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A STUDY OF THE MOTOR LEARNING OF PHYSICALLY AWKWARD CHILDREN UNDER THREE INSTRUCTIONAL CONDITIONS

BY

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Of all sad words of tongue and pen

the saddest of all are

"...it might have been."

THE UNIVERSITY OF ALBERTA

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A STUDY OF THE MOTOR LEARNING OF PHYSICALLY AWKWARD GIRLS UNDER THREE INSTRUCTIONAL CONDITIONS submitted by JANICE CAUSGROVE in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE

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ABSTRACT

This study attempted to examine the motor performance and learning of physically awkward girls using the Knowledge Based Approach to Motor Development described by Wall, McClements, Bouffard, Findlay, and Taylor (1985). The first purpose of the study was to investigate the relationship of physical awkwardness and procedural skill. It was assumed that skill in tracking a target is a manifestation of procedural knowledge. An Apple Macintosh computer with a mouse was used to measure tracking performance and RMS error was utilized as a measure of overall accuracy in tracking. The performance of a tracking task by grade 5 physically awkward girls was compared to the performance of grades 5 and 3 expert and novice girls. It was found that the tracking performance of the physically awkward girls was similar to that of novice performers two years their junior. Both the grade 5 awkward girls and the grade 3 novices exhibited a large amount of error and a great deal of variability in tracking over 10 trials. The poor tracking skill of these two groups was assumed to be a manifestation of their poor procedural knowledge about tracking tasks.

The second purpose of the study was to investigate how the tracking performance of awkward hirls is affected by declarative and metacognitive instructional conditions when tracking a familiar pattern. The results indicated that the instructional conditions had no significant effect. It was noted, however, that the awkward girls

performed the best under the metacognitive condition and the most poorly under the declarative condition. These results were surprising in that the Knowledge Based Approach would posit that tracking performance would be most skilled under the declarative condition and least skilled under the control condition. It was hypothesized that motivation (affective knowledge) and personal strategies for performance (based on declarative and metacognitive knowledge) influenced the results.

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INTRODUCTION

A BRIEF OVERVIEW

Over the past twenty years, an increasing amount of interest has been directed toward a group of children who are often described as "clumsy" or "awkward". These children are characterized by ineffective and inefficient movement which, in turn, puts them at a disadvantage in terms of play opportunities (McMath, 1980). Movement experiences play an important role in social development, the development of self-concept and self-esteem, as well as in a child's ability to explore the environment (McMath, 1980). For this reason, the lack of movement competence of physically awkward children has some very serious implications indeed.

The focus of research to date has been on the design of procedures (or tests) to identify physically awkward children. Other research has sought to simply define what actually constitutes physical awkwardness and to develop theories about the syndrome. However, this group is so variable that almost no two children are alike in their disability, and therefore the results are often more descriptive than definitive (McMath, 1980). However, research does show that there is a good chance of teachers having two awkward children in every class they teach (Gordon & McKinlay,1980; Henderson & Hall, 1982; Keogh, Sugden, Reynard, & Calkins, 1979; Gubbay, 1975).

Physically awkward children are "children without known neuromuscular problems who fail to perform culturally normative skills with acceptable proficiency" (Wall, 1982, p. 254). Culturally normative skills are those that are "generally used within a specific culture at certain ages by the majority of the people" (Wall, 1982, p. 254). Because of their inadequate motor performance, physically awkward children experience a great deal of failure and rejection from their peers (McMath, 1980). Furthermore, due to the unhappiness experienced in play situations by these children, they often come to avoid participation in physical activity (Gordon & McKinlay, 1980; Wall, 1982; Whiting, Clark, & Morris, 1969).

Knowledge-Based Approach to Motor Skill Acquisition

Wall, McClements, Bouffard, Findlay, and Taylor (1985) outline a heuristic approach to motor development that stresses the importance of knowledge about action that children acquire during development. This approach acknowledges the importance of genetic endowment in motor skill acquisition, but also emphasizes the critical role that knowledge gained through experience (acquired knowledge) plays. Furthermore, this approach identifies five types of acquired knowledge: procedural, declarative, affective, and metacognitive knowledge as well as metacognitive skills. Figure 1 illustrates a simple conceptualization of these five types of knowledge in the development of acquired knowledge about action.

Within the motor domain, procedural knowledge "underlies all aspects of an action including the perceptual, cognitive, response initiation, and execution phases (Singer, 1980; Stelmach & Diggles,

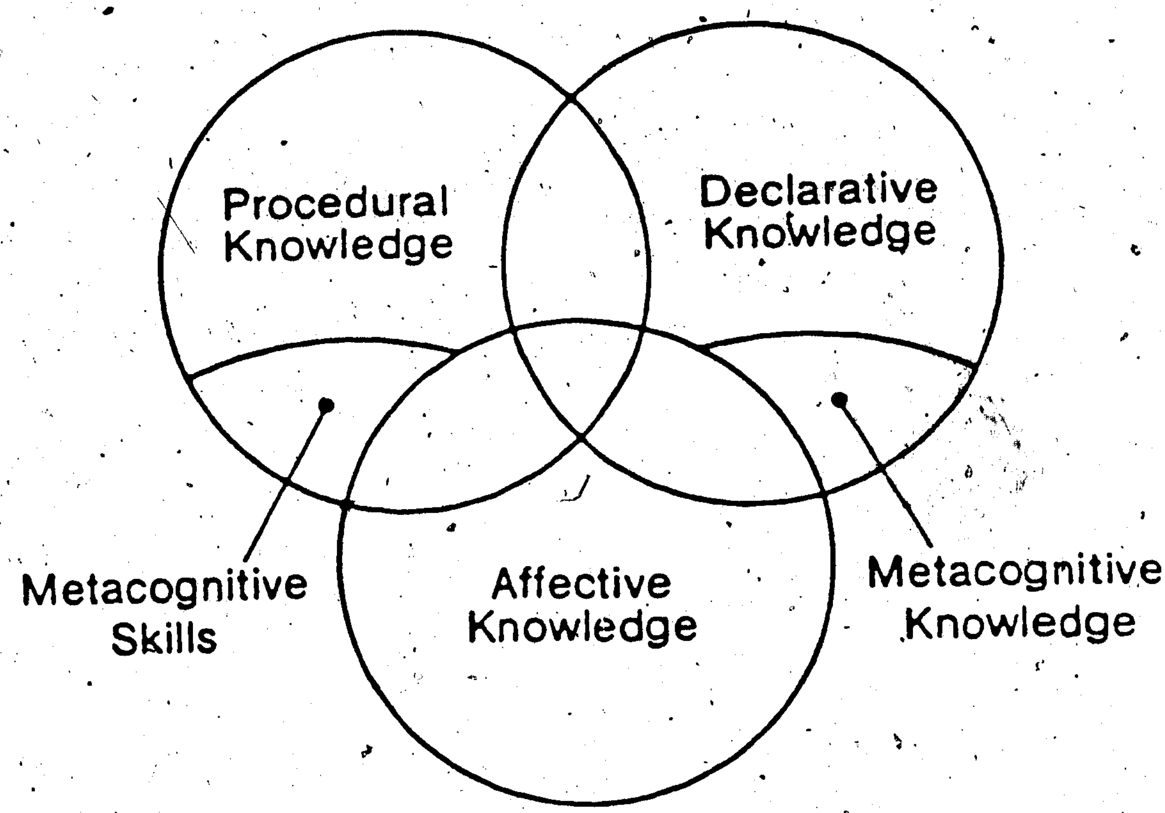

FIGURE 1

A Simple Conceptualization of the Five Types of Knowledge Relevant to a Knowledge-Based Approach to Motor Development

Note: Adapted from "A knowledge based approach to motor development: Implications for the physically awkward" by A.E.Wall et al., 1985, Adapted Physical Education Quarterly, 3, p.32.

1982)" (Wall et al., 1985, p. 29). Procedural knowledge is, quite simply, how to do something. It is knowledge about the general and specific features of each action and how to meet the requirements of that action. Wall and his colleagues (1985) describe declarative knowledge as consisting of both concrete concepts and abstract ideas about the world, but it is essentially information about something. "Declarative knowledge about action refers to factual information stored in memory which will influence the development and execution of skilled action" (p. 30). One acquires this knowledge through interactions with the environment and it is continually being added to, modified and restructured as one gains more experience in the movement domain. Furthermore, as their declarative knowledge about action increases, children "begin to attach expanded conceptual meanings to their actions, and these conceptual meanings in turn stimulate their use and understanding of their actions" (p. 31).

Affective knowledge refers to the subjective feelings an individual attaches to actions in a given context (Wall et al., 1985). As with the other types of acquired knowledge about action, affective knowledge is acquired through interactions with the environment. The nature (or outcomes) of these interactions will cumulatively affect the development of feelings of competence in movement situations as well as the development of one's self-concept (Harter, 1978, 1981, 1982). Moreover, Griffin and Keogh (1982) indicate that affective knowledge influences an individual's patterns of activity selection, performance level, and persistence when in difficulty. Affective knowledge certainly affects one's motivational state and, thus influences the acquisition of both procedural and declarative knowledge.

Metacognitive knowledge is knowledge of one's own cognitions; it is the understanding of one's own knowledge (Brown, 1978). Wall et al. (1985) suggest that as this type of knowledge develops, children become increasingly aware of what they can and cannot do. For instance, Brown (1977) suggests that in problem-solving and learning situations, efficient metacognitive skills include the ability to: (1) predict capacity limitations; (2) be aware of the available heuristic problem-solving routines; (3) identify and characterize the immediate problem; (4) choose appropriate problem-solving strategies; (5) monitor and control the operation of these strategies, and; (6) evaluate the success or failure of the chosen strategies in relation to the task demands. Thus, "metacognitive knowledge about action refers to a person's awareness of procedural, declarative, and affective knowledge about action" (Wall et al., 1985, p. 32). Metacognitive skill, according to the knowledge-based approach, is the "instantiation or use of metacognitive knowledge about action" (p. 32). Metacognitive skill, therefore, may be used to control one's actions in certain situations.

The knowledge-based approach to motor development posits that skill development depends not only upon age and maturation, but also on the learning experiences available to the person to acquire skills. However, learning experiences in the motor domain may not be readily available to physically awkward children simply because of inaccessibility due to their avoidance or withdrawal from movement opportunities. The end result is that physically awkward children do not have the opportunities to develop the knowledge about action deemed critical to motor development in the knowledge based approach.

Wall et al. (1985) put forward the notion that the 5 domains of knowledge interact in the performance of skilled action. Koutsouki-Koskina (1986) investigated this interaction to see if different levels of procedural skill resulted in different abilities to make use of declarative and metacognitive knowledge about action. Koutsouki-Koskina's results were unclear, and the question still remains: do low levels of procedural skill lead to an inability to use declarative and metacognitive instructions in the performance of a task?

JUSTIFICATION OF THE PROBLEM

The reason for undertaking this study was to further investigate the relationship of physical awkwardness and procedural skill, and to see how awkward children responded when given declarative and metacognitive information regarding the motor task. It was assumed in this study, as it was in Koutsouki-Koskina's (1986), that skill in tracking a target is a manifestation of procedural knowledge. A child's demonstrated knowledge of the concept of shapes was assumed to be one manifestation of declarative knowledge. Finally, "metacognitive knowledge was defined as the child's awareness of her knowledge of these concepts while the use of problem solving and monitoring strategies were assumed to be metacognitive skills" (Koutsouki- Koskina, 1986, p. 6).

The purpose of this study was twofold. The first purpose was to compare the procedural knowledge (as measured by the performance of a tracking skill) of grade 5 physically awkward subjects to that of grade 5 and grade 3 nonawkward subjects found in Koutsouki- Koskina's (1986) study. Koutsouki-Koskina's results indicated a relative consistency between trials in the performance of both grade 3 and grade 5 expert groups, and a marked inconsistency between trials in the performance of both corresponding novice groups. Furthermore, although the grade 3 novice group was less skilled than their grade 5 counterparts, Koutsouki-Koskina suggested that the level of skill within each group was much more important than chronological age in determining performance. In fact, the performance of the grade 3 skilled group was similar in accuracy to that of the grade 5 skilled group and less variable than that of the grade 5 novice group.

Thus the first purpose of this study was to examine the performance scores, the trends of scores over trials, and the variability between trials of awkward grade 5 girls, to determine the extent to which their performance is similar to peers and younger girls of two skill levels (expert and novice performers).

Koutsouki-Koskina (1986) also studied the effects of three instructional conditions on the performance of novice and expert grade 3 and grade 5 girls. The three instructional conditions include: a control condition in which subjects were simply asked to track the moving target; a declarative condition in which subjects were told of and shown the figure 8 pattern to be tracked, and; a metacognitive condition in which subjects were given the suggestion that the pattern to be tracked is familiar. Results of Koutsouki-Koskina's (1986) study indicate no significant difference in performance of the tracking skill among the three instructional conditions for the skilled children in both grades. Koutsouki-Koskina explained these findings by suggesting that these children were skilled enough to recognize that the path of the target was a figure 8. The instructional conditions, therefore, had no effect because they simply provided redundant information. The performance of the novice children in grade 5 also showed no significant difference among instructional conditions, although the control condition was slightly better than the other two conditions. Koutsouki-Koskina proposed that this group of children had decided to use their own set of strategies which the experimenter's instructions in the declarative and metacognitive conditions interfered with. The performance of the least skilled children, the grade 3 novices, was most improved in the metacognitive condition and their performance in both declarative and metacognitive instructional conditions was better than in the control.

Thus, a second purpose of this study is to investigate whether or not the three instructional conditions (control, declarative, metacognitive) differentially affect the performance of physically awkward girls when tracking a familiar pattern, such as the figure 8.

CHAPTER TWO

REVIEW OF THE LITERATURE

PHYSICAL AWKWARDNESS

Physically awkward children are "children without known neuromuscular problems who fail to perform culturally-normative skills with acceptable proficiency" (Wall, 1982, p. 254). Culturally normative skills are those skills that are used by the majority of the people in a particular culture at certain ages (Wall, 1982). Acceptable proficiency refers to planned, purposeful, and precise behavior that varies with age, gender, and sociocultural environment (Wall, 1982).

The physically awkward are presently seen as a subgroup of the learning disabled population. Depending upon the study, the incidence of physical awkwardness is generally believed to be anywhere between 5% and10% of the school-aged population. In addition, there appears to be some controversy as to whether or not boys and girls are affected equally. These inconsistencies may be related to the absence of a standard assessment tool used to identify awkward children. A large number of identification procedures have been developed by both the medical and educational professions, designed to identify children experiencing difficulties or who will experience difficulties in the perceptual-motor domain (Gubbay, Ellis, Walton, & Court, 1965; Henderson & Hall, 1982; Keogh 1966, 1968, 1978; Keogh et al., 1979; Lewko, 1977; Stott,1966; Taylor, 1982; Umansky, 1983; Weir, 1986). As well there is an additional problem there is an additional problem of an inability on the part of researchers to agree on standard criteria and methods to use in determining whether a child is awkward or not, and, if so, to what degree. Consequently much of the research thus far has been preoccupied with justifying the use of a specific identification procedure, rather than being directed toward further in-depth investigations of the disability itself and the possibility of developing remedial strategies.

A large portion of the research into the phenomenon of physical awkwardness is comprised of descriptive studies. These studies clearly illustrate what a variable group the physically awkward are. Researchers have found a myriad of characteristics often associated with clumsiness. For example, Walton, Ellis and Court (1962) described an awkwardness in a variety of skills such as dressing, feeding, and walking, and great difficulty with writing, drawing and copying. Awkward children frequently have difficulty with such perceptual tasks as recognizing objects and fitting shaped blocks into their appropriate holes. Often there is evidence of concomitant dysarthia and a delay in starting to speak (Walton, 1963). Others have found that there may be a discrepancy between the verbal and performance scores on the Weschler Intelligence Scale for Children (Gubbay, 1978; Walton et al., 1962). Moreover, physically awkward children are two times more likely than normal children to exhibit reading problems (Taylor, 1982).

It becomes evident that there is no such thing as a typical clumsy child. Awkwardness may involve both fine and gross motor coordination, or either in isolation (Gordon & McKinlay, 1980) and problems may involve either or both receptive and expressive components of a skilled movement (Dare & Gordon, 1970). Truly, this is a heterogenous group.

A concern that is stressed repeatedly in the literature is the importance of early identification of physically awkward children in order to lessen or prevent the emotional and behavioral problems that often occur. Specifically, the deficit in motor performance inevitably leads to failure, disappointment, and frustration. Because there are no overt neurological signs, physical awkwardness is not as easily recognized as other disabilities and, therefore, these children receive less sympathy and understanding (Gubbay, Ellis, Walton & Court, 1965). The poor motor performance of clumsy children means that they are often inept at (or even excluded from) games, are frequently the target of teasing and ridicule, and may experience difficulty making friends (McKinlay, 1978; Reuben & Bakwin, 1968). The resulting loss of self-confidence may cause these children to avoid activities they are actually capable of. Moreover, Paine (1968) points out that physically awkward children are often disruptive in the classroom so that sometimes emotional difficulties are suspected as the primary problem. Consequently, clumsy children have often been described as lazy, misbehaved, untidy, difficult, irritating, or even mentally dull by parents and teachers.

Figure 2 illustrates a syndrome of behaviors proposed by Wall (1982) and further developed by Taylor (1984) that attempts to explain the downward spiral of behaviors these children exhibit as a result of their lack of motor proficiency.

Because these children have great difficulty hiding their poor motor performance from others in play and game situations, they are often ridiculed by their peers and excluded from future group play situations. Ultimately, inadequate motor performance combined with the related social difficulties lead awkward children to withdraw from participation in physical activity, especially group situations. Withdrawal results in a lack of practice of the very skills these children need for positive participation. Lack of practice, in turn, inhibits further motor development and increases the existing performance differences between awkward children and their peers. Moreover, the delay in motor development these children experience can generate negative psychological and social consequences; the development of a low level of self confidence and self-esteem in addition to rejection by their peers may cause the physically awkward to exhibit a pattern of disruptive behavior in an attempt to mask their movement difficulties.

Notwithstanding a heterogeniety of symptoms as expressed by Gordon and McKinlay, 1980; Gubbay, 1978; McKinlay, 1978; Paine, 1968; Reuben and Bakwin, 1968; Taylor, 1982, 1984; Wall, 1982; Walton et al., 1962, researchers have generally adopted one of three basic approaches to the etiology of physical awkwardness: the deficit hypothesis (Gubbay et al., 1965; Henderson & Stott, 1977), the developmental delay theory (Gordon & McKinlay, 1980; Illingworth, 1968), or a cognitive processing approach (Glencross, 1978; Morris & Whiting, 1971; Wall, 1982).

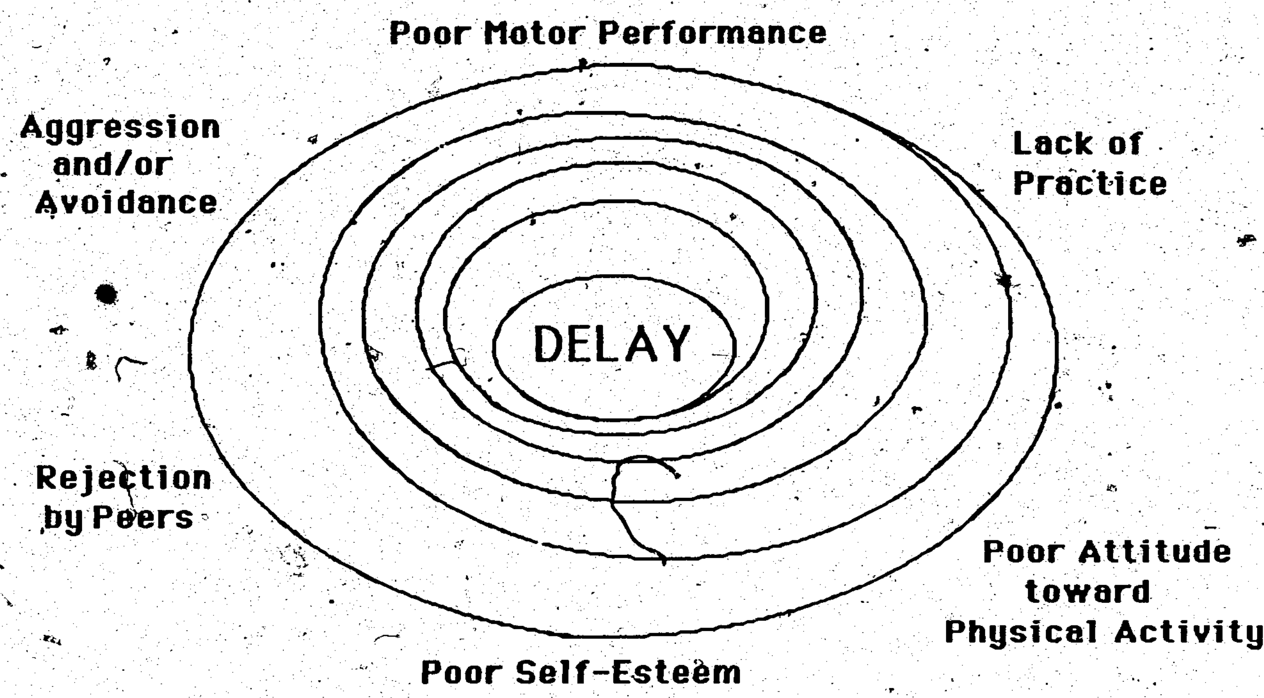

FIGURE 2

Downward Spiral of Behaviors in the Syndrome of Physical Awkwardness

Deficit Hypothesis

The first approach, deficit hypothesis, suggests that the deficit in the motor performance experienced by physically awkward children is due to brain damage, although this damage is not necessarily detectable. The literature stemming from the deficit approach has linked the impaired motor performance of clumsy children to such conditions as choreiform syndrome (Prechtl & Stemmer, 1962) and minimal cerebral dysfunction (Paine, 1968). An interesting observation made by Prechtl and Stemmer (1962) is that there is definitely an increase in the incidence of complications before, during and after the birth of awkward children and that one factor that may be linked to awkwardness is anoxia during pregnancy.

Because brain damage is the suspected cause of awkwardness, the deficit hypothesis places limitations on the improvement in motor skill performance that can be expected through remediation.

Developmental Delay

The second approach, developmental delay theory, characterizes physical awkwardness as a developmental disorder due to delayed maturation of the nervous system. (However, no effort is made to explain why the children are developmentally delayed.) Not surprisingly, this approach predicts a much more favorable prognosis for awkward children than the deficit hypothesis.

Supporters of developmental delay theory emphasize the need for additional practice by clumsy children to develop skills. According to Gordon (1976), children demonstrating mild deficits of motor organization may only need extra practice (provided they are motivated and rewarded) to overcome their difficulties. Children with severe deficits, however, may need the tasks to be broken down into component parts. These parts are then demonstrated to the child, accompanied by a verbal commentary. It is acknowledged, however, that if a child is exceptionally poor at a particular skill, continued practice will not likely improve the performance to a normal level. Therefore, one must consider the initial level of performance as well as the desirability of a particular skill when deciding whether or not to attempt to improve the child's performance of it (Dare and Gordon, 1970).

Cognitive Processing

The third and more recent approach to the study of physical awkwardness is from a cognitive processing approach. This approach is less concerned with the underlying etiology of awkwardness than the previous two approaches, and instead focuses on the processes involved in movement skill performance. This approach has emerged from research based on information processing models. Specifically, it is more concerned with the processes involved in the ability to receive and perceive input stimuli, to organize and store this information, to make appropriate decisions based on the use of suitable strategies, and to efficiently plan and execute movement responses that, in turn, elicit feedback through the various loops which control and define goal-directed behavior over trials (Wall,1982).

Coming from the cognitive processing approach, Keogh (1975) introduced the concept of phases in the development of skilled motor performance. Keogh suggests that there are two phases to motor skill development: movement consistency and movement constancy. Movement consistency develops until the child is about six years old and is "the development of a repertoire of skills that are characterized by efficient patterning and ordering of movements to solve everyday living problems in an appropriate and reliable way" (Wall, 1982, p.257). The child learns how to initiate and control motor skills in situations of relatively low spatial and temporal loads. Movement constancy is the flexible use of movement consistencies in a variety of situations. Keogh (1977) suggests that a child must progress from the phase of movement consistency to that of movement constancy at an age-appropriate pace in order to cope with the rapid increases in task demands of play and game situations when the child enters school. The increased temporal and spatial demands of tasks require both the ability to predict, and the flexible use of skills learned in the movement consistency phase of the child's motor development.

Another important contribution to the study of motor skill development is the theory of different levels of control in movement skill development (Glencross,1978). Glencross suggests that with practice, a skilled performer is able to relegate more and more skilled behavior from the attention consuming executive level to the routinized motor program level. Therefore, a skilled performer is able to free increasing amounts of attention to deal with more difficult situations (e.g. increased temporal and spatial uncertainty) or novel situations. In addition, as skilled behaviors become routinized motor programs, the execution of these skills becomes more precise. An unskilled performer, on the other hand, performs at the executive level and cannot cope with increasing task demands. This person is quickly thrust into the frustrating situation of information overload.

An integrated approach to the study of physical awkwardness that recognizes the importance of both genetic and environmental influences in the development of skilled motor performance was proposed by Wall (1982). This approach acknowledged both the developmental aspect of skill acquisition in addition to the increasing complexity of task demands that a child is expected to respond to as he or she grows older. In fact, school-aged children are expected to participate in fast-paced play and sports that require both accuracy and consistency in physical skills. According to Glencross (1978), accuracy and consistency require the use of automatized higher level motor programs. Furthermore, the development of these higher level plans occurs only after consistent practice over long periods of time. With reference to the physically awkward, however, Wall (1982) suggests that these children demonstrate a lack of skill in cognitive-motor tasks such that even practice situations become frustrating episodes of information overload. Clumsy children are, in effect, prevented from practicing and, consequently, cannot acquire the skills they need to participate.

KNOWLEDGE-BASED APPROACH TO SKILL ACQUISITION

In a more recent article, Wall et al. (1985) predicted that motor development is influenced by both genetic endowment (age and maturation) and acquired knowledge about action. Acquired knowledge about action is the knowledge gained through experience; its development depends on the availability of learning experiences in the motor domain. However, because of their withdrawal from physical activity, these learning experiences may not be readily available to the physically awkward.

Acquired knowledge about action is divided into three major types: procedural knowledge, declarative knowledge and affective knowledge. As was illustrated previously in Figure 1, metacognitive knowledge and metacognitive skills can also be differentiated.

Procedural Knowledge About Action

Procedural knowledge about action is knowledge about the general and specific features of each action and how to meet the requirements of that action. "Thus it is postulated that procedural knowledge, stored in schema form, underlies the instantiation of all aspects of an action sequence including the stimulus identification, perception, decision-making, response selection and execution, and the evaluation of intrinsic and extrinsic feedback (Singer, 1980; Norman and Shallice, 1980; Gallistel, 1981; Stelmach and Diggles, 1982)" (Wall et al., 1985, p.4). This knowledge is stored in a generalized form in schemas. " At each stage of an action sequence, considerable flexibility is provided by the use of control schemas that access relevant information from lower level schemas (Kozminsky, Kintsch, & Bourne, 1981)....Furthermore, perceptual, decision-making and response execution schemata can be linked together to control complex skills" (Wall, 1985, p.4).

The developmental level of one's procedural knowledge base in the motor domain is reflected in the quantity and quality of automatized motor skills one has available. A skilled performer uses deliberate attentional control less often than a novice or unskilled performer because a skilled performer is able to relegate more skilled behaviors from executive control to routinized motor programs (Gentile, 1972; Glencross, 1978). The result is that a skilled performance is characterized by precise and consistent execution of motor skills. In fact, a well developed procedural knowledge base is reflected in this consistency and precision in the execution of an increasingly large number of motor skills.

Declarative Knowledge About Action

Declarative knowledge about action is "factual information stored in memory which will influence the development and execution of skilled action" (Wall et al., 1985, p.30). For instance, it includes knowledge of the function of the neuro-muscular system, knowledge of gravity, momentum, friction and the principles related to force production and absorption, as well as knowledge of the spatial and temporal aspects of the performance environment that directly dictate the type of action executed (Arend, 1980). Like the other types of knowledge, declarative knowledge about action is gained through continuing interactions with the environment. As new knowledge is added to the declarative knowledge base, the existing knowledge is modified and restructured.

During the preschool years, declarative knowledge about action is largely nonverbal. "However, as children develop knowledge about their actions, the actions of others, and the effects of actions on objects, they begin to use language to describe them" (Wall et al., 1985, p.30). The ability to verbalize declarative knowledge about action is an extremely valuable tool to use in attempts to control action under certain conditions. For example, when teaching a new skill, an instructor can utilize verbal instructions to correct and guide the learner's movements.

One of the most important types of declarative knowledge about action is information about body image (Wall et al., 1985). As children experiment with movements, they learn to identify body parts, their relationship to each other and to external objects, and later verbalize this knowledge in positional and directional terms (Morris & Whiting, 1971). As their declarative knowledge about action develops, children "begin to attach expanded conceptual meanings to their actions, and these conceptual meanings in turn stimulate their use and understanding of their actions" (Wall et al., 1985, p.31). Thus the development of procedural and declarative knowledge is inter-related.

Affective Knowledge About Action

Affective knowledge about action refers to the subjective feelings that individuals attach to their actions within specific contexts. As affective knowledge about action develops, it is critically important for children to experience success in movement situations. Griffin and Keogh (1982) outline how such experiences are necessary for a child to develop a sense of movement confidence which will influence the child's pattern of activity selection, level of performance, and persistence in the face of difficulty. Therefore, the affective domain influences the acquisition of procedural and declarative knowledge.

Harter (1978, 1981, 1982) suggests that continued success experiences will result in a feeling of competence and the cumulative effects will contribute to the development of a positive self-concept. Recurring failure, on the other hand, will produce negative feelings of competence and confidence. Undoubtedly, this will affect the motivational state of the child to participate in future movement situations. An inordinate amount of failure may cause the child to experience learned helplessness (Dweck, 1980).

Learned helplessness is the perception of independence between one's response and the outcome of an event (Seligman, 1975). A child of low skill in the motor domain will likely experience a great deal of failure in movement situations. As a result, this child will probably begin to avoid such situations or, when forced to participate, will do so only half-heartedly. If the failure experiences continue, the child may come to believe that no matter what the response, the end result will always be failure.

According to Wall et al. (1985), "perhaps the most striking characteristic of physically awkward children other than their lack of physical proficiency is their difficulty in the affective domain" (p. 38).

Metacognitive Knowledge and Skills About Action

"Metacognitive knowledge about action is knowing about how to move" (Wall et al. 1985, p. 31). It is the ability to evaluate both the demands of the task at hand and one's own resources; it is knowing what one can and cannot do. "Metacognitive skill refers to the instantiation or use of metacognitive knowledge about action" (p. 32). Metacognitive skill is reflected in an extensive repertoire of strategies for a wide array of learning situations and an ability to select the most appropriate strategy following consideration of: (a) the goal; (b) the nature of the task demands, and; (c) one's own strengths and weaknesses relative to the activity (Palincsar, 1986). Moreover, use of the chosen strategy is continually evaluated to ensure that it is, in fact, the most appropriate strategy.

According to Brown (1982), metacognitive knowledge and strategies are late-developing so that even child experts "are limited in the degree to which their learning and processing can be extended across domains....Children are not only hampered by being universal novices, for even when they do gain expertise, it tends to be strictly constrained by context" (p. 106). However, as metacognitive knowledge and skills develop, children become more effective problem solvers and learners (Wall et al., 1985). In fact, in novel, dangerous, or difficult situations, children often use specific metacognitive skills to consciously control their attempts to learn. Accepting that metacognitive knowledge is essentially one's awareness of one's procedural, declarative, and affective knowledge, and that metacognitive skill is the instantiation of this knowledge (Wall et al., 1985), it is likely that awkward children develop very little metacognitive knowledge and skill. Because of their poor motor performance and related difficulties (e.g. withdrawal behavior), the continuous learning experiences needed to acquire procedural, declarative, and affective knowledge about action may not be available to physically awkward children. Hence, Wall and his associates suggest that "inasmuch 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" (Wall et al., 1985, p.38).

The authors of the knowledge-based approach stress the importance of knowledge about action in the development of motor skills. Due to the nature of their disability, physicaly awkward children do not have the opportunities to experience play and game situations in which knowledge about action develops. Therefore, physical awkwardness is viewed as a developmental problem due to a lack of knowledge in all five types of knowledge about action (Wall et al., 1985).

RECENT STUDIES DONE IN THE MOTOR DEVELOPMENT CLINIC

The Motor Development Clinic of the University of Alberta, has developed a program designed to improve and optimize the motor performance of physically awkward children. In addition, several investigations into the different aspects of the syndrome of physical awkwardness described by Wall (1982) have been undertaken in the clinic.

A Leisure Pursuits Questionnaire was designed and utilized by Clifford (1985) in a study of the leisure time pursuits of seven physically awkward children. The subjects of this study were initially identified as awkward from the results of two administrations of the Motor Performance Test Battery (Taylor, 1982), given one year apart, and the Gross-Motor Performance Rating Scale (Umansky, 1983). The results of the motor performance test battery showed considerable variability of scores between and within the two test sessions. Moreover, all seven subjects scored below the mean ratings for physical awkwardness on Umansky's rating scale.

As is predicted in the syndrome of awkward behavior proposed by Wall (1982), Clifford found a tendency for her subjects to avoid culturally normative leisure-time pursuits such as team sports, community- sponsored activities, social organizations, and involvement in camps. In fact, the results indicated that these children participate in relatively few activities. Instead, they spend the majority of their leisure time watching T.V. and playing home video games. With reference to physical activities, the awkward children prefer individual activities normally performed by younger children. These activities are characterized as being of low spatial and temporal demands, in addition to low organization. Clifford (1985) questioned whether this apparent preference for individual activities is a choice made by awkward children or if it is forced upon them. According to McKinlay (1978) and Reuben and Bakwin (1968), awkward children are often excluded from play and games because of their poor motor performance. On the other hand, Wall (1982) suggested that awkward children choose to withdraw from group games and play as a result of their ineptness in these situations and the subsequent ridicule they receive.

Clifford (1985) also found that the subjects of her study usually choose younger playmates. A number of the parents indicated that their children do not have any after-school playmates who are not relatives. These results were expected by Clifford (1985) for at least two reasons: first, as was previously mentioned, Clifford found a tendency for awkward children to participate in activities chosen by younger children, and; second, McKinlay (1978) and Reuben and Bakwin (1982) have reported that physically awkward children experience difficulty in making and keeping friends.

Surprisingly, the results of Harter's Perceived Competence Scale (1981) indicated that the children have a general feeling of competence in play activities. Clifford referred to these findings as "both surprising and suspect" (p. 39). Further, she suggested that more items are required to accurately measure feelings of competence in physical activity, and noted that none of the questions on Harter's scale dealt with culturally- normative activities. It is also possible that the children answered the questions falsely in an attempt to protect their egos.

The leisure-time activities profiles compiled by Clifford

(1985), using the Leisure Pursuits Questionnaire, lend support to the syndrome of physical awkwardness (Wall, 1982). As the syndrome predicts, the awkward children seem to have little interest and involvement in physical activity, especially group activities.

Paton (1986) conducted a relatively comprehensive study of the physical fitness levels of forty-one physically awkward children. The specific tests administered were: the shuttle run, the standing long jump, partial curl-ups, and push-ups (from the Canada Fitness Award Programme); anthropometry measures (height, weight, girth measurements for upper arm, forearm, and calf, as well as skinfold measurements for the tricep, bicep, subscapular, suprailiac, supraspinale, abdominal, front thigh and medial calf areas), and; the PWC-170 bicycle ergometer test of cardiovascular fitness.

Paton (1982) found that physically awkward children are characterized by poor fitness levels. Specifically, as a group, they scored below the 30th percentile on six of the seven measures taken. The lowest results were obtained on the PWC-170 test (where over half of the subjects scored below the 20th percentile), partial curl-ups, and push-ups. Most of the children were unable to do even one push-up and, because a new protocol was used in both the curl-ups and push-ups (see the Canada Fitness Awards, 1984), one has to question whether the results of these two tests reflect purely a lack of fitness or also indicate a lack of procedural knowledge.

Interestingly, the results of the skinfold measures do not indicate any tendency toward obesity. These findings do not comply with those reported in an earlier study by Clifford (1985). Clifford noted that six of the seven physically awkward children involved in her study had a tendency to be overweight. However, Clifford's results were obtained through observation only; she did not gather any anthropometric data. Furthermore, because the study included only seven children, the generalizabilty of Clifford's study is limited.

The results of Paton's (1985) study provide some support for the contention put forth by Wall (1982) "that there is a direct link among poor motor proficiency, avoidance of physical activity, and low fitness" (Paton, 1986, p. 99).

A recent study by Marchiori (1987) was undertaken to examine the differences in procedural knowledge between two physically awkward children and two age-matched nonawkward children on the stationary slap shot. "The first purpose of this study was to examine the performance differences between the two groups. The second purpose was to investigate the pattern of performance changes which might accrue from 1200 practice trials of the slap shot by the two physically awkward children" (p. 36). The results indicated a relative consistency in the movement patterns and timing of the nonawkward subjects, as measured by the angular velocity curves and the peak stick velocity times in relation to contact with the puck respectively. The nonawkward subject who had played one year of organized hockey produced the most consistent and efficient movement pattern.

The physically awkward subjects exhibited very inconsistent movement patterns and erratic timing. Furthermore, even after 1200 practice trials over 6 weeks, the physically awkward children were unable to attain a consistent movement pattern for the slap shot.

Marchiori's (1987) results clearly indicate the deficit in procedural knowledge experienced by physically awkward children, as demonstrated through the performance of the culturally-normative stationary slap shot. However, these findings also raise some questions as to whether or not physically awkward children can improve their skill performance through practice. Wall et al. (1985), and others who endorse the developmental delay hypothesis, stress the need for practice of response-loaded skills by awkward children in order to gain the minimal level of proficency required to participate in play and game situations. This is, in effect, what the awkward subjects of Marchiori's (1987) study did for 1200 trial over 6 weeks. These children, however, were still unable to produce consistent movement patterns.

It is possible that Marchiori's results were influenced by a lack of motivation during practice sessions on the part of the awkward subjects. One must take into consideration that the children were required to practice 40 trials per day, 5 days per week for 6 weeks, under the supervision of their parents. It is possible that the results might have been different if the children had been allowed to make their own choice of when and where to practice; one would expect a difference in the motivation levels of the children, had they chosen to practice rather than been told to do so. If this were the case, then it might have been that the results of the study were biased by the negative emotional effects (i.e. affective knowledge) of the awkward subjects.

The level of motivation exhibited by a child is a clear indication of the affective knowledge the child has for the task in that particular context. (Bearing in mind that affective knowledge is situationally specific.) Thus, had the awkward subjects in Marchiori's study been allowed to choose when and for how long they practiced, perhaps their affective knowledge about the stationary slap-shot might have been different. However, it would then have been very difficult to accurately monitor each subject's practice, let alone ensure they were practicing at all. A better situation would be one in which the subjects had volunteered to participate in the study, motivated by their own desire to improve their skill at the task.

In the knowledge-based approach, Wall et al. (1985) state that an individual's affective knowledge affects the acquisition of procedural and declarative knowledge. If the affective knowledge (about the stationary slap-shot) of Marchiori's subjects was such that they were not motivated during their practice sessions, then this lack of motivation would have influenced their ability to acquire any further procedural and declarative knowledge. Therefore, it is possible that the inability of the awkward children in Marchiori's (1987) study to produce a consistent movement pattern is an indication of their affective knowledge, rather than just procedural knowledge.

Meek (1987) designed the Physical Activity Performance Questionnaire (PAPQ) to analyze the attitudes and intended behaviors of physically awkward children toward physical activity. Three groups of subjects, mildly awkward, severely awkward, and nonawkward, were instructed to indicate their "best" and "worst" performed activities as well as their "favorite" and "least favorite" physical activities. " 'Attitudes' were determined through a series of questions that asked the respondents to indicate the degree to which they favored these activities. 'Intended behaviors' involved the child's evaluation of expected performance for the same physical activities" (p. 77). In addition, the children were asked to indicate their attitudes and intended behaviors for culturally normal activities (running fast, riding a bicycle, skating, and swimming).

Meek found that the nonawkward children had the most favorable attitudes toward activity, with the mildly awkward group having more favorable attitudes than the severely awkward group. The results of the question indicating "best" and "worst" performed activities fell into the same hierarchial formation. [illegible] of these findings comply with the behaviors described in the syndrome of physical awkwardness.

Conversely, the results of the analysis of attitudes toward culturally normative activities differ considerably from those above. Meek found no significant differences in the attitudes of the three groups toward culturally normative activities. These results are clearly not what one would expect of the two awkward groups based on the syndrome of physical awkwardness (Wall, 1982) and the knowledge-based approach (Wall et al., 1985). Meek explained his findings by clarifying that his questionnaire did not ask how often or how well the child performed the activity, and, in addition, the activities were not contextually defined. Therefore, the awkward children may have considered the activites in the best context they could imagine. According to Clifford (1985), this would probably be in an individual context characterized by low organization. Furthermore, it is likely that the awkward children indicated favorable attitudes toward culturally normative activities in an effort to protect their self-image and self-esteem (Meek, 1987).

When the activities were considered with reference to the task demands (simple, reactive, complex), Meek found that the two awkward groups differed significantly from the nonawkward group in the types of activities they identified as "best" and "worst"performed. Suprisingly, there were larger differences between the mildly awkward and nonawkward groups than there were between the severely awkward and nonawkward groups. The results indicated a tendency for severely awkward and nonawkward children to favor complex activities as their "best" performed. Meek suggested that

> the severely awkward children may not perform even simple tasks well, which would explain their preference for the more attractive and acceptable in [sic] complex tasks. Conversely, the mildly physically awkward children are more confident in their abilities in those activities that they can perform regardless of each activity's task demands and thus, do not need to conform to expected preferences" (p. 110).

Meek hypothesized that age would influence the attitudes of the awkward children in that the older children, who had had the syndrome for a longer period of time sould show less favorable attitudes and intentions towards physical activity. The results indicated that this was not the case; age had no effect upon the attitudes of the awkward children.

Most importantly, Meek discovered that even though the attitudes of the awkward children were less favorable than those of the nonawkward children, the awkward groups still indicated positive attitudes toward physical activity. These results are in accord with those found by Clifford (1985) using Harter's Perceived Competence Scale. However, this finding does not confirm the description of the syndrome of physical awkwardness as described by Wall (1982) and Wall et al. (1985). Again, Meek suggests that these results may have occurred because his questionnaire did not specify the context of the activities and it was not determined whether the child actually performed the activity, or how well and how often. Notwithstanding Meek's attempts to explain these results, it is clear that more research is needed into the attitudes of awkward children toward physical activity before any definite conclusions are drawn.

The results of the studies done in the Motor Development Clinic generally confirm Wall et al.'s (1985) contentions that physically awkward children possess poor procedural skills and experience difficulties in the affective domain. Furthermore, these studies also confirm many of the behaviors in the syndrome of physical awkwardness described by Wall (1982).

EXPERT-NOVICE DIFFERENCES AND THE KNOWLEDGE BASED APPROACH.

In the knowledge-based approach, Wall et al. (1985) stress the importance of acquired knowledge about action in learning and performance of motor skills. As was mentioned earlier in this section, acquired knowledge about action is made up of five different types of knowledge (Wall et al., 1985). Moreover, it is domain-(activity) specific. In other words, one can have a great deal of knowledge in tennis, and very little about wrestling and skiing.

Domain-specific knowledge about action is that which separates an expert from a novice. For instance, Chi (1978) conducted a well-known investigation of expert-novice differences in memory development with the game of chess. Chi found that 10-year old experts were better able to recall the positions of the chess pieces than novice adults. However, a subsequent digit span test resulted with the children able to memorize fewer digits than the adults on a given trial, and the children requiring more trials than the adults to learn 10 digits. Presumably the strategic knowledge necessary to perform these two memory tasks did not change with the stimuli; it was the content knowledge of the subjects that changed. In other words, the children's memory superiority was restricted to the chess domain in which they were experts.

Jones and Miles (1978) conducted an investigation in which expert and novice subjects were asked to watch a film of a tennis player in the act of serving, and then to predict where the ball would land. The study included three conditions: first, with the film cut off 336 ms. after impact of the ball on the racquet; second, with the film cut off 126 ms. after impact, and; third, with the film cut off 42 ms. before impact. The results showed significant differences in the accuracy of predictions between experts and novices in all three conditions, with the largest differences in the third condition. Therefore, the domain-specific knowledge of the expert and novice subjects influences their ability to predict the flight of the tennis ball and, consequently, their tennis skill.

Allard, Graham, and Paarsalu (1980) investigated the ability of basketball players and nonplayers to recall and recognize structured and unstructured situations of offense and defense. These authors found that basketball players were able to recall more structured situations. There no difference was found between the ability of the two groups to recall unstructured situations.basketball players and the novices to recall unstructured situations. Again, one can see the important effect that domain-specific knowledge has on the ability of the basketball players to remember specific information about basketball.

In addition to differentiating between experts and novices, the knowledge-based approach predicts that "expertise in a specific domain influences the learning of a given task" (Wall, 1985, p. 14). Similarly, Chi (1983) explains that individuals acquire new knowledge by mapping new information into existing schemas. Furthermore, the existing knowledge in the schema cues the learner's attention by indicating what information is missing.

In a study of high knowledge and low knowledge baseball players, Chiesi, Spilich, and Voss (1979) found that the high knowledge players were able to acquire new knowledge in the baseball domain more quickly and easily than low knowledge players. In addition, the high knowledge players acquired a greater quantity of new knowledge. The authors suggested that the high knowledge players were able to acquire new knowledge more efficiently because they have a large knowledge base in the baseball domain.

The above studies indicate that an expert is an expert due to a well-developed knowledge base. Additionally, Cheisi et al. (1979), Chi (1983), Lawson (1984), and Wall (1985) indicate that domain-specific knowledge enables the expert to generate more effective problem solving strategies than a novice. It seems that "such metacognitive skills as planning, monitoring, and evaluating are directly influenced by the domain-specific knowledge of the person (Glacer, 1984)" (Wall, 1985, p. 16).

Koutsouki-Koskina (1986) looked at the differences in procedural skill of experts and novices, and at the differences in the abilities of these two groups to utilize declarative and metacognitive information to improve their performance. Koutsouki-Koskina (1986) investigated the performance of a tracking task by skilled and unskilled children from grades 3 and 5. Her findings indicated a relative consistency between trials in the performance of grade 3 and grade 5 skilled groups, and a marked inconsistency between trials in the performance of both corresponding novice groups. Furthermore, although the grade 3 skill groups were less skilled that their grade 5 counterparts, Koutsouki-Koskina notes that

> the level of skill [expert, novice] within each group is a much more important determinant of performance than is the chronological age of the subjects. In fact, the skilled grade 3 groups are less variable that the novice grade 5 groups, and the accuracy of their tracking performance is similar to that of

their older skilled counterparts (p. 63).

Koutsouki-Koskina (1986) also studied the effects of three instructional conditions on the performance of novice and expert grades 3 and 5 girls. The three conditions included: a control condition in which subjects were simply asked to track the moving target; a declarative condition in which subjects were told of and shown the pattern to be tracked, and, a metacognitive condition in which subjects were given the suggestion that the pattern to be tracked was familiar. The results indicated that there was no significant difference in performance of the tracking skill among the three instructional conditions for the skilled children in both grades. Koutsouki-Koskina explained these findings by suggesting that these children "already possess sufficient declarative and metacognitive knowledge, as well as metacognitive skill, to optimize their performance" (p. 90). In other words, the skilled performers quickly recognized the path the target was following.

The performance of the novice children in grade 5 also showed no significant difference between instructional conditions, although the control condition was slightly better than the other two conditions. Koutsouki-Koskina hypothesized that these children were also skilled enough to recognize the path of the target, but "they were old enough to have developed tracking strategies of their own. Thus, when the declarative and metacognitive strategy instruction conditions were given, they had the effect of disturbing the strategies that the girls had already decided upon using to track the target" (p. 74).

The performance of the least skilled group, the grade 3 novices, was most improved in the metacognitive condition and their performance in the metacognitive and declarative instructional conditions was better than in the control condition. Koutsouki-Koskina claimed that the results for this group "were exactly congruent with the predictions that were made prior to the start of the experiment; that is, tracking performance was definitely improved when the subjects realized that the figure to be tracked was, in fact, a figure eight" (p. 55). With this explanation, however, one must question why the grade 3 novices in the metacognitive condition performed better than those in the declarative condition? After all, the children in the declarative condition received a demonstration and verbal description of the figure 8-shaped target. In the metacognitive condition, the subjects were cued to direct their attention to finding out the shape of the path, but they still had to discover the actual shape of the target on their own. Therefore, one would expect the results of the declarative condition to be superior to those of the metacognitive condition.

CHAPTER THREE
METHODS AND PROCEDURES

GENERAL METHODS

The protocol used in this study was designed by Koutsouki-Koskina and is reported in Koutsouki-Koskina (1986). However, for the benefit of the reader, the protocol is outlined below.

Experimental Task

Koutsouki-Koskina's reasons for using the tracking task in her study were that it included culturally normative skills and it was an ecologically-valid task with which to measure one type of procedural skill. Tracking tasks involve a great deal of repetition and regularity during and over trials and, as a result, one can assume a "certain amount of predictability in learning and performing the task" (Koutsouki-Koskina, 1986, p. 48). Moreover, Poulton (1957) contended that tracking tasks are a suitable test of whether of not learning takes place and what kinds of general and specific strategies are used by the individual to perform the task.

FIRST TEST SESSION

Subjects

The subjects were sixteen physically awkward girls enrolled in four elementary schools within the Edmonton Public School Board. The girls were all in grade 5, between the ages of 9 and 11. The subjects were previously identified as awkward by Weir (1986).

Apparatus

As in Koutsouki-Koskina's (1986) study, an Apple Macintosh computer with a "mouse" was used to measure tracking performance. The computer program generated a dark dot, 1cm in diameter, as the moving target. A cross-shape of equal size acted as the cursor which the subjects used to track the moving target via the mouse. A computer program recorded both the position of the target and the subject's response in terms of XY coordinates. There were 247 data points for both the criterion and the response with time remaining constant across data points. The difference between the criterion XY and the response XY was calculated.

The computer screen was positioned on a desk directly in front of the subject. The mouse was also placed on the desk, directly in front of the subject's mid-line. The experimenter was seated beside the subject and controlled the experimental protocol via the computer keyboard.

Procedures

Each child was given 15 trials. The first two trials were demonstration trials and the subjects simply observed the moving target. The next three trials were considered practice trials and were not included in the data analysis. The target moved for approximately 15 seconds following the path of a bean-shape, followed by a 3 second interval between trials which allowed the computer to record the data. Subjects initiated their own trials and were reinforced following the 5th, 8th, 11th, and 14th trials.

Subjects were taken out of their classroom in order to be tested during the school day. Subjects were seated and given a brief introduction to the computer and the "mouse". All subjects were tested on their knowledge of various geometric shapes (see Appendix III). As in Koutsouki-Koskina's (1986) study, they were then given the following instructions:

> Notice that when I move the mouse on the desk, the cross moves on the computer screen and it goes wherever I want it to go. As soon as I move the cross and place it on the dot and push the button on the mouse once, the dot will start moving to different places on the screen. I want you to move the cross with the mouse and take it wherever the dot goes.
>
> You have to keep the cross on the dot if you can, for as long as the dot moves. Before you start, I am going to let you watch the dot. (Once the dot starts moving) see, you have to move the cross with the mouse like this, and try to keep it on the dot.
>
> If it is too hard to keep the cross on the dot, try to keep it as close to it as you can. You can only use your right hand and you will start your own games by pushing the mouse button once. Do you have any questions? If not, remember, do not stop moving your cross unless the dot stops moving. Hold the mouse. Ready? Push the button. (p. 50)

The last ten trials were used to describe the procedural skill of the awkward subjects on this tracking task. Means over 10 trials for each subject were used to make initial comparisons of the awkward group and the non-awkward groups.

SECOND TEST SESSION

Subjects

The subjects from the pretest participated in the experimental test session. The subjects were randomly assigned to the three instructional conditions.

Apparatus and Task

The apparatus was the same as that of the pretest. The task was also the same except the pathway of the target was changed to that of a "figure 8 lying on its side". Again, the computer program recorded the criterion and the subject's response in terms of XY coordinates. The figure 8 shaped target produced 285 data points for both the criterion and response, with time remaining constant across data points. As in Test Session One, the difference between the criterion XY and the response XY was calculated.

Procedures

Subjects were randomly assigned to three experimental conditions and each was given twenty trials. The first condition was a control condition in which instructions were given as in the pretest. The second condition included a demonstration trial in which the subjects observed the target making a figure 8 shape. The trace of the pathway was visible on the screen for only one trial. In addition, subjects were given the following instructions: "the target will follow [the path of a figure 8 lying on its side]. Knowing the path, you should be able to track the target more easily" (Koutsouki-Koskina, 1986, p. 56). In the third condition, subjects were given the following instructions: "the dot will be following a path of a figure you know. If you can find out the figure the target is drawing it should help you to keep your cross on the dot. So, try to find out what the figure is" (Koutsouki-Koskina, 1986, p. 56).

All subjects in all experimental groups were reminded that they should try to keep their cross on the dot as it moved. Reinforcement was given following the 4th, 8th, 12th, 16th, and 18th trials by saying "good work, try to keep your cross on the dot" (Koutsouki-Koskina, 1986, p. 56)

RESEARCH DESIGN

The research design for the initial test session involved a 5 (skill groups: grade 5 awkward, grade 5 expert, grade 3 expert, grade 5 novice, and grade 3 novice) X 10 (trials) analysis of variance. The research design for the second test session was a 3 (experimental conditions) X 20 (trials) analysis of variance. Only the awkward subjects were included in this second analysis.

The Dependent Variable

The dependent variable was the Root Mean Square (d) Error (RMSE). The RMSE provided information on how far the response cursor (child's response) was from the target. The formula as described by Poulton (1974) is:

$$RMSE = \sqrt{\frac{1}{n} \Sigma e_{di}^{2}}$$

In this formula, **e** is the difference between the stimulus and response measured in units of 1.85mm at data point **d** for trial **n** is the number of data points per trial.

CHAPTER FOUR
RESULTS

INTRODUCTION

Two questions were asked in this study:

1. How does the performance of a tracking task by grade 5 physically awkward girls compare to the performance of the grades 5 and 3, expert and novice girls from Koutsouki-Koskina's (1986) study?
2. When tracking a familiar pattern (a figure 8, lying on its side), how is the performance of grade 5 physically awkward girls affected by the following three instructional conditions:
   a. a control condition where subjects were asked to track the moving target,
   b. a declarative condition in which subjects were told of and shown the figure 8 pattern to be tracked, and,
   c. a metacognitive condition in which subjects are given the suggestion that the pattern to be tracked is a familiar shape?

ANALYSIS OF THE FIRST TEST SESSION

The RMS error was calculated for the last 10 of 15 iterations for each of the awkward subjects. The individual means from each iteration were reviewed so that extreme scores, which were two standard deviations above or below the mean for a particular subject, were replaced by the mean error score for the subject over the 10 trials. The assumption was made that trials with such huge error scores reflected lack of attention to the task on the part of the subject. The procedure was also applied to RMS error scores calculated on the grades 5 and 3, expert and novice subjects from Koutsouki-Koskina's (1986) study. The mean RMS error scores for the five skill groups can be seen in Table 1.

TABLE I

Mean, High and Low RMS Error Scores for the Five Skill Groups (Test Session One)

SKILL GROUP	MEAN RMS ERROR	HIGH SCORE	LOW SCORE
Grade 5 Expert	21.33	25.63	16.98
Grade 3 Expert	27.49	32.57	21.64
Grade 5 Novice	33.52	42.57	29.39
Grade 3 Novice	43.50	49.58	39.93
Physically Awkward	46.00	103.53	25.38

A two-way analysis of variance with repeated measures on one factor (DERS:AVOV26) was run on the corrected RMS error scores. Specifically, the design was 5 (groups) X 10 (iterations), with iterations as the repeating factor. The outcome of this analysis can be seen in Table 2.

For this and all subsequent analysis, $p < .05$ was accepted as significant. The analysis clearly revealed a significant difference

TABLE II

Analysis of Variance of RMS Error Scores

Skill Groups by Trials

(Test Session One)

SOURCE OF VARIATION	SS	DF	MS	F	P
BETWEEN SUBJECTS	0.1485E+06	75			
A	0.6621E+05	4	16551.547	14.310	0.000
SUBJECTS WITHIN GROUP	0.8212E+05	71	1156.622		
WITHIN SUBJECTS	0.8141E+05	684			
B	0.1163E+04	9	129.269	1.095	0.365
AB	0.4615E+04	36	128.206	1.086	0.339
B X SUBJECTS WITHIN GROUP	0.7547E+05	639	118.105		

between skill groups ($F = 14.310$, $p = 0.000$). However, there were neither any significant differences revealed within trials ($F = 1.095$, $p = 0.365$) nor any group x trial interactions ($F = 1.086$, $p = 0.339$). Further analysis of between group contrasts can be seen in Table 3. The Scheffe Comparisons revealed significant differences between the physically awkward group and: (1) the grade 5 expert group ($F = 10.181$, $p = 0.000$); (2) the grade 3 expert group ($F = 5.527$, $p = 0.001$), and; (3) the grade 5 novice group ($F = 2.694$, $p = 0.038$). Furthermore, the grade 3 novice group was significantly different from both the grade 5 skilled group ($F = 7.969$, $p = 0.000$) and the grade 3 skilled group ($F = 4.013$, $p = 0.005$). Finally, the difference between the grade 5 expert and novice groups was also significant ($F = 2.484$, $p = 0.051$).

TABLE III

Results of Scheffe Comparisons of Unweighted

Within Group Main Effects

(Test Session One)

GROUPS	F RATIO	PROBABILITY
Grade 5 Expert and Grade 5 Novice	2.484	0.051
Grade 5 Expert and Grade 5 Awkward	10.181	0.000
Grade 5 Expert and Grade 3 Expert	0.594	0.668
Grade 5 Expert and Grade 3 Novice	7.969	0.000
Grade 5 Novice and Grade 5 Awkward	2.694	0.038
Grade 5 Novice and Grade 3 Expert	0.586	0.674
Grade 5 Novice and Grade 3 Novice	1.669	0.167
Grade 5 Awkward and Grade 3 Expert	5.527	0.001
Grade 5 Awkward and Grade 3 Novice	0.104	0.981
Grade 3 Expert and Grade 3 Novice	4.013	0.005

Figure 3 illustrates the mean RMS error scores and standard deviations of the five groups (grade 5 skilled, grade 3 skilled grade 5 novice, grade 3 novice, physically awkward). The grade 5 and grade 3 skilled groups exhibited the least amount of error ($\bar{X}$ = 21.33, S.D. = 5.34 and $\bar{X}$ = 27.49, S.D. = 6.20, respectively). The grade 5 novice group had a mean RMS Error score of 33.52 and a standard deviation measure of 9.56. The grade 3 novice and physically awkward groups were the least skilled, with mean error scores of 43.50 and 46.00 respectively, and standard deviations of 15.01 and 25.30 respectively.

As can be seen in Figure 4, the tracking performances of the grade 3 novices and the physically awkward girls are characterized by a great deal of inter-trial variability. Conversely, both of the skilled groups and the grade 5 novices exhibited relatively consistent performances. Figure 4 also illustrates that there were no significant changes in trend over 10 trials for any of the 5 skill groups.

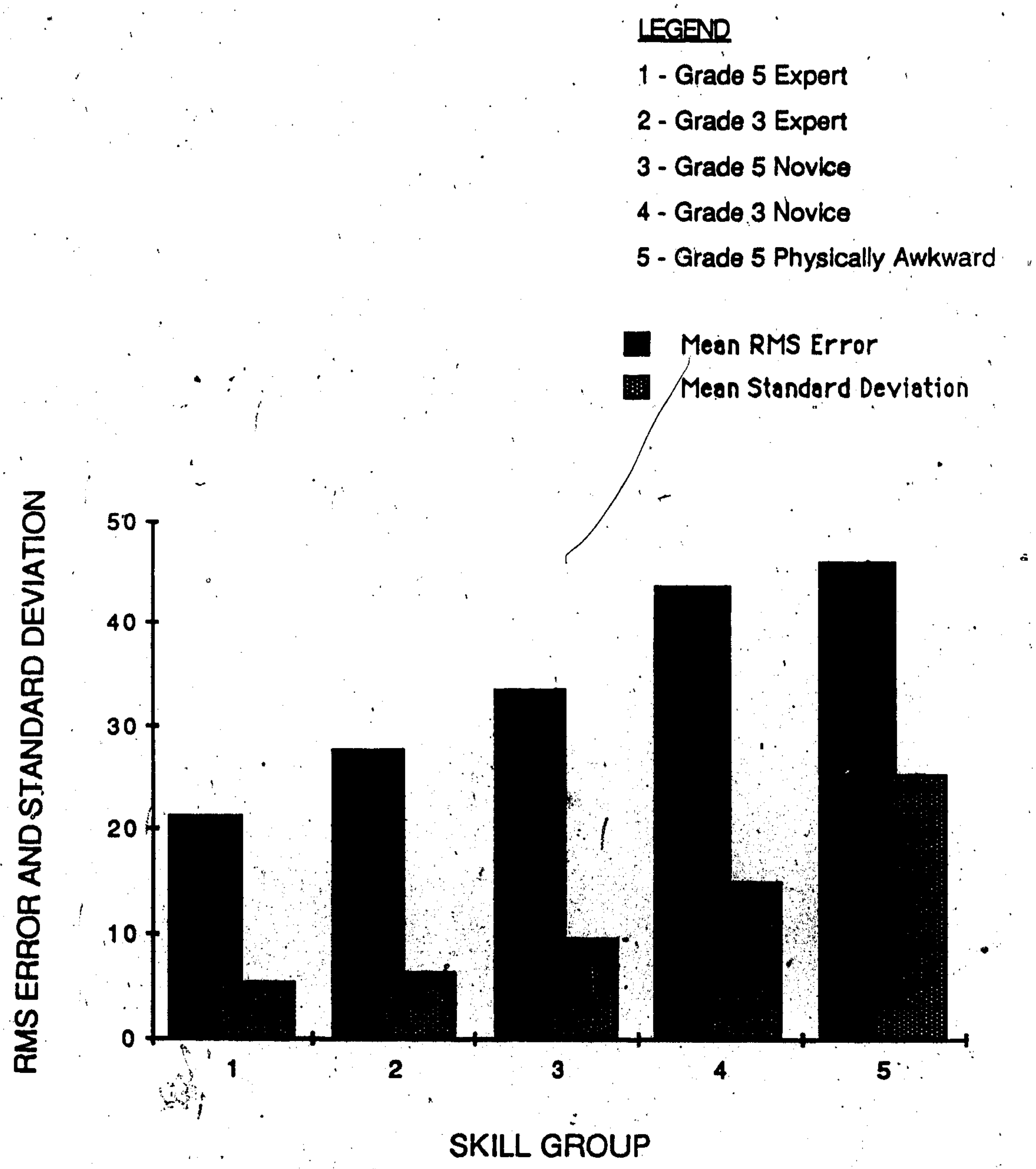

FIGURE 4

Mean RMS Error Scores and Standard Deviations of 5 Skill Groups

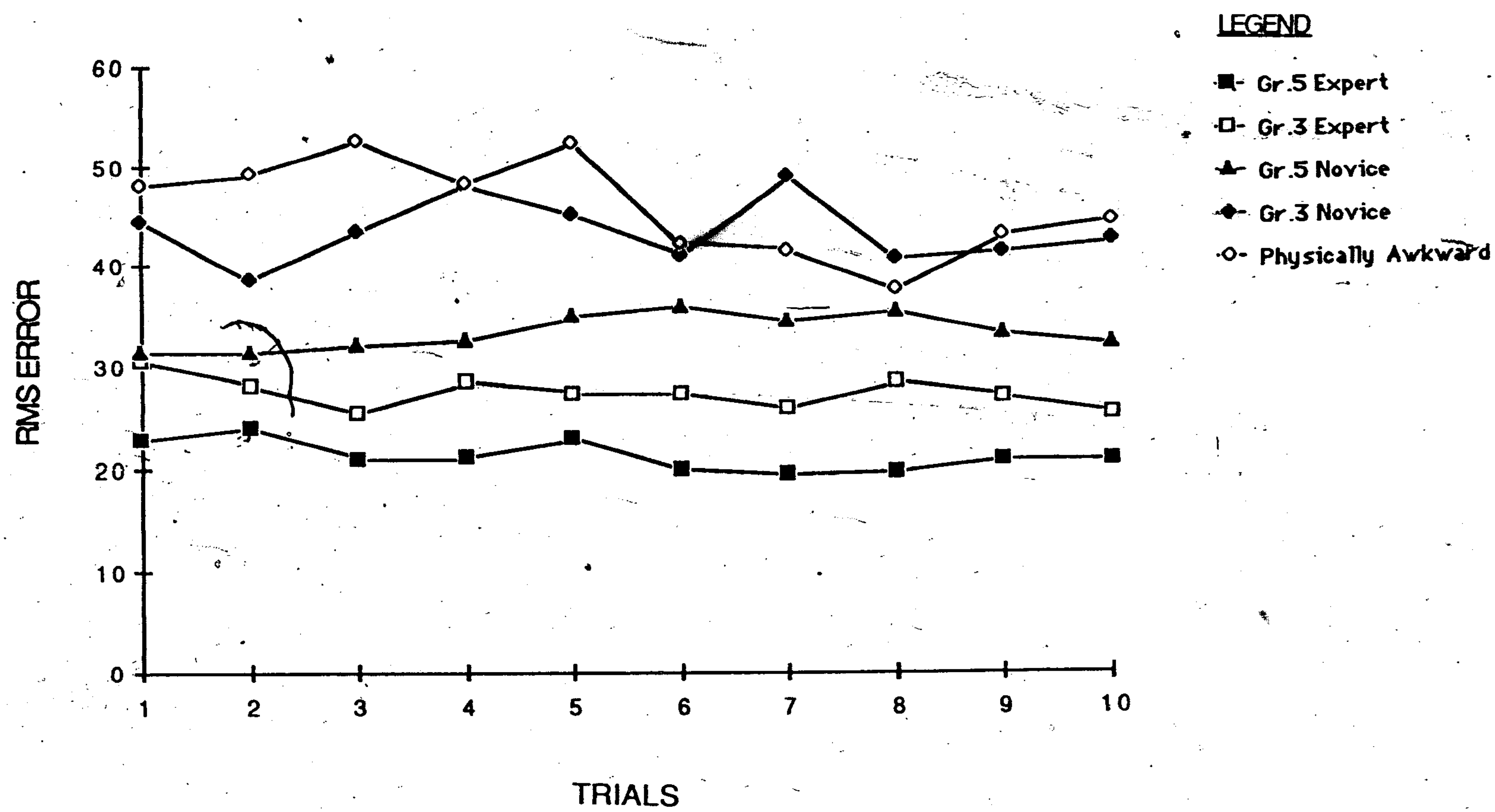

FIGURE 4

Root Mean Square Error Scores of Skill Groups over 10 Trials

ANALYSIS OF THE SECOND TEST SESSION

Again, a two-way analysis of variance with repeated measures on one factor (SPSSX:ANOVAR) was run on the corrected RMS error scores from test session two. The design was a 3 (instructional conditions) X 20 (iterations) design, with iterations as the repeating factor.

Table 4 presents the mean RMS error scores of the groups under three instructional conditions. Table 5 presents the results of the analysis. The main effect of instructional conditions was clearly not significant ($F = 1.966$, $p = 0.183$). In addition, the main effect for iterations was not significant ($F = 1.438$, $p = 0.111$), and there were no interactions ($F = 1.040$, $p = 0.414$).

TABLE IV

Mean, High and Low RMS Error Scores of Groups Under Three Instructional Conditions

INSTRUCTIONAL CONDITION	MEAN RMS ERROR	HIGH SCORE	LOW SCORE
Control	40.47	67.20	27.83
Declarative	47.88	75.99	26.48
Metacognitive	28.74	40.70	21.39

TABLE V

Analysis of Variance of RMS Error Scores,

Three Instructional Conditions by Trials,

(Test Session Two)

SOURCE	SS	DF	MS	F	P
A (groups)	18625.625	2	9312.813	1.966	0.183
S-WITHIN	56835.000	12	4736.250		
B (trials)	4026.563	19	211.924	1.438	0.111
AB	5823.750	38	153.257	1.040	0.414
BS-WITHIN	33597.125	228	147.356		

Figure 5 graphically presents the mean RMS error scores and standard deviations for all three instructional conditions. Similar to the results of the grade 3 novice group in Koutsouki-Koskina's (1986) study, the performance of the metacognitive instruction group was superior (although not significantly) to both the declarative instruction group and the control group. In addition, the physically

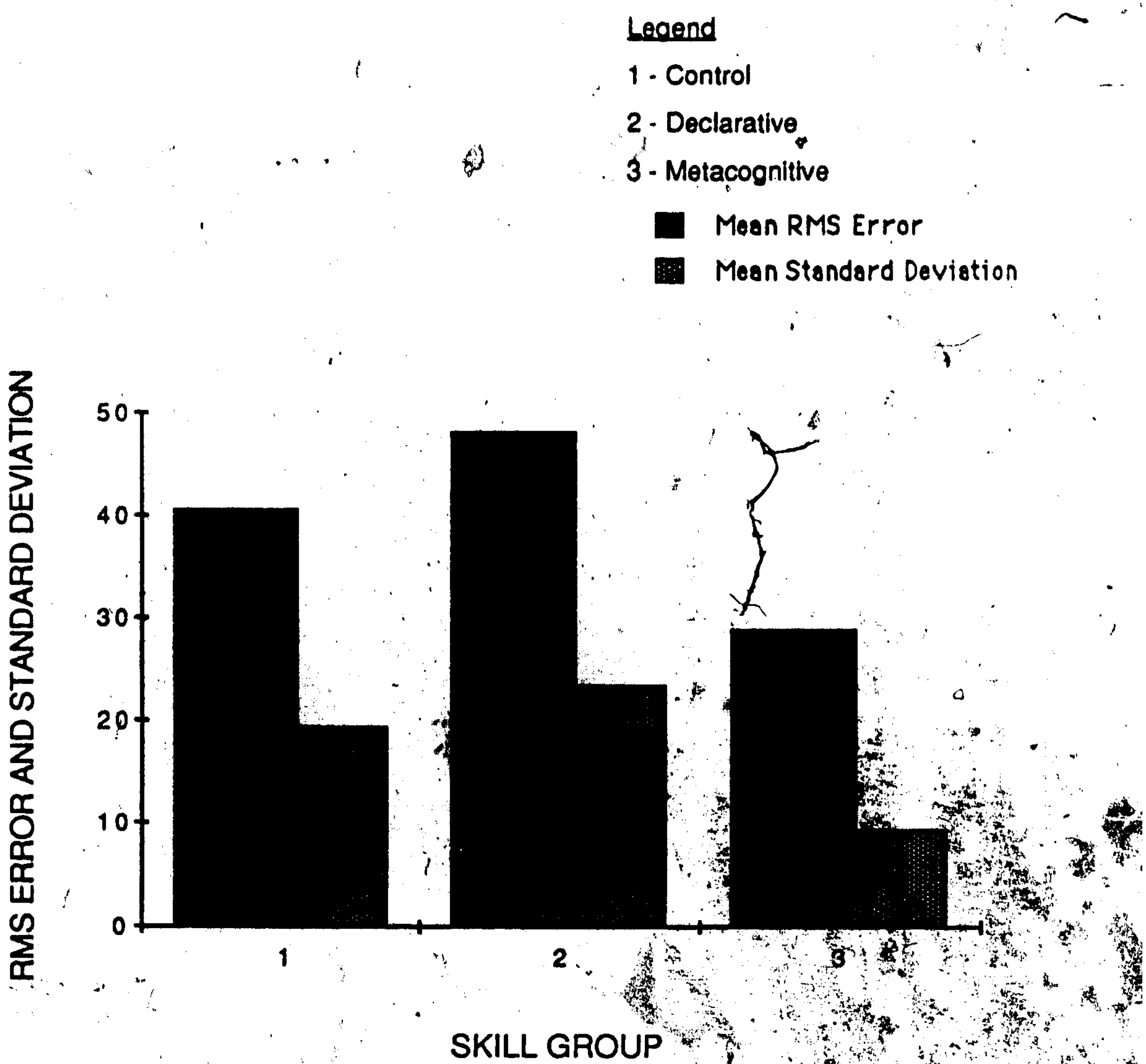

FIGURE 5
Mean RMS Error Scores and Standard Deviations of Groups Under Three Instructional Conditions

awkward subjects in the study performed the poorest in the declarative condition.

Figure 6 illustrates the relatively high degree of inter-trial variability exhibited by the control and declarative instruction groups. Conversely, the metacognitive group was relatively consistent in performance.

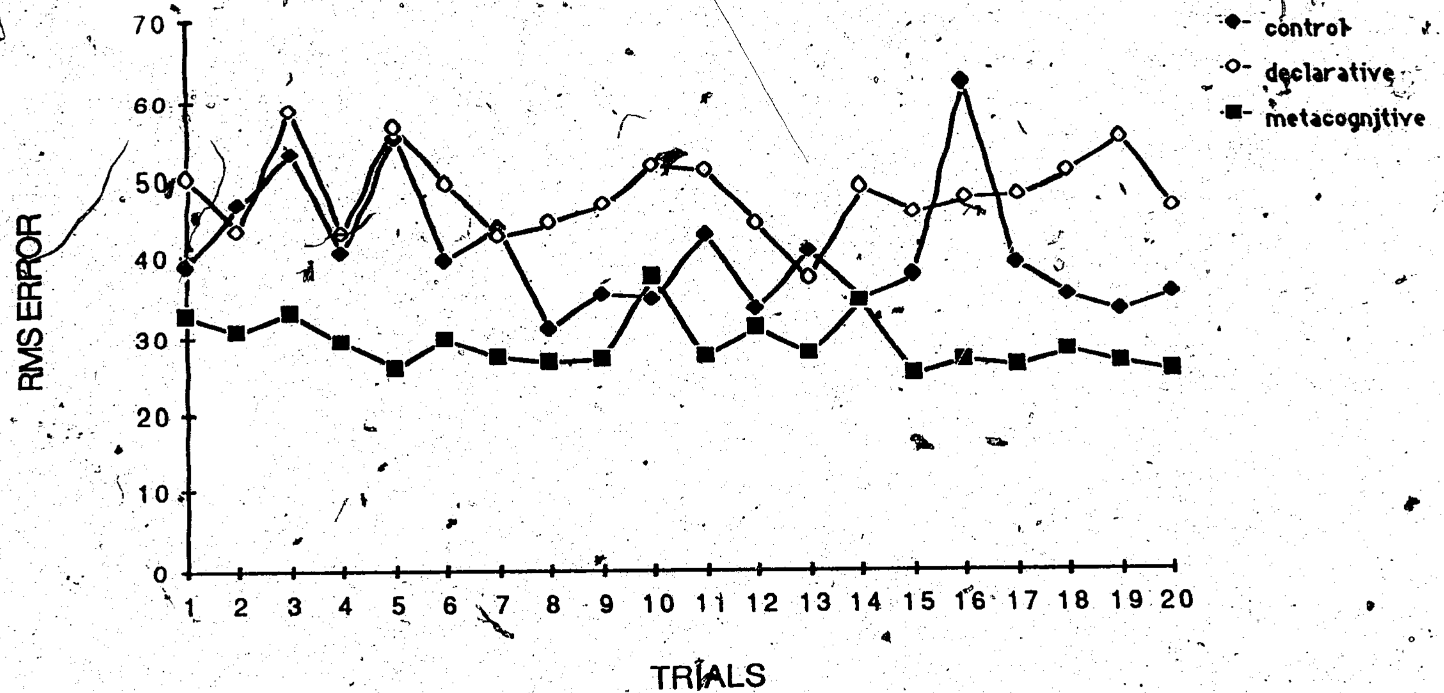

FIGURE 6

ROOT MEAN SQUARE ERROR SCORES OVER 20 TRIALS OF GROUPS UNDER THREE INSTRUCTIONAL CONDITIONS

CHAPTER FIVE

DISCUSSION

ANALYSIS OF PROCEDURAL SKILL

The purpose of the first test session was to determine the procedural knowledge of physically awkward girls and to compare this knowledge to that of peers and younger girls of two skill levels (expert and novice). The results indicate that the procedural knowledge of the grade 5 awkward girls, as measured by their performance of a tracking task, differs significantly from that of expert and novice girls of the same age as well as skilled younger girls.

Performance Levels.

As was mentioned earlier, the dependent variable for this study is the root mean square error score. Table 1 in the previous chapter presents the mean RMS error scores for the five skill groups. As is predicted in the knowledge based approach (Wall et al., 1985; Wall, 1985), the performance of the physically awkward group was significantly lower than that of their peers. When compared to younger girls, it was found that the awkward girls are significantly less skilled than grade 3 experts. In fact, the results indicated that the tracking performance of the physically awkward group is similar to that of novice performers two years their junior.

Figure 3 illustrated that the physically awkward girls are significantly less skilled than the grade 5 expert and novice groups as

Koutsouki-Koskina's (1986) finding that "the level of skill within each group is a much more important determinant of performance than is the chronological age of the subjects" (p. 63). In addition, the present study illustrates, as did Koutsouki-Koskina's (1986) results, that the older girls within the expert and novice skill groups are more skilled than their younger counterparts. As Koutsouki-Koskina (1986) suggested, these differences "probably reflect differential experience backgrounds in fine-motor tasks within the age groups" (p. 79).

These results tell us little about the underlying cause of physical awkwardness. Both the developmental delay theory and the deficit hypothesis would predict that the tracking performance of the children would be less skilled than that of their peers and skilled younger girls. Therefore, it is not possible to draw any conclusions regarding the particular etiology of physical awkwardness.

Variability

Figure 4 in the previous chapter reveals, as Koutsouki-Koskina (1986) noted, a relative consistency in the tracking performance of the two expert groups. This finding is consistent with the description of skilled tracking performance by Adams (1961), Franks (1980), and Poulton (1952). Specifically, these authors indicate that as skill in tracking increases, performance is characterized by: (1) a reduction in the amount of error between the stimulus and the response, and; (2) increasing consistency in the stimulus and the response, and; (3) increasing consistency in the reduction of that error. Koutsouki-Koskina (1986) found marked variability in the tracking performance of grade 5 and grade 3 novices. Results of the present study indicate a great deal of inter-trial variability in the performance of the grade 3 and the grade 5 physically awkward girls. However, although less consistent than the skilled trackers, the performance of the grade 5 novice girls is certainly less variable than that of the grade 3 novices and awkward girls. Koutsouki-Koskina (1986) suggested that the skilled groups were skilled enough to recognize the pattern and to track it with relatively little error. Although they had greater RMS error scores than the skilled groups, it appears that the grade 5 novices also recognized the pattern to be tracked. Whether or not they eventually recognized the path the target was following, the grade 3 novices and physically awkward children demonstrated low procedural skill in tracking the task.

Learning Curves

There is no evidence of a learning trend in the results of any of the skill groups. Again, the skilled subjects and the grade 5 novices probably recognized the pattern to be tracked during the five practice trials. Therefore, no improvement occurred due to recognition of the target and 10 trials is likely not a sufficient number to produce an improvement in procedural tracking skill. The awkward and grade 3 novices may have recognized the target at some point during the session but the inaccuracy and inter-trial variability exhibited by the two groups suggests that the task may have been too difficult for them.

Figure 6 in the previous chapter illustrates that there was no learning effect evident in the performance of the physically awkward children over 20 trials (in the second test session). This finding, in combination with the poor performance of the awkward children throughout the study, indicates that perhaps the task was too difficult for them. Because of their poor procedural knowledge, the awkward subjects performed at the attention-consuming executive level described by Glencross (1978). As a result, they were unable to attend to the predictable aspects of the task to generate their own motor program and improve their performance.

It is possible that there may have been an affective component affecting the results; the task may not have been as motivating as it could have been. Conversely, if the task had involved a PAC.MAN visibly eating up the target, there may have been some changes in performance over 10 trials.

The results of the first test session support Wall et al.'s (1985) a statement that "physically awkward children are clearly behind their peers in procedural knowledge" (p. 37). Moreover, it was found in the present study that the procedural knowledge of grade 5 awkward girls, as measured by performance of a tracking task, is similar to that of novices in grade 3.

EFFECT OF INSTRUCTIONAL CONDITIONS

The second test session was undertaken to determine how the performance of a tracking task by grade 5 physically awkward girls is affected by three instructional conditions (control, declarative, metacognitive). The results indicate the instructional conditions had no significant effect on tracking performance. The tracking performances of subjects in the control and declarative conditions were characterized by a great deal of error and inter-trial variability. This is consistent with the results of test session number one. The metacognitive group, however, demonstrated relative consistency in performance. Based on the description of physical awkwardness in the knowledge-based approach (Wall et al., 1985), this finding was not expected.

Although the differences were not significant, the analysis revealed that the tracking performance was most skilled in the metacognitive condition and least skilled in the declarative condition. These results are surprising. It was expected that the performance of the subjects in the declarative condition would be the most skilled because of their awareness of the target to be tracked. In the declarative condition, the subjects were given verbal and visual information about the path the target would be following. Research has shown that if the tracking task is predictable, subjects are able to improve their tracking performance by using this information to generate their own movement pattern (Adams, 1961; Poulton, 1957). Therefore, it was expected that subjects in the declarative condition would achieve the most skilled performances.

It should be noted that the mean RMS error score for the declarative group was greatly distorted by one of the subjects. The corrected RMS error score of this subject is 75.99 while the mean score for the group is 47.88. (Without her sc[illegible]roup's mean score would have been 38.21). Because of the small size of the sample, this subject's extreme scores over 20 trials had a dramatic effect on the mean RMS error score of the group. However, even with these scores removed the mean score under the declarative condition was still greater than those under the metacognitive and control conditions.

It was also expected that the performance of subjects in the control condition would be the least skilled. Subjects in the metacognitive condition were told that the target was following the path of a familiar shape, and that it would be easier to track the target if they could figure out what this shape was. Conversely, in the control condition, subjects were simply instructed to track the target. Why, then, did the awkward subjects perform most poorly in the declarative condition, and least poorly in the metacognitive condition?

In considering an explanation of these results, some anecdotal information regarding the motivation level of the awkward subjects during the second test session was taken into account. Specifically, the tester noted that the majority of the girls appeared "bored" and "unmotivated" during this session. In support of this observation and according to the syndrome of physical awkwardness (Wall, 1982), the lack of tracking skill experienced by the awkward children in the first test session may have resulted in a desire to avoid or withdraw from subsequent participation in similar situations. In other words, the awkward children were likely not motivated to participate in the second test session. Moreover, it is widely-accepted that motivation directly affects one's ability to learn and perform; low motivation impairs learning performance. In fact, Wall et al. (1985) state in the knowledge-based approach that affective knowledge (e.g. motivation) affects one's ability to acquire procedural and declarative knowledge. However, perhaps the children were more motivated to perform in the metacognitive condition. These instructions may have caused the metacognitive condition to appear more "game-like" to the children than the other two conditions, and, as a result, they may have been more motivated to perform. Briefly, subjects were told that the target was following a familiar pattern and that it would be easier to track if they could figure out what this shape was. (It is interesting to note that, like the awkward subjects in the present study, the nonawkward grade 3 novices in Koutsouki-Koskina's (1986) study also achieved the most skilled performance in the metacognitive condition.) Low procedural knowledge, however, prevented the performance of the metacognitive group from being significantly better than that of the declarative and control groups.

According to the knowledge-based approach (Wall et al., 1985), the subjects in the declarative and metacognitive condition were unable to make effective use of the additional information provided to them because they lack the procedural knowledge to which this information is applied. In other words, the awkward subjects are such poor trackers that they must direct all of their attention toward the actual tracking movement. Consequently, the awkward children were not able to direct attention toward the consideration of possible strategies to improve their performance. Hence, the instructional conditions had no significant effect on their performance of the tracking skill.

Perhaps the three instructional conditions did differentially affect the tracking performance of the awkward children. However, these differences may have been hidden by the extreme variability in performances within each instructional group. Figures 5 and 7 in the previous chapter illustrate the inter-trial variability exhibited by the awkward subjects throughout the study. In addition, the physically awkward are characterized as being an extremely heterogenous group. As a result, larger numbers of subjects may be needed to study the effects of various treatment conditions on awkward children. Because the present study used a relatively small number of awkward children, the effects of the instructional conditions may have been hidden in the variability of performances.

The poor tracking performance demonstrated by physically awkward subjects in the first test session was assumed to be a manifestation of their lack of procedural knowledge. The purpose of the second test session was to examine how different instructional conditions affect children with poor procedural knowledge. The results indicate that the instructional conditions had no significant effect on the performance of a tracking task by physically awkward children. This finding is interesting in light of the results of the grade 3 novice group in Koutsouki-Koskina's (1986) study.

The tracking performance of the least skilled group in Koutsouki- Koskina's (1986) study, the grade 3 novices, was affected by the instructional conditions; the control group performed significantly more poorly than the declarative and metacognitive groups. The results of the first test session in the present study indicated that the physically awkward subjects are similar in tracking skill (procedural knowledge) to the grade 3 novices from Koutsouki- Koskina's study. However, the instructional conditions had no effect on the performance of the awkward children. This may indicate that the physically awkward are not simply children with developmental delay or extreme practice deficits. If that were so, then their performance should have paralleled that of the novice grade 3 girls from Koutsouki-Koskina's (1986) study. However, practice deficits, compounded by obstructive affective knowledge, or inadequate metacognitive skills may be at the root of the problem. Testing of younger awkward children may help to determine the nature of the difficulty. It is, therefore, still unclear as to whether or not declarative and metacognitive instructions affect the performance of a tracking skill by subjects with poor procedural knowledge.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The purpose of the study was twofold. The first purpose was to assess the procedural knowledge of grade 5 physically awkward children and to compare it to the procedural knowledge of peers and younger girls of two skill levels. The second purpose was to investigate the effect of declarative and metacognitive instructions on the procedural skill of awkward children. It was assumed in this study that tracking skill is a manifestation of procedural knowledge, that knowledge of the concept of shapes and the ability to follow verbal instructions reflect declarative knowledge, and finally that metacognitive skill is reflected in the use of problem-solving and monitoring strategies.

It was found, as the knowledge-based approach (Wall et al., 1985) contends, that physically awkward children are significantly behind their peers in procedural knowledge. In fact, the procedural skill of the grade 5 awkward girls was similar to that of grade 3 novice performers.

This study also found that declarative and metacognitive instructional conditions had no affect on the tracking performance of the awkward girls. It appears that the poor procedural knowledge of these girls precluded their ability to make use of either the declarative or metacognitive information.

It is unclear what conclusions that can be drawn from the results of the second test session, due to a number of uncertainties. First, the results of the second test session appear to contradict the findings of Koutsouki-Koskina (1986). Specifically, Koutsouki-Koskina found that the instructional conditions did affect the performance of the tracking task by grade 3 novice performers who, incidently, exhibit procedural skills similar to those of the awkward performers. Second, it is possible that the declarative and metacognitive instructions did have an affect on the performance of the awkward subjects, but that might have been hidden within the extreme variability in performance within each instructional condition. Third, it is possible that knowledge in the affective domain influenced the performance of the awkward girls during the second test session.

It was noted that both the awkward girls in the present study and the grade 3 novices in Koutsouki-Koskina's (1986) study were most skilled in the metacognitive instructional condition. The reasons behind this are not clear but it was speculated that the affective domain may have had a positive influence on performance in the metacognitive condition. The task under these conditions may simply be more motivating.

Although the generalizability of the results is limited due to the small sample size and the specificity of the task, the study provided further support to the importance of acquired knowledge to the acquisition and performance of motor skills. The results also reinforced the importance of domain specific knowledge. Similar to Koutsouki-Koskina's (1986) results, the present study found that skill level (expert, novice, physically awkward) is a much more important determinant of performance than is chronological age. However, it is clear that more research is needed concerning the effect of declarative and metacognitive instruction on the procedural skill of awkward children. Moreover, because of the obvious implications for the development of remedial programs, this question should be a priority for future research.

RECOMMENDATIONS

1. Larger numbers must be included in future studies into the effect of instructional conditions on physically awkward children. In the present study, the effects of the declarative and metacognitive instructions on the performance of the awkward children were unclear due to the extreme variability of this group in combination with the small sample size.
2. It would be valuable to alter the task so that it is more motivating to the subjects. For example, a situation similar to PAC.MAN would likely be more motivating.
3. It would be interesting to include both younger and older children in future studies in order to determine if the procedural deficit and affective difficulties experienced by awkward children increase with age. Likewise, it would be interesting to see if the effects of the declarative and metacognitive instructions changed with the age of the awkward children.

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APPENDICES

APPENDIX I

The Shape to be Tracked for Test Session One

APPENDIX I

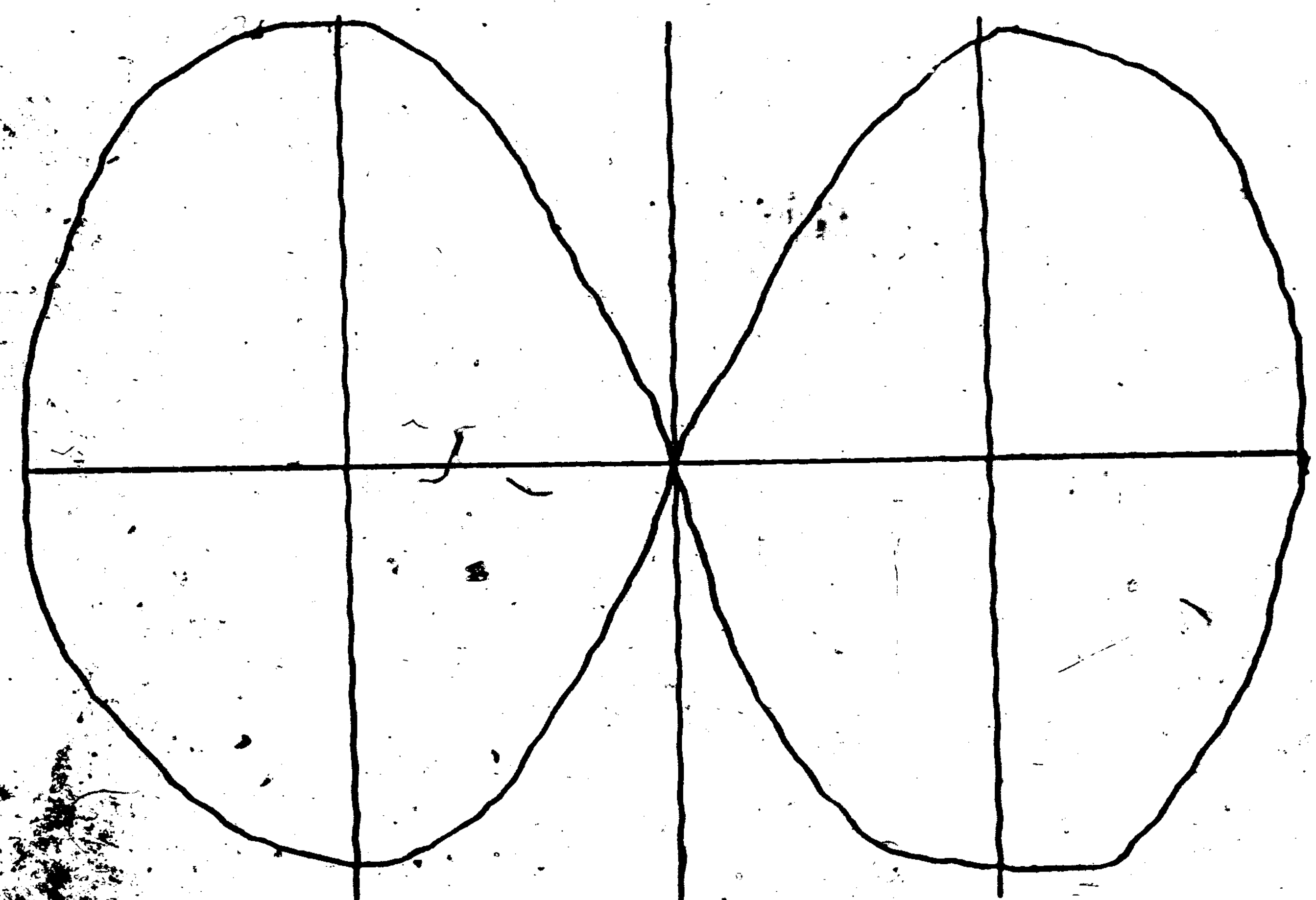
The Shape to be Tracked for Test Session One

APPENDIX II

The Shape to be Tracked for Test Session Two

APPENDIX II

The Shape to be Tracked for Test Session Two

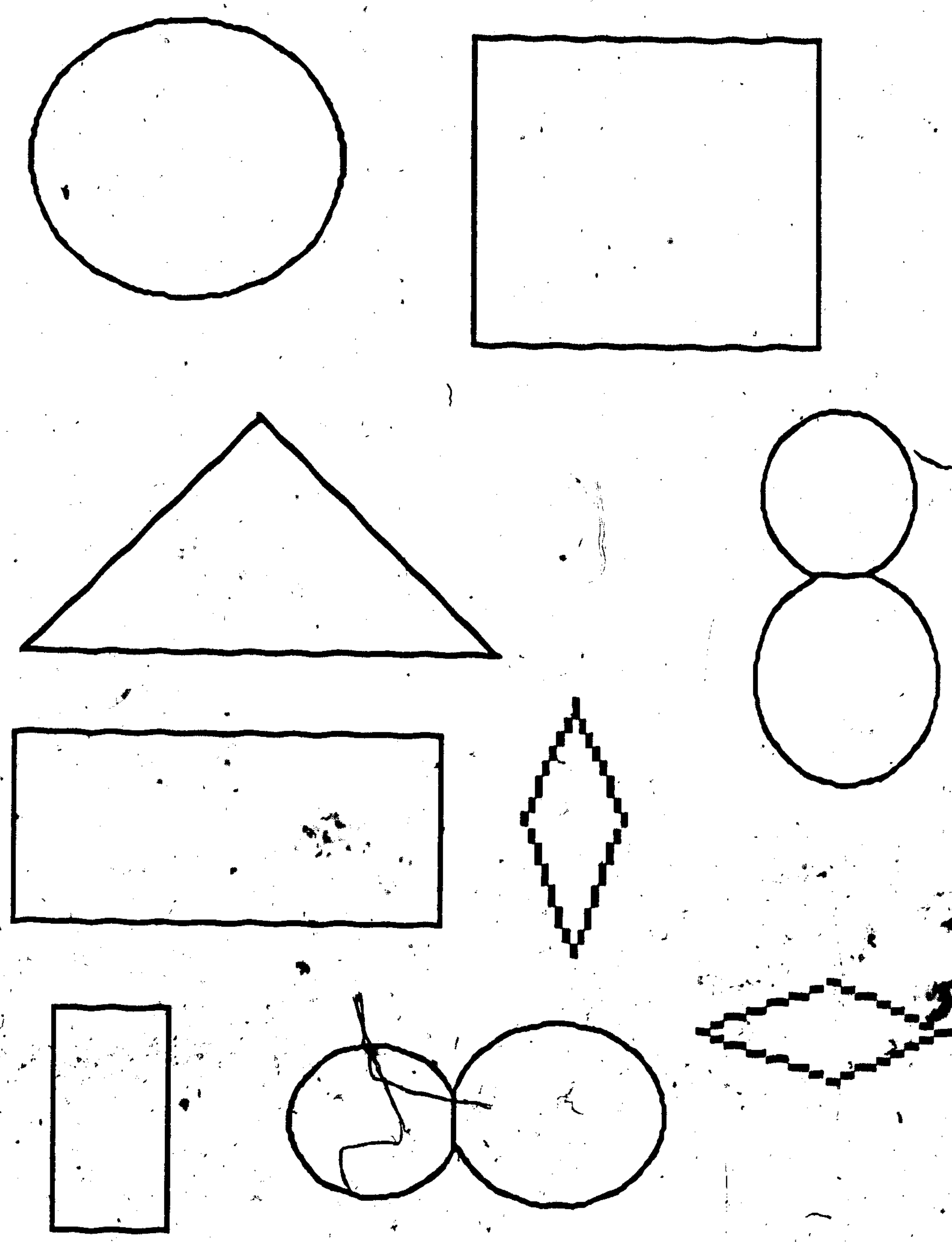


APPENDIX III

The Test for Declarative Knowledge of Shapes

APPENDIX III

The Test for Declarative Knowledge of Shapes



APPENDIX IV

Uncorrected RMS Error Scores of Subjects in Test Session One

APPENDIX IV

Uncorrected RMS Error Scores of Subjects in the Test Session One

Grade 5 Expert	Grade 3 Expert	Grade 5 Novice	Grade 3 Novice	Physically Awkward
25.33	32.57	42.57	49.58	103.53
24.67	32.22	42.27	48.55	84.24
24.22	31.73	40.16	48.40	65.83
23.39	31.34	38.31	47.87	58.63
22.90	31.10	38.28	47.69	53.18
22.82	29.55	37.56	46.26	46.52
22.48	28.48	36.41	46.08	46.27
22.48	27.95	35.21	45.66	42.00
21.86	27.15	34.70	43.45	40.99
21.67	26.15	32.87	42.73	35.48
21.26	25.70	32.27	42.28	33.71
18.46	24.02	32.12	42.27	33.26
18.15	23.14	29.90	40.53	32.23
18.12	22.69	29.47	40.51	32.00
16.98	21.64	29.39	39.93	26.08
		24.41		25.38

APPENDIX V

Uncorrected RMS Error Scores of Awkward Subjects in Test Session Two

APPENDIX V

Uncorrected RMS Error Scores of Awkward Subjects in Test Session Two

Control	Declarative	Metacognitive
67.20	88.11	40.70
44.04	48.47	32.23
33.46	41.99	27.67
32.31	39.88	26.18
28.04	28.32	23.99