A Comparison of Metacognitive and Procedural Knowledge of Ball Catching by Physically Awkward and Non-Awkward Children

by

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Metacognitive and Procedural Knowledge of Catching:

Physically Awkward

Physically awkward children are less efficient at motor skills than their non-awkward peers. This study was designed to evaluate procedural and metacognitive knowledge of ball catching skills of physically awkward and non-awkward children. It was hypothesized that physically awkward children would show a deficit in metacognitive knowledge of ball catching skills when compared to their non-awkward peers. The relationship between metacognitive knowledge and procedural knowledge was also assessed to determine if children knew what they did.

Three groups of subjects participated in the study. One group of 16 physically awkward children, age 6 - 11 years, completed the entire battery of tests. One group of 16 non-awkward children, 6 - 11 years of age, completed the procedural knowledge hierarchy and the metacognitive knowledge of self-ball catching skills questionnaire. Another group of 62 non-awkward children, 6 - 11 years old, completed the metacognitive questionnaire of ball catching skills.

Three tests were designed for this study. The procedural knowledge test was created as an eleven item catching hierarchy. Physically awkward children did not perform as well as non-awkward children, also performance increased with age for the non-awkward children. The metacognitive knowledge questionnaire of ball catching skills consisted of ten multiple choice questions. The test was administered

individually. Physically awkward children showed a limited deficit in metacognitive knowledge when compared to their non awkward peers. The results suggested that procedural and metacognitive knowledge do not develop at the same rate and that a deficit in procedural knowledge is not indicative of a similar deficit in metacognitive knowledge for the skill of ball catching.

The metacognitive knowledge of self-ball catching skills questionnaire was identical to the metacognitive knowledge questionnaire except the questions were worded to ask the subject how he or she caught the ball rather than to indicate the best wat to catch the ball. Comparison of the metacognitive questionnaire of self-ball catching skill and the procedural knowledge test suggested that children, age 6-11 years, have a reasonable idea of how they performed a catch.

Résumé

Les enfants physiquement non coordonnés sont moins efficaces en habiletés motrices que leurs pairs qui sont coordonnés. Cette étude a été mise sur pied pour évaluer les connaissances procédurales et métacognitives des habiletés à attraper une balle chez les enfants physiquement coordonnés ou non. Il fut admis comme hypothèse que les enfants non coordonnés physiquement montreraient un manque de connaissances métacognitives des habiletés pour attraper une balle comparés à leur pairs qui sont coordonnés. La relation entre la connaissance métacognitive et la connaissance procédurale a aussi été évaluée afin de déterminer si les enfants savaient ce quils ont fait.

Trois groupes de sujets ont participé à l'étude. Un groupe de 16 enfants non-coordonnés physiquement, âgés entre 6 et 11 ans, ont complété la batterie entière de tests. Un groupe de 16 enfants coordonnés, âgés de 6 à 11 ans, ont complété le questionnaire sur la hiérarchie de connaissances procédurales et les connaissances métacognitives des habiletés à attraper par soi-même une balle. Un autre groupe de 62 enfants coordonnés, de 6 à 11 ans, ont complété le questionnaire métacognitif des habiletés à attraper une balle.

Trois tests ont été préparés pour cette étude. Le test sur les connaissance procédurales a été créé comme hiérarchie de onze items à attraper. Les performances des enfants physiquement non coordonnés n'étaient pas aussi bonnes que celles des enfants

coordonnés. Le questionnaire des connaissances métacognitives pour attraper une balle était composé de dix questions à choix multiples. Le test fut administré individuellement. Les enfants physiquement non coordonnés un démontré un déficit limité de connaissances métacognitives comparés à leurs pairs qui sont coordonnés. Les résultats suggèrent que les connaissances procédurales et métacognitives ne se développent pas au même rythme et un déficit en connaissances procédurales ne signifie pas un déficit similaire en connaissances métacognitives en ce qui concerne l'habileté à attraper une balle.

Le questionnaire sur les connaissances métacognitives des habiletés à attraper une balle par soi-même était identique à celui sur les connaissance métacognitives, à l'exception que les questions ont été formulées afin de demander au sujet comment il ou elle a attrapé la balle plutôt que d'indiquer la meilleure manière d'attraper la balle. Une comparaison entre le questionnaire métacognitif sur l'habileté à attraper une balle et le test de procédures indique que les enfants âgés entre 6 et 11 ans, avaient une idée raisonnable de la façon de faire une prise. (attraper la balle).

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Chapter 1

Introduction

"In physical education every child fails at one time or another by coming in last on the relay team, by missing the basket or the field goal which would have tied the game, by choking in the swimming pool. How often must a child fail in order to be labeled clumsy, awkward, uncoordinated, handicapped?. How long does a label, once internalized, endure?" (Sherrill, 1983, p.7). Answers to these questions are not readily forthcoming, but are important issues for children participating in physical education classes. It is the responsibility of physical educators to ensure that each child is given a chance to succeed, and to build feelings of confidence and self-esteem. Recognition of children with movement difficulties and attempts to understand reasons why children have motor problems are the first steps in meeting this challenge.

Children with motor impairments despite normal intelligence and absence of brain damage have been recognized since the 1930's (Gubbay, 1975). However, it has only been in the past two decades that the disorder has been

recognized as a possible handicap that requires remediation (Henderson & Stott, 1977). Such children are usually referred to as being physically awkward.

Wall (1982) defined physically awkward children as "children who fail to perform culturally-normative skills with acceptable proficiency" (p. 254). Culturally-normative skills are defined as those skills which are commonly used by a majority of people within a culture at certain ages. Wall (1982) states that "proficiency in motor skills is characterized by purposeful, planned, and precise behavior" (p. 254' but acceptable proficiency varies with age, gender, and sociocultural environment of a person. Catching a ball is one culturally-normative skill for 6 - 11 year old North American children. Acceptable proficiency varies with age, a 9 year old is generally expected to catch more skillfully than a 6 year old. Different specifications define 'acceptable proficiency' for each age and cultural group.

Despite such theoretical definitions of physically awkward children, there is some controversy when operationally defining the term. Several researchers have tried to find reliable methods of identifying physically awkward children. Gubbay (1975) and Keogh (1968) defined physical awkwardness as children scoring at or below the 10th percentile of a motor test with age appropriate norms. Henderson and Hall (1982) and Keogh, Sugden, Reynard, and Calkins (1979) suggested that a child must score poorly on

several tests prior to determining that the child is physically awkward. The Test of Gross Motor Impairment (1984) designed by Stott, Moyes and Henderson was constructed to identify children with mild to moderate motor impairments. Children scoring below the 15th percentile are considered as having some motor impairment. There are a number of clinical descriptions of physically awkward children (Gubbay, Ellis, Watson, & Court, 1965; Keogh 1968), but there is no single trait which identifies a child as physically awkward. The use of multiple measures appears to be an acceptable method of identifying the children. It has been recognized that physically awkward children comprise a heterogeneous group, and manifestations of the syndrome vary for different children (Gordon & McKinlay, 1980; Torgeson & Dice, 1980; Wall, 1982). Thus multiple measures may assure that a broader range of motor deficiencies are taken into account.

Incidence of physical awkwardness is between 5-6% of the general school population (Gubbay, 1975; Henderson & Hall, 1982). Keogh et al (1979) identified 3-4 times as many males as females although Gubbay (1975) found equal gender incidence of physically awkward children in schools.

Wall, McClements, Bouffard, Findlay, and Taylor (1985) proposed a knowledge-based model of motor development with direct implications for the physically awkward child. They postulate that there are four major types of knowledge

about action: procedural, declarative, affective, and metacognitive. Each form of knowledge develops and is essential for skillful execution of a motor act. All four types of knowledge interact to allow an individual to develop proficient control of action (Wall et al, 1985).

Procedural knowledge refers to knowledge of how to do something, and is assessed by the performance of an action. "An action sequence may be viewed as the instantiation of procedural knowledge about action" (Wall et al., 1985, p.29). Presumably if a person can catch a ball he or she has a certain degree of procedural knowledge of ball catching. Measurement of a person's performance is considered to quantify a person's procedural knowledge of the particular action.

Declarative knowledge about action refers to information about how to perform an action, the constraints involved,and the type of movement which is necessary. This type of information is stored in memory. Knowledge of morphological, biochemical, and environmental constraints, as well as body image and spatial coding combine to form declarative knowledge (Wall et al., 1985).

Affective knowledge about action refers to subjective feelings people attach to their actions (Wall et al., 1985). Success experiences are essential for the growth of positive affect of movement. Positive affective knowledge of action enhances the relationship between procedural and

declarative knowledge. Negative feelings in the affective domain hinders optimal development of the affective domain and may cause poor motor performance. Physically awkward children generally have poor affective knowledge about action. Reuben (1968), Shaw (1982), and Wall (1982) report that a physically awkward child's self-esteem is generally lower than his or her peers. Problems in motor skills are visible to many people. It is almost impossible to hide one's inability to perform in gym class. Adler (1982) and Reuben (1968) noted that physically awkward children were ridiculed and avoided oy classmates. Proficiency in physical education is important for social status in a child's peer group (Adler, 1982). Poor skills, as exhibited by awkward children, lead to lower status. A double-edged sword is evident in this relationship with poor performance leading to failure experiences and negative affect, as well as negative feelings of action hindering proficient motor performance. Physically awkward children are thus at a disadvantage in forming positive affective knowledge about action.

Metacognition in relation to action can be defined as one's "knowledge of the process controlling (one's) own motor behavior" (Newell & Barclay, 1982, p.202). Metacognition can be broken down into two elements, knowledge and skill (Brown, Bradsford, Ferrera, & Campione, 1982; Flavell & Wellman, 1977).

Metacognitive knowledge about action refers to being "consciously aware of what (one) can or cannot do in thousands of action situations" (Wall et al., 1982, p. 31-32). It is awareness of procedural, declarative, and affective knowledge about action. Metacognitive knowledge is a higher form of declarative knowledge as it also refers to information stored in memory. It develops as children become aware of situations and variables which effect performance. An example of metacognitive knowledge is a runner who can take into account pertinent variables such as distance, temperature, wind and altitude and know at what pace he or she can comfortably complete the run. If the runner begins too quickly he or she will have difficulty maintaining pace the entire distance.

Metacognitive skill, also called executive control, is more directly related to actual performance. Wall et al. (1985) placed metacognitive skill within the domain of procedural knowledge. Metacognitive skill includes self-regulatory mechanisms, planning, monitoring, and evaluating outcomes (Brown et al., 1983; Newell & Barclay 1982). Wall et al., (1985) defined metacognitive skill as " the instantiation or use of metacognitive knowledge" (p.32).

The effect of metacognition on performance has not been established. Controversy as to the exact relationship between metacognition and performance exists, although Newell & Barclay (1982), Wall (1985), and Wellman (1983) do

agree that metacognition has some effect on motor performance. Wellman (1983) proposed a hypothetical linear relationship between metacognition and performance. As knowledge of the effect of a strategy increases, so does the likelihood of using that strategy, thereby increasing quality of performance. Assuming that this postulated relationship is correct , it would appear that as people acquire more metacognition, procedural knowledge improves.

The four types of knowledge contained within the Wall et al. (1985) model interact to allow an individual to develop proficient control of action. They appear to develop in a spiral fashion building increasingly skilled movement patterns. A symbiotic relationship exists between the knowledges, thus a breakdown in one type of knowledge would affect the interplay of all the knowledges with a resulting decrement in performance. To date there is no published research which has studied this relationship, particularly between metacognition and performance. The Wall et al. (1985) model implies that increasing one type of knowledge would influence the other three types of knowledge. A deficit in one type of knowledge should lead to less than optimal performance. From the model it appears that adequate performance can not be attained if there is a deficit in any of the knowledge types.

Physically awkward children are clearly behind their peers in motor skill development (Gubbay, 1975; Henderson &

Hall, 1982; Henderson & Stott, 1977; Keogh et al., 1979; Reuben & Bakwin. 1968; Wall et al., 1985). Thus poor procedural knowledge characterizes physically awkward children, procedural knowledge being measured by a child's overt actions. Since procedural knowledge is poor one question of interest is to explore the status of the other knowledges.

Haubenstricker (1982) defined physical awkwardness as one type of learning disability, specifically as "those (children) whose learning disability is manifested primarily in inadequate or inappropriate motor behavior. Such children are often referred to as uncoordinated, awkward, or clumsy" (p. 41). Learning disabled children have been found lacking in metacognitive knowledge and skills as well as procedural knowledge (Butterfield, 1981; Cullen 1985; Slife, 1985; Wong, 1985; Wong, 1986). Therefore it might be argued that physically awkward children have poor metacognition which hinders optimal procedural knowledge.

The opposite to that hypothesis is that since physically awkward children are of normal intelligence and without physical impairment (Gubbay, 1975; Henderson & Hall, 1982; Wall, 1982) they have the opportunity to acquire substantial declarative knowledge which leads to accurate metacognitive knowledge. If physically awkward children are found to possess declarative and metacognitive knowledge equal to their peers then their poor performance must be

caused by factors other than those dimensions of the person's knowledge base.

Observing a clumsy child perform a motor task provides a subjective measure of procedural knowledge but gives little information about the other types of knowledge (Newell & Barclay, 1982; Seigler, 1983). Inferences as to the status of a child's declarative, affective, and metacognitive knowledge cannot be made on observation of performance alone (Seigler, 1983). Thus one cannot assume that the cause of less than proficient motor performance is linked to poor declarative and metacognitive knowledge, although Wall et al. (1985) suggest that this relationship exists. Wall et al. (1985) stated that "in as much as physically awkward children have much less knowledge about action than their peers, they should have qualitatively and quantitatively different metacognitive knowledge and skills about action" (p. 38).

Physically awkward children present one method of testing the Wall et al. (1985) model of motor skill development. Reid (1988) suggested that the study of physically awkward children is one approach to understanding motor skill development at all levels of proficiency. Physically awkward children are at the low end of the spectrum of motor skill development. Discovering why they have poor procedural knowledge of action may lead to a

fuller understanding of motor skill development in all people, and to better techniques of teaching movements.

Further research based on the Wall et al. (1985) model will aid in discovering where a breakdown in the relationship of the different knowledges occurs which leads to poor motor control. A physically awkward child who has difficulty catching a ball lacks procedural knowledge of ball catching. Whether the problem lies in not knowing how to catch the ball (declarative and metacognitive knowledge) or in the instantiation of the knowledge (procedural knowledge), or a combination, is not known. Ascertaining the quantity and quality of a child's procedural and metacognitive knowledge may give information to the relationship between the types of knowledges and their roles in performance.

Statement of the Purpose

The purpose of this study is to establish the relationship between metacognitive and procedural knowledge of ball catching skills of physically awkward children and their non-awkward peers. It is also the purpose of this study to compare self-metacognitive knowledge of physically awkward and non-awkward children to their performance on the procedural knowledge test, to determine if children know how they are moving.

Hypotheses

1. Physically awkward children will show a deficit in metacognitive knowledge when compared to their non-awkward peers.

2. There will be a relationship between metacognitive and procedural knowledge of catching.

Subhypothesis

1. The metacognitive test for physically awkward children and their non-awkward peers will be reliable.

Delimitations

1. The participant's age range is 6 - 11 years old.

2. Only subjects who score on or below the 15% of physical skill ability for their age, as measured by the Stott, Moyes, and Henderson Test of Motor Impairments (1984) will be used.

3. The children are enrolled in the Aqua Percept Program at the Pointe-Claire Aquatic Center, Quebec.

Limitations

1. Metacognitive knowledge will be measured by a questionnaire designed for this study. Effort will be made to establish the validity of the questionnaire, by comparing metacognitive answers to actual performance of non-awkward children. Problems of distortion and tacit knowledge of performance are inherent in collecting metacognitive data. A positive relationship between answers on the metacognitive portion of test and what is done on the procedural part of the test, and an increasing agreement percentage with age, will be an indication that the measurement device is valid.

2. Physically awkward children will be operationally defined a children whose motor abilities fall into the lowest 15% of their age group. Incidence reports indicate 5 - 6% of the general population is physically awkward. Some of the children identified may not be identified as clumsy if different criteria were used.

Definitions

Affective knowledge - subjective feelings attached to actions (Wall et al., 1985).

Declarative knowledge - knowledge of facts, including morphological, biomechanical, environmental constraints, body image and spatial coding (Chi, 1981; Wall et al. 1985).

Procedural knowledge - knowledge of procedures and rules [Chi, 1981] which determine a sequence of action, an instantiated schema (Newell & Barclay, 1982).

Metacognition - a person's knowledge about his own or other's psychological, social, and physical behavior and abilities (Newell & Barclay, 1982).

Metacognitive knowledge -"knowledge about what one does or does not know" (Wall et al., 1985, p.31).

Metacognitive skill - the functional manifestations of metacognitive knowledge (Findlay, 1985).

Physically awkward children - "children without known neuromuscular problems who fail to perform culturally normative motor skills with acceptable proficiency" (Wall, 1982, p. 254).

Culturally-normative skills - "skills generally used within a specific culture at certain ages by a majority of people" (Wallet al., 1985, p. 23).

Chapter 2

Review of Literature

Introduction

This study was designed to assess the differences between physically awkward and non-awkward children in metacognitive and procedural knowledge of ball catching skills. This chapter is concerned with reviewing literature pertinent to this problem and will be divided into three main parts: i) Physically awkward children, ii) A knowledge based model of motor development, and iii) Metacognition.

Physically Awkward Children

Physical awkwardness affects 5-6% of the school population (Gubbay, 1975; Henderson & Hall, 1982; Keogh et al., 1979; & Wall, 1982). In each average class room of 30 children 1 to 2 of these children may be physically awkward. This type of motor problem was recognized around the middle 1900's (Paton, 1986) but wide spread recognition was not gained until 1962 when the British Medical Journal published a brief article on 'Clumsy Children'. Since that time the physical, emotional, and psychological problems of physically awkward children has gained considerable interest.

Several researchers have defined physical awkwardness

and concur that the overriding problem is one of motor difficulty in everyday motor skills. Wall (1982) stated "Physically awkward children are children who fail to perform culturally-normative skills with acceptable proficiency" (p.254). Haubenstricker (1982) explained that awkward children "Are those whose learning disability is manifested primarily in inadequate or inappropriate motor behavior" (p. 41). Gubbay (1975) similarly stated " the clumsy child ... is defined as one whose ability to perform skilled movement is impaired, despite normal intelligence and normal findings on conventional neurological examination." (p.233) Thus physically awkward children are of normal intelligence but have difficulty performing the same motor skills as their peers of the same age and culture.

Characteristics

Physically awkward children have been described by the many characteristics which are listed in Table 1 (Ellis & Court, 1962; Gubbay, 1975; Gubbay, Ellis, Walton, & Court, 1965; Haubenstricker, 1982; Reuben & Bakwin, 1968).

Table 1: Characteristics of Physically Awkward Children

1	-no known neurological damage but may have soft neurological signs
2	-the syndrome is developmental or congenital, normal motor skills were never developed
3	-speech develops slowly and indistinctly
4	-awkward performance of everyday activities: eating, dressing, riding a tricycle
5	-slow learning activities of daily life
6	-mild delay in acquiring motor milestones
7	-poor handwriting
8	-need high attention to task to perform adequately.
9	-immature levels of performance when compared to peers
10	-inconsistency in performance
11	-perseveration of a task
12	-mirroring, inability to separate directional movements from those of a leader
13	-asymmetry of body parts in activities that normally require bilateral use of limbs
14	-loss of dynamic balance
15	-falling after performance of gross motor skills
16	-extraneous movements during gross motor skills
17	-inability to maintain a rhythmical pattern
18	-inability to control force
19	-inappropriate motor planning.

Not all children will show all characteristics, and some physically awkward children may have accompanying

disorders. For example, Taylor (1982) found a higher incidence of physical awkwardness in children with reading learning disabilities than when all school children were considered. Haubenstricker (1982) also found that many learning disabled children had poor motor skills. Keogh (1968) found the 25% of educationally subnormal boys were physically awkward compared to a 7% incidence rate for their educationally normal peers. McKinlay (1982) pointed cut that physical awkwardness can affect children with intelligence quotients ranging from gifted to mentally retarded. Intelligence has often been measured using the Weschler Intelligence Scale for Children. This test may be broken down into two scores, verbal and performance. Many researchers have found that physically awkward children score significantly higher on the verbal test than on the performance test (British Medical Journal, 1962; Gubbay et al., 1965; Peters, 1975; Reuben & Bakwin, 1968; & Walton, 1962.) Thus physically awkward demonstrate average ability by scoring in the normal range for the verbal portion of the Weschler Intelligence Scale but their physical disabilities prevent them from obtaining high scores in the performance section. Therefore physically awkward children are usually of normal intelligence, and are often defined as such, but the syndrome may also be present in conjunction with other disorders.

Etiology

Physically awkward children make up a heterogeneous group (Haubenstricker, 1982; Henderson & Hall, 1982). In 1962 the British Medical Journal published a paper to increase awareness of the syndrome. At that time causes were assumed to be diverse and from three major areas; delayed maturation of the nervous system, minimal signs of cerebral palsy, and perinatal anoxia. At the same time Prechtl and Stemmer (1962) and Walton, Ellis, and Court (1962) suggested that birth injury, either peri-, neo-, or early post-natal anoxia were important etiological factors.

As research continued the importance of adverse birth history, as early as 18 weeks after conception, was linked to physical awkwardness (Denckla, 1984; Gordon and McKinlay, 1980; Taylor, 1982; Wall, 1982). Other causes were also recognized: neurological soft signs (Denckla, 1984, Taylor, 1982), defects in cerebral organization (Denckla, 1984; Gubbay et al., 1965; Gubbay, 1975; Reuben and Bakwin, 1968), genetic endowment (Wall, 1982), and a breakdown of cognitive processes (Roy, 1983; Torgeson, 1977; Wall, 1982). To date there has been no cause of physical awkwardness established, but that the syndrome stems from a diverse number of causes has been widely accepted.

Terminology

When discussing physical awkwardness it appears that several terms are being used to describe the same syndrome. Developmental apraxia (Gubbay, 1975), developmental dyspraxia (Denckla, 1984) and physically awkward are terms used to describe what appears to be the same group of children.

Gubbay (1975) equated the term developmental apraxia with physical awkwardness. The term developmental implies congenital or early acquired defect or disorder in the acquisition of a particular function (p.40). Apraxia is a pathological condition which is characterized by an inability to carry out voluntary movements, where the inability is not due to motor paralysis, ataxia, or dementia (Roy, 1982). Definite brain injuries are associated with apraxia though the exact location of the lesion is not the same for every case. One important difference between apraxia and developmental apraxia is that apraxia is characterized by a loss of motor skills which once were normally developed while developmental apraxia indicates that the motor skills were never developed.

Roy (1982) outlined different types of apraxia: ideational, ideomotor, frontal, and premotor, as well as the resulting impairments. He has attempted to outline the region of the brain damaged and to explain the effect of the damage on the information processing systems and resultant motor errors.

Though there are distinct differences between apraxia and clumsiness the study of apraxia has given the field of awkward children important information. In fact neurologists suggest that study in the pathologies of people with motor difficulties coupled with theoretical aspects of movement is important in comprehending motor learning and the organization of the motor systems (Geschwind, 1975).

Denckla (1984) and subsequently Cermak (1985) have introduced the term developmental dyspraxia to refer to children demonstrating motor planning disorders. Cermak (1985) hypothesized that developmental dyspraxia is a disorder of sensory integration which interferes with a child's ability to plan and execute skilled or non-habitual motor tasks. The impairment is congenital or developmental.

Denckla (1984) asserted that developmental dyspraxia is the failure to learn or perform voluntary motor activities despite adequate strength, sensation, attention, and volition. This definition is similar to Roy's (1983) definition of apraxia. Denckla (1984) used the term synonymously with clumsiness.

There are many similarities when comparing the symptoms associated with physical awkwardness, developmental apraxia, and developmental dyspraxia. And when examined closely these similarities suggest that the terms may actually describe the same awkwardness syndrome. The terms seem to differ according to why there is a deficit in motor skills. Physical awkwardness accepts a diverse number of causes; developmental

apraxia implied some type of brain injury while developmental dyspraxia suggested a disruption in sensory integration. At the present time there is no known cause for the syndrome, so all of these theories must be considered.

Identification

The identification of physically awkward children is not an easy task. As a result of diverse etiological factors and characteristics there are no clear cut guidelines as to who is physically awkward.

Presently physically awkward children are usually identified after they enter elementary school, with only extreme cases being apparent during the first three or four years of life (Gubbay, 1975). There are several reasons for this: i) skill demands become more complex during the school years so that motor abilities are more taxed and deficits become apparent (Wall, 1982), ii) the child is expected to perform daily living tasks efficiently and independently and a lack of these skills becomes a problem (Gubbay, 1975), iii) untidy handwriting, fidgetiness, apprehension of physical education classes become apparent when a child begins school (Gubbay, 1975), iv) comparison with peers shows a gap in motor ability which widens with age (Gubbay, 1975), v) if tests of motor proficiency are performed too young (under four years) the results will include those children whose skill will improve with maturity and do not need extra help

(Gordon, 1980).

At the other end of the spectrum Denckla (1984) suggested that gross or global clumsiness may be spotted as early as eight months, with reliance on poor performance of motor skills. She also found that motor difficulty, especially the inability to hop, at age four was a good indicator of physical awkwardness at age seven. This finding lends feasibility to identification of physical awkwardness in the preschool years without obtaining a large number of false findings. An advantage of early identification is to help overcome some of the emotional and social problems encountered by a physically awkward child.

An additional problem associated with identifying physically awkward children is the lack of specific criteria designed for this purpose. There is controversy among researchers as to how to operationally define physical awkwardness. It is well known that physically awkward children make up a heterogeneous group and that manifestations of the syndrome varies from child to child. (Gordon & McKinlay, 1980; Torgeson & Dice, 1980; Wall, 1982). Therefore it is important to assess a variety of abilities before labelling a child as awkward. A physically awkward child may be adept at swimming but unable to run or catch a ball.

The use of multiple measures in determining if a child is physically awkward appears to be an accepted method of assessment. Keogh, Sugden, Reynard, and Calkins (1979) used

three measures in an attempt to identify a group of physically awkward children. Classroom teachers were asked to fill out a questionnaire about movement skills, physical education personnel were asked to rate via observation their movement skills and movement related behaviors, and a movement performance test was administered. Each measure identified a slightly different group as physically awkward. Children scoring in the lowest 10% of the population on two tests were considered physically awkward. Henderson and Hall (1982) also used multiple measures, five different tests were administered. They obtained scores on : 1) a neurological examination, 2) the Motor Impairment Test, 3) The Weschler Intelligence Scale for Children, 4) the Schonell Reading Test, and 5) the children were referred as having motor impairments by their teacher. The results indicated a 5% incidence of clumsiness and showed that physically awkward children scored significantly lower than non-awkward children on the Motor Impairment Test and the neurological examination. Both research papers emphasized the need for multiple measures due to the fact that physically awkward children " do not form a single group but vary widely in their characteristics" (p. 459, Henderson & Hall. 1982).

Haubenstricker (1982) has pointed out several advantages to early identification of physically awkward children. Early childhood is the period when a child's greatest gains in postural control and skill development are made, and also the time when deprivation may have the

greatest negative effects. The implications for early identification and help seem critical in light of the emotional and social problems encountered by clumsy children. A multiple measures approach appears to be necessary in light of the varying characteristics shown by physically awkward children. Use of a single measure would likely overlook a percentage of physically awkward children. It seems possible to accurately identify physically awkward children in the first year of elementary school (Henderson & Hall, 1982; Keogh, 1979) but it is not clear if identification before this age is accurate.

Self Concept

Self concept of the clumsy child is one area for concern. It has been well documented that children who display awkward physical movements are at the mercy of their peers (Adler, 1982; Shaw, Levine, Belfer, 1982; Wall, 1982). Teasing and isolation of a child from his or her peer group, either on the playground or in the classroom can be very difficult for a child to deal with. Shaw et al.(1982), Reuben and Bakwin (1968), and Wall (1982) stated that a physically awkward child's self-esteem is generally lower than his or her peers. Adler (1982) and Reuben and Bakwin (1968) noted that physically awkward children have difficulty making friends. Wall (1982), Adler (1982), and Reuben and

Bakwin (1968) noted that these children were avoided and ridiculed by classmates.

Adler (1982) interviewed 51 children and their parents. The children had difficulties in physical education classes. Adler compared the results of the interview and questionnaire with the results of a control group of pupils without physical education problems. He found that children who performed poorly in physical education classes had problems in self-confidence and that they were less popular with their peers than children who did not experience motor difficulties. Shaw et al. (1982) administered two scales of self-esteem to 23 eight to twelve year old boys in a hospital clinic for learning disorders. Significantly lower self-esteem was found in the gross motor delayed group than in the nondelayed group. Reuben and Bakwin (1968) and Walton et al (1962) gathered information through case histories and found that physically awkward children experienced emotional problems including feelings of inadequacy and loss of self-esteem. Walton et al (1962) stated that " a feeling of inferiority seemed unavoidable in these apraxic children, especially when they reached the age of active physical competition where their limitations were piteously exposed" (p. 609).

Problems in motor skills are visible to many people as opposed to other types of learning disabilities. It is almost impossible to hide one's inability to perform in gym class, as opposed to a poor score on a reading test which may not

come to the attention of the whole class. Therefore the nature of physical awkwardness allows evaluation of the child by others (Wall, 1982, Walton, 1962). Adler (1982) suggested that proficiency at physical education is important for social status in one's peer group. These observations make it clear that the physically awkward child will almost always encounter social difficulties.

A Knowledge-Based Model of Motor Development

Roy (1983), Torgeson (1977), and Wall (1982) have expressed concerns about a breakdown of cognitive processes in physically awkward children and learning disabled children. Information processing occurs readily in normal children but functions poorly in awkward children. A deficit in the information processing system may cause poor performance (Hulme, 1982; Kalverboer, 1983; Mulder, 1983; Schellekens, 1983). However there is no agreement as to where the deficit occurs in the information processing system, and in fact it may occur in different places for different children. The information collected from the environment must be adapted and stored as knowledge, and be recalled when a similar situation occurs to facilitate performance. Wall et al. (1985) hypothesized a relationship of knowledge and performance to explain the interplay between

these two variables.

Wall et al. (1985) proposed a knowledge based model of motor development with direct implications to the physically awkward child. They hypothesize that there are four types of knowledge of movement; procedural, declarative, affective and metacognition. The four types of knowledge interact to provide proficient control of movement.

It is suggested that all four types of knowledge develop in a spiral fashion to build movement patterns. If there is a breakdown in the relationship between the knowledges efficient control of movement will not occur. This may be one problem of physically awkward children although the specific breakdown is unknown. The relationship within and between the knowledges appears to be complicated and requires considerable study. For this research project procedural and metacognitive knowledge were of primary concern, but a brief accounting of declarative knowledge, affective knowledge, and metacognitive skills is beneficial to understanding the complete model.

Procedural knowledge refers to how to do something and is measured by performance (Wall et al., 1985). It is the actual movement. Therefore if a person can do something then he or she is assumed to possess procedural knowledge of that movement. If a child can catch a ball, he or she has some degree of procedural knowledge of ball catching. The amount of skill shown in ball catching is indicative of the degree of procedural knowledge. Thus a physically awkward child has

less proficient procedural knowledge of ball catching than an expert. Procedural knowledge is the only type of knowledge in the model that is measurable through movement. The cause of poor procedural knowledge is not known though lack of practice or prior execution of a movement may play a key role. If a person has never performed a movement then he or she has no procedural knowledge of that movement. With practice procedural knowledge increases, and according to the Wall et al. model the other types of knowledge will also develop.

Declarative knowledge refers to factual information about a movement, which is stored in memory (Wall et al., 1985). Information about body image, spatial coding, and other movement concepts are stored within this domain. Arend (1980) described three constraints that affect skilled movement which constitute declarative knowledge. The first constraint referred to a person's knowledge of their own body, neurological, muscular, and skeletal functions and limitations. Coupled with the second and third constraints; physical limitations such as gravity, and environmental constraints give important information about how to perform a skill. Declarative knowledge is acquired, "through countless data driven interactions between the person and environment" (Wall et al., 1985, p.30).

It is thought that very young children possess declarative knowledge in a non-verbal state. As they develop and gain experience they begin to attach verbal labels to

their spatial coding system. The development of declarative knowledge is essential to the development of skilled movement, children who do not understand spatial concepts will have difficulty following instructions on how to perform an action. Front, back, left, right, are all terms used in explaining how the body moves during an action sequence.

Affective knowledge refers to subjective feelings a person attaches to actions in many movement situations (Wall et al., 1985). This type of knowledge is acquired through many different movement experiences. People have sports they prefer and ones they do not care for, this represents affective knowledge. For example, some people may have had a bad experience on a bicycle and consequently dislike bicycling, therefore they have acquired negative affective knowledge of bicycling. Children develop positive affective knowledge through success experiences if the majority of attempts at an action are met with success. On the other hand if the child continuously fails at his or her attempts to perform the movement he or she will probably come to dislike that activity, negative affective knowledge. The child who continually meets with failure or disapproval in his or her attempts at an action will develop feelings of incompetence. Consequently negative subjective feelings toward movement will arise and this in turn effects the relationship between all three types of knowledges.

Metacognition refers to what one knows about his or her own cognition (Wellman, 1983). The term can be broken

down into two parts, metacognitive knowledge and metacognitive skill. Wall et al. (1985) place metacognitive knowledge under the domain of declarative knowledge, and metacognitive skill within procedural knowledge. Metacognitive knowledge refers to "knowing what one knows or does not know " (Wall et al, 1985, p. 31) about their own procedural, declarative, and affective knowledge. Metacognitive skill is the "instantiation or use of metacognitive knowledge about action" (p.32). Metacognition is essentially a new concept development by John Flavell and introduced in 1971 (Trabasso, 1983). Since that time considerable research has been carried out in an attempt to precisely define the term.

The knowledge-based model of action by Wall et al. (1985) suggested that

> the efficiency of the conscious control of action depends on the adequacy of the knowledge base that a person has acquired. Individuals who have acquired a wide array of automized skills (procedural knowledge) are more likely to be able to respond to different task demands within a given performance environment. At the same time, accurate declarative knowledge about performance environments will also facilitate skilled action. When individuals face novel or technically different situations, their cognitive and metacognitive skills might allow them to access their knowledge about action in a more systematic and efficient manner so that they are better able to control their attention from both a performance and learning perspective. (p.36).

Therefore adequate knowledge implies good movement performance.

Physically awkward children are behind their peers in procedural knowledge (Wall et al., 1985) and therefore might

have different declarative, affective, and metacognitive knowledge than their peers. Discovering the type and magnitude of the differences in the knowledge base between physically awkward and non-awkward children is essential in understanding why the physically awkward children perform motor skills poorly.

Metacognition

During the late sixties and early seventies, there was a shift from S-R psychology to a cognitive approach. The later approach is concerned with knowledge stored as generic concepts, as opposed to isometric patterns, and leads to the idea of an executive control. The theory of metamemory was developed from this new orientation by Flavell (Trabasso, 1983).

Metacognition is a broader term for metamemory. Metamemory refers specifically to what an individual knows about his or her own memory, whereas metacognition refers to what one knows about his or her own cognition (Wellman, 1983).

There is widespread agreement that the term is ambiguous. Brown, Bradsford, Ferrara, and Campione (1983) summed up the ambiguity when they wrote: "... it is clear that metacognition is not only a monster of obscure parentage but also a many-headed monster at that." (p.124). Metacognition is best described as a cover term that

encompasses a family of related processes. These processes are distinguished by what Wellman (1983) terms a "central distinction", the distinction between engaging in a form of cognition and knowledge of that cognition (metacognition).

Prototypic instances of metacognition are easily recognizable and widely accepted (Wellman, 1983). One example is the tip of the tongue phenomenon, where the person knows something (a word, name) but is unable to execute the act (say the word or name). The fact that many people know that certain strategies aid performance is also an example of metacognition. We can picture these examples as being the body of the monster, but as we approach the monster's many heads ambiguity as to what is and is not 'meta' increases - the edges become fuzzy. Agreement between different theorists as to what is meta breaks down.

Wall et al. (1985) and Newell and Barclay (1982) have attempted to define metacognition with reference to action, and to incorporate this type of knowledge into models of movement. Metacognition of action is knowing about knowing how to move (Wall, 1985). It is this type of metacognitive knowledge that is of particular interest to physical educators.

Definition

As mentioned earlier metacognition can be broken down into two elements: knowledge and skill. Metacognitive

knowledge refers to one's knowledge about cognition. It is stable, statable, late developing (Brown et al., 1983), and can be further broken down into two categories of knowledge, sensitivity and variables. The taxonomy is taken from Flavell and Wellman (1977) but the definition given in terms of action was obtained from Newell and Barclay (1982). Sensitivity, the first type of metacognitive knowledge, involves a minimum of two aspects. The first is knowing that skilled action is required to complete the act successfully. The second aspect refers to a person's awareness of context or situational cues which define the act. For example, an impromptu game of football with a group of friends defines quite different task demands than the final game of the CFL playoffs.

The second category of metacognitive knowledge refers to variables which affect performance: person, task, and strategy. The person variable can be divided into two sub-categories: 1) "trait" which defines the morphological constraints, and 2) "state" which refers to proprioceptive monitoring to allow knowledge of ongoing action.

The task variable refers to knowledge of characteristics which affect difficulty and the complexity level of an act. An example would be a skier who is aware that a steep slope is more difficult than a gentle slope.

Strategy, the final variable, is concerned with the performer's knowledge of movement configurations which can be invoked voluntarily to complete an act in a skillful manner.

For instance, if a person wants to get to the other side of a swimming pool he or she might solicit the movement configuration of the front crawl to complete the act skillfully as opposed to performing the dog paddle.

Metacognitive skill, also called executive control, is more directly related to actual performance. Metacognitive skill includes self-regulatory mechanisms, planning, monitoring, and evaluating outcomes. This knowledge may not be conscious, especially for well-learned tasks.

A comprehensive definition of metacognition has been attempted, many different variables adding up to create knowledge of what a person knows about knowing how to move. The components may be summarized as follows:

Metacognitive Knowledge

1) Sensitivity is skilled action required, awareness of situational cues.

2) Variables -
   Person - trait, state
   Task - characteristics of difficulty
   Strategy - movement configurations

3) Metacognitive Skill
   Self-regulatory mechanisms - planning, monitoring, evaluating.

Measurement

Measuring a person's metacognition has presented several problems. The most common form of measurement has been verbal reports. Inherent in verbal reports are many complications which must be taken into consideration if the

data are to be used with confidence. The purpose of this section is not to give a complete guide to the use of verbal reports, but instead to highlight some of the problems.

Brown et al. (1983) refer to three problems associated with verbal reports: i) the potential for distortion of information, especially by children, ii) the fact that few investigations have been concerned with reliability and consistency between what is said and what is actually done, and iii) the probability that during automized routines cognitive processes are often not available to consciousness. Despite these problems different types of verbal data may be collected, and some types are more useful than others. Ericsson and Simon (1980) give a comprehensive review of the use of verbal reports as data and they classify verbalizations within several categories which should be taken into account when evaluating the data. They include; task (primary or secondary), time (predictive, concurrent, or retrospective), recoding (general or specific), directed or undirected data.

Verbal reports can be useful, but careful consideration should be given to the many variables concerned and researchers should be aware of the type of verbal data reported. An analysis of performance will often provide strong indications of the adequacy of verbalized information.

Metacognition has also been measured using on-line measures (Brown et al., 1983). These measurements include the

time expended on a task. An example is that more time is required to read passages which contain contradictory sentences or that breach standard grammatical convention. Another form of measurement is the monitoring of facial signs. Eye movements related to preceding information or instructions or facial signs of confusion are two examples. Brown et al. (1983) reported that younger children were more likely to show nonverbal signs of confusion at appropriate times of an act than to report verbally that the message was not clear.

Ericsson and Simon (1980) suggested that an analysis of an action may provide an indication of the reliability of verbalized information. It would seem appropriate to collect at least two types of data, on-line and verbal. If they coincide it is possible to be quite confident that the verbal data is an accurate measure of the metacognitive processes utilized in performing an act. To rely on actual performance alone may lead to erroneous interpretations. Newell and Barclay (1982) have suggested that a person, particularly a child, may use a strategy but be unaware that he or she is employing it.

One pattern of a child's use of strategies is a U shaped pattern of errors (Brown et al., 1983). Young children may use, but be unaware of many different strategies and commit few errors, as the child becomes aware of the use of strategies he or she will use one specific strategy in all situations, right or wrong, and the number of errors

increases. Gradually, the child "enters the period of metaprocedural reorganization" (Brown et al., 1983, p.120) when different strategies are integrated and theory is developed. Consequently, with only observation or performance, it would be difficult to differentiate between the beginning and end of the U pattern. Verbal data collected simultaneously with performance observations would greatly enhance the value of the data. Seigler (1983) reinforces this point in saying that we cannot infer children's reasoning from their error patterns. Because this is a developmental problem, it is necessary to be conscious of this issue when evaluating children.

In the present study an essentially non-verbal method of assessing metacognitive knowledge was developed to avoid some of the pitfalls of the verbal technique noted above. Photographs of various developmental levels of catching behavior were shown to the children. They were required to chose the photograph which best depicted a mature catch (Questionnaire of Metacognitive Knowledge of Ball Catching) and which best represented their own catching pattern (Questionnaire of Metacognitive Knowledge of Self-Ball Catching Skills).

Development

Metacognition is a developmental phenomenon (Chi, 1978; Gerber, 1983; Lawson, 1984; Mischel & Mischel, 1983;

Reeve & Brown, 1985). A general pattern of development has emerged: children become more realistic and accurate in assessing their own cognitive capabilities with increasing age and mental ability (Levine, Yussen, Derose, & Pressly, 1978). Also, metacognitive development cannot be separated from the development of a child's knowledge base (Chi, 1978).

There remains controversy as to the age at which metacognition is first seen. The controversy seems to center on two factors, i) the method used to collect the data, and ii) definition of metacognition.

The first issue, the method used to collect data, refers to verbal measures compared with on-line measures. Brown et al. (1983) reported that " on-line measures reveal earlier sensitivity than stringent demands for verbal reporting" (p. 115). Open-ended questions asked of young children can lead to problems of interpretation making such questions minimally useful. On-line measures have reported metacognitive abilities in children ranging from 2 1/2 to 4 years of age (Smith & Tager-Flusberg, 1982; Wellman, 1983; Wellman, Ritter, & Flavell, 1975). Verbal data concerning metacognitive development suggests that verbalization about metacognition begins around the sixth year of life (Brown et al., 1983; Mischel & Mischel, 1983). The differences in results could be due to the greater sensitivity of on-line measures.

The second issue, the definition of metacognition, arises in evaluations of development because there are no

clear cut guidelines as to what a child must do to be considered to possess metacognition. Wellman (1985) considered a sign of metacognitive knowledge as being that a child realizes that there is a mental world that exists apart from the physical (real) world. Given this assumption, he stated that metacognition begins at a very young age, approximately 2 1/2 to 3 years. Wellman based his conclusion on the fact that

> metacognition consists of a large multifaceted theory of mind ... and three supportable propositions. First, that very young children, 2- and 3- year-olds, grasp the existence of the mental world ... Second, children of this age and younger also understand much about the distinction between reality and not reality ... Third, development of an understanding of reality are intertwined. (p.29).

The knowledge and use of generalization of strategies has been one indicator used to determine a child's metacognitive development. The extent to which strategies are generalized seems to reflect different levels of development. Wellman (1975) found that children as young as 3 to 4 years engaged in simple strategies. Smith and Tager-Flusberg (1982) found that 3 to 4 year-old children exhibited some use of metalinguistic abilities. Brown et al. (1983) argued that strategies must not only be used, but must be generalized over a wide variety of tasks, before the child can be considered to possess metacognition, and thus they find the emergence of metacognitive abilities around the sixth year of life. In fact, they describe the phenomenon as late-developing.

There is agreement throughout the literature on how

an individual develops metacognitive knowledge and skills. Of central concern is the development of an adequate, stable knowledge base (Chi, 1978; Lawson, 1984; Newell & Barclay, 1982; Wall et al., 1985) including declarative, procedural, and affective knowledge. To emphasize this point Chi (1981) insists that greater use of strategies with increasing age is actually a by-product of greater content knowledge, because strategies are essentially a generalized form of specific procedural knowledge. It may be that strong general strategies are acquired after content knowledge is developed.

Two other factors which contribute to the development of metacognition are interaction with the environment (experiences) and socialization. Certainly the wealth of information which is attained through one's experience cannot be omitted from developmental issues. Poor performances from children reared in impoverished environments attests to the need for multiple experiences in order to develop efficient skills to cope with a variety of tasks (Cullen, 1985).

Socialization may be examined through the change from other-regulation to self regulation. Young children are dependent on parents, teachers, or some authority figure to guide them in problem-solving situations. A transfer of executive control from expert to child is a crucial aspect of socialization (Brown & Reeve, 1985; Brown et al., 1983). Cullen (1985) stated "that it is on the basis of these experiences (adult-child interactions in early childhood) that self-regulative capacities gradually emerge" (p.28). The

internalization of executive control is gradual and follows a set pattern (Brown et al., 1983). Socialization and the transfer of executive control occur in an informal parent-child environment, but may also be taught through specific programs if necessary (Cullen, 1985; and Brown & Reeve, 1985).

The path of metacognitive development is being discovered, but much remains to be learned about the child's early development of cognition. That increased content knowledge, the transfer of executive control, and experience all contribute to metacognition is well established, but the relative importance and precise timing of these elements is still open to question.

Metacognition and Action

Several models of how metacognition is used during a task have been created. Butterfield (1981) devised a four stage model but application to a motor task is not clear. Brown et al. (1983) also discussed how metacognition works. Newell and Barclay (1982) explained how metacognition can be applied to action. metacognition has traditionally been studied using memory or puzzle tasks. The motor domain requires overt practise and monitoring actions (proprioceptive and kinesthetic knowledge). This is taken into account in Newell and Barclay's (1982) description of metacognition and action. Eight steps from the initiation of

a task to its completion have been identified: (p. 109)

1 Does the situation require skilled effort?

2 Are you aware of the task to be solved? (complexity, danger, task variables)

3 Are you aware of context within which task is presented?

4 No specific strategy known - evaluate available strategies.

5 Make initial trial and error response.

6 Monitor execution.

7 Evaluate response.

8 Evaluate strategy - response - outcome before making next response.

Metacognition is developed in this manner while the evaluation of available strategies is an example of the use of metacognition. Evaluating the strategy and resulting performance serves to further develop metacognition.

Consider a practical example and the choices a performer would have to make. Perhaps an eight year old has joined little league softball and is about to attend his or her first practice. He or she has not had much batting experience and begins to evaluate the situation answering the first four steps of the model; 1) the situation does require skilled effort, 2) the task is to hit the ball before three strikes, 3) the task is presented in a practise session thereby relieving the tension of a game atmosphere, but still one will be performing in front of peers so there is some

social pressure to do well, 4) no specific strategy is known, but my father told me how to hold the bat, stand at the plate, and watch the ball. Once the questions about the task are answered, it is possible to attempt the task. If the batter is successful then the strategy may be repeated the next time. If the batter is not successful then the strategy must be evaluated to find where things went astray. For example the strategy may be correct but the execution poor, which may be concluded if, while monitoring the action a mistake was perceived. Another case may call for a change in strategy, or a revision in the same strategy. Whatever the change the whole process is repeated over and over until the response is correct.

Effects on Performance

That metacognition has a role in action has been established (Newell & Barclay, 1982; Wall et al., 1985), but the effect of metacognition on performance is less certain. Wellman (1983) proposed a hypothetical linear relationship between metacognition and performance. As knowledge of the effect of a strategy increases, so does the likelihood of using that strategy. Wellman recognizes that this is a "straw model" which unduly simplifies the relationship between metacognition and performance, but he asserts that it provides a useful starting point to generate experimental

situations. Assuming that this postulated relationship is somewhat accurate, it would appear that as a person acquires more metacognition performance improves. In a similar vein, Wall et al. (1985) stated that "the efficiency of the conscious control of action depends on the adequacy to the knowledge base" (p. 36). The knowledge base is comprised of declarative, procedural, affective, and metacognitive knowledge.

The relationship of metacognition to action can be defined as one's "knowledge of the processes controlling (one's) own motor behavior" (Newell & Barclay, 1982, p. 202). Processes that affect behavior are numerous, and range from physiological to environmental inputs. The argument seems to be that as one increases knowledge of person, task, and context variables, one can begin to exert control over what is to be done with the stimuli. Consider the process of attention. Young children are easily distracted (Miller, 1985), which causes a considerable number of accidents. A common scenario is the 3 year old riding a tricycle while looking at older children playing ball in the park. He or she then rides off the sidewalk and falls over. A parent picks up the child and says " Remember to pay attention to what you are doing. Look where you are going!" As the child gains experience he or she realizes that he or she must give attention to the task at hand to avoid such spills. As maturation continues, the child learns that some tasks require little attention and that another task can be

performed simultaneously, but that if trouble arises, attention must be focused on the difficult task. Newell and Barclay (1982) give a typical example:

> one of us (KMN) often finds himself leaning over to turn the car radio down or off as he leaves the interstate to enter a busy traffic area, which ties in rather nicely with the fact that driving in towns is more attention demanding than driving on the interstate! (p. 200)

Therefore performance should improve as metacognitive knowledge and skills increase. Wall et al. (1985) attempted to explain the process of automization of action as a result of well-learned knowledge. Efficient performance will not occur if the performer must attend to every movement. Current theory relies on schemas or well-learned motor patterns which are run off automatically, without conscious control of the performer. In Wall et al.'s terms, such schemas represent a person's procedural knowledge. By definition metacognitive skills monitor action. If during the action sequence something goes wrong metacognition comes into play by the way of trouble shooting. The performer becomes aware of his or her actions and uses his or her knowledge to correct the performance. Performance is enhanced by automation of action sequences, leaving the performer open to attend to other stimuli (cues), but with the knowledge that his attention will be drawn back to the action if a problem arises.

A baseball catcher is one performer who must rely on automated sequences to perform successfully. If he or she had to consciously think of every head, neck, shoulder, elbow,

wrist and hand movement of each catch, he or she would not be in a very good position to look at where the ball is. On the other hand if the catcher begins to miss a lot of catches he or she will need to become conscious of what his or her arms and legs are doing.

Deficit in Metacognition

One method of study is to observe subjects who show a deficit in the relevant process (Roy, 1982). Learning disabled and mentally retarded persons have been found lacking in metacognitive knowledge and skills (Butterfeild, 1981; Cullen, 1985; Slife, 1985; Wall et al., 1985; Wong, 1985; & Wong, 1986).

Observations of persons who are learning disabled and mentally retarded have shown that these individuals do not spontaneously use strategies in their repertoire when faced with a problem solving situation (Wong, 1985). If strategies are taught, they are usually 'welded' to a specific context and are not generalizable (Wong, 1986). When the subject approaches a task similar but not identical to the training task he or she will not instantiate the appropriate strategy.

Metacognition training programs have been developed which attempt to teach children different strategies and how to employ them. The ultimate goal is for the child to a) maintain knowledge of the strategy, and b) to generalize use of the strategy across a variety of situations. The assumption behind metacognitive training programs is that

development of organized strategic behavior in the inefficient learner will promote effective learning (Cullen, 1985). It must be stressed that metacognition alone is not enough to assure efficient use of strategies in appropriate situations. The child's knowledge of the context is equally important for there is an interdependence between one's knowledge base and metacognition (Chi, 1978; Wong, 1986). Chi (1981) has suggested that the use of metacognitive skills (strategies) without an adequate knowledge base will not elevate performance above the limitation imposed by a lack of knowledge. Therefore, it is important to teach both general content knowledge and metacognitive skills. A well established and stable knowledge base will make the use of new strategies easier (Wong, 1986).

Brown et al. (1983) and Tharp and Gallimore (1985) have outlined similar training programs to teach metacognitive skills. They stated that to avoid the problem of welding strategy and task, skills should be trained free from situational constraints. Both programs used a strategy on many tasks to avoid welding one strategy to one task. One question that may be raised is whether the effects of the training programs are due to "rule announcements" or to "the use of multiple exemplars". Justice (1985) found that experience in cognitive tasks did not increase metacognition, but that if mentally retarded people were given specific information on the effects of a strategy, there was an increase in their metacognitive awareness.

Two populations which might benefit from metacognition training are the learning disabled and the mentally retarded. However, training programs for mentally retarded persons with a mental age of six or less have met with little success (Wong, 1986) for generalization abilities do not occur until a mental age of seven (Butterfeild, 1981). Wong (1986) emphasized that metacognition deficit was one contributor to the problems of learning disabled children and could enable us to understand the failure of certain children, but it was by no means a central problem for every child nor was it the 'key' to understanding learning disabilities. Therefore careful consideration must be given to the choice of recipients of metacognition training.

Little research has been undertaken to study the role of metacognition in the field of motor behavior. Markman (1973, cited by Newell and Barclay, 1982) asked children to predict their motor performance on two tasks. She found that children were almost as accurate as adults in assessing how they would perform the tasks. This accurate metacognition was explained by the use of two familiar tasks, jumping and carrying marbles, of which the children had a good knowledge base and efficient strategies.

Findlay (1986) studied declarative and procedural knowledge of children using an aiming task. She was interested in assessing differences in maturation, development of strategies and knowledge across four age groups, 5, 7, 9, and 11 years. The test consisted of four

tasks, the first involved rolling a ball down a chute to a target, the second in predicting the path of a ball rolled down the chute, the third used the same set up as the second task but the ball was rolled. The fourth task was a replication of task two. Any differences between task two and four were attributed to experience from task three. Findlay found that maturation effected performance with older children reducing their error scores quicker than younger children. Knowledge appeared to play a large part in determining how the subjects scored. Younger children had to rely on experience gained during the test and scored lower than older children who had more knowledge and rules about the task before attempting the test. Thus it appears from both studies that experience, or knowledge base, has an effect on performance.

Wall et al. (1985) attempted to link action and knowledge by constructing a model of knowledge about action. They postulated that physically awkward children are deficient in the procedural knowledge of action. Under Wall et al.'s definition, metacognitive skills are an ingrained part of procedural knowledge and therefore, physically awkward children are deficient in metacognitive skills. According to Wall et al., metacognitive skills "are the essence of the conscious control of action" (p.38). This conclusion implies that metacognitive training is necessary in addition to increasing content knowledge, if efficient movement is to be developed by physically awkward children.

And yet to date there is little empirical evidence to support metacognition's role in procedural knowledge. One could make a strong intuitive case that if physically awkward children are of normal intelligence their content knowledge base and their knowledge of strategies might be average, their ability to perform an action (procedural knowledge) being the key to the problem.

Rebel (1987) gathered data on declarative and procedural knowledge of ball catching over several age groups. The subjects ranged in age from 5 to 12 years. She found that though the younger children were behind the older children in procedural knowledge they were nearly equal to them in declarative knowledge. Therefore it appears that the knowledge types do not develop at the same rate and that declarative, and hence metacognitive knowledge, may develop prior to procedural knowledge. Realizing where the problem lies in a child's ability to perform will aid the instructor in designing effective programs.

One benefit in metacognition training programs lies in the affective domain. It has been will documented that learning disabled children generally have low self-esteem, poor motivation, and feelings of inadequacy (Reuben and Bakwin, 1968; Shaw et al., 1982; & Wall, 1982). Cullen (1985) hypothesized that a link exists between the affective and cognitive dimensions. She postulated that increasing metacognition will allow a child to cope better n a variety of situations and therefore to feel a sense of control,

which, in turn, would improve the child's feelings about himself or herself. Wall et al. (1985) stated

> Their (physically awkward) lack of interest in physical activity, their loss of self-esteem and lack of confidence in movement situations, and their lack of persistence in challenging action situations reflect their metacognitive knowledge of their difficulties in the procedural, declarative, and affective domains. (p.40)

Increasing metacognitive knowledge may improve the affective domain of the physically awkward child.

Summary

For skilled movement to occur there must be optimal interplay between all knowledge types, procedural, declarative, affective, and metacognition. A good knowledge base coupled with efficient strategies should result in good metacognitive knowledge. A deficit anywhere in the system will affect performance. Physically awkward children are behind their peers in procedural knowledge (Wall et al., 1985) as measured by performance of everyday movements. Thus it can be assumed that somewhere in the model there is a breakdown in the relationship between the knowledges which prevents efficient control of movement. Undertaking the process of measuring the different types of knowledge should lead to information as to where a deficit occurs, which in turn may lead to methods of intervention specifically designed to help the physically awkward child gain efficient movement skills.

Metacognitive knowledge was measured in this study to

determine if a breakdown in the relationship between the knowledges occurred in the declarative/metacognitive domain. Since we are aware that procedural knowledge of physically awkward children is behind their peers that leaves two knowledge domains; declarative/metacognitive, as metacognitve knowledge is under the domain of declarative knowledge, and affective knowledge to measure. It has been well documented that physically awkward children have poor affective knowledge (Adler, 1982; Reuben & Bakwin, 1968; Shaw et al., 1982; Wall, 1982; Walton et al., 1962). Measures of declarative knowledge and metacognition in physically awkward children are not readily forthcoming. Since physically awkward children are of normal intelligence it is possible that their metacognitive knowledge is equal to their peers. Determining the relationship between metacognitive knowledge and procedural knowledge would help lead to methods of intervention specifically designed to help the physically awkward child gain efficient movement skills.

Chapter 3

Methodology

The purpose of this study was to establish the relationship between metacognitive and procedural knowledge of ball catching of physically awkward children and their non-awkward peers. It was also the purpose of this study to compare self- metacognitive knowledge of physically awkward children and their peers to performance on the procedural knowledge test. The following chapter is divided into four sections: (1) Subjects; (2) Instrumentation; (3) Procedures; (4) Design and Treatment of the Data.

Subjects

Participants were children 6 - 11 years old who attended the Aqua Percept program at the Pointe Claire Aquatics Center. All subjects had been screened using the Stott, Moyes, and Henderson Test of Motor Impairment, Henderson Revision (1984). Since identifying physically awkward children is a problem, three criteria were set for the present study: (1) the subjects must be recommended by the Director of the Aqua Percept Program at the Pointe Claire Aquatics Center; (2) the subjects must score in the lowest 15% of the population measured by the Test of Motor Impairment (Stott, Moyes, & Henderson, 1984); (3) the subjects have no known neuromuscular problems.

Clumsy children comprise a heterogeneous group (Gordon & McKinlay, 1980; Henderson & Hall, 1982; Haubenstricker, 1982; Wall, 1982), and often have associated learning disabilities (Taylor, 1982) although awkwardness may be recognized by itself. Identification of the physically awkward child is a controversial topic. Despite a number of clinical descriptions of physical awkwardness there is no single method of identifying clumsiness. Gubbay (1975) and Keogh (1968) defined clumsiness as scoring below the 10th percentile on motor tests with age appropriate norms. Henderson and Hall (1982) assessed physical awkwardness by teacher's ratings of the children, while Keogh et al. (1979) required a rating of clumsy on 2 out of 3 tests. Thus for the purpose of this study a multiple measurement approach was utilized.

The Test of Motor Impairment was selected because it is designed to identify children with slight to moderate motor impairment from 5 to 11 + years of age. The test has been standardized and validated. The following categories of movement skills are identified: (1) manual dexterity, (2) ball skills, and (3) static and dynamic balance. The test is comprised of eight tasks which differ in each category according to age. Four age bands were identified, 5-6 years, 7-8 years, 9-10, and 11 years and upward, with tasks increasing in difficulty as age increased. This test was not designed to differentiate the genders.

Scoring on the Test of Motor Impairment is designed to identify only the lowest 15% of the population. Pass criteria does not differentiate the top 85% of the population for these children are considered to be without motor impairment. Scoring is divided into three categories, pass, borderline, and fail. A borderline score identifies children who fall below the 15th percentile and above the 5th percentile of motor ability for their age. A failure score indicates a child who's motor ability is in the lowest 5% of the population. A total score is obtained from all 8 tasks, the range being 0-16. A passing score on any item is recorded as 0. A score of 0 - 3.5 is considered a pass, 4 - 5.5 borderline, and 6 + is a fail.

Incidence of physical awkwardness has been estimated at 5-9% of the school population (Gubbay, 1975, Henderson & Hall, 1982; Keogh, 1968). The operational definition for this study is the lowest 15% of the population, because the test of Gross Motor Impairment was designed to identify this portion of the population. Therefore subjects who scored 4 or below were considered to fall within this criteria.

It is possible for children to obtain a failure score in one category of the test and passing scores in the other two categories. This can result in an overall borderline score indicating that the subject falls into the lowest 15% of the population. Therefore some children

defined as physically awkward may perform ball skills very well but have difficulty in static and dynamic balance. Since this study was interested primarily in ball skills children who received a passing score in ball skills were eliminated.

Children with known neuromuscular problems were eliminated. This is in accordance with Wall's (1982) definition of physical awkwardness. Parents of the subjects were asked if their child has been examined for neuromuscular problems, and if so to indicate the results.

The Aqua Percept program at the Pointe Claire Aquatics Center is a recreation program designed for children with motor problems. It is a perceptual motor program which is split between the gymnasium and the pool. Identification, through subjective means by the director of the Aqua Percept program was taken as an additional criterion of physical awkwardness . The director initially recommended 23 children for the study. Sixteen of the 23 children met the required criteria and participated in the study.

Therefore children participating in this study met 3 criteria: (1) scoring in the lowest 15% of the population measured by the Stott, Moyes, and Henderson Test of Motor Impairment, (2) recommendation by the Aqua Percept program director, and (3) no known neuromuscular problems.

Children without motor impairment were tested at Greendale Elementary school during class time. The catching hierarchy and metacognitive questionnaire were administered to all children.

Instrumentation

...hing knowledge was assessed in three ways. A test of ... acognitive knowledge of catching, a test of metacognitive knowledge of self-ball catching skills, and the procedural knowledge test were admimistered.

Metacognitive Knowledge

Metacognitive knowledge, "knowledge of what one knows or does not know" (Wall et al. 1985, p. 31) was measured by a questionnaire consisting of verbal and non-verbal methods of answering. Conventionally metacognition has been measured using verbal reports. Unfortunately there are many problems inherent in the use of verbal reports as data (Brown et al., 1983; Ericsson & Simon, 1980). Three main problems associated with verbal reports are: (1) the potential for distortion of information, especially by children, (2) the fact that few investigations have been concerned with reliability and consistency between what is said and what is done, (3) the probability that during automized routines cognitive processes are often not available to consciousness (Brown et al., 1983). To minimize the problems of verbal data, non-verbal data was collected

when possible, through video-taping, and metacognitive data was compared to what the subjects actually did. Ericsson and Simon (1980) suggested that an analysis of an action compared to verbalization may provide an indication of the validity of verbalized information. If what is said matches what is done it can be assumed that the verbal data is accurate.

The metacognitive questionnaire consisted of ten questions. The questions were designed to reflect general knowledge of how to catch a ball, and were geared to the skill level of six to eleven year old children. The questionnaire is listed in Appendix B. The rationale for each question follows:

Question 1: What ball is easiest to catch?

This question was represented by three balls commonly used in children's play. The three red rubber playground balls, one 5" diameter ball (small), one 8" diameter (medium) ball, and one 10" ball (large) were placed before the subject. The subject was asked to indicate which ball was the easiest to catch.

Gallahue (1982), Robertson and Halverson (1984), and Wickstrom (1983) agreed that a large ball is easiest for a child to catch. Robertson and Halverson (1984) hypothesized that a large ball is easier to catch because it may be caught successfully using immature catching patterns.

Question 2: Which child is most likely to catch the ball?

It is well known that to catch a ball one must look at the ball. This question was represented by photographs of a child looking at the ball, turning his eyes away, and turning his head away. The photographs are presented in Appendix B.

One concern identified by Ericsson and Simon (1980) in collecting directed verbal data is that if a person is offered a set of alternative answers one must know if these answers conform to the person's internal representations. Photographs of a child may be representative of their internal referents.

Question 3: How long should a child watch the ball?

An extension of question 2 attempts to identify between immature and mature catching patterns. To achieve a mature catching pattern the catcher must track the ball through its flight (Faut, 1971; Kruger & Kruger, 1977; Robertson & Halverson, 1984; Wickstrom, 1983; Whiting, 1969).

This question was represented by a drawing of a ball's flight between thrower and catcher (Appendix B). Three points along the flight were indicated, the child was

asked to choose the position which best reflected the point to which he watched the ball.

It has been documented that immature catchers often turn their head away from the ball and shut their eyes (Wickstrom, 1983). Successful catching is facilitated by watching the ball through most of its flight.

Question 4: Which is the best way to catch the ball?

This question was represented by four pictures ranging from an immature catching position to the mature position, that may be seen in Appendix B. The position of arms and hands in ball catching have been well studied. There is agreement in the literature as to the progression of catching skills (Gallahue, 1982; Kruger & Kruger, 1977; Robertson & Halverson, 1984; Wickstrom, 1983).

Immature: 1. Arms stiffly extended in front of body, fingers extended and tense palms upward.

Intermediate: 2. Elbows bent slightly at side, arms held in opposition,. Palms face each other, thumbs upward.

Vise-like: 3. Elbows bent, bottom hand facing upward, top hand facing forward.

Mature: 4. Arms relaxed at side, forearms held in front of body, elbows semiflexed, palms forward, inward, and downward.

The child was asked to show which picture displays the way one should prepare to catch a ball. Wickstrom (1983) found that 7 - 9 year old children sometimes used the vise-like position and were able to catch successfully.

Question 5: From which distance is it easiest to catch the ball?

Three distances, 3m., 5m., and 8m., were marked off by masking tape on the floor of the gymnasium. The catcher positioned herself at a stationary point, the thrower stood at the 3 meter mark facing the catcher, then at the 5 meter mark, and then stood at the 8 meter mark. No balls were thrown and caught. The child was asked which distance was easiest to catch a ball from.

Arnheim and Sinclair (1979) suggested shorter throwing distances were easiest to catch from. Optimum for beginner catchers being 1.5 meters, for intermediate skill level 3 - 4.6 m., and for mature catching patterns 6 - 9.2 m.. The three distances chosen for this test were 3m. - intermediate level, 5 m. - skilled level, and 8 m. from which it would be very difficult to catch a ball. Catching a ball thrown from 8 m. requires more estimates in the path of the ball than a ball thrown from 5 m. The 3m. distance represented the distance easiest to catch from, the 5 m. distance being easier than 8m.

Question 6: Which is the best way to place your feet when catching a ball?

Arnheim and Sinclair (1979) and Faut (1971) argued that a forward - backward stride was more efficient than a parallel stride. The forward - backward stride increases the catcher's base of support (Arnheim & Sinclair, 1979).

The subjects were shown three pictures, (Appendix B), one of a child's feet in a forward - backward stance, and one of a child's feet in a parallel stance, and one of a child standing with feet together. The subjects were asked to select the picture which best represented the way one placed their feet while preparing to catch a ball.

Question 7: Which picture shows the easiest way to catch the ball?

This question was represented with pictures of a child preparing to catch a ball standing still, a child preparing to catch the ball while jogging, and a child preparing to catch a ball while moving slowly, taking only a few steps. The photographs are shown in Appendix B. Robertson and Halverson (1984) described three stages of body positioning during catching. Initially there is no body adjustment made in response to the flight of the ball. Gradually the catcher moves arms and trunk in relation to the ball's flight path. Finally, arms, trunk and feet move

to adjust to the oncoming ball. It appears that the beginning catcher finds it difficult to combine catching and moving, but with experience and increased skill level it becomes possible to catch a ball while moving. Kruger and Kruger (1977) state that a ball thrown in a direct path (to the catcher) is easier to catch than if you must move in some direction to intercept the ball.

Question 8: In which direction is it eaiest to catch a ball?

Pictorial representations (Appendix B) were used to show a child moving forward, backward, and sideways in preparation to catch a ball. Recent analysis of catching skills has shown that it is easier for a catcher to move laterally than forward or backward (Kruger & Kruger, 1977; Wickstrom, 1983). Subjects were asked to indicate which direction was easiest to move in while attempting to catch a ball.

Question 9: Which is the best way to catch this ball?

Three pictures (Appendix B) were shown to the subjects, one of a child squatting while holding the mit along the ground palm up. The second picture showed a child kneeling on one knee while holding his mit palm down, above the ground, preparing to trap the ball between the mit and the ground. This method of stopping the ball will cause difficulty in throwing the ball to another player during a

softball game. The third picture was of a child kneeling on one knee while holding the mit at ground level, palm up. The subjects were asked to chose the picture representing the best way to catch the softball using a softball mit.

Question 10: Which ball is easiest to catch?

Three balls were shown to the children, soft, medium and hard. The soft ball was represented by a 5" nerf ball, the medium ball by a 5" rubber playground ball, and the hard ball by a 5" volleyball type ball. The soft and medium texture balls were deemed easier to catch than the hard ball because if the catcher misses the ball and gets hit by it less damage is done by the softer balls. Children often play 'dodge ball', a game in which the ball is thrown at opponents, and other similar games with rubber playground balls, thus they may realize that the softer balls pose less physical threat than the hard balls.

The questionnaire was repeated two weeks following the initial testing. The same locations and test protocol were used.

Metacognitive Knowledge of Self-Ball Catching Skills

In order to assess if the children knew what they were doing when they caught the balls the metacognitive

knowledge questionnaire of self-ball catching skills was administered to the children who performed the procedural knowledge test. The metacognitive knowledge questionnaire of self-ball catching skills was identical to the metacognitive knowledge questionnaire of ball catching skills except the emphasis was on "how do you catch the ball" instead of "what is the best way to catch the ball". The answers were represented in the same manner as in the metacognitive knowledge questionnaire, but the questionnaire was reworded as seen in Appendix C.

Reliability of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills

The reliability of the questionnaire of ball catching skills was assessed by the test-retest method. Reliability of a test "refers to the dependability of scores ... Reliability is popularly defined as the tendency toward consistency exhibited by an individual's repeated performance of one behavior" (Safrit, 1981; p. 82). The reliability of the questionnaire was found to be 82% for physically awkward children and 81% for non-awkward children. When corrected for chance agreement by kappa, the reliability coefficients were 73.4% for physically awkward children and 71.9% for non-awkward children. These scores prove that subhypothesis 1 was supported by data collected for this thesis.

Procedural Knowledge

Procedural knowledge, the knowledge of how to do something includes both internal processing and overt behavioral responses (Wall et al., 1985). Procedural knowledge was measured by scoring a number of catching tasks. The test is descibed in Appendix A.

The procedural knowledge test consisted of 11 ball catching tasks, 3 trials for each task, which encompassed all the information asked by the metacognitive questionnaire. It was scored using Cashin's Catch and Process Scale (Belka, 1985). This scale provided a rating of 0 - 5 points for each catch (Appendix D). The scoring was modified to provide a rating scale ranging from 1 to 6 points. This was done for computing purposes. One point was added to each step of the scale, thus a score of 0 changed to 1, a score of 1 to 2, and a score of 5 to 6. A clean catch, simultaneous two hand grasp with immediate control, was awarded 6 points. If no attempt was made to catch the ball a score of 1 was given. The scores for the three trials for each question were averaged. The scores for all questions were added together to give a score for the procedural test, a range from 66 - 11 points was possible. A score of 66 points indicated very good procedural knowledge of ball catching, the subject having successfully caught all tossed balls . A score of 22 or less denoted poor

procedural knowledge with the possibility of no catches having been completed.

The procedural knowledge test was videotaped. This was done for two reasons: 1) to facilitate scoring, and 2) to enable the comparison of the procedural knowledge test to the self-metacognitive test of ball catching skills.

The testing was performed in the gymnasium at the Pointe Claire Aquatics Center and of Greendale Elementary school. All children enrolled in the Aqua Percept program used the gymnasium on a regular basis. Non-awkward children were taken from Greendale Elementary school, these children used the gymnasium on a regular basis. It has been found that motor skills may best be understood when a person is viewed within an environmental context in which he or she is comfortable (Wade & Davis, 1982,). The familiar environment of the gymnasium, where ball activities are frequently engaged in, was used to reduce effects caused by an unfamiliar test and tester.

Procedures

Written permission was obtained for the screening test and the procedural knowledge test. Permission for the metacognitive test was included in the form given to the physically awkward children, and was supplied by the elementary school for the non-awkward children.

The testing was carried out in the gymnasium at the Pointe Claire Aquatics Center and Greendale Elementary school. The gymnasiums were used exclusively for testing during the designated times. The subjects were tested one at a time.

Three seperate groups of children were tested and protocol varied slightly for each group. Sixteen physically awkward children were given the three tests, the metacognitive test of ball catching skills, the metacognitive questionnaire of self- ball catching skills, and the procedural test in one session. The metacognitive test of ball catching skills and the metacognitive test of self-ball catching skills were given alternately before and after the procedural knowledge test. Sixteen non-awkward children were given the metacognitive questionnaire of self-ball catching skills and the procedural knowledge test at the same time. Sixty-two non-awkward children completed the metacognitive questionnaire of ball catching skills at a seperate time. Procedures for administering the test were identical for all groups except the non-awkward children were not given the test of metacognitive knowledge of ball catching skills alternately before and after the procedural knowledge test.

The gymnasium was set up for the testing prior to bringing subjects into the room. A video camera was positioned on the side wall of the gymnasium at

approximately a 45° angle to the center. The subject stood in the center circle for the testing. Masking tape was placed at three distances from the center circle: 3m., 5m., and 8m. The masking tape was 12 inches long and 1 inch wide. An X was marked with masking tape on the side of the gymnasium opposite from the camera, on the center line and boundary lines to indicate throwing positions.

Each subject was greeted in the hallway outside of the gymnasium by the tester. If parents were accompanying the child they were asked to remain outside of the gymnasium for the duration of the testing.

The testing began with one of the metacognitive knowledge questionnaires, either of ball catching skills or self-ball catching skills, for the physically awkward children. Since non-awkward children were given only one metacognitive questionnaire at the time of the procedural knowledge test half of the non-awkward group completed the questionnaire prior to the procedural knowledge test and half after. Subjects completed the questionnaires before or after the procedural test in random order. The tester said to the subject "Now I have a few questions about ball catching that I would like you to answer. Come sit down on the bench while I ask you the questions. I want you to think about each question and give me the answer you think is correct." The subject was asked the 10 questions involved in the metacognitive knowledge test outlined in Appendix B

and C. After the child gave his or her answer the tester said "Good. Now let's go on to the next question."

Two metacognitive questionnaires were given to the physically awkward children who performed the procedural knowledge test. One questionnaire was worded to ask the children to indicate the best, or most mature method of ball catching, the questionnaire of ball catching skills. The second questionnaire was designed to find out if the children knew what they were doing when they caught the balls. The questions were worded to ask the children "how did you catch this ball?", the questionnaire of self-ball catching skills as seen in Appendix C. These questionnaires were administered alternately before and after the procedural knowledge test to avoid confounding of practice with the results of the questionnaire. The metacognitive knowledge questionnaire of self-ball catching skills was administered alternately before and after the procedural knowledge test for the non-awkward group.

Visual presentations for both metacognitive questionnaires, with the exception of questions 1, 5, and 10, were laid out in a photo album. Only photographs or drawings pertaining to the question being asked were viewed at any one time. Questions 1 and 10 were represented by three balls placed on the floor in front of the subject. For question 5 the subject was asked to stand in the center circle of the gymnasium, the tester stood at

the three distances marked by masking tape, no balls were thrown and caught. The tester recorded the subjects' answers on a paper.

The procedural knowledge test, an eleven item catching hierarchy was administered individually. This test was an adaptation of the catching hierarchy used by Rebel (1987) the validity of which has been shown. The subject was asked to stand in the center circle of the gymnasium and face the tester. The tester said the following to the subject:

> "This is an activity to find out how you catch balls. I am going to throw the ball to you, and I want you to try and catch the ball. Now try to catch the ball when I throw it to you. Ready?"

The balls were thrown in the order indicated by the procedural test in Appendix A. After each successful catch the tester said "Good catch!". If the subject did not catch the ball for two throws the tester said "Good try!". If the subject was not having much success and appeared to become distressed the tester said "Don't worry, just try your best to catch the ball." The tester scored each catch upon reviewing the video tape.

If the tester observed that a throw was not correct the throw was repeated. The balls thrown had to be within

the boundaries marked by the masking tape. Approximately 2 out of every 33 throws had to be repeated. A second person scored 50% of the subjects to establish interrater reliability at 96.4%. That indicates that both scorer's agreed on the score given on each catch for 96.4% of the catches scored by the two scorers. The catches were scored while viewing the video-tape. This allowed the scorers to view a catch several times if necessary. An interrater reliability of 96.4% indicates good consistency in the scoring of the catches between the two scorers.

Upon completion of the testing the subjects were thanked and given a small token of appreciation. The tester walked the subject to the door of the gymnasium and thanked the parents for their cooperation if they were waiting for their child.

The metacognitive test was readministered two weeks following the initial testing to establish reliability of the questionnaire. The testing took place in the gymnasium of the Pointe Claire Aquatics Center, and and at Greendale Elementary school. The same protocol as in the first testing was followed except the procedural knowledge test was not performed.

Treatment of the Data

The data was analyzed to assess: (1) the difference in procedural knowledge between physically awkward children and their non-awkward peers, (2) the difference in metacognitive knowledge between physically awkward children and their non-awkward peers, and (3) to determine the agreement between procedural and metacognitive knowledge of self-ball catching skills. Scores for procedural and metacognitive knowledge were collected for 16 physically awkward and 16 non-awkward children.

A t-test was performed on the data collected from the procedural knowledge test. The scores obtained form the non-awkward group were compared to the scores from the physically awkward children. The subjects were divided by age into 5 groups, 6 years, 7 years, 8 years, 9 years and 10 years of age. A confidence level of .01 was considered adequate to show significant differences between the groups, a confidence level of .001 was actually obtained.

The results of the metacognitive knowledge questionnaire of ball catching skills were analysed question by question. The answers given by physically awkward children and their non-awkward peers were compared to ascertain any differences between the two groups.

Ericsson and Simon (1980) suggested that an analysis of action may provide an indication of the validity of verbalized information. If what is said and what is done coincide we may be quite confident that the verbal data is an accurate measure of the metacognitive processes utilized in performing an act. Though most of the questions may be answered nonverbally, for example by choosing a picture, agreement of data will add strength to the validity of the metacognitive data. To rely on actual performance alone to measure metacognitive knowledge may lead to erroneous interpretations. Seigler (1983) pointed out that one cannot infer children's reasoning from their performance. In fact Newell and Barclay (1982) stated that it is possible for a person, particularly a child, to use a strategy but be unaware that he or she is employing it.

Responses by each individual for the metacognitive knowledge of self-ball catching skills questionniare were compared to that person's responses during the procedural portion. This was done by reviewing the videotape of the catching hierarchy to determine if the person did what he or she indicated he or she would do. A grid was made for each question indicating the item of the catching hierarchy, the corrresponding answers on the metacognitive questionnaire, and if there was agreement between the two items. The percentage of subjects who were in agreement with regard to both types of knowledge were calculated. Hildebrand et al's (1977) prediction logic technique, delta, was used to

calculate the degree of consistency between the procedural knowledge test and metacognitive knowledge test of self ball catching skills. This technique incorporated a method of weighting the severity of an error. Percentage agreement and delta were calculated for physically awkward and non-awkward children to allow comparisons between the two groups.

Chapter 4

Results

The purpose of this research was to explore children's metacognitive and procedural knowledge about ball catching. Of particular interest was to assess any differences in these types of knowledge between physically awkward and non-awkward children. Also an answer to the question " Do children know what they actually do?" was attempted by comparing answers on the procedural and metacognitive knowledge tests. This chapter will be divided into three sections: (1) Procedural knowledge, (2) Metacognitive knowledge, (3) Comparison of procedural and metacognitive knowledge.

Procedural Knowledge

Procedural knowledge was assessed by a hierarchy of catching skills. The hierarchy was designed to meet the criteria that older children should be able to successfully complete more items than younger children. By definition a hierarchy includes both easy and difficult items, thus young children should not be able to complete all items and consequently will receive a lower score than older children who successfully catch the majority of balls thrown to them.

The catching hierarchy was scored by Cashin's Scale modified to include a range from 1 to 6, 1 being given if

no attempt was made to catch the ball, and a score of 6 attained if the ball was caught cleanly. Scores per person could range from 11 to 66. Average scores, by age group, are given in Table 2.

Table 2: Average Scores on Procedural Knowledge Test

	Age					
	6	7	8	9	10	Avg.
Non-awkward	45.7	47.3	48.0	57.9	60.7	51.9
n=	(3)	(4)	(3)	(3)	(3)	(16)
Physically Awkward	36.7	32.2	46.5	53.1	43.3	42.4
n=	(3)	(4)	(3)	(3)	(3)	(16)

t=3.32 P<.001
df=26

Inspection of the data indicates that scores increased by age of the children. Non-awkward children scored higher than physically awkward children across all age groups. A t-test showed that the two groups were significantly different at a .001 level of confidence.

Metacognition

Metacognitive knowledge was measured by two questionnaires consisting of 10 questions each, which pertained to catching a ball. Each child was asked to choose one of three or four alternatives which best answered the

question.

Reliability of the Metacognitive Knowledge Questionnaire

Reliability of the questionnaire was established by retesting the subjects 1 to 2 weeks after the initial questionnaire was given. Sixteen physically awkward and 62 elementary school children, representing the non-awkward population, were given the questionnaire twice. Test-retest reliability was an acceptable 82% for physically awkward children and 81% for non-awkward children. The reliability of the questionnaire was corrected for chance agreement by the kappa coefficient as outlined in House, House, and Campbell (1981). The basic formula for the kappa coefficient is: (p.46)

$$\text{coefficient} = \frac{Po - Pc}{1 - Pc}$$

Po=observer proportion of agreement
Pc=chance agreement

The corrected reliability for the metacognitive questionnaire was 73.4% for the physically awkward children and 71.9% for non-awkward children.

The reliability per question ranged from 94.8% to 63.8%, when corrected with kappa from 92.2% to 46.0%. Elimination or a change in format in the low reliability questions would enhance the overall reliability of the questionnaire. In particular questions 4 and 6 had low reliability, 67.2% and

63.8% respectively.

Metacognitive Questionnaire of Ball Catching

Sixteen physically awkward children and 62 non-awkward children answered the questionnaire, The breakdown per age is described in Table 3.

Table 3: Age of Subjects

	6 - 7	8 - 9	10 - 11	Total
Physically Awkward	7	6	3	16
Non-awkward	21	21	20	62

While both male and female children were tested, there was no difference between the genders in knowledge of ball catching, consequently all subsequent data is reported without concern of gender.

The questionnaire was analyzed by question. Tables 4 to 13 represent the number of children who chose each response. Results are from the questionnaire of ball catching skills, which method represents the best way to catch a ball, and from the first testing.

Table 4: The number of subjects selecting ball size alternatives (Question 1: Which ball is easiest to catch?)

Response	Age 6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (10")	1(14)	4(19)	3(50)	7(33)	2(67)	9(45)
B (8")	5(72)	4(19)	1(17)	4(19)	0(0)	5(25)
C (5")	1(14)	13(62)	2(33)	10(48)	1(33)	6(30)
Total	7(100)	21(100)	6(100)	21(100)	3 (100)	20(100)

* P.A. - Physically awkward () denotes percentage
N. A. - Non-awkward

The majority of non-awkward children in the first two age groups, 6-7 and 8-9, felt that the 5" ball was the easiest to catch. The 10-11 year old non-awkward children were divided about which ball was easiest to catch though a slight majority preferred the larger ball. Physically awkward children did not show a preference for any one ball size. The small group size of the physically awkward group compared to the non awkward group, may have resulted in the unclear data.

Table 5: The number of subjects selecting eye position alternatives when catching a ball. (Question 2: Which child is most likely to catch the ball?)

Response	Age 6 - 7 P.A.	6 - 7 N.A.	8 - 9 P.A.	8 - 9 N.A.	10 - 11 P.A.	10 - 11 N.A.
A (Look away)	0(0)	1(5)	1(14)	0(0)	0(0)	0(0)
B (Turn away)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
C (look at ball)	7(100)	20(95)	6(86)	21(100)	3(100)	20(100)
Total	7(100)	21(100)	7(100)	21(100)	3(100)	20(100)

()denotes percentage

The majority of all children, both physically awkward and non-awkward, responded that the best way to catch the ball is to look at the ball. One physically awkward child and one non-awkward child answered differently.

Table 6: The number of subjects selecting alternatives to how long to watch the ball during its flight. (Question 3: How long should a child watch the ball?)

Response	Age 6 - 7 P.A.	6 - 7 N.A.	8 - 9 P.A.	8 - 9 N.A.	10 - 11 P.A.	10 - 11 N.A.
A (till caught)	5(72)	14(67)	6(100)	20(95)	3(100)	17(85)
B (1/2 way)	0(0)	6(29)	0(0)	1(5)	0(0)	3(15)
C (not at all)	2(28)	1(5)	0(0)	0(0)	0(0)	0(0)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

Most physically awkward and non-awkward children thought that a child should watch a ball through out its entire flight. Eleven, or 17.7 %, of non-awkward children and two, or 12.5%, of physically awkward children chose alternate answers. In general most children felt that it was advantageous to watch the entire flight of the ball.

Table 7: The number of subjects responding to which stance is the best for ball catching. (Question 4: Which is the best way to catch the ball?)

Response	Age 6 - 7		8 - 9		10 - 11	
(position)	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (intermediate)	1(14)	2(10)	3(50)	1(15)	0(0)	0(0)
B (vice)	1(14)	0(0)	0(0)	1(15)	0(0)	0(0)
C (immature)	0(0)	11(52)	0(0)	7(33)	0(0)	7(35)
D (mature)	5(72)	8(38)	3(50)	12(57)	3(100)	13(65)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

The main difference between physically awkward and non-awkward children was the number of non-awkward who believed that the use of the immature stance to catch the ball was best. Twenty-five, or 40%, of non-awkward children chose answer 'C' while no physically awkward children thought this answer was best. A slight majority, 68.8% physically awkward and 53.3% of non-awkward children, felt answer 'D' the mature stance was the best method of catching the ball. The intermediate and vice alternatives were the least popular, with 3 non-awkward and 2 physically awkward chosing Answer 'A', the intermediate stance. Only 1 physically awkward child

and one non-awkward child felt the vice position was best.

Table 8: The number of subjects selecting distance alternatives. (Question 5: From which distance is it easiest to catch the ball?)

Response	Age 6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (3 m.)	5(71)	13(62)	2(33)	14(67)	3(100)	6(30)
B (5 m.)	2(29)	8(38)	2(33)	5(24)	0(0)	12(60)
C (8 m.)	0(0)	0(0)	2(33)	2(9)	0(0)	2(10)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

Two-thirds (64.3%) of the non-awkward 6 - 9 year olds felt that it was easiest to catch a ball from 3 m. One-third (30%) of the 10- 11 year old non-awkward children chose answer 'A', 3 m., compared to all three of the physically awkward children. This was still less in actual subjects than the number of non-awkward children choosing this alternative. The majority of 10-11 year old non-awkward children felt that 5 m. was the best distance from which to catch a ball. The physically awkward and younger children suggested that 3 m. was the easiest distance.

Table 9: The number of subjects selecting feet placement alternatives in ball catching. (Question 6: Which is the best way to place your feet when catching a ball?)

Response	Age 6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (parallel)	5(71)	10(48)	2(33)	11(52)	3(100)	11(55)
B (together)	2(29)	9(42)	2(33)	8(38)	0(0)	0(0)
C (forward-backward)	0(0)	2(10)	2(33)	2(10)	0(0)	9(45)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

Half of the non-awkward children thought that a parallel stance was the best way to place your feet when preparing to catch a ball, 10 out of 16 (62.5%) physically awkward children chose this answer also. One quarter of both groups (27% and 25%) felt placing your feet together was the best preparation to catch a ball. Only 2 physically awkward children chose answer 'C', feet in a forward-backward stance while 13 (21%) of non-awkward picked this answer.

Table 10: The number of subjects selecting speed alternatives. (Question 7: Which picture shows the easiest way to catch a ball?)

Response	Age 6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (moving fast)	3(43)	3(14)	3(50)	0(0)	3(100)	0(0)
B (standing still)	4(57)	15(72)	3(50)	20(95)	0(0)	10(50)
C (moving slowly)	0(0)	3(14)	0(0)	1(5)	0(0)	10(50)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

All 10 - 11 year old physically awkward children felt that it was easiest to catch a ball while running quickly though none of their non-awkward peers chose this answer. The 10 -11 year old non-awkward children were equally divided between catching a ball while standing still or while moving slowly, both less difficult than catching while running quickly. The majority (83.3%) of 6 - 9 year old non-awkward children felt that standing still was the easiest way to catch a ball, but only 7 out 13 (53.8%) physically awkward children were in agreement. Four non-awkward children between the ages 6 and 9 chose answer 'C', moving slowly while catching a ball, compared to 10 of the oldest children representing a difference of 9.5% to 50%.

Table 11: The number of subjects selecting direction alternatives. (Question 8: In which direction is it easiest to catch a ball?)

Response	Age					
	6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (backward)	1(14)	8(38)	1(17)	4(19)	1(33)	8(40)
B (forward)	3(43)	10(48)	4(67)	17(81)	2(67)	11(55)
C (sideway)	3(43)	3(14)	1(17)	0(0)	0(0)	1(5)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

A slight majority of both groups thought that catching a ball while moving forward, or in alternate terms, a ball that is thrown short of the person was easier to catch than a ball thrown too far (backwards) or a ball thrown to either side. 61.3% of non-awkward and 56.3% on physically awkward chose this answer. Twenty (32.3%) non-awkward children felt moving backwards was easiest compared to only 3 (18.8%) physically awkward who chose that answer. A higher proportion of physically awkward children, 25% compared to 6.5% of non-awkward children felt that 'moving sideways' was the easiest direction in which to catch a ball.

Table 12: The number of subjects selecting softball catching position alternatives. (Question 9: Which is the best way to catch this ball?)

Response	Age					
	6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (up-squat)	5(72)	6(29)	0(0)	11(52)	1(33)	6(30)
B (down-one knee)	1(14)	5(24)	3(50)	1(5)	0(0)	1(5)
C (up-one knee)	1(14)	10(47)	3(50)	9(43)	2(67)	13(65)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

The main difference between these answers was holding the mit palm up, or palm down. Most of the children picked one of the two answers indicating the softball mit held palm up. Three quarters, 75%, of physically awkward children and 88.7% of non awkward children chose either answer 'A' or 'C'. There was some confusion as to which leg position was the best method to catch a softball rolled along the ground, the children indicated that it would depend upon which sport and position a child was playing.

Table 13: The number of subjects selecting ball texture alternatives. (Question 10: Which ball is easiest to catch?)

Response	Age					
	6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
A (soft)	6(86)	15(71)	0(0)	8(38)	1(33)	7(35)
B (med)	1(14)	4(19)	3(50)	11(52)	0(0)	10(50)
C (hard)	0(0)	2(10)	3(50)	2(10)	2(67)	3(15)
Total	7(100)	21(100)	6(100)	21(100)	3(100)	20(100)

() denotes percentage

Nearly half of the children felt that a soft nerf ball was the easiest to catch, 48.3% of the non-awkward and 43.8% of the physically awkward children chose answer 'A'. Five physically awkward children (31%) thought that a hard ball (volleyball type) was easiest to catch in comparison only 7 of the non-awkward children, or 11.3%, agreed.

Interrater reliability for the procedural knowledge test scored by Cashin's Catch and Process Five Point Scale was 96.4%. The rating scale is explained in Appendix D.

Comparison of Procedural and Metacognitive Knowledge of Self-Ball Catching Skills

Procedural and metacognitive knowledge of self-ball catching skills were compared to assess if the children knew what they were actually doing. The procedural knowledge test, and the metacognitive knowledge questionnaire were designed to gather information on the same aspects of ball catching.

The degree of association between metacognitive knowledge and procedural knowledge was assessed via Hildebrand, Laing, and Rosenthal's (1977) prediction logic technique. This statistic is designed to evaluate the degree of association between two variables. The formula has a proportionate reduction in error (PRE) which allows weighting of the answers as they stray from a perfect relationship. A perfect relationship between two variables, shown in a R x C matrix is along the diagonal. Using the PRE method answers one unit from the diagonal are weighted less, or are less serious, than answers two units from the diagonal.

One premise of this measure is that it reflects the reduction in error due to some information about one variable the person has attained, and uses, to make a decision about another variable. The relationship between metacognitive and procedural knowledge is not clearly defined but for the purpose of this thesis the prediction that metacognitive knowledge predicts procedural knowledge will be made. This

can be denoted as:

$$P = \begin{matrix} X_1 & Y_1 \\ X_2 & Y_2 \\ X_3 & Y_3 \end{matrix}$$

That is, P predicts the if X1, a metacognitive knowledge choice, is chosen it should lead to a specific type of procedural knowledge, Y1, to be acted out. For example a child says that he or she looks at the ball while catching, metacognitive knowledge choice X1, then the procedural knowledge test should show the child looking at the ball while catching it, Y1. If both X1 and Y1 are completed then metacognitive and procedural knowledge are in agreement. If X1 and Y2 are completed the answer is not on the diagonal (X1,Y1; X2,Y2; X3,Y3) and the two types of knowledge are not in agreement. This would indicate that the child is not accurate in knowing what he or she does.

One limitation when using this statistic is that the different options of each variable must differ in terms of correctness. In order to weigh the cells it is assumed that the options close to the diagonal, ie. the perfect relationship, are more correct than the options further away. This weighting of answers required subjective judgements in Questions 6 and 8 of the metacognitive questionnaire. Two of the answers to each of these questions were not very different in their degree of error. The answer deemed most correct was placed one unit from the diagonal with the other answer positioned in the space two units away. Therefore statistically the closeness between the options does not

exist. It is with this limitation in mind that the results are presented.

Hildebrand et al.'s (1977) measure is written as V P, using weighted cells the notation is W V P . Scores range from 0 - 1.0, with 1.0 denoting a high association between the two variables, and 0 no association. The results are shown in Table 14.

Table 14: The measure of association between metacognitive knowledge of self ball catching skills and procedural knowledge .

	W P	
Question	P.A.	N.A.
1	0.484	0.533
2	0.791	1.00
3	0.742	1.00
4	0.579	0.866
5	0.360	0.582
6	0.510	0.546
7	0.284	0.151
8	0.203	0.027
9	0.742	0.387
10	0.889	0.707
X	0.558	0.550

* P.A. - Physically Awkward children
N.A. - Non-awkward children

The measure of association between metacognitive knowledge of self ball catching skills and procedural knowledge is .558 for physically awkward children and .550 for non-awkward children. This represents an approximate 55% agreement between the two tests.

These results are very similar when a simple percentage of agreement between the two tests, without an error weighting device was calculated, as noted in Table 15.

Table 15: The percentage agreement between metacognitive knowledge of self ball catching skills and procedural knowledge .

Question	P.A.	N.A.
1	46.7	50.0
2	80.0	100.0
3	73.3	100.0
4	33.3	35.7
5	46.7	57.1
6	33.3	42.9
7	53.3	21.4
8	28.6	23.1
9	73.3	23.1
10	90.9	53.8
X	55.9	51.2

Overall physically awkward and non-awkward children scored basically the same on both methods of evaluating the degree of agreement between what children think they are doing and what they actually are doing. Slightly over half of the time, or 55.9%, (by simple percent agreement) physically awkward children could predict their body movements for certain ball catching tasks. Non-awkward children were able to accurately predict their body movements 51.2% of the time.

Questions 2, 3, and 10 showed the highest amount of agreement, with scores up to 100% or 1.0 delta. Most children realized that they watched the ball through its entire flight, they indicated that softer balls were easiest to catch and demonstrated this during the procedural knowledge test. Questions 1 and 5 were close to the 50% mark, but the W V P indicates that children choose answers further away from the perfect relationship more often than in the other three questions. This indicates that for Question 1, regarding ball size, more children who did not choose the large ball, selected the small ball rather than the medium sized ball. With regard to Question 5 more children selected 8m. for question 5 than 5 or 3m., the longer distance representing greater error.

Questions 7 and 8 received the lowest amount of agreement between metacognitive knowledge of self-ball catching skills and procedural knowledge, though percentage agreement for physically awkward children for question 7 is

53.3% the W V P is 0.284. This measure indicates that the majority of answers that did not fit the perfect relationship were two units from the diagonal, and thus deemed a worse error than choosing the answer one unit from the diagonal. If these two questions are omitted delta values rise to .637 for physically awkward children and .703 for the non-awkward group.

The final comparison between metacognitive and procedural knowledge assessed the amount of agreement between the two variables as a function of age, as seen in Table 16. Age could be considered a compounding variable since as children grow older they gather more information. The amount of information is proportional to the amount of experience, in this case experience in ball catching, and therefore may not increase solely as a function of age.

Table 16: The number of children who agreed between metacognitive and procedural knowledge by age.

Question	Age					
	6 - 7		8 - 9		10 - 11	
	P.A.	N.A.	P.A.	N.A.	P.A.	N.A.
n =	7	7	6	5	2	2
1	2	2	4	4	1	1
2	5	7	5	5	2	2
3	4	6	6	5	1	2
4	2	3	2	2	0	0
5	3	2	2	4	2	2
6	2	3	3	2	1	0
7	2	2	4	0	2	1
8	2	1	1	2	1	0
9	5	2*	4	1	2	0
10	5	2*	5	4	/	1
%	45.7	44.1	60.0	58.0	66.6	45.0

* n = 6

There was approximately 15% difference in the amount of agreement between metacognitive and procedural knowledge when comparing physically awkward and non-awkward children in the first two age groups. The 8-9 year old children knew what they did about 60% of the time and 6 -7 year old children 45% of the time. The largest difference between physically awkward children and non-awkward children was in the 10 - 11

year old group, physically awkward children scored 66.6% and non-awkward 45%. The very small number of children in this group leaves these numbers open to question, extreme care should be taken in drawing any inferences to the populations involved.

Chapter 5

Discussion

The purpose of this research was to examine differences between physically awkward and non-awkward children with regard to metacognitive and procedural knowledge of ball catching. This was done by administering a questionnaire of ball catching skills to assess metacognitive knowledge, and a hierarchy of ball catching skills to test procedural knowledge. This chapter will be divided into five parts: 1) Procedural knowledge; 2) Reliability of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills; 3) Results of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills by Age; 4) Results of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills, physically awkward compared to non-awkward children; 5) Comparison of Metacognitive Knowledge of Self-Ball Catching Skills and Procedural Knowledge.

Procedural Knowledge

The procedural knowledge test consisted of eleven ball catching items. It was designed to be progressively more difficult. Specifically younger children were not expected to perform as well as older children. This proved to be correct

as each group's average score increased with age. This is in accordance with Rebel (1987) who administered a similar hierarchy of ball catching skills to elementary children. Normally children's motor skills increase with age through out the elementary school years. Coordination, speed, and accuracy in gross motor skills improve as children grow older and acquire more experience (Cratty, 1973).

Physically awkward children did not show as clear a developmental pattern as the non-awkward children for the procedural knowledge. However this was likely due to the smaller number of children tested. Nine year old children, three children in the group, scored higher than any other age group, including the two 10 year old children tested. Three six year old children scored higher than the four seven year old children. Though a definite answer as to why 10 year old children did not perform better than 6 - 9 year old children is not available, two reasons can be postulated. The first reason is the extremely small sample, n = 16, which allowed for only 2- 4 people per age group. This small sample can not be taken to represent the entire population of physically awkward and non-awkward children.

The second reason may be the high variability in performance of physically awkward children (Haubenstricker, 1982) which could greatly influence a small group. Less variability in the non-awkward groups may account for the developmental accuracy despite the small group of sixteen.

Physically awkward children are better at some tasks

than others. This was clearly seen during the screening test, The Test of Motor Impairment by Stott, Moyes, and Henderson (1984). There were four categories of tasks, and it is possible to obtain a high score in one category, but due to low scores in the other areas the person may fall into the lowest 10% of the population. Children who scored high in the catching section of the test were eliminated, but variability in catching skills still existed. It appears that the 10 year old children were both particularly poor catchers. While the emergence of a developmental trend was desirable recognition that the physically awkward subjects as a group are poor catchers is more important to the findings of this study.

Physically awkward children scored significantly lower than non-awkward children across all age groups on the procedural knowledge test. The differences within each age group ranged from 17.4 points between the ten year old groups to 1.5 points for the eight year olds.

By definition physically awkward children show a deficit in procedural knowledge (Gubbay, 1974; Haubenstricker, 1982; Wall, 1982). In fact poor procedural knowledge is the main characteristic of physically awkward children. This was supported by the procedural knowledge scores obtained from the ball catching hierarchy with physically awkward children scoring consistently lower than non-awkward children. Thus the results confirm the selection of subjects.

Results of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills of Non-Awkward Children By Age

The questionnaire of ball catching skills was designed to assess the metacognitive knowledge of ball catching in elementary school children. The questionnaire was made up of ten multiple choice questions. Answers to the questions were represented by photographs, one drawing, one question represented by the tester, and two questions by balls of varying size and hardness. Two types of questions were included in the questionnaire, first, questions with known answers that is, documented by research. Secondly, questions to which the correct answer was not clear were included. Therefore it was assumed that the children who answered the questionnaire would give some insight into certain issues of ball catching.

Metacognitive knowledge is a higher form of declarative knowledge and develops as children become aware of situations and variables which affect performance. Metacognition is a developmental phenomenon (Chi. 1978; Gerber, 1983; Lawson, 1984; Mischel & Mischel, 1983; Reeve & Brown, 1985) in which children acquire more accurate metacognitive knowledge with age, mental ability, and increased experience.

Three age groups of 21 children each, 6-7, 8-9, and 10-11 years, were given the questionnaire of ball catching

skills. Seven questions were answered similarly across all three age groups indicating no developmental trend. On three of the questions older children answered differently than younger children.

Specifically the differences were on questions 1, 6, and 7. Question 1 asked "Which ball is easiest to catch?". Three balls were shown to the children, a large (10") ball, a medium (8") ball, and a small (5") ball. Six to seven year old children felt it was easiest to catch the small ball, the older two age groups chose the large or medium ball. Gallahue (1982), Robertson and Halverson (1984), and Wickstrom (1983) suggested that a large ball was easiest to catch because of the ability to successfully employ an immature catching pattern. Logically the younger age group would be using an immature catching pattern more frequently than the older children. Therefore they should be aware that it is easier to catch a large ball than a small ball using this method. Rebel (1987) asked elementary school children a similar question. The majority of children in her study felt that it was easier to catch a large ball than a small ball. This was the first question asked the children in the present study It may be possible that the younger children, in particular, wanted to get the correct answer to the question so that they chose the most difficult answer. Another possibility is that the small ball was not small enough to be very difficult. The 5" ball was also the last alternative presented during the multiple choice question, order may have had an effect on the answer.

Changing the order of the question and of the answers should be attempted to ascertain if this affected the answer to this question.

The second question answered differently across the age groups was Question 6 "Which is the best way to place your feet when catching a ball?" Forty percent of 6 - 7 and 8 - 9 year old children felt that standing with feet together was the best stance to use in preparation to catch a ball, no 10 - 11 year old children chose this answer. Arnheim and Sinclair (1979) and Faut (1971) indicated that a forward-backward stance was the most efficient stance for catching, the main reason being that it increases the catcher's base of support. The parallel stride would also increase the base of support, and in fact was more popular than the forward-backward stride. Standing with feet together gives the least amount of balance but was quite popular with the younger two age groups. This isn't surprising in light of the fact that many 6-7 year old children catch with their feet together, as seen during the procedural knowledge test. This is in accordance with Robertson and Halverson (1984) who described three stages of body positioning during catching;
1) initially there is no body adjustment to the flight of the ball, 2) with experience the catcher's arms and trunk begin to adjust to the oncoming ball, and 3) movement of the feet is incorporated. Therefore the younger age groups answered according to their catching level. As predicted by the Wall et al.(1985) model their procedural and metacognitive

knowledge was poorer than the older children's for this particular skill. Rebel (1987) obtained very similar results when testing declarative knowledge of ball catching skill in elementary school children.

The third question in which the three age groups answered differently is an extension of the previous question. Specifically question 7 asked "Which picture shows the easiest way to catch a ball?". Three answers were provided; 1) moving fast, 2) standing still, and 3) moving slowly. A clear majority of the younger two age groups, 90.5% of 6-7 year old children, and 95.2% of the 8-9 age group indicated that standing still was the easiest method of ball catching. As discussed earlier this is in keeping with younger children's developmental level. Also it is easier to catch a ball when it is thrown directly to the catcher, eliminating the need for movement, than when the ball is tossed some distance away. Younger children may relate this near guarantee success rate to easiest, while older children may realize that in fact moving slightly increases the number of balls that they are able to catch. As they become adept at catching balls while moving they can catch a greater number of balls. Fifty percent of the 10-11 age bracket chose the standing still option, the other 50% decided that "moving slowly" was the best answer. This is likely because some of the 10-11 year old children had reached and mastered the final stage of body movement during catching, and as Rebel (1987) suggested they may enjoy a greater challenge.

The lack of age differences in the remaining seven questions indicates that younger children have good , mature metacognitive knowledge about the ball catching skills asked in this questionnaire. This finding is in agreement with Rebel (1987) who found that younger elementary school children showed a deficit in declarative knowledge about ball catching on only a very limited number of factors when compared to older elementary school children. Rebel (1987) found that younger children differed mainly with respect to less effective body positions. This is in accordance with the answers from Questions 6 and 7.

Of the remaining seven questions the majority of children answered with the most mature responses, or those responses deemed correct by previous research. It may be that the questionnaire was too easy, more difficult questions may have shown greater developmental differences. The questionnaire may also have been too broad. Limiting the domain, for example questions posed solely on one aspect of ball catching, may require more in depth knowledge of the skill and then produce stronger developmental trends.

Question 8 "In which direction is it easiest to catch a ball?" was answered similarly across the three age groups but not in accordance to the literature reviewed. Three options were provided: a) backward, b) forward, c) sideways. Some confusion seems to exist as to the best answer to this question. Kruger and Kruger (1977) and Wickstrom (1983) suggest that moving laterally to catch a ball is easier than

forward or backward. Herkowitz (1978) felt that difficulty in catching increased as the catcher moved forward, sideways, and then backwards. The children in this study answered that catching a ball while moving forward was easier than catching while moving backward which was easier than moving sideways. The authors mentioned in the above discussion do not provide empirical data to support their suggestions. Thus further analysis of this aspect of ball catching is needed to discover the most mature answer.

Overall there appeared to be limited differences in metacognitive knowledge of non-awkward children across the three age groups. Of the three questions in which differences in answers were substantial two of the questions had clear developmental reasons as to why metacognitive knowledge of these skills should vary among elementary school children. In general, within the confines of this test, elementary school children possess accurate metacognitive knowledge of ball catching skills.

Results of the Questionnaire of Metacognitive Knowledge of Ball Catching Skills: Physically Awkward Compared to Non-Awkward Children

The main hypothesis of this thesis asked if physically awkward children have a deficit in metacognitive knowledge compared to their non-awkward peers. By definition physically awkward children possess less procedural knowledge of ball catching skills than their non-awkward peers. According to Wall et al's (1985) model all of the knowledges are

interrelated and the development of each type of knowledge is effected by the status of each knowledge category. Thus if procedural knowledge is poor, metacognitive knowledge would likely be impoverished. In contrast physically awkward children are of normal intelligence (Gubbay, 1975) and therefore may have equivalent declarative and metacognitive knowledge but be unable to utilize this information during motor performance.

During the acquisition of a motor skill the first attempts are mainly trial and error with the method and results being stored as declarative knowledge, information as to how to do something. As the store of declarative knowledge increases the child is able to improve his or her skill ability because he or she knows how movements effect the outcome. Since the knowledges are intertwined and affected by each other, procedural knowledge should improve simultaneously due to the effects of practise and increased declarative knowledge.

Metacognitive knowledge is a higher form of declarative knowledge and refers to the knowledge of what one knows (Wall et al., 1985). Metacognitive knowledge is acquired in the same fashion as declarative knowledge, from information acquired through numerous interactions with the environment (procedural knowledge).

Due to the physically awkward children's normal intelligence it could be assumed that they gain an equal amount of information from each motor skill trial.

Declarative and metacognitive knowledge could therefore be equivalent to non-awkward children and in the present study this seems to be the case. Answers obtained in eight out of the ten questions showed strikingly similar metacognitive knowledge between the two groups. However, after an equivalent number of trials a physically awkward child does not perform the skill as efficiently as a non-awkward peer, therefore the physically awkward child possesses poorer procedural knowledge of ball catching.

Although each knowledge category is intertwined with the others and is posited to develop in a spiral fashion (Wall et al., 1985) it seems possible for one knowledge type to develop faster than another. For example Reid and Todd (1988) shared an anecdote of a seven year old trying to perform a motor skill. The child tried to do the skill as directed but failed. Responding to an instruction cue he explained that yes, he knew what to do, but just couldn't do it. Somehow declarative and metacognitive knowledge had increased beyond procedural knowledge. This same problem seems to apply to physically awkward children as the data from this study indicates very little difference in the metacognitive knowledge of ball catching skills of physically awkward children and their non-awkward peers.

Physically awkward children exhibited less mature metacognitive knowledge than their peers in answering two questions. The majority of physically awkward children, 56.2%, felt that moving fast or running while catching a ball

was easier that catching while standing still. The answer standing still received the remaining 43.8% of the answers. The non-awkward children responded in favor of standing still, 72.6%, with only 4.8% of answers in favor of moving fast. The answer ''moving fast' is the most difficult method to catch a ball. Physically awkward children showed less procedural knowledge on this task. No balls were successfully caught by physically awkward children when attempting to catch while running. As Wall et al.'s (1985) model would predict poor procedural knowledge leads to poor metacognitive knowledge.

The second difference was that more physically awkward children felt it was easier to catch a hard ball compared to a softer ball than non-awkward children. One third of the physically awkward children felt that it was easier to catch a hard ball (volleyball type) than a soft (nerf) ball or medium (playground) ball. This compared to 11% of non awkward children choosing this answer. Physically awkward children may not have realized that a hard ball hurts if it procedural knowledge, in accordance with Wall et al. (1985).

One reason for the differences shown by the physically awkward children may possibly be due to their perception of tasks performed by their classmates. They may have interpreted the success of their non-awkward peers on the playground of being able to catch balls on the run, and to catch hard balls as the easiest way to catch a ball. Low self-esteem of physically awkward children (Adler, 1982;

Reuben & Bakwin, 1968; Wall, 1982) may also have played a role in the answers on the metacognitive knowledge questionnaire. It is possible that the children choose answers that they knew they were not capable of in an effort to boost their self-esteem, trying to convince themselves and the tester they were able to catch better than they could.

Reliability of the test of metacognitive knowledge of self-ball catching skills was not assessed due to the similarity to the metacognitive knowledge of ball catching skills questionnaire. However reliability and validity could be assessed to provide further information on this type of test.

The hypothesis that physically awkward children have a deficit in metacognitive knowledge of ball catching skills was not supported by the overall results of this study. The metacognitive knowledge of ball catching skills of physically awkward children was generally equivalent to their non-awkward peers.

Comparison of Procedural and Metacognitive Knowledge of Self Ball Catching Skills

The purpose of comparing metacognitive and procedural knowledge of ball catching skills was to find out if children know what they are actually doing. From the results of this study it can be concluded that elementary age school children, both physically awkward and non-awkward, know what they are doing to catch a ball 55% of the time. If two

questions which had low agreement are deleted the value rises to approximately 67% of the time.

There was a slight age effect, with a few more of the older children showing a consistency between procedural and metacognitive knowledge than younger children. Approximately 45% of the 6-7 year old children knew how they moved, 59% of the time for 8-9 year old children, and 55.8% for the 10-11 year age group. Physically awkward 10 - 11 year old children agreed 45% of the time while non-awkward children agreed 66.6% of the time. The younger two age groups showed no difference between physically awkward and non-awkward children on this measurement. Older children showed a slight improvement over the younger groups. Thus with the exception of 10 - 11 vear old physically awkward children, as age increased there was greater consistency between what was said and what was done.

Subhypothesis 1 was concerned with the relationship between procedural and metacognitive knowledge of ball catching skills. From this study it was found that physically awkward and non-awkward children could predict their body movements for catching a ball approximately 55% of the time. Older children were more accurate in predicting their movements than younger children. When the two questions with the lowest agreement were deleted the rate of overall agreement jumped to 67%. No guidelines appear in published research to guide the decision of what is good and what is poor agreement. With respect to the young population tested

for this thesis an agreement rate ranging between 44.1% to 66.6% can be interpreted to mean that children have a fairly good idea of what they are doing. Two reasons why the agreement rate was not higher may be that tacit knowledge could not be elicited, and that the children may not have been aware of the automized routines. The children may have been using certain strategies and methods to catch a ball but were unaware they were doing it, as suggested by Newell and Barclay (1982).

One reason the skill of ball catching was chosen was that elementary school children have had at least a little practice and therefore have some knowledge about it. During learning a child passes through several stages, first a child gains experience through practice and begins to build an adequate knowledge base (Chi, 1978; Lawson, 1984; Newell & Barclay, 1982; Wall et al., 1985). Then the child develops strategies to deal with different situations. Finally the routines become automatic and conscious control is not needed for performing routine skills (Wall et al., 1985). Brown et al. (1983) suggested that automized routines are often not available to consciousness, and therefore are difficult for the performer to recall.

Ericsson and Simon (1980) and Newell and Barclay (1982) felt that comparing an action to verbalized information about that action would give an indication of the reliability of the verbalized data. Though answers for this questionnaire did not have to be verbalized they had to be brought to

consciousness. Some information may not have been accessible to the conscious mind. Newell and Barclay (1982) also pointed out that people, particularly children, may use a strategy without being aware they are using it and therefore would not be able to give information about the method.

Summary

Physically awkward children displayed poorer procedural knowledge than their non-awkward peers. Metacognitive knowledge of ball catching skills varied little between physically awkward and non-awkward children and across age groups. This may have been due to physically awkward children possessing an adequate knowledge base or the questionnaire being too easy. Neither physically awkward nor non-awkward children showed very high consistency between the procedural knowledge test and the questionnaire of metacognitive knowledge of self ball catching skills.

Chapter 6

Summary and Conclusions

The purpose of this research was to assess procedural and metacognitive knowledge of ball catching skills of physically awkward and non-awkward children. Metacognitive knowledge of self ball catching skills was then compared to procedural knowledge to ascertain if the children were aware of what they were doing. This chapter will be divided into 5 sections: 1) Summary of the Methodology, 2) Summary of the Findings, 3) Conclusions, 4) Implications/Applications of this Research, 5) Recommendations for Further Studies.

Summary of the Methodology

Three tests were administered; the procedural knowledge test of ball catching skills, the metacognitive knowledge test of ball catching skills, and the metacognitive knowledge test of self-ball catching skills. The physically awkward children were each given all three tests. Sixteen non-awkward children were given the procedural knowledge test and the metacognitive test of self-ball catching skills. In addition a different group of sixty-two non-awkward children answered the metacognitive knowledge questionnaire of ball catching skills. Thus children who performed the procedural test were given the metacognitive test of self-ball catching skills.

The procedural knowledge test was a hierarchy of

catching skills. The test consisted of eleven catching items arranged from easy to more difficult. The hierarchy was designed for this study. The tasks were chosen to show developmental differences between different age groups. Also the procedural test corresponded to the questions of the metacognitive questionnaire. This was done to enable a comparison of the two types of knowledge.

The procedural knowledge test was administered individually by the tester. Physically awkward children were tested in the gymnasium at the Pointe Claire Aquatics Center where they attended the Aqua Percept program on a regular basis. Non-awkward children were tested in the gymnasium at Greendale Elementary School where they attended classes. A familiar environment was used to reduce anxiety associated with the testing procedures. The testing procedures were identical for both groups.

The gymnasiums were marked with masking tape at strategic points to aid the thrower during the procedural knowledge test. The test was videotaped so that scoring, using a modified version of Cashin's five point scale, could be done after the test. Each child received three trials of each item on the hierarchy. If a throw was perceived as not accurate by the thrower, the throw was repeated, this happened an average of 2 out of 33 throws.

The metacognitive knowledge test of self-ball catching skills was designed to find out if children knew what they were actually doing. The questionnaire consisted of ten

questions which reflected the items of the catching hierarchy. The questionnaire was administered to the children individually on an alternating basis, before and after the procedural knowledge test to avoid confounding the results.

The questionnaire was designed with multiple choice answers. The answers for seven of the questions were represented pictorially, the answers to the remaining three questions were represented by various balls and distances. The answers were recorded by the tester as the subject indicated which option he or she chose. The answers were compared to the procedural knowledge test using percent agreement and Hildebrand et al.'s (1977) prediction logic technique.

The questionnaire of metacognitive knowledge of ball catching skills was identical to the previous questionnaire except that the wording was altered. This questionnaire asked the children to indicate the 'best' or 'easiest' method to catch the ball rather than how "they" caught. The questionnaire was administered on an individual basis and was repeated two weeks later to assess reliability.

Physically awkward children completed the questionnaire alternately before or after the procedural knowledge test. Non-awkward children who completed the questionnaire did not necessarily perform the procedural knowledge test. The test was given at a different time than the procedural knowledge test and more children were assessed. The questionnaire was administered during school hours with the children coming

from their classrooms to an open space commonly used for school activities. Answers were indicated by the children and recorded by the tester.

Summary of the Findings

Physically awkward children displayed poorer procedural knowledge of ball catching skills than non-awkward children. Performance on the catching hierarchy increased with age for non-awkward children.

The metacognitive knowledge questionnaire of ball catching skills yielded little difference in the metacognitive knowledge of physically awkward and non-awkward children. There was little difference between the age groups. Sever out of the ten questions showed no differences in the metacognitive knowledge of ball catching skills , while two questions suggested developmental differences.

The comparison of procedural and metacognitive knowledge of self-ball catching skills was performed question by question. The overall consistency between the two tests was slightly over 55% for both groups. There was a range of consistency within the questionnaire of 100% to 15%.

Conclusions

Based upon the findings of this study, and within the limitations of the design, the following conclusions have

been made.

1. Physically awkward children showed minimal difference in metacognitive knowledge of ball catching skills when compared to their non-awkward peers. Seven out of the ten questions showed no difference in metacognitive knowledge. Three questions were answered differently by both groups but only two of the questions could be attributed to developmental differences. Both questions pertained to body position during catching. Rebel (1987) also found that younger children showed a lack of metacognitive knowledge of ball catching skills pertaining to body positioning compared to older children.
2. There was a moderate relationship between metacognitive knowledge of self ball catching skills and procedural knowledge of ball catching.
3. The reliability of the metacognitive test for physically awkward and non-awkward children was moderately high.

Implications/Applications of the Research

The findings of the procedural knowledge test of this study showed that physically awkward children displayed poorer procedural knowledge of ball catching than their non-awkward peers. This is in accordance with previous research as the definition of physically awkward children is centered around their poor performance of physical activities (Gubbay, 1975; Haubenstricker, 1982; Henderson & Hall, 1982;

Wall et al., 1985).

The procedural knowledge test was designed as a catching hierarchy, starting with simple items and graduating to more difficult ones. The hierarchy was confirmed as older non-awkward children were able to complete more items than younger non-awkward children. Each successive age group scored higher than the previous group. The physically awkward children did not follow the same pattern. Some younger age groups scored higher than older age groups. This may have been due to the extremely small group size. The procedural knowledge test should be administered to a large group of 6 - 11 year old physically awkward children to study the development of procedural knowledge in this population.

The metacognitive knowledge of ball catching skills of physically awkward children was very similar to that of non-awkward children. There was very little difference across age groups in metacognitive knowledge in both physically awkward and non-awkward children. This finding did not show the relationship between the two types of knowledge suggested by the Wall et al. (1985) knowledge-based model of motor development. The model predicted that if one type of knowledge increased the related knowledges would increase also. Thus an increase in procedural knowledge would be reflected by better metacognitive knowledge. Though non-awkward children displayed better procedural knowledge than physically awkward children, and older non-awkward children performed better than younger groups, there was limited

differences in metacognitive knowledge between the groups. This suggests that metacognitive knowledge may not develop at the same rate as procedural knowledge. The findings of this study are in agreement with Rebel (1987) who found limited differences in metacognitive knowledge of ball catching skills in elementary school children aged 5 - 12 years.

Metacognitive knowledge of self-ball catching skills was designed to find out if children knew how they moved their bodies when preparing to catch a ball. When the results of the questionnaire were compared to the procedural knowledge test it was found that the children, physically awkward and non-awkward, knew how they placed their bodies just slightly over 55% of the time When the two questions which had the lowest consistency were deleted the agreement between the tests rose to 68%. This measure did increase slightly with age but the small group size did not give a very accurate measure of each age group. Replication of the study with larger groups at each age level might show more developmental trends.

That children are not sure of how they are moving their bodies should be of concern to physical education teachers. For instructions to be effective the children must be able to implement them. Body awareness and kinesthetic awareness may be one area of physical education in which teachers can provide instruction. Instructing a group of children in body awareness and self-metacognitive skills and then measuring whether procedural knowledge, performance, had increased

would give information as to effective teaching methods.

Recommendations for Further Studies

1. The procedural knowledge test could be repeated with a larger group of subjects. A greater number of subjects, physically awkward and non-awkward, across each age group would enhance any inferences drawn to the populations.
2. The metacognitive questionnaire could be revised, eliminating, changing, or rewording low reliability questions.
3. The questionnaire of metacognitive knowledge of self-ball catching skills could be administered to a larger group of subjects. All subjects would have to perform the procedural knowledge test so that a comparison of the two tests could be done.
4. Metacognitive training, to enhance knowledge of what one is doing, could be given to a group of subjects. Procedural knowledge of a skill could be measured before and after the training program to assess any positive effects.
5. The metacognitive knowledge questionnaire could be rewritten to contain more difficult questions of ball catching. Narrowing the questions to specific issues in ball catching might increase the degree of difficulty and yield greater developmental differences.

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Appendix A

Procedural Knowledge Test

1. Catch a small ball thrown directly to catcher from 5 m.
2. Catch a medium ball thrown directly to catcher from 5 m.
3. Catch a large ball thrown directly to catcher from 5 m.
4. Catch a medium ball thrown directly to catcher from 3 m.
5. Catch a medium ball thrown directly to catcher from 8 m.
6. Catch a medium ball thrown 1.5 m. to the right.
7. Catch a medium ball thrown 1.5 m. to the left.
8. Catch a medium ball thrown 1 m. in front of you.
9. Catch a medium ball thrown 1 m. in back of you.
10. Catch a ball while jogging across the gymnasium, the ball thrown from 8 m. to the middle of the gymnasium.
11. Catch a small ball rolled along the ground from a distance of 5 m. using a softball mit.

Appendix B

Metacognitive Knowledge Test I

Ball Catching Skills

1. What ball is easiest to catch?

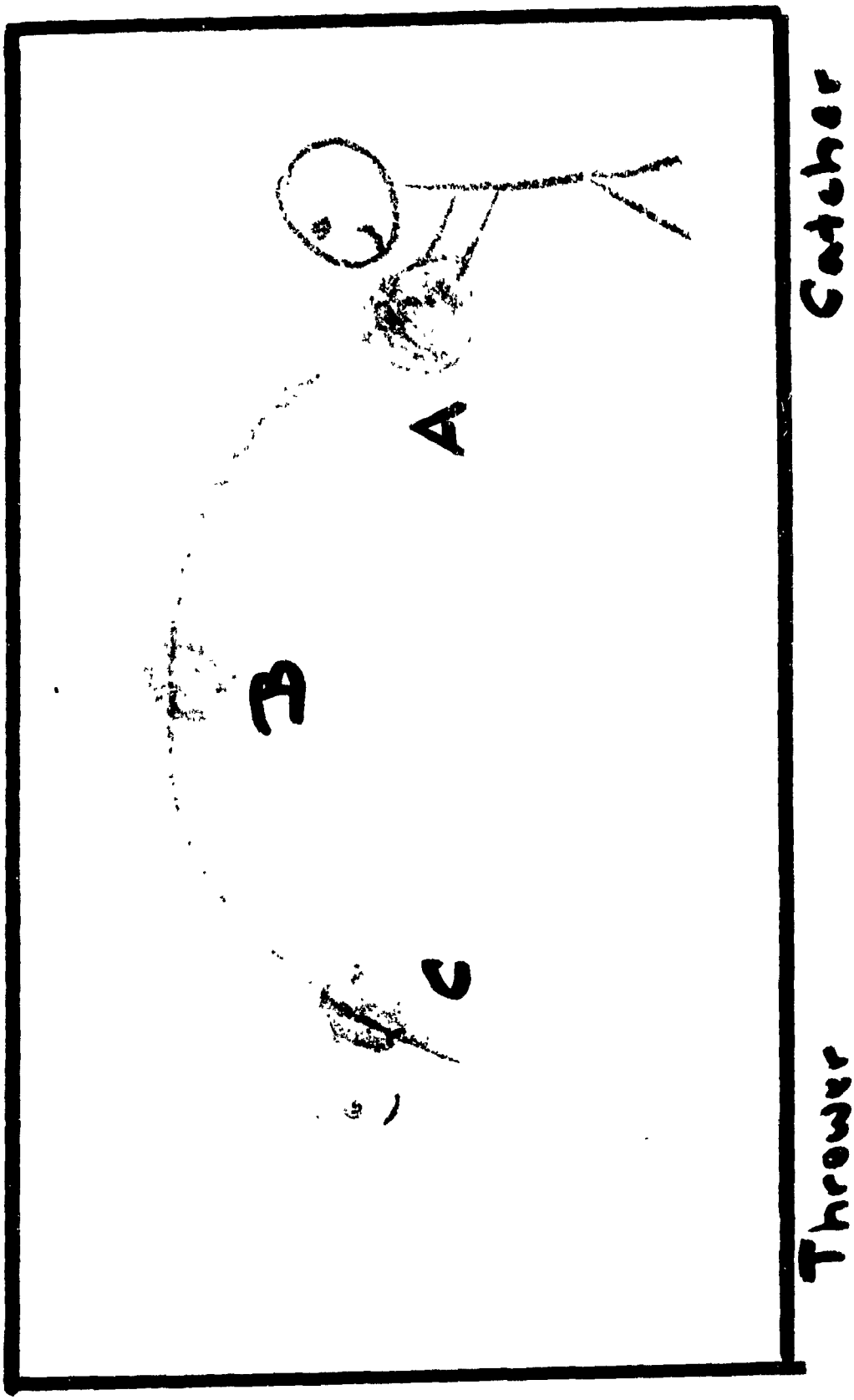
   A - large (10")
   B - medium (8")
   C - small (5")

2. Which child is most likely to catch the ball?

A - eyes turned to the side
B - head turned away
C - look at the ball

3. How long should a child watch the ball?

A - till caught
B - midway through flight
C - not at all


Catcher
A
A
C
Thrower

4. Which is the best way to catch the ball?

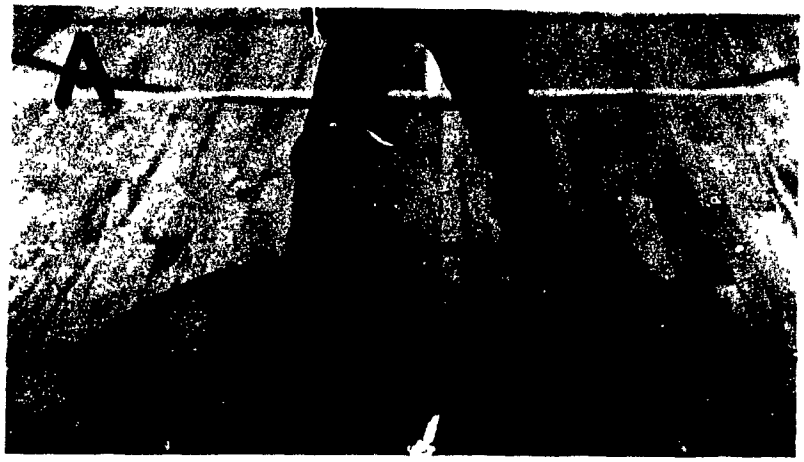
A - intermediate position
B - vise position
C - immature position
D - mature position

5. From which distance is it easiest to catch the ball?

A - 3 m.
B - 5 m.
C - 8 m.

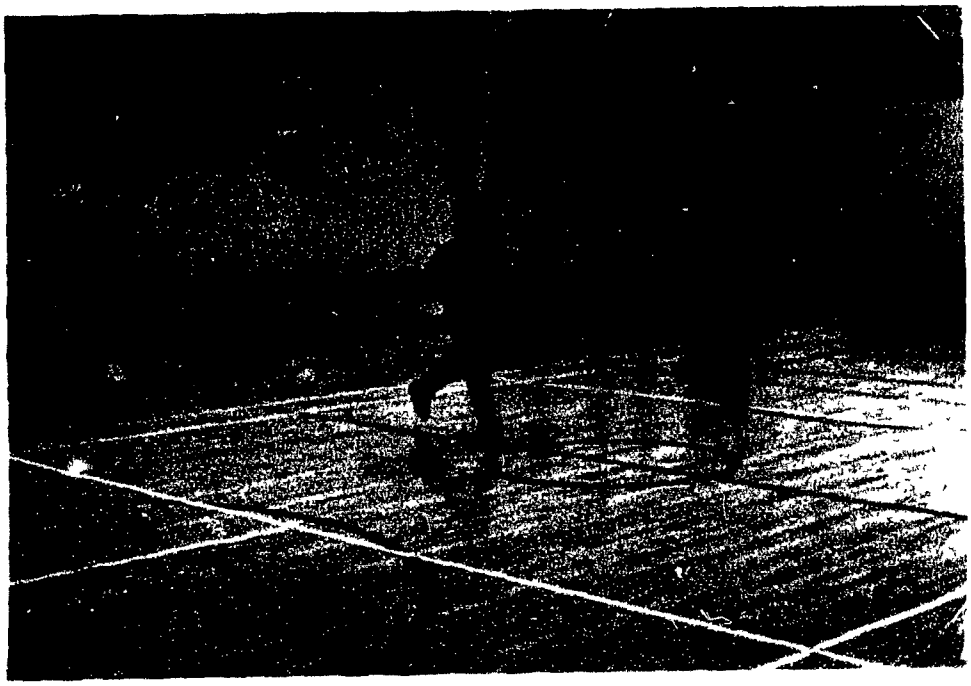
6. Which is the best way to place your feet when catching a ball?

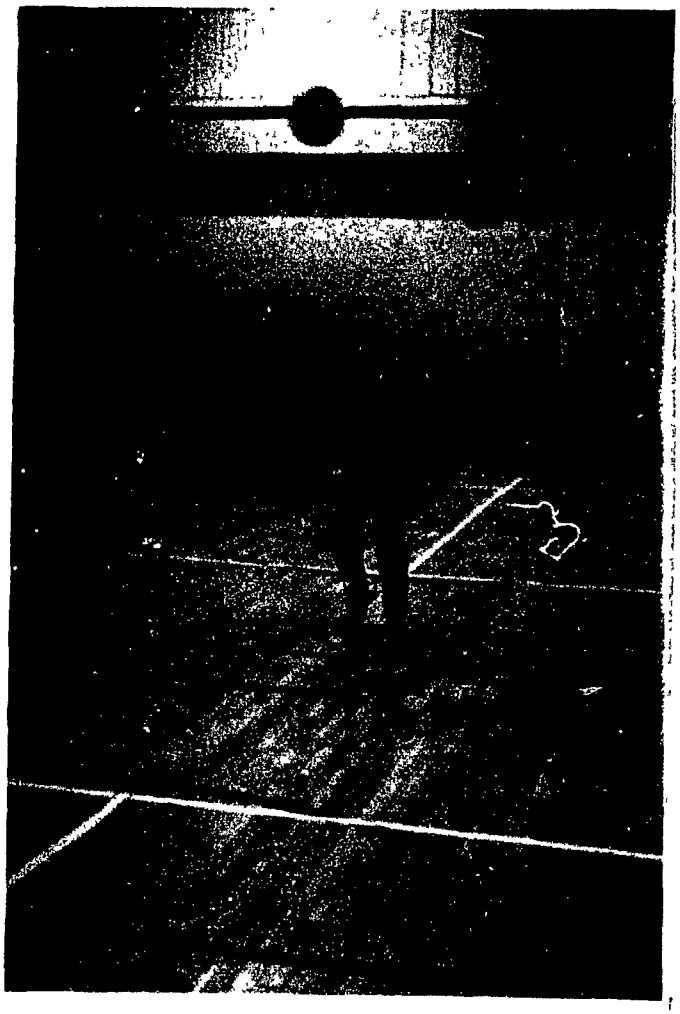
A - parallel stance
B - feet together
C - forward-backward stance



7. Which picture shows the easiest way to catch the ball?

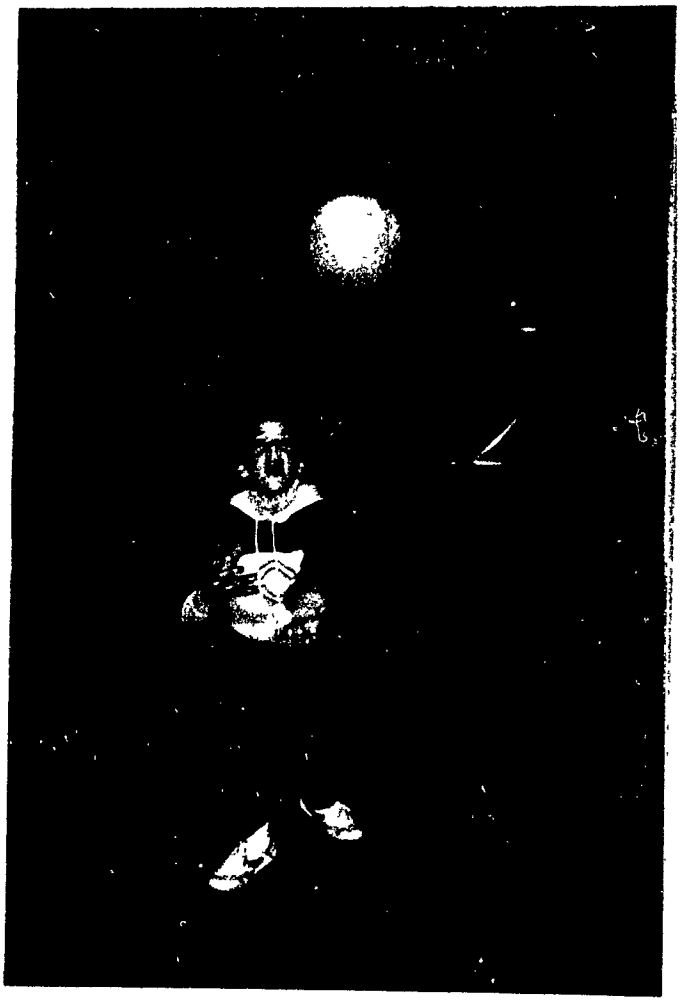
A - jogging
B - standing still
C - moving slowly

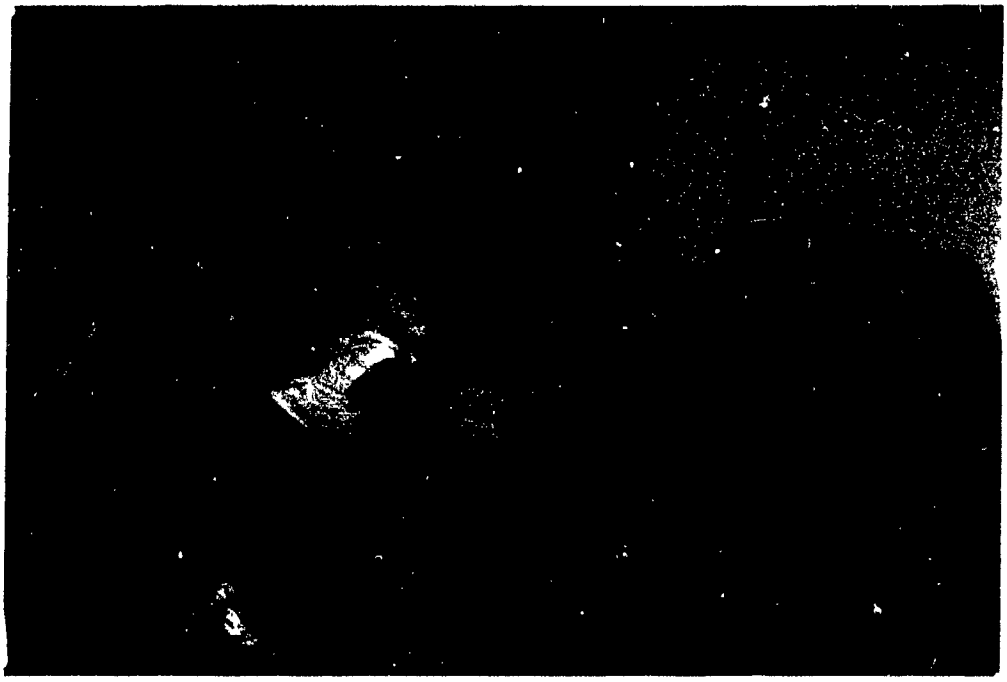




8. In which direction is it easiest to catch a ball?

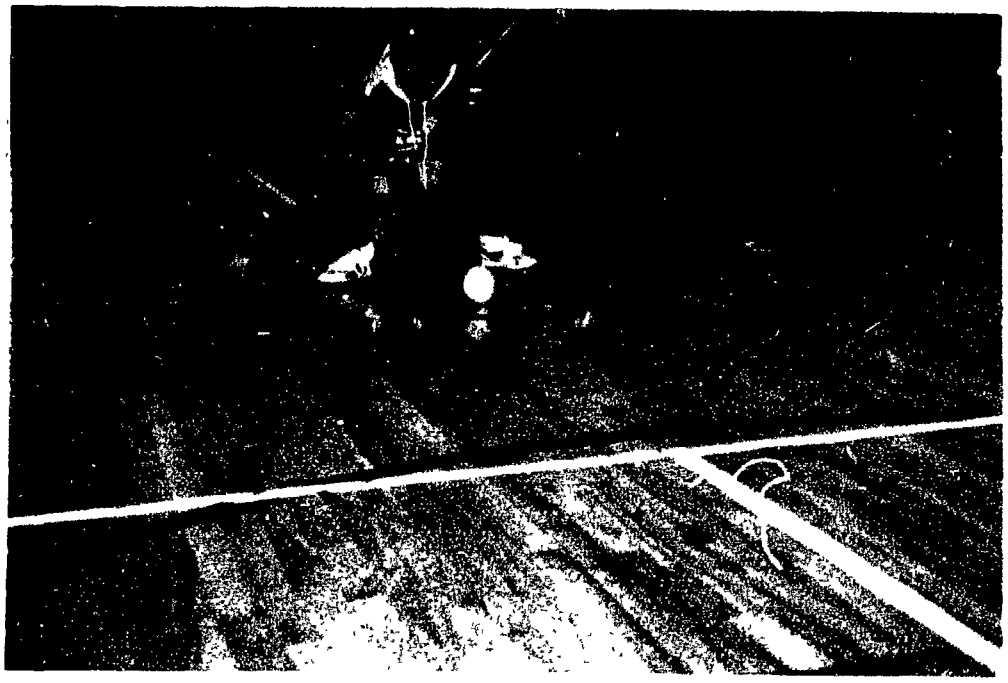
A - backward
B - forward
C - sideways

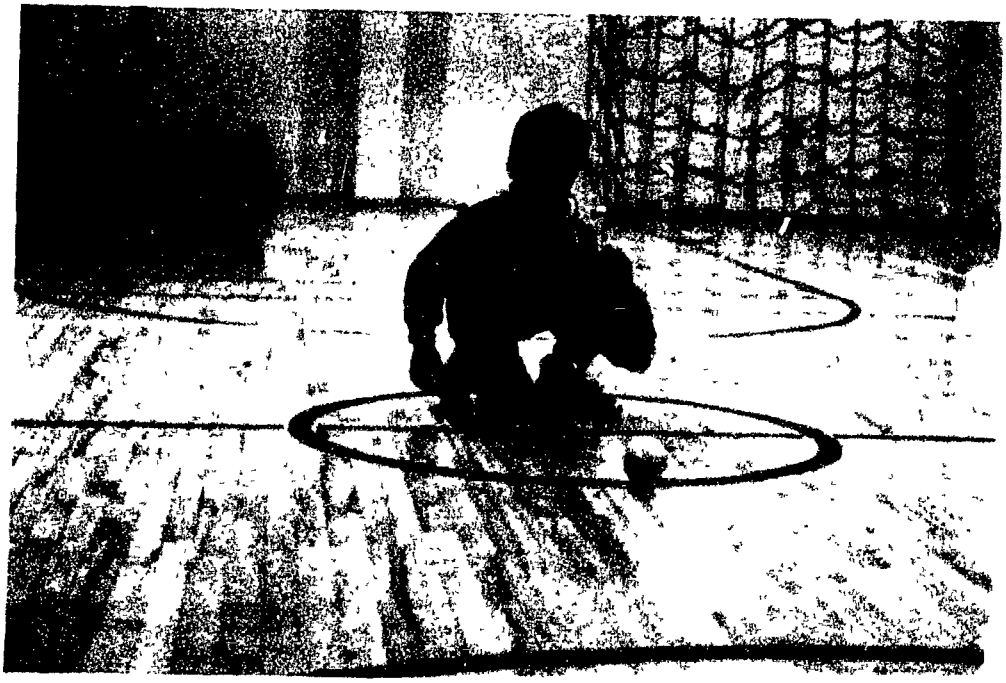


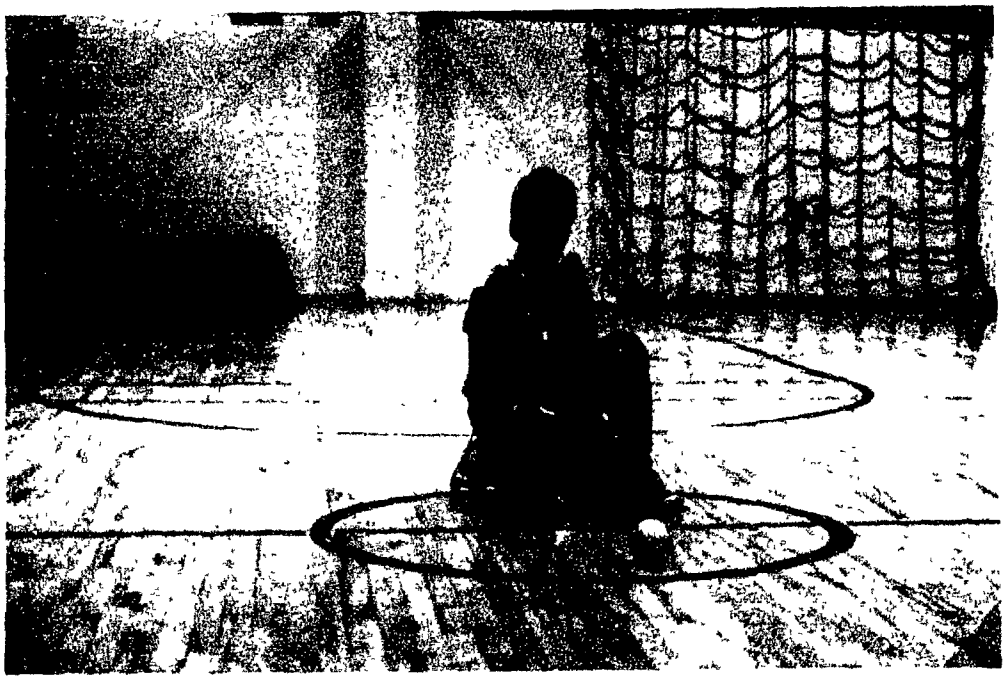


9. Which is the best way to catch this ball?

A - palm up, squatting
B - palm down, kneeling
C - palm up, kneeling







10. Which ball is easiest to catch?

A - soft (nerf) ball
B - medium (rubber) ball
C - hard (volley-ball type) ball

Appendix C

Metacognitive Knowledge Test II

Self Ball Catching Skills

1. Which ball is easiest for you to catch?

   - large (10")
   - medium (8")
   - small (5")

2. How do you catch the ball?

   - look at ball
   - eyes turned to the side
   - head turned away

3. How long do you watch the ball in the air?

   - till caught
   - midway through flight
   - not at all

4. Which one of these is most like you when catching a ball?

   - mature position
   - intermediate position
   - vise position
   - immature or intermediate

5. From which distance is easiest for you to catch a ball?

   - 3 m.
   - 5 m.
   - 8 m.

6. How do you place your feet when catching a ball?

   - parallel stance
   - feet together
   - forward-backward stance

7. Which is the easiest way for you to catch a ball?

   - while jogging
   - while standing still
   - while moving slowly

8. In which direction is it easiest for you to catch a ball?

   - forward
   - backward
   - sideways

9. How would you catch this ball?

   - palm up, squatting
   - palm down, kneeling
   - palm up, kneeling

10. Which ball is easiest for you to catch?

   - soft (nerf) ball
   - medium (rubber) ball
   - hard (volley-ball type) ball

Appendix D

Cashin's Catch and Process Scale

(modified scoring)

Points	Type	Description
6	Clean Catch	simultaneous 2 hand grasp immediate control
5	Juggle Catch	initial hand contact, not simultaneous without immediate control followed by 2 hand catch with control
4	Basket Catch	use of other body parts other than hands and fingers to enable a successful catch hands and fingers may be used
3	Hands Contact	hands touched ball attempt to catch failed ball dropped to floor
2	Attempt	attempt to catch made no hand contact ball dropped to floor
1	No Attempt	no visible attempt made to catch or stop ball

Appendix E

As a graduate student in the Physical Education Master's program at McGill University I am interested in exploring the motor abilities of children. The Aqua Percept program provides an opportunity to access children who may exhibit a small degree of motor impairment. Studying the abilities of this group will hopefully lead to better understanding of how motor abilities are acquired and effective teaching methods.

I would like to administer the Stott, Moyes, Henderson Test of Motor Impairment to your child. The test is comprised of eight motor activities: a peg board task, lacing task, tracing task, catching a ball, throwing a bean bag, balancing, jumping, and heel-toe walking. Administration of the test will take place at the Pointe Claire Aquatics Center at a mutually convenient time. Testing time is approximately 20-30 minutes.

The purpose of this test is to screen children's abilities so that I may select a group of children to participate in a future study. This study is concerned with identifying a relationship between how a child performs a task and what he or she knows about performing the task. If your child is a candidate for this study I will elicit further permission from you.

As a mother of a young child with slight motor impairment I share your concern about the development of motor abilities: certainly an important aspect in today's society. If you have further questions or concerns please do not hesitate to contact me at 453-6318.

Thank your for your cooperation,

Teri Todd

Parent's signature

Child's name

Date

Child's date of birth

Telephone number

Appendix F

As a graduate student in the Physical Education Master's program at McGill University I am interested in exploring the motor abilities of children. Studying the abilities of elementary school children will hopefully lead to better understanding of how motor abilities are acquired and effective teaching methods.

I would like to administer a hierarchy of ball catching skills to your child. This hierarchy was designed to reflect abilities of children from Grade 1 to 6. The purpose of this test is to gather data on the abilities of typical elementary children who experience motor difficulties.

A video tape of each child will be taken during the ball catching hierarchy. The sole purpose of the video tape is to score the catches. The only people viewing the tape will be myself and my advisor at McGill University. The tape will be destroyed once the scoring is complete.

As a mother of a young child I share your interest in the development of motor abilities; certainly an important aspect in today's society. If you have further questions or concerns please do not hesitate to contact me at 453-6318.

Thank-you for your cooperation,

Teri Todd

Parent's signature

Child's Name

Date

Child's date of birth

Child's grade level