderson &

Hall, 1982; Revelj, 1987; Sovik & Maeland, 1986), however, referral is often not initiated until the elementary school years (Karnes & Stoneburner, 1983; Kirk, 1987). Although motor problems can be detected earlier, learning difficulties do not emerge until a child begins school and must master certain skills in order to succeed. Sovik and Maeland (1986) stated that "although clumsiness can be observed during the preschool period, problems related to this kind of behaviour will meet the child when he starts his regular schooling" (p.40). At this point, the child may be showing secondary signs of social/emotional problems as well as frustration due to repeated failures at school (Dare & Gordon, 1970; Gubbay, 1975; Knuckey & Gubbay, 1983).

Henderson and Hall (1982) believed that clumsiness is more easily detected in the young child as compared to the older child. The problem becomes masked in the older child as related difficulties emerge, coupled with the fact that the teacher has less opportunity to observe the older child performing movement-related activities as more time is spent in sedentary academic pursuits. In considering both the increased risk of learning difficulties among clumsy children and the belief that motor problems can be more easily observed in the young child, early screening well before school entry would appear to be a very worthwhile enterprise.

One difficulty in carrying out early screening in the past has been the lack of effective testing instruments (Barnes, 1982, Lichenstein & Ireton, 1984, Meisels, 1987, Revelj, 1987). In

1982, the Miller Assessment for Preschoolers (MAP) was developed as a screening tool for preschoolers, to assist in filling this void. This test has been standardized and validated and is considered to be psychometrically sound (Miller, Lemerand & Cohn, 1989, Slaton, 1985). The MAP test items cover a wide range of developmental areas including sensory integrative and neurodevelopmental parameters (Provost, Harris, Ross & Michnal, 1988).

The development of a reliable and valid test instrument has not been the only barrier to implementing early screening programs. Apart from the economic ramifications, there is the controversy which surrounds early screening. There are those who feel early screening and consequent labelling may be detrimental to a young child, however there are others who argue that early screening is beneficial to the child. In terms of motor and learning difficulty, there is support in the literature for early screening and evidence of greater success for remediation in the younger child (Haubenstricker, 1982; Kirk, 1987). Ozols and Rourke (1988), in their discussion of math-related learning disabilities, stated that, "If these children can be identified during the early school years (5 to 8 years of age), it is possible that many of their more serious academic and interpersonal difficulties could be addressed early and, possibly, could be ameliorated" (p. 45).

Satz, Taylor, Friel, and Fletcher (1978) recognized the need for early detection before formal schooling "at a time when the

central nervous system may be more plastic and responsive to change and when the child is less subject to the shattering effects of repeated academic failure" (p. 316). As Goldberg, Shiffman, and Bender (1983) pointed out, "The prospects of remedial success are greatly improved if the children's learning disability can be recognized before they become enmeshed in a pattern of frustration and failure" (p. 15). Lichenstein and Ireton (1984) are also in agreement with the notion that "the pattern of failure becomes more firmly entrenched over time" (p.5). It is for these reasons that the effectiveness of early screening has received such widespread attention.

While there have been many studies examining motor proficiency and learning difficulties in the older school-aged child (Henderson & Hall, 1982; Roussounis, Gausson & Stratton, 1987; Tarnopol & Tarnopol, 1979), there has been less research focussing on the younger preschool population. This study will therefore, concentrate on the younger child, examining both motor proficiency and early learning of academic subjects, including number and counting concepts, in an effort to identify common factors.

#### Statement of Problem

The purpose of this study was to determine the relationship between motor proficiency and preacademic difficulties in children ages 4 years 3 months to 5 years 8 months.

### Hypotheses

The following hypotheses are proposed for this study:

1. The children who score poorly on the MAP also perform poorly on a complex motor skill pursuit tracking task.
2. The children who perform poorly on MAP items requiring spatial perception and organization (see Appendix A - MAP Test Items) also have difficulty with the number/counting concept test items (indicated in Appendix B).
3. The children who perform poorly on MAP spatial items and on number/counting concept items also demonstrate difficulty performing a complex motor skill pursuit tracking task.

### Justification

Research has underlined the importance of early remediation of motor problems in preschoolers as the implications for learning and later academic success are evident. This study examined the relationship between motor proficiency on a complex motor skill pursuit tracking task and factors associated with early learning difficulties in preschoolers. In particular, this study focussed on the relationship between early development of visual spatial skills, sequencing and arithmetic ability. In working towards minimizing the deleterious effects of learning problems in children, this study aimed to strengthen our understanding of common factors at work in the young child.

### Operational Definitions

clumsiness: Used to describe children who "have severe problems in developing adequate skills of movement in the absence of general sensory and intellectual impairments and without showing signs of overt neurological damage" (Hulme & Lord, 1986).

preacademic difficulty: Refers to difficulty developing the "prerequisite skills that a child needs to learn the academic subjects" (Kirk, 1987, p. 78) and can be manifested in terms of a sensory, motor, or visual perceptual deficit in the absence of overt neurological damage or disease.

spatial perception: "This kind of spatial ability requires the subject to determine spatial relationships with respect to the orientation of their own bodies, in spite of distracting information" (Tracy, 1987, p. 124).

## Chapter II

### Literature Review

Clumsiness has long afflicted children and their ability to function adequately, however, it has only been in the last 20 years that studies involving this population have been carried out. Attention was first directed to the topic of clumsiness in children by Walton, Ellis and Court (1962) and Gubbay, Ellis, Walton and Court (1965) in case studies. Later, researchers discovered that a higher preponderance of learning difficulties were seen in clumsy children (Henderson & Hall, 1982; Sovik & Maeland, 1986).

This link between clumsiness and academic performance provoked further studies examining different areas of academic learning and motor difficulty. Specifically, researchers have examined the underlying component processes in children with motor difficulties. There has been evidence suggesting that visual spatial abilities are deficient in clumsy children and hence, certain learning skills are affected (Greenes, 1979; Hermelin & O'Connor, 1986; Rayner, 1986). These results point to the importance of early identification of motor difficulties; and suggested that clumsiness in a young child may be a clue to later learning problems. The traditional belief that clumsiness in a young child is not serious and will diminish with age, is open to debate.

Indeed, there is evidence that the motor problems seen in

clumsy children are long-term in nature affecting many areas of functioning. In a recent longitudinal study examining the motor proficiency of 34 teenagers previously identified as clumsy at six years of age, the researchers concluded that "The effects of being 'clumsy' are evident into the teenage years and manifest themselves not only in the motor domain but also in other areas" (Losse, Henderson, Elliman, Hall, Knight & Jongmans, 1991; p. 64).

The neglect in studying the younger preschool child is partly due to the fact that until recently there was a lack of adequate assessment batteries which could accurately identify the at-risk group. As Revelj (1987) stated, "Certainly a major cause of the inadequate service provided to preschool children with minimal cerebral deficits was the lack of an objective, standardized assessment tool for testing preacademic difficulties at the preschool level" (p. 15). Lichenstein and Ireton (1984) argued that "Many instruments currently available for developmental screening are relatively new and unproven, lacking in psychometric qualities, and devoid of research support" (p. 29). This view is also supported by Meisels (1987). It seems that identification and remediation of this at-risk group continues to be a challenge for educators and health professionals alike.

#### Early Identification and Screening

Karnes and Stoneburner (1983) conceded that "preschool

screening is a relatively new phenomenon" (p.160) and observed that "large numbers of impaired children proceed undetected through the regular school programs each year" (p.161). Lichenstein and Ireton (1984) also supported the notion of preschool screening and stated that "a substantial number of children are struggling or failing in school" (p.5).

More recently, in a research review of clumsy children, Hulme and Lord (1986) optimistically concluded that "recognition of clumsiness in children has been relatively slow in developing, but the problem is now quite widely recognized" (p. 267). There is, however, no mention of screening for identification of the problem except to say that as recognition of the problem grows, it is likely that more children will be referred. Henderson (1987) lamented that too much attention has been focussed "on the bright clumsy child to the detriment of the less intellectually able in normal schools" (p. 512) and discussed the value of utilizing neurological, cognitive as well as motor components in assessment of the clumsy child.

Historically, screening for learning problems in young children was left to parents or preschool personnel, but more predominantly the "classroom teacher is usually the first to take note of anomalous patterns of behavior" (Weener & Senf, 1982, p.1061). Weener and Senf (1982) noted that teacher referrals tended to largely consist of hyperactive children because of their disruptive behaviour, whereas "withdrawn or hypoactive children with similar patterns of academic performance are less

likely to be referred" (p.1061).

In spite of the conflicting results regarding the use of teacher rating scales, the National Joint Committee on Learning Disabilities (1985) in the U.S., recommended the use of screening instruments in addition to teacher rating scales as an adjunct to early identification of learning disabilities in the preschool child.

Revelj (1987) noted that part of the problem in screening young children was that "previously, evaluators have not had a testing instrument which was objective, precise, and definitive to identify preschool children with preacademic problems" (p. 10). Other authors have attested to the ineffectiveness of many of the screening tools that have been available (Barnes, 1982; Lichenstein & Ireton, 1984; Meisels, 1987), stating that many of the measures "leaves much to be desired, and in some cases there is little or no evidence on their effectiveness" (Barnes, 1982, p. 6). Meisels (1987) stated that "the most frequent abuse of developmental screening results from using tests that have no established reliability and validity" (p. 4) and accused professionals of continuing to use invalid and unreliable screening tools.

#### MAP As A Screening Tool

Miller's (1982) conclusion that an effective, comprehensive preschool screening test was sadly lacking served as the impetus for her development of the Miller Assessment for Preschoolers

(MAP) (p.596). The MAP is the result of 10 years of research involving over 4000 children and 800 test items (Miller, 1988). This screening test consisted of 27 core items and was designed to evaluate children aged two years nine months to five years eight months; these items are administered to a child as a series of games. The MAP has been validated in terms of children at-risk and those not at-risk (Miller, 1989; Miller & Shouten, 1988; Miller & Sprong, 1986). Children in the at-risk group were referred by teachers, parents or physicians, and excluded children with diagnoses such as cerebral palsy or other organic brain syndromes. The standardization process was extensive, based upon a randomly selected population of 1,200 preschoolers. Predictive validity testing of the MAP was carried out with approximately one-quarter of the children in the standardization sample (N = 338) using two sets of criterion measures, four years after initial testing. Although minor differences between the MAP standardization sample and the predictive validity sample were found, the distribution of the MAP scores for the predictive validity sample closely resembles that of the standardization sample (Miller, 1987).

The MAP has in fact been praised for providing comprehensive standardization data with promising reliability and validity studies (Slaton, 1985). As Miller, Lemerand and Cohn (1989) stated, "the cross-validation of the MAP in three separate studies with essentially the same positive results provides a solid foundation for use of this test in classifying children as

at-risk for school problems during their preschool years" (p. 380). The MAP also exhibits acceptable internal reliability ( $r = .79$ ) and high interrater reliability ( $r = .98$ ). Indeed, the MAP was considered to be psychometrically sound (Slaton, 1985) and included a wide range of developmental areas including sensory integrative and neurodevelopmental parameters (Provost, Harris, Ross & Michnal, 1988). The foundations index, in fact, included many items generally found in a standard neurological evaluation (Provost et al., 1988). As neurological dysfunction is thought to be responsible for learning problems in many cases (Cruickshank, 1977; Stewart, 1980), the foundations index composed of 10 neurological items, assisted in examining these factors considered the building blocks for successful learning in school.

Prior to the development of the MAP, there were attempts to detect early learning difficulties in the young child through various screening processes, but with little success (Henderson & Hall, 1982). The reasons for the failure ranged from lack of a valid assessment tool to identify children at-risk for later learning difficulties, to the process being too time consuming or ineffective to be of practical value. There were also those who feel that early screening may label the child prematurely. However, as Gordon and McKinlay (1980) pointed out "early screening does not mean the child has to be 'labelled', but the teacher can be alerted to the possibility of problems arising". Karnes and Stoneburner (1983) also believed that while children

should not be hastily labeled, there is much promise for early remediation of the learning disabled child and the potential benefits far outweigh this risk.

Many educators and researchers fully supported the concept of early screening for learning difficulties in the preschool child (Barnes, 1982; Gordon & McKinlay, 1980; Karnes & Stoneburner, 1983; Kirk, 1987; Lichenstein & Ireton, 1984; Miller, 1982; Satz, Taylor, Friel & Fletcher, 1978). As Karnes and Stoneburner (1983) stated, "When there is no mass screening, only the more severely handicapped are likely to be identified" and "children with potential learning disabilities will be overlooked" (p.173).

#### Preacademic Problems Versus Slow Learner

The suggestion that preacademic problems may exist in the young child is a relatively new concept. In 1985, the National Joint Committee on Learning Disabilities (NJCLD) discussed early identification of preschool children and the importance of detecting preschool children with "specific developmental delays or deficit patterns that often are early manifestations of learning disabilities" (p. 2). The NJCLD (1985) stated that "these manifestations include atypical patterns of development in cognition, communication, motor abilities, and/or social and personal behaviors that adversely affect later academic learning" (p. 2). Kirk (1987) also supported the view that learning disabilities in the preschooler "affect the prerequisite skills

that a child needs to learn the academic subjects" (p. 78). He believed that learning disorders are identified at the preschool level and "if not remediated at an early age, they will contribute, singly or in combination, to disabilities in learning the academic subjects later on" (p. 78). As the NJCLD (1985) has emphasized, "the preschool years represent a critical period during which essential prevention and intervention efforts are most effective" and, therefore, professionals "must attend to the needs of preschool children whose development is characterized by patterns of specific deficits" (p. 2).

Educators have historically identified the slow learner, believing these are the children at-risk for future learning problems. However, there is a clear distinction made between the child who is developing more slowly than his peers overall (the developmentally delayed child) and the clumsy child who exhibits a variable developmental profile. Karnes and Stoneburner (1983) stated that "the potentially learning disabled child may be characterized as one who demonstrates a markedly uneven developmental sequence" (p.152). Historically, the clumsy child has been labeled as delayed and was assumed to be intellectually inferior in relation to his peers. In discussing the clumsy child, Gordon and McKinlay (1980) stated that "because of a reluctance to attempt motor tasks there is a tendency to accuse them of laziness or misbehaviour or they may be suspected of being mentally dull" with these children usually receiving less sympathy and understanding (p. 2). The developmentally delayed

child may also exhibit signs of clumsiness or motor impairment, however, there is a danger in assuming that both occur concomitantly. As discussed earlier, there is evidence to suggest that the clumsy child is at-risk for early learning difficulties or preacademic problems.

### Visual Spatial Abilities and the Clumsy Child

Recent studies have shown that clumsy children often demonstrate a deficit in the area of spatial perception and some researchers have theorized that this may be the cause of their motor and academic difficulties (Hulme, Biggerstaff, Moran, McKinlay, 1982; Lord & Hulme, 1987; O'Brien, Cermak & Murray, 1988).

The clumsy child has been described as having certain core characteristics, although researchers agree that they are a heterogenous group (Dare & Gordon, 1970; Henderson & Hall, 1982; Lord & Hulme, 1987). These characteristics have been identified as: average to above average intelligence with a significantly higher verbal than performance IQ on the Wechsler Intelligence Scale for Children (WISC), impaired motor function interfering with many daily activities, discrepancy in motor performance, absent or minimal neurological signs indicative of cerebellar, pyramidal or extrapyramidal impairment.

These characteristics do not include any mention of a perceptual deficit, however, results of studies by Hulme, Biggerstaff, Moran, and McKinlay (1982) and Hulme, Smart, Moran,

and McKinlay (1984) indicated that significant impairment in perceptual processing of visual spatial information existed in clumsy children. These researchers examined perceptual processes in clumsy children, particularly performance in visual, kinaesthetic and cross-modal judgements of length in clumsy children as compared to age-matched controls. They found that clumsy children demonstrated impaired performance on visual judgement of length which could not be explained in terms of memory or poor motor control of the eyes. Hulme and colleagues argued that "poor visual perception, particularly of spatial information, may contribute to the movement problems of clumsy children" (Lord & Hulme, 1987, p. 250). The dominant role of visual perception in performing motor skills is supported by Murphy and Gliner (1987) in their study of visual and motor sequencing ability in normal and clumsy children. Results of this study indicated that clumsy children had greater difficulty in their ability to recall and sequence visually presented material. The authors concluded that "visual discrimination, recall, and sequencing appear to be difficult areas for some clumsy children" (Murphy & Gliner, 1987, p.101).

Schellekens, Scholton and Kalverboer (1983) focussed attention on the response time and movement organization of clumsy children versus a control group in performing visually guided hand movements. The task involved continuous tapping between targets at different intervals. The spatial characteristics of the hand and arm movements were recorded as

well as the temporal characteristics of the tapping. The clumsy children performed at a slower rate in tapping with their movements being less smooth; and their pattern of acceleration/deceleration was different than the normal control group. This supports the notion that clumsy children have more difficulty with spatial and temporal movement components.

Smyth and Glencross (1986) conducted a study in which processing of proprioceptive and visual stimulus information was investigated in clumsy children as well as age-matched controls. The results of this study indicated that clumsy children experienced greater difficulty in processing proprioceptive information manifested in the form of longer latency periods. Although this study only involved a small number of subjects (8 clumsy children and 8 controls), the finding that clumsy children have more difficulty with the perception of proprioceptive information is supported by previous research (Bairstow & Laszlo, 1981; Hulme, Biggerstaff, Moran, & McKinlay, 1982).

#### The Use of Tracking in Analyzing Motor Proficiency

As a means of examining factors associated with motor control and proficiency, some researchers have analyzed tracking performance in children (Kerr & Blais, 1987; Kerr & Blais, 1988; van der Meulen, Denier van der Gon, Gielen, Gooskens, & Willemse, 1991). The tracometer, which represents a complex motor coordination task, involves turning a steering wheel attached to a pointer. In this tracking task, the object is to align the

pointer with an illuminated light which randomly appears in one of five horizontal positions. The responses of the subject are recorded by a computerized system linked to a cassette tape. This task involves visual and motor sequencing, visual spatial perception, visual motor coordination, directionality as well as the processing of proprioceptive and kinaesthetic information. This complex motor task has been used in research examining the motor performance, specifically reaction time and movement time, of retarded children with Down syndrome as compared to controls (Kerr & Blais, 1987; Kerr & Blais, 1988). They demonstrated that Down syndrome students, while being capable of learning this task, did so in a manner which was quite distinct from the controls or other retarded students.

Similarly, van der Meulen et al., (1991) utilized an arm-tracking task to investigate tracking performance in normal and clumsy children. In this study, target signals moving unpredictably along a straight line had to be tracked with and without visual feedback. Results indicated that clumsy children demonstrated a lower tracking quality and longer delay than the normal children. The longer delay manifested by the clumsy children was interpreted by the investigators as possibly being an adaptation to their motor difficulties. The researchers concluded that "tracking performance may be a useful tool for the study of clumsiness" (van der Meulen et al., 1991, p. 127).

### Learning Difficulties and Clumsiness

The fact that clumsy children have a higher frequency of learning difficulties as compared to their peer group, has been well documented in the literature. Henderson and Hall (1982) discussed the relationship between motor proficiency and learning difficulties pointing out that "a large proportion of children of normal intelligence who experience learning difficulties in other aspects of their schoolwork, such as reading or number, also exhibit clumsiness" (p.448). This conclusion has also been reached by Sovik and Maeland (1986) in their study of clumsy third-graders. Achievement tests administered to these children indicated that "a considerably higher frequency of LD, particularly in spelling and writing, but also in reading and mathematics, was found in the sample of clumsy subjects than in the comparable group" and these results were supported by teacher ratings of these academic areas (p. 52).

In a study by Roussounis, Gaussen, and Stratton (1987), children attending primary school were identified as clumsy using the Standardized Motor Test Battery (SMTB) and then matched for age and sex with a control group. They were then followed-up two years later with respect to educational and motor performance using the SMTB. Results indicated that "the clumsy children were found to have impaired educational attainment, particularly in writing, compared to their controls, and their motor performance although much improved was still very inferior to controls" (p.377).

In a study which analyzed the visual motor problems in learning disabled children as compared to age-matched controls, Mattison, McIntyre, Brown and Murray (1986) examined error components as being primarily perceptual, conceptual, motoric or some combination of these factors. The results indicated that the visual-perceptual and perceptual-conceptual components were intact in the learning disabled group, however, the motor-coordinative component and the integration between this component and the visual-perceptual component were disturbed. The researchers postulated that perhaps higher level integration across the visual and motor modalities were impaired in the learning disabled children. Therefore, a deficit in this integrative function could result in a discrepancy between the sensory input and the motor output. Mattison et al. (1986) concluded that learning disabled children demonstrated a disturbance in this integrative function by "performing well on tasks requiring visual ability, but failing to accurately complete tasks that required simultaneous visual and motor ability" (p. 53). In terms of remediation, the authors recommended providing special attention to motor coordination skills, particularly, "helping the child develop increased hand-eye motor coordination and general body control as well as basic motor concepts, e.g., directionality and spatial position" to assist in their overall visual motor development (Mattison et al., 1986, p. 53).

### Visual Spatial Skills and Mathematical Ability

There have been many studies implicating visual spatial skills in the development of early arithmetical ability in the young child (Greenes, 1979; Guay & McDaniel, 1977; Ozols & Rourke, 1988; Skolnick, Langbort & Day, 1982; Tarte, 1990). As Hermelin and O'Connor (1986) stated, "The association of spatial ability with processes involved in mathematics ... is well attested" (p. 150).

Smith (1964) examined spatial ability and mathematical achievement in secondary school teenagers. It was concluded that an individual's ability to solve high level mathematical problems reflected greater spatial ability than individuals who could not solve these problems. A later study by Guay and McDaniel (1977) investigated the relationship between elementary school, or low level mathematics achievement and spatial abilities in children, suggested that high mathematics achievers had greater spatial ability than low mathematics achievers. The researchers further concluded that the relationship between mathematical achievement and spatial ability existed for children exhibiting high level as well as low level spatial abilities.

The notion that mathematical ability and spatial thinking were highly correlated among elementary school children was supported by Cohen (1985). Cohen (1985) suggested that the discrepancy between spatial skills and mathematical performance may be due in part to the fact that there is little consistency among studies in measures used for spatial abilities. This

highlights the importance of defining spatial ability and accurately describing tests and procedures used for measuring spatial ability.

A study by Francis-Williams (1976), in which researchers examined preschool children who had sustained neurological damage in the newborn period, also supported this premise. Scores of academic achievement were compared to the control group during a follow-up study of these children at the junior high level. Francis-Williams (1976) reported that many of the children in the experimental group scored below their chronological age level on a computational skill test. She reported that the two children who demonstrated very severe disorders of visuo-spatial and perceptuo-motor abilities in the preschool period continued to show this disability at age 8 or 9 years and, in fact, were found to have a very specific disability in forming number concepts. She concluded that "visuo-spatial disability at four years should be regarded as an indication of possible difficulty in understanding number concepts in later school learning" (p.76). Despite the small sample, the results of this study may have provided the impetus for further research in the area.

More recently, Rourke (1989) investigated a population of learning disabled children who demonstrated specific difficulties in mathematics. Rourke and Strang (1978) initially identified three groups of children, ages 9 to 14 years, based on their performance on the reading, spelling and arithmetic subtests of the Wide Range Achievement Test (WRAT). While all three groups

were impaired in math ability, Group 1 consisted of children who were uniformly impaired in reading, spelling and arithmetic; Group 2 consisted of children who were relatively proficient (though still impaired relative to age norms) in arithmetic, as compared with their poor performance in reading and spelling (2.0 years below their WRAT Reading/Spelling grade-equivalent scores); and Group 3 consisted of children demonstrating average to above average performance in reading and spelling, but impaired in math performance (2.0 years below their WRAT Reading/Spelling grade-equivalent scores). All subjects demonstrated full scale IQs within the 86-114 range.

Groups 2 and Group 3 were of particular interest as they demonstrated equally impaired levels of performance on the WRAT Arithmetic subtest, but very different levels of performance in word recognition and spelling. A study by Rourke and Finlayson (1978) revealed that Group 3 demonstrated well developed auditory perceptual and verbal skills, but somewhat impaired visual perceptual and organizational skills. This was in contrast to Group 2 who performed well on tests of visual perceptual organizational abilities and relatively poorly on measures of verbal, and in particular, auditory perceptual abilities.

It is most interesting to note that performance on complex psychomotor tasks and measures of tactile perception were very different between Group 2 and Group 3 according to studies by Rourke and Strang (1978). The children in Group 2 performed within the average range in performing psychomotor tasks, whereas

the children in Group 3 demonstrated bilateral impairment on two measures of psychomotor abilities and bilateral impairment on a composite measure of tactile perceptual abilities (with impairment more marked on the left side of the body). The children in Group 2 performed significantly better than Group 3 on this composite measure of tactile perceptual abilities using the left hand.

The third study in the series carried out by Strang and Rourke (1983) compared performance between Group 2 and Group 3 children on nonverbal problem-solving tasks. This investigation revealed that Group 3 children made significantly more errors on this test than Group 2 children and "Group 3 children performed especially poorly on those subtests that require a substantial degree of 'higher-order' visual-spatial analysis" (p. 173). A parallel study by Ozols and Rourke (1988), examined a younger group of learning disabled children (ages 7 to 8 years), and were able to clearly identify a specific math-related disability characterized by inferior scores on visual perceptual and visual spatial measures. Ozols and Rourke (1988) described this group of children as exhibiting "outstanding problems in visual-spatial organization and synthesis, bilateral psychomotor and tactile-perceptual deficiencies, and impaired nonverbal concept formation and reasoning" (p. 45). Rourke (1989) referred to this group of children as nonverbal learning disabled (NLD) as a result of their distinct deficit patterns in the nonverbal, psychomotor and spatial areas.

Rourke and Strang (1983) concluded that the deficits apparent in Group 3, that is, the bilateral psychomotor impairment and poorly developed visual perceptual organizational abilities, were "precisely those abilities...that are most important for the acquisition of adequate sensory-motor experience" (p. 178). The researchers further deduced that the reason for failure of mathematical reasoning abilities to develop in this group of children, can at least be partly attributed to inadequate sensory motor experience. Hence, Rourke and Strang (1983) suggested a cause and effect relationship between motor deficits and a specific math-related learning disability.

It terms of development, it is apparent that early movement, manipulation and exploration in a child's play experiences are critical in the development of spatial ability (Eckert, 1982; Harris, 1978; Skolnick, Langbort, & Day, 1982). It is these early sensory motor experiences which Rourke and Strang (1983) claimed are important in later mathematical achievement; and their suggestion that lack of these experiences can place a child at-risk for developing non-verbal learning disability deserves attention (Rourke, 1989).

#### Visual Perceptual Skills and Reading Ability

There have been a multitude of studies and proposed causes of reading difficulties in children ranging from difficulties in ocular-motor control, directionality, visual tracking and memory, spatial relationships and orientation, to decoding skills and

difficulty in verbal rehearsal and language. However, as Goldberg, Shiffman and Bender (1983) pointed out, "there is very little authoritative data available on the basic causes of reading disability" and they suggested that this was due to the extremely complex nature of reading and our limited understanding of it (p. 7).

Nonetheless, researchers have studied reading disabilities in an attempt to better understand the influencing factors. It is certain that reading problems cannot be attributed to the influence of any single variable and in fact, a child with a reading problem usually is deficient in a number of academic readiness skills (Bell & Aftanas, 1972; Jordan, 1989). However, researchers have documented a particular cognitive profile or cluster of variables associated with reading difficulties in children. The most popular theory is one advocated by Velutino (1978) in which the role of verbal deficits in children with reading difficulties was emphasized. This contention was supported by Gordon and McKinlay (1980) in their statement that "reading retardation is more often part of a disorder of language development" (p.4).

Rayner (1986) maintained that dyslexics consist of heterogenous subgroups, one of which are readers with a general language deficit and another group of readers with a visual spatial deficit. In addition, there be may a third group of dyslexics demonstrating a mixed pattern of both language and visual spatial deficits (Rayner, 1986). A study by Gordon (1988)

examined individual differences in performance on academic achievement tests in relation to tasks of specialized cognitive function associated with processing in the right and left hemispheres. Researchers tested 1,042 elementary school children in terms of visual spatial and verbosequential skills and compared results to academic achievement test results. The results indicated that deficient readers performed poorly on verbosequential tasks, but at average or above average levels on visual spatial tasks. Gordon (1988) concluded that for some individuals, spatial skills improve reading achievement, perhaps because of flexibility to use more brain functions, whereas others appear to be 'locked into' the visual spatial mode of thought and are unable to use their verbosequential skills.

However, there are other variables which emerge in relation to reading problems and these are discussed in the multivariate analysis study of the relationship of perceptual-motor development to learning readiness in kindergarten children by Solan, Mozlin and Rumpf (1985). The researchers warned that one must not "neglect important visual-perceptual, sensory-motor and intersensory skills which may be just as important to succeed in a learning environment" (p. 337). Solan et al. (1985) concluded that "the additive nature of perceptual-motor factors and their correlation with reading ability often has been neglected" (p. 343).

There have also been studies associating deficient motor performance to reading difficulties in children. Taylor (1982)

examined 128 control children and 112 reading disabled children ages 8 to 12 years to determine differences in motor skill performance. The results indicated that the reading disabled children performed more poorly on the catching, balance and jumping tasks. The researcher used a 15 item motor performance test battery over a five month period. She identified nearly eleven percent of the total sample as severely awkward and of these, 17 children also experienced reading difficulties. The results of this study provided "substantial evidence for the concomitance of physical awkwardness and reading disability" (Taylor, 1982, p. 108). This conclusion follows with the general agreement in the literature that children with learning difficulties show evidence of motor deficits.

Francis-Williams (1976) conducted a study of 44 high risk preschoolers to examine later intellectual development and school achievement. It was found that the children who had attained low scores on preschool form copying demonstrated severe reading retardation at follow-up. Karnes and Stoneburner (1983) discussed the role of visual perception in reading, specifically the ability to recognize and name stimulus figures as one of the best predictors of reading and general achievement. Gordon and McKinlay (1980) also supported the view of visual perceptual disabilities being associated with reading retardation. Goldberg, Shiffman and Bender (1983) stated that reading difficulties often result from "a marked difficulty with perception of shape, form and spatial relationships" (p. 45).

The authors illustrated this by pointing out that 8 or 9 year old children with reading problems "may have no grasp of the spatial arrangement of the words in a sentence and be quite unable to copy simple geometric forms from memory even with the originals before them" (Goldberg, Shiffman & Bender, 1983, p. 45). Other researchers have pointed to the implications of difficulty in spatial orientation and directionality which can lead to reading and learning difficulties (Jordan, 1989; Penso, 1984).

A study by Penso (1984) examined the horizontal directionality as well as hand and eye dominance of 351 children and their ability in learning to read, write and spell. The researcher concluded that a higher incidence of learning difficulties was found in children who scan visually and move their hands in a right to left direction than those who prefer the left to right direction. Jordan (1989) also noted difficulty with directionality as well as encoding when he stated, "Dyslexic children do not automatically master language symbols, and they do not automatically perceive left to right and top to bottom" (p. 13).

There is research pointing to poor sequencing ability as an important factor in children with reading difficulty (Cohen, 1985; Gordon, 1988; Jordan, 1989; Mason, Katz, & Wickland, 1975; Pavlidis, 1986). This phenomena is demonstrated in the study by Gordon (1988) in which children who performed poorly on measures of verbosequential skills demonstrated deficient reading and language achievement. West, Morris, and Nichol (1985) also

suggested a sequencing problem in their statement that "poor readers have a spatial order deficit underlying their reading problems" (p. 30). Pavlidis (1986) noted that dyslexics have a motor-sequential problem which is reflected in their erratic eye movements. As Mason, Katz, and Wickland (1975) concluded in their study of reading ability, spatial order memory, and item memory in Grade six children, "The notion of a sequencing or order deficit in poor readers is by no means new" (p. 615). Jordan (1989) discussed the repercussions of poor sequencing in a dylexic child's day to day life such as the inability to remember the alphabet, months of the year, a series of chores or a set of instructions given in class. He stated that dyslexics were "generally handicapped in any situation that requires them to comprehend sequence" (p. 16), and lamented the misfortune of these children being regarded as irresponsible when they are in actual fact, confused (Jordan, 1989).

In discussing research which examined eye movement patterns in dyslexic and normal children, Pavlidis (1986) concluded that "the finding that dyslexics exhibit erratic eye movements during reading is almost indisputable" (p. 100). The irregular eye movement patterns seen in dyslexic children during reading has also been noted during non-reading tasks (Pavlidis, 1986, 1981). Pavlidis (1985, 1986) have theorized that erratic eye movements do not cause reading problems, but are the result of the same brain malfunction which the author believed explains the language, attentional, synchronization and sequential problems

also seen in dyslexic children. Jordan (1989) also stated that dyslexic children have a different way of seeing as they read which "is a critical block in developing reading skills" (p. 14). Geiger and Lettvin (1987) have studied the visual ability in dyslexics and found that they have poor central vision; instead dyslexic children see at an angle and must actually focus away from the word in order to decode it.

From the preceding information, it is evident that there are many complicating factors involved in examining antecedents in the young child which may lead to later reading problems.

### Chapter III

#### Method

The following is a discussion of the methodology used for this research study and includes: subject selection, instruments and procedure used as well as data collection and analysis. This study was approved by the University Human Research Committee and by the Renfrew County Board of Education.

Subjects. In this study, 50 children (male and female) ranging from 4 years to 5 years 8 months, were selected from 3 kindergarten classes at an elementary school in the town of Arnprior, Ontario. A consent form was sent to the parents requesting permission to test their child, stating the purpose of the research study and describing the type of testing to be administered (see Appendix C - Letter of Parental Consent).

Instruments. The subjects were tested using two different tools: (1) The Miller Assessment for Preschoolers (MAP), a screening test designed to identify children at-risk for learning difficulties and (2) a complex eye-hand coordination task (pursuit tracking task) which measures the subjects' ability to respond to four levels of directional probability across four levels of movement difficulty.

In addition, a classroom evaluation questionnaire was completed by the teacher. The classroom evaluation questionnaire

was developed based on the five MAP domains discussed below. The questionnaire was designed to determine the teacher's perception and rating of the child's functional level. The motor components included in the questionnaire involved questions regarding gross and fine motor coordination skills such as ability to form letters, use of scissors and balance. There were also questions regarding visual perceptual skills such as the ability to recognize letters, numbers and shapes; and questions regarding spatial perception and sequencing ability. In addition, questions regarding emotional and psychosocial factors were included such as reaction to new movements or games, attention span and atypical behaviours (See Appendix C - Classroom Evaluation).

The Miller Assessment for Preschoolers (MAP) was used and consisted of 27 core items focussing on five domains or indices: Foundations Index (neurodevelopmental performance), Verbal Index (language), Non-verbal Index (memory, problem-solving and visual perception), Coordination Index (gross, fine and oral motor) and Complex Tasks Index (combined abilities). The test used percentile scores based on the standardization sample. Scoring guidelines are: 0-5% "refer" for further evaluation (red category), 6-25% "watch" or monitor carefully (yellow category), and 26-99% "developmentally average" or normal limits (green category).

MAP test items are presented in the form of games, designed to stimulate interest (See Appendix A - MAP Test Items). Miller

(1988) stressed in the instruction manual that testing should be "gamelike", so it was perceived as fun and so the child performed optimally. The MAP "is designed for sensitivity to the lower end of the performance scale" (Miller & Sprong, 1987, p. 68) and in fact "many children who perform poorly on the MAP do well on more traditional developmental assessments which, in the past, have failed to identify many of the mild or moderately disabled children at an early age" (Slaton, 1985, p. 70).

In this study, the assessment was expanded to include 9 additional items adapted from MAP Standardization Screen Test (1990); these consisted of number and counting concept items (See Appendix B). The rationale for this addition was that these particular concepts had critical relevance to the development of early arithmetic skills as discussed in the literature review.

The discrete pursuit tracking task was developed at the National Research Center in Ottawa (Buck, Leonardo, & Hyde, 1981) and represented a complex problem solving task. The subjects were required to respond to a light on a screen by moving a steering wheel which directs the pointer (Figure 1). The aim was to align the pointer with a target light in one of five horizontal positions. Once the pointer has been aligned within the boundaries of the target light (2.4 mm.) for 200 msec, the light is extinguished and another light is simultaneously illuminated in one of the other four positions. The light randomly appeared in one of these five positions following each successful placement of the pointer.

As the subject remained on each target light for 200 msec, each response was considered a discrete movement and recorded as such. One trial on the pursuit tracking task consisted of 100 responses. The subjects completed four trials. The actual breakdown within each trial consisted of 50 movements to the left, 50 movements to the right, with each of the 20 possible between-target movements occurring 5 times. Each of the five positions was associated with a specific directional probability. This probability reflected the chances of the next target light illuminating in a certain direction. For example, position 1 or 5 was associated with 100 per cent probability that the next target light would illuminate to either the right or left respectively. Similarly, starting from position 3, directional probability was 50 per cent and when starting from position 2 or 4 and moving to positions 1 or 5 (respectively) directional probability was 25 per cent.

The task permitted the collection of large amounts of data in a short time period, as each discrete response (between-target movement) can be broken down into separate cognitive (decision-making) and motor components (some 27 items). Data regarding error frequency and direction, as well as response time, was easily recorded by the cassette tape linked to the test apparatus.

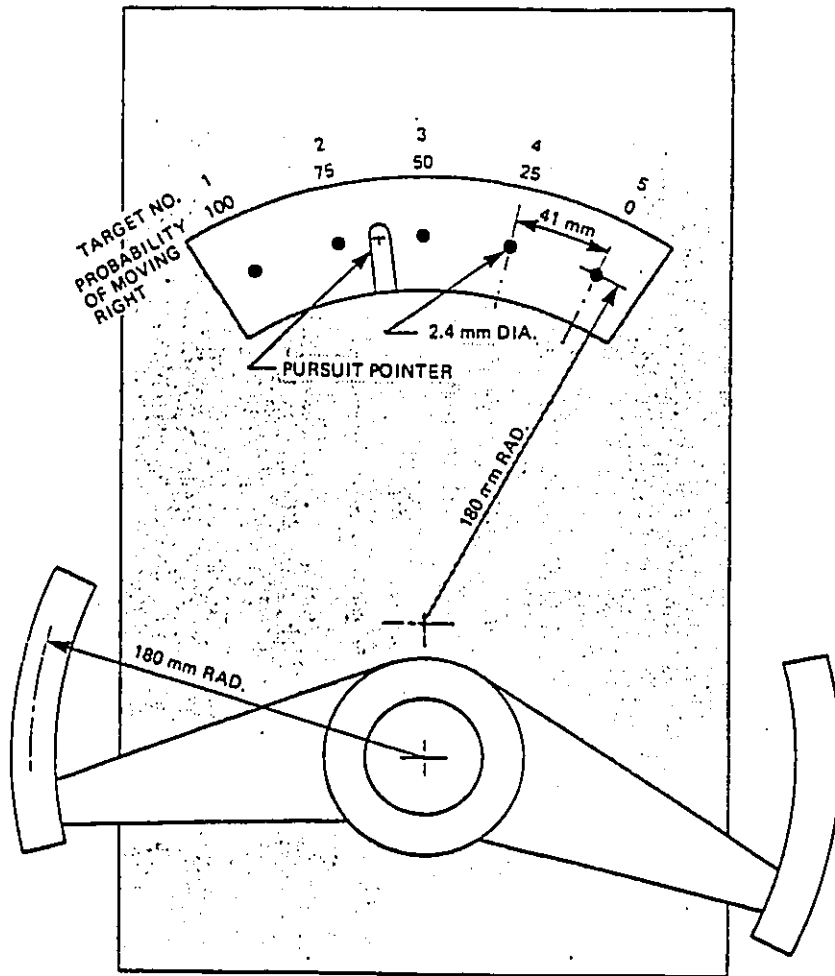


Figure 1 Front plan of pursuit tracking task showing directional probability of moving to the right.

Procedure. The MAP and pursuit tracking task were administered in two separate 30-40 minute sessions. The tester was a registered occupational therapist with 10 years of pediatric therapy experience, and specialized training in the administration of the MAP, as well as previous experience in administration of the pursuit tracking task.

The children were tested individually at school in a quiet room. The MAP was administered in the first 30 minute session, following standardized testing procedures outlined in the MAP manual (Miller, 1988). The number/counting concept items were administered on a separate day, prior to the administration of the pursuit tracking task, during a second 30-40 minute session. Care was taken to set up the tracking task so that the screen was positioned at child's eye level and a comfortable seating arrangement was provided with feet flat on the floor. The lighting was dimmed so that the lights on the screen could easily be seen, thereby avoiding any problems with reflection off the screen. Each subject was encouraged to complete 4 trials of 100 responses per trial, however in the event that a subject was unable to complete 4 trials during the first session, a second session was arranged on another day to complete the remaining trials.

The task was presented as a game where the subjects were asked to use the steering wheel to pretend "drive". Subjects were instructed to watch the screen carefully to try and "catch the light" as quickly as possible each time it appears. Each

subject was given a brief demonstration followed by a practice period of extinguishing 5 target lights on the screen.

Analysis. The MAP was used to identify children within the three categories of performance delineated by the test: red for alert, yellow for monitor and green for average performance. The results were then examined and subjects placed in a high or low performance group based on their overall MAP percentile score. The high performance group included children with a total percentile score between 32% and 64% on the MAP and the low performance group included children with a total percentile score at or below 17% on the MAP. The subjects were also divided according to low or high performance on spatial/sequencing items and number/counting concept items. Subjects in the high and low performance groups in the areas described above were examined in terms of their performance on a complex motor skill task (pursuit tracking task). High and low performance group subjects were equated for age in all cases.

The data from the pursuit tracking task were used to provide the six major dependent variables in this study. These variables were as follows:

- 1) Non-Overshoot Movement time (NMT) - measured as the time from the initiation of the movement until successful alignment with the target light, without first overshooting the target.
- 2) Overshoot Movement time (OMT) relative to overshoot

errors - measured as the time from the initiation of the movement until successful alignment with the target light, after first having overshoot the target.

- 3) Overshoot score (OS) - reflects the number of movements which overshoot the target light before a correct alignment was achieved.
- 4) Decision score in terms of choosing direction incorrectly (DS) - reflects the number of movements initiated in the wrong direction.
- 5) Reaction time (RT) relative to directional probability - measured as the time from presentation of the target light until the initiation of the movement as it relates to a specific position and associated probability.
- 6) Average response time (ART) - measures time on average to complete a single response and is a measure of overall performance efficiency.

The data from all the above measures were averaged within trials, with each trial consisting of a 100 responses. The analyses of data for the pursuit tracking task involved calculating a series of Group X Trial X Distance/Probability ANOVAs, with repeated measures on the latter two factors. The data were analyzed for possible interactions between high and low performance groups on both overall MAP scores, number/counting concept items, as well

as on the spatial items. Post hoc differences were analyzed using the Scheffé post hoc test.

The teacher ratings as measured by the classroom evaluation questionnaire were included in the overall analysis with the MAP outcomes and tracking task components using the Pearson product-moment correlation.

## Chapter IV

## Results

The results reflect the three main analyses which examined differences in tracking task performance between high and low performance groups based on scores from (a) the MAP, (b) specified MAP spatial items, and (c) number/counting concept items. For each analysis, Group One was identified as the low performance group and Group Two was identified as the high performance group. The children in Group One and Group Two were equated by age as closely as possible for all three analyses.

Analysis for MAP Groups

For this analysis, the children were divided into Group One and Group Two according to MAP performance results with 20 subjects in each group. Group One consisted of children who performed in the lower end of the scale ( $M = 11.5 \pm 4.7$ ) according to total MAP scores and Group Two were identified as the high performance group ( $M = 46.3 \pm 12.7$ ) based on the MAP scores. The difference between the MAP score means was significant ( $t(38) = 11.4, p < .01$ ). Group One consisted of 14 males and 6 females with a mean age of 4 years 9 months; Group Two consisted of 9 males and 11 females with a mean age of 4 years 8 months. Table 1 provides a summary of means and standard deviations for group comparison using MAP scores.

Table 1

Means and S.D.'s for Group Comparison Using MAP Scores (msec.)

	RT	OMT	DS <sup>a</sup>	OS <sup>a</sup>	NMT	ART
Group 1						
Mean	597	3638	14.0	77.6	1460	3633
S.D.	6.9	65.9	.5	.7	33.7	97.7
Group 2						
Mean	574	3433	11.1	69.8	1537	3307
S.D.	5.6	51.2	.5	.9	34.7	76.7

Note. RT = reaction time; OMT = overshoot movement time; DS = decision score; OS = overshoot score; NMT = non-overshoot movement time; ART = average response time.

<sup>a</sup>DS and OS are expressed as the average number of errors per trial.

The only significant Group main effects were for decision score ( $F(1,38) = 4.83, p < .05$ ) and overshoot score ( $F(1,38) = 6.42, p < .05$ ); with Group One recording higher error scores for both variables. A significant Boundary Distance effect for overshoot score ( $F(3,114) = 48.91, p < .01$ ) indicated that all subjects made fewer movement errors when moving to targets closer to the boundary of the display; this Boundary Distance effect was previously identified by Buck, Leonardo & Hyde (1981).

In terms of overshoot movement time, a significant Distance main effect existed ( $F(3,114) = 47.92, p < .01$ ). Post-hoc analysis revealed that subjects were significantly faster at short movements (41mm-82mm) as compared to the longer movements (123mm-164mm); subjects were also significantly faster at 41mm as compared to 82mm. Similarly, a significant Distance main effect was also found for non-overshoot movement time (NMT), ( $F(3,114) = 22.40, p < .01$ ). Here, post hoc analysis revealed significant differences between all four distances, with faster movement times for shorter distances.

For reaction time, there was a significant Probability main effect ( $F(3,114) = 19.67, p < .01$ ), which was reduced from 609 msec. at the 25% probability level to 547 msec. at the 100% probability level. Post hoc analysis indicated that when direction was 100% probable, reaction time was significantly faster than for the 50% and 25% probability levels, and that subjects were significantly faster at the 75% level of probability as compared to 25% probability.

There was a significant difference in decision score associated with the four levels of directional probability ( $F(3,114) = 7.19, p < .01$ ), in that, the numbers of decision score errors were significantly increased for subjects when directional probability was 25% as compared to 100%. The Probability and Distance effects seen were in agreement with Buck, Leonardo and Hyde (1981); and were also repeated for the spatial and number/counting concept analyses. The means and standard deviations for Probability and Distance effects for total MAP score analyses are presented in Table 2.

For both average response time and overshoot movement time, there were significant Trial effects. Significant differences were found across Trials for overshoot movement time ( $F(3,114) = 5.75, p < .01$ ), where the overshoot movement time from Trial One to Trial Four was reduced from 3820 msec. to 3497 msec.; and for average response time ( $F(3, 114) = 4.83, p < .01$ ), where average response time was reduced across trials from 3685 msec. to 3428 msec. This represents an improvement in performance across trials and indicates a significant learning effect. Again, this effect was repeated for the spatial and number/counting concept analyses. These results also reflect the fact that overshoot movement time is the largest contributor to average response time, which in itself can be considered the best overall measure of performance efficiency for this task.

Table 2

Means and S.D.'s for Probability and Distance Effects in MAP  
Analysis (msec.)

Probability		100%	75%	50%	25%
RT	Mean	547	577	608	609
	S.D.	7.1	8.7	9.0	9.7
DS <sup>a</sup>	Mean	10.5	12.1	13.0	14.5
	S.D.	.55	.53	.64	.92
Distance		41mm	82mm	123mm	164mm
NMT	Mean	1180	1430	1614	1806
	S.D.	27.7	31.3	36.6	75.4
OMT	Mean	3122	3372	3737	3910
	S.D.	66.1	80.3	82.9	90.4

Note. RT = reaction time; DS = decision score; NMT = non-overshoot movement time; OMT = overshoot movement time.

<sup>a</sup>Scores are expressed as number of errors per trial.

### Analysis for Spatial Groups

In this analysis, the children were divided into Group One and Group Two based on specified spatial items from the MAP with 17 subjects in each group. Group One consisted of children who performed in the lower end of the scale ( $M = 47.5 \pm 8.2$ ) according to scores on the spatial items and Group Two was identified as the high performance group ( $M = 75.8 \pm 4.3$ ) based on MAP spatial component scores. The difference between the MAP spatial score means was significant ( $t(32) = 12.6, p < .01$ ). Group One consisted of 11 males and 6 females with a mean age of 4 years 10 months; Group Two consisted of 6 males and 11 females with a mean age of 4 years 9 months. Table 3 provides a summary of means and standard deviations for group comparison using spatial scores.

The only Group significant main effect for this analysis was in overshoot score ( $F(1,32) = 5.44, p < .05$ ), with the low performance group (Group One) having a significantly higher rate of overshoots. A significant Boundary Distance effect for overshoot score was demonstrated ( $F(3,96) = 47.25, p < .01$ ); this Boundary Distance effect indicates that all subjects made fewer errors when moving to targets closer to the boundary of the display.

Table 3

Means and S.D.'s for Group Comparison Using Spatial Scores(msec.)

	RT	OMT	DS <sup>a</sup>	OS <sup>a</sup>	NMT	ART
Group 1						
Mean	589	3630	13.7	78.0	1423	3604
S.D.	7.5	74.9	.6	.8	29.3	97.3
Group 2						
Mean	581	3362	11.6	69.3	1558	3261
S.D.	7.5	57.3	.5	1.1	42.6	87.2

Note. RT = reaction time; OMT = overshoot movement time; DS = decision score; OS = overshoot score; NMT = non-overshoot movement time; ART = average response time.

<sup>a</sup>DS and OS are expressed as the average number of errors per trial.

Significant Distance main effects were found for overshoot movement time ( $F(3,96) = 31.65, p < .01$ ) and non-overshoot movement time ( $F(3,96) = 19.38, p < .01$ ). In terms of overshoot movement time, post hoc analysis revealed that subjects were significantly faster at short movements (41mm-82mm) as compared to the longer movements (123mm-164mm), and subjects were also significantly faster at 41mm as compared to 82mm. In terms of non-overshoot movement time, post-hoc analysis indicated that subjects were significantly faster at short movements (41mm-82mm) versus longer movements (123mm-164mm).

There was a significant Probability main effect for reaction time ( $F(3,96) = 29.04, p < .01$ ), which was reduced from 612 msec. at the 25% level of probability to 543 msec. for the 100% probability level. Post hoc analysis revealed that in terms of reaction time, subjects were significantly faster at 100% and 75% levels of probability as compared to 50% and 25% levels of probability. Significant improvement was shown across Trials for overshoot movement time ( $F(3,96) = 9.04, p < .01$ ), overshoot movement time was reduced from 3919 msec. for Trial One to 3358 msec. for Trial Two, reaction time ( $F(3,96) = 4.13, p < .01$ ) which decreased from 604 msec. to 568 msec. across trials, overshoot score ( $F(3,96) = 2.73, p < .05$ ), which decreased from 758 msec. to 723 msec. across trials and average response time ( $F(3,96) = 10.15, p < .01$ ), which decreased from 3767 msec. to 3297 msec. across trials. Taken together, these changes indicate a significant learning effect taking place.

### Analysis for Number/Counting Concept Groups

In this analysis, the children were again divided into Group One and Group Two based on their number and counting concept performance, with 13 subjects in each group. The children were scored on a pass/fail basis and were placed in the low performance group if they failed more than five items out of a total of nine items. The high performance group consisted of children who passed more than six items out of a total of nine items. Both groups consisted of 7 males and 6 females with a mean age of 4 years 6 months for Group One and a mean age of 4 years 9 months for Group Two. Table 4 provides a summary of means and standard deviations for group comparison using number/counting concept scores.

Analysis of variance revealed significant Group main effects for average response time ( $F(1,24) = 8.51, p < .01$ ), overshoot movement time ( $F(1,24) = 6.12, p < .05$ ) and reaction time ( $F(1,24) = 8.44, p < .01$ ). This indicated that the children who performed poorly in the area of number and counting concept (Group One) had a significantly slower average response time as well as a significantly slower reaction time; in addition, these children took significantly longer to correct their movements once they overshoot the target. However, as distinct from the previous two analyses, there were no significant Group differences for either overshoot score or decision score.

Table 4

Means and S.D.'s for Group Comparison Using Number/Counting  
Concept Scores (msec.)

	RT	OMT	DS <sup>a</sup>	OS <sup>a</sup>	NMT	ART
Group 1						
Mean	628	3680	12.3	79.0	1477	3718
S.D.	7.5	68.4	.54	.84	36.8	90.8
Group 2						
Mean	549	3186	12.8	73.7	1402	3140
S.D.	5.4	62.2	.57	1.01	37.3	83.4

Note. RT = reaction time; OMT = overshoot movement time; DS = decision score; OS = overshoot score; NMT = non-overshoot movement time; ART = average response time.

<sup>a</sup>DS and OS are expressed as the average number of errors per trial.

A significant Distance main effect existed for overshoot movement time ( $F(3,72) = 27.09, p < .01$ ). Post-hoc analysis revealed a significant main effect for distance in that subjects were significantly faster at short movements (41mm-82mm) as compared to the longer movements (123mm-164mm). Subjects were also significantly faster at 41mm as compared to 82mm. The significant Distance main effect was also found for non-overshoot movement time ( $F(3,72) = 17.59, p < .01$ ). Post hoc analysis revealed significant differences between all four distances.

A significant Probability main effect was found for reaction time ( $F(3,72) = 19.89, p < .01$ ). Post hoc analysis indicated that subjects were significantly faster at the 100% and 75% levels of probability as compared to the 25% level of probability; similarly, subjects were significantly faster at the 100% level of probability as compared to the 50% level of probability.

Significant improvement was demonstrated across Trials for overshoot movement time ( $F(3,72) = 4.94, p > .01$ ), which was reduced from 3770 msec. to 3340 msec., reaction time ( $F(3,72) = 5.90, p > .01$ ), which was reduced from 611 msec. to 576 msec., and average response time ( $F(3,72) = 3.96, p < .05$ ), which was reduced from 3679 msec. to 3361 msec. As with the previous analyses, this indicated a significant learning effect taking place across trials.

### Correlational Analysis

The results of correlational analysis using Pearson's product-moment correlation are shown in Table 5. The correlational analysis was carried out using all subjects ( $n = 50$ ).

The significant positive correlation between overshoot rate and average response time ( $r = +.55$ ,  $p < .01$ ) is not surprising. As previously stated, average response time is a measure of overall efficiency in performance. Therefore, it would appear reasonable that the greater the rate of overshooting the target, the slower the average response time for the subject or conversely, the lower the rate of overshoots, the faster the average response time.

The significant negative correlation between average response time and teacher rating ( $r = -.41$ ,  $p < .01$ ) indicated that the slower a child's average response time (ART), the lower the teacher rating for that child or the faster the ART, the higher the teacher rating. This supports the notion that response time is important in everyday performance and a slow response time in this motor task may be associated with difficulties the children may be having in other skill areas.

Table 5

Pearson Correlation Matrix of Variables


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	ART	OS	MAP	SP	NO	T-R
ART	-					
OS	.55**	-				
MAP	-.22	-.35*	-			
SP	-.23	-.37**	.70**	-		
NO	-.21	-.29*	.26	.36*	-	
T-R	-.41**	-.41**	.60**	.77**	.40**	-

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Note. ART = average response time; OS = overshoot score; SP = spatial; NO = number; T-R = teacher rating.

\*\*p < .01, \*p < .05.

A significant negative correlation also existed between overshoot rate and spatial skills ( $r = -.37, p < .01$ ), between overshoot rate and number/counting concept ( $r = -.29, p < .05$ ), between overshoot rate and teacher rating ( $r = -.41, p < .01$ ), and between overshoot rate and MAP performance ( $r = -.35, p < .05$ ). Taken together, these results indicated that the higher the rate of overshoots, the lower their performance on spatial items, the lower their performance on number/counting concept items, and the lower their MAP performance; with the converse also being true. These results offered support for the contention that there was a significant relationship between certain aspects of motor performance and preacademic difficulties; specifically the relationship between spatial task performance and abilities in basic arithmetic. This outcome was in agreement with Rourke's findings using slightly older subjects.

There was a significant positive relationship between teacher rating and MAP score ( $r = .57, p < .01$ ), between teacher rating and spatial skills ( $r = .77, p < .01$ ) and between teacher rating and number/counting concept ( $r = .40, p < .01$ ). This indicated that children in the high performance MAP group were also rated highly by the classroom teacher; likewise, children in the high performance spatial and number/counting concept group were also rated highly according to teacher evaluation with the converse in both cases being true. These correlations lent further support to the reliability of the MAP and its spatial components as a screening tool, in that they do appear to reflect

the teacher evaluations which are based on the overall classroom performance. While these associations do not imply a causal relationship, they supported the notion that children who did well in the area of number/counting concept were more likely to be rated highly in other aspects of classroom performance and conversely, children who did poorly in developing early number/counting concept skills were more likely to have other difficulties in the motor as well as academic areas.

The significant correlation between performance on spatial items and performance on number/counting concept ( $r = .36, p < .05$ ) lent support to the notion that spatial skills are important in the development of basic number/counting skills as suggested by Greenes (1979) and Rourke (1989).

Chapter V  
Discussion

The purpose of this study was to investigate the relationship between motor proficiency and preacademic difficulties in the preschooler, by comparing performance on the MAP, specified spatial items and number/counting concept items, with performance on a pursuit tracking task. Subjects were subdivided into three groupings of high and low performance based on (a) total MAP score (b) MAP spatial items (c) number/counting concept items.

The primary hypothesis was only partially supported in this study. The children in the low performance MAP group only demonstrated poor performance in certain components of the pursuit tracking task. In particular, they showed a significantly greater rate of overshoots and a significantly increased decision score rate, as compared to the control group. Although, the low performance group made more decision errors, comparison of the average response time between the two groups yielded no significant difference. This implied that the low performance group may have been compensating in some way. The increased decision score rate and overshoot score implied that the children in the low performance group may have had a basic processing problem; which leads to the speculation that, perhaps if these children were encouraged to slow down, they would have made fewer decision and overshoot errors on the tracking task.

In this particular motor task, errors could be compensated for by movement speed and, therefore, overall performance efficiency would not be substantially affected. However, in the classroom, often error in performance leads to negative consequences for the child and cannot necessarily be compensated for by speed. In reality, accuracy is more important than speed of response and a second chance to accomplish the task may often not be given within the same context. This suggests that these type of children (low performance MAP children) could perhaps improve their performance with encouragement and guidance from the teacher to slow down.

The low performance spatial group demonstrated very similar performance difficulties as the low performance MAP group. The main difference between these two groups appeared to be in the fact that the low performance spatial group did not demonstrate the same difference in decision score rate as seen in the MAP group. Both the low performance spatial and MAP groups overshot the target at an increased rate, however average response times were the same for Group One and Group Two in both cases, indicating a compensatory effect. This high rate of overshoots suggests difficulty identifying spatial location and judging distance for successful alignment with the target light. There was mild support for the notion that as far as this motor task is concerned, the children that did poorly on MAP or particularly on the spatial items, had difficulty in judging distance and identifying spatial location. The fact that children with motor

problems often have difficulty with judging distance and processing of visual spatial information is supported by Hulme et al. (1982) and later research by Lord and Hulme (1987); Hulme et al. (1982) discussed the poor performance on visual, kinaesthetic and cross-modal judgements evidenced in clumsy children. This leads to the possible consideration of an alternative explanation for the high rate of overshoots in the low MAP and spatial groups, demonstrated in this study. Integrative difficulties between visual perceptual and motor coordination components were found to be disturbed in learning disabled children according to research by Mattison et al. (1986); perhaps the difficulty in overshooting the target seen in this younger population was an early sign of integrative disturbances. In relation to this disturbance, one must also consider the irregular eye movement patterns seen in dyslexics, according to studies by Pavlidis (1986). Certainly, difficulty in this area would impact on visual tracking performance and hence, motor proficiency overall.

The subgroup which exhibited distinctly poor performance on the tracking task were those children who demonstrated poor number/counting concept skills. These children demonstrated a significantly slower average response time (ART) which is an indicator of overall decreased performance efficiency in this task. These children also demonstrated a significantly slower overshoot movement time (OMT) and a significantly slower reaction time (RT) as compared to the control group. In other words, these children proved to be slower in making decisions

(uncertainty associated with the choice of direction) and in correcting unanticipated movement errors. However, they were not slower in making correct movements, nor did they make more errors in terms of choosing direction incorrectly. Their difficulty appeared to arise in the speed with which they make decisions regarding choice or how quickly they adjust to change.

The high and low performance number/counting concept groups were functioning at the same level of efficiency in terms of decision and overshoot score, however, the low performance group is responding slower in terms of time. As mentioned, this slow response was seen in two particular areas: reaction time and overshoot movement time. Each of these measures reflected conditions where there is a lack of predictability: reaction time reflects an uncertainty in terms of direction and overshoot movement time reflects unanticipated changes in movement. In one sense, this may support Rourke's (1989) contention that children with difficulty in arithmetic may have perceptual-motor problems. The poor performance on the tracking task demonstrated by the group of children who had difficulty with number/counting concept may be a reflection of this underlying perceptual-motor difficulty discussed by Rourke.

The significant association demonstrated between performance on spatial items and counting/number performance, while not causal, also offered partial support for the secondary hypothesis in this study: that children who perform poorly on MAP spatial items would also have difficulty with number/counting concept

items. This is in agreement with Strang and Rourke (1985) who found that children who had specific learning difficulties in arithmetic exhibited poorly developed visual perceptual abilities stemming from inadequate sensory motor experiences. The negative correlation between overshoot rate and spatial performance, and between overshoot rate and number/counting concept performance also offers partial support for the third hypothesis: that children who performed poorly on spatial items and on number/counting concept items would also demonstrate difficulty performing a complex motor skill pursuit tracking task.

All three groups demonstrated significant probability, trial, and distance effects. This indicated that a significant learning effect took place and that these preschoolers were indeed able to perform this complex motor skill task.

Overall, the results of this study did not indicate a direct link between children at-risk for learning difficulties and their performance on a pursuit tracking task. Examination of tracking task components leads to the conclusion that a basic processing problem may exist in the low performance MAP group. These children were also rated poorly on teacher evaluations suggesting evidence of lower functioning in other skill areas. The increased decision score and overshoot rate seen in this group may be lowered by encouraging these children to slow down; perhaps performance in the classroom may also be improved with similar encouragement.

The high rate of overshoots seen in both the low performance

MAP and spatial groups may be linked to difficulty in identifying spatial location and difficulty judging distance. This area of deficit has been previously identified in research with clumsy children by Hulme et al. (1982) as well as Lord and Hulme (1987). Alternative explanations worthy of examination are: integrative disturbances between visual perceptual and motor coordination components in research with learning disabled children by Mattison et al. (1986) and irregular eye movement patterns seen in dyslexic children in studies by Pavlidis (1986).

The results of this study did suggest a link between the children who scored poorly on number and counting concept items and two performance components of the pursuit tracking task; specifically (1) their difficulty in responding to uncertainty, seen in their increased reaction time and (2) difficulty reacting to unanticipated changes in movement, seen in their increased overshoot movement time. Previously, Rourke (1989) suggested a link between children who performed poorly in arithmetic and perceptual-motor functioning. In particular, the children who scored poorly on number/counting concept items demonstrated a longer average response time, a longer reaction time and a longer time to correct movements, once they overshoot the target. The longer overshoot movement time indicates difficulty dealing with the unexpected. As their non-overshoot movement time was not significantly different, one can conclude that once these children knew which movement they had to make, they could move as quickly as the high performance subjects. However, they had a

tendency to make more movement errors, implying a lack of control, and took longer to correct their unanticipated movement errors. This lack of motor control is supported by numerous studies involving learning disabled children (Mattison et al., 1986; O'Brien et al., 1988), with reasons for this motor deficit ranging from difficulty processing visual perceptual information to integrative difficulties between visual perceptual and motor coordination components. Learning disability subtypes have been examined by researchers and specific subtypes have been analyzed in relation to different areas of academic performance and perceptual motor functioning.

The work by Rourke and Strang (1978) and Rourke and Finlayson (1978), was primarily with older children, 9 to 14 years of age, however the findings from the present study utilized a younger population, 4 years 3 months to 5 years 8 months of age, and appeared to support and extend Rourke and colleagues' contention regarding the underlying perceptual-motor difficulty of children exhibiting problems in arithmetic.

In examining the performance of the low spatial and MAP groups, one questions why this group of children did not also demonstrate greater difficulty in responding to uncertainty. What is it about the number/counting concept items which isolates low performance children in terms of having a slower reaction time, but is not demonstrated in the low performance spatial or MAP group? It would appear that for this age group, the number/counting concept items captured an element of uncertainty

as well as lack of structure, not as predominant in the spatial items. Uncertainty in the sense that the task does not provide clues as to what the response should be and the lack of structure adds to this uncertainty.

The spatial and MAP items are generally more structured and predictable, often requiring that the child copy a particular pattern or sequence of actions. However, a loose pile of coins offers no organization or structure which would provide an immediate clue as to their total. Hence, a strong element of uncertainty and lack of structure is present in the number/counting concept items, which the child must overcome. Likewise in the tracking task, once a target is illuminated, it's spatial location is known, however, prior to this, the task provides for varying levels of predictability in regard to the direction of the subsequent movement: again the child must work to overcome the lack of certainty regarding choice of direction. This process occurs once again when a target is overshoot, in that the child must re-organize/re-structure their response and overcome uncertainty regarding direction. Perhaps it is these elements which contributed to the increased average response time and increased reaction time seen in this particular group of children. Alternative explanations discussed earlier, such as difficulty integrating visual perceptual and motor coordination components and difficulty in visual tracking or eye movement patterns, must also be considered.

In this study, the counting task necessitated the child to

visually scan in some direction depending on how the child chose to arrange the coins. Children in the low performance number/counting concept group made more errors in counting perhaps as a result of visual scanning difficulty and/or sequencing and organization. There are researchers who point to visual sequencing ability and spatial order memory as important factors in reading ability (Gordon, 1988; Jordan, 1989; Mason et al., 1975). Perhaps this group of children are exhibiting early warning signs of later reading difficulty.

In essence, perception is our interpretation of the information presented and represents the attempt to give structure to the world we live in. Thus, it would seem reasonable that an underlying perceptual problem might be the common link between the motor difficulties exhibited during the tracking task and the difficulty in performing tasks involving number/counting concept. However, other variables not included in this study, such as poor visual sequencing and tracking, spatial order memory and integrative disturbances, cannot be discounted.

Certainly, the overall decreased efficiency seen in the performance of the tracking task, evident in children with poor number/counting concept abilities and their specific difficulty in handling uncertainty, is deserving of attention.

Recommendations:

The tracking task has proven to be a valuable complex motor skill task which can be used effectively with younger children and which has the ability to measure different components of motor skill proficiency. The following are recommendations for future research in the area of motor proficiency and the development of early learning problems in preschoolers;

1. A larger sample size focussing more closely on number/counting concept skills to investigate the link between these skills and motor proficiency in greater detail.
2. Inclusion of a greater number and variety of spatial test items and number/counting concept test items.
3. A study which includes measurement of attentional abilities.
4. A study which includes specific evaluation of visual tracking and sequencing.

## Chapter VI

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## Appendix A

MAP Test Items

1. Tower: The Big Building Game
2. Sequencing: The Put Away Game\*
3. Block Designs: The Make-a-Building Game\*
4. Block Tapping: The Watching Game\*
5. Stereognosis: The Feely Game\*
6. Finger Localization: The Finger Game
7. Object Memory: The Remembering Game
8. Puzzles: The Make-a-Picture Game
9. Figure-Ground: The Hide and Seek Game
10. The Draw-a-Person Game\*
11. Motor Accuracy: The Draw-a-Cage Game
12. Vertical Writing: The Bunny Hop Game
13. Hand-to-Nose: The Mr. Thumbuddy Game
14. Romberg: The Statue Game
15. Stepping: The Marching Game
16. Walks Line: The Walking Game
17. Supine Flexion: The Make-a-Ball Game
18. Kneel-Stand: The Stand Up Game
19. Imitation of Postures: The Simon Says Game\*
20. Tongue Movements: The Funny Tongue Game
21. Rapid Alternating Movements: The Stamp Game\*
22. Maze: The Find Your Way Game\*
23. General Information: The Questions Game
24. Follow Directions: The Do It Game\*

25. Articulation: The Word Game
26. Sentence Repetition: The Repeat Me Game\*
27. Digit Repetition: The Number Game\*

Note. The items marked with \*asterisk indicate test items with a spatial, sequencing and organizational component as specified by Miller (1988).

## Appendix B

Number/Counting Concept Test Items

**The "Money" Game:** Number and Counting Concept (Miller, 1990)

**Materials:** 15 pennies, 1 quarter, 1 nickel

**Scoring:** Each correct response will be scored 1 and each incorrect response scored 0. Discontinue after 3 consecutive scores of 0.

For Item 2, the highest number to which the child correctly counts (while pointing to the corresponding penny each time) will be recorded.

**Administration:** Say Now we're going to play The Money Game.

**Item 1:** Group 15 pennies in front of the child and say **Count these pennies out loud. How many are there?** Place 1 of the pennies in front of the child and say **Here is one. You count the rest.** After the child responds to this item, remove all the pennies.

**Item 2:** Place the quarter, nickel and 1 penny in front of the child approximately one-quarter of an inch apart, but not in a row. Say **Which one of these is the biggest?**

**Item 3:** Remove the nickel, leaving the quarter and penny in front of the child. Say **Which one is smaller?**

**Item 4:** Replace the nickel and say **Which one of these coins is the smallest?**

**Item 5:** Remove the quarter and the nickel. Make 3 groups of pennies: one group of 1 penny only, another group of 10 pennies

and another group of 4 pennies. Arrange the groups so that the first group of 1 penny is at the child's left, the second group lies in front of the child and the third group is at the child's right. The pennies in the groups should be placed flat on the table and not in rows or stacked. Say **Which group has the most pennies?** Do not allow the child to manipulate or regroup the coins.

Item 6: Point to the group of 4 pennies and say **Which group has more than this group?**

Item 7: Point to the group of 4 pennies and say **Which group has less than this group?**

Item 8: Make 2 groups of 4 pennies each and 1 group of 7 pennies. The group with 7 pennies should be in the middle. Say **Which two groups have the same number?**

Item 9: Make 1 group of 2 pennies and 1 group of 4 pennies. Pick up the group of 4 pennies and close your hand around it. Say **I have four pennies in my hand.** As you add the other 2 pennies to your hand, say **Now I'm going to put two more pennies in my hand.** Close your hand and say **How many pennies are in my hand altogether?** Do not allow the child to see or count the pennies in your hand.

Appendix C

Letter of Parental Consent

Letter of Parental Consent

Researcher: Katya Feder, B.M.R., O.T.  
 Research Supervisor: Robert Kerr, Ph.D.; 564-9134

Dear Parents:

A study concerned with the early screening of children for potential learning difficulties is being conducted by a graduate student at the University of Ottawa, School of Human Kinetics. The Research Committee of the Ottawa Board of Education has granted permission to the researcher to request your cooperation in this study.

The purpose of the research is to screen children for potential learning difficulties. The focus is on the perceptual-motor development of young children, 4 - 5 years of age, as difficulties with basic motor tasks have been identified as indicators of possible later academic difficulties. The intent is not to diagnose any children, but to indicate whether they may be at-risk and, therefore, should receive further evaluation.

Participation by your child in this study will entail two 30 minute sessions during school time. Children will be tested individually by a trained tester. The Miller Assessment for Preschoolers (session one) is presented as a series of games, e.g. draw-a-person, build a block tower, find the missing star in the picture. The complex motor task (session two) is like a video game which involves turning a steering wheel to "catch" a series of lights. The classroom teacher will also be asked to offer comments on their impressions of the child's fine and gross motor behaviour.

All information will be kept strictly confidential. This information will not appear in any school records, will be seen only by the researcher involved in this study, and will be used solely for research purposes.

If you have any questions, please call the research supervisor at the number given at the top of this letter.

We would be grateful for your cooperation. Whether or not you wish your child to participate, please complete the attached form and return it to the school within the next week. If you are interested in having your child participate in the study, research staff will contact you soon.

Yours truly,

Katya Feder, B.M.R., O.T.

-----  
 I hereby \_\_\_\_\_ give permission  
                   \_\_\_\_\_ do not give permission  
 for my child \_\_\_\_\_ to participate in the  
 study.  
 Signature of parent or guardian \_\_\_\_\_ Date \_\_\_\_\_

This information is protected under the Freedom of Information and Protection of Privacy Act, 1989 (Bill 49).

## Appendix D

Classroom Evaluation

The purpose of this questionnaire is to identify potential problem areas in different domains such as motor coordination, visual perception, attention and verbal abilities. These findings will be related to the childrens' performance on the Miller Assessment for Preschoolers and the tracking task. Please rate each child in terms of what would normally be expected for their age level. If the behaviour has not been observed or is unknown, leave the space blank.

Name of Child \_\_\_\_\_

Poor	Some Difficulty	Average
------	--------------------	---------

Gross Motor

1. general physical strength (as compared to others his/her age)
2. endurance for activity (as compared to others his/her age)
3. ability to perform balancing activities such as hopping, jumping or skipping
4. ability to throw/catch ball
5. ability to understand concepts such as right, left, front or back as it relates to his/her own body
6. sense of position or movement in space (while walking in classroom, hallways, on playground, etc.)
7. awareness of or sensitivity to touch (eg. difficulty recognizing familiar object by touch; demonstrates touch avoidance or dislike)

Fine Motor

1. cuts along a straight line
2. cuts along a curved line
3. cuts out a shape
4. strings small beads
5. ability to draw, color, trace
6. ability to grasp pencil or crayon adequately
7. ability to form or print letters

Verbal

1. ability to recount a simple story.
2. ability to express self verbally.
3. articulation (ability to pronounce words).

**Visual Perceptual**

1. recognizes letters/numbers/shapes
  2. ability to follow simple instructions
  3. visual sequencing ability (eg. formulates story using picture cards or follows bead sequence pattern)
  4. visual memory (eg. ability to remember picture or symbol shown earlier)
  5. ability to complete age appropriate puzzles
- 

Please indicate which rating (never/rarely, sometimes, often) describes the following behaviours:

NEVER	SOMETIMES	OFTEN
or		
RARELY		

1. Appears stiff and awkward in his/her movements
2. Appears clumsy, frequently falling or bumping into objects or others
3. Demonstrates poor posture (always seems to be leaning against something, shoulders slump forward)
4. Shies away from playground equipment.
5. Performs fine motor activities quickly and result is usually sloppy
6. Avoids fine motor activities
7. Printing is too dark, too light, too large, too small
8. Consistently uses right or left hand
9. Drools

**Behavioural**

Distractible  
 Restless  
 Slow worker  
 Disorganized and messy  
 Short attention span  
 Hyperactive  
 Can't follow directions  
 Is easily frustrated  
 Can not get along with others  
 Accident prone

**General Comments:**