AN ABSTRACT OF THE THESIS OF

Deborah L. Adams for the degree of Doctor of Philosophy in Human Performance presented on January 21, 1994.

Title: The Relative Effectiveness of Three Instructional Strategies on the Learning of an Overarm Throw for Force

Abstract approved: Redacted for Privacy

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This study investigated the relative effectiveness of three instructional strategies on the learning of an overarm throw among preadolescent females. Subjects were randomly assigned to one of the following instructional strategies: a correct model supplemented with verbal cues, a learning model supplemented with verbal cues, and verbal cues only. The performance outcome, the quality of the motor reproduction, and the accuracy of the cognitive representation of the skill were measured to elucidate the effectiveness of the instructional strategies. A pictorial-arrangement test and a cognitive recognition test of correct form were used to describe the quality of the cognitive representation. The performance of an overarm throw was evaluated using both a behavioral analysis and biomechanical techniques to provide information about form and outcome.

All groups were tested on four occasions, prior to each day of a three day instructional strategy intervention and two days after instructional intervention. A 3 X 4 (Instructional Strategy X Test Session) repeated measures DM

MANOVA incorporated the dependent variables: overarm throwing form score, pictorial-arrangement test score, and a dynamic cognitive recognition score. The results of the repeated measures DM MANOVA revealed a significant test session main effect only (Wilks Lambda = .226, $\underline{F}(9,25) = 9.40$, $p<.001$). Follow-up univariate F tests and trend analyses indicated that subjects in all groups showed significant improvement in overarm throwing form and in the accuracy of the cognitive representation of the motor skill. A 3 X 4 (Instructional Strategy X Test Session) repeated measures ANOVA's were employed to separately analyze four kinematic variables. The results obtained from the ANOVA's, based on an alpha value of .02, indicated statistically nonsignificant improvement in performance of the overarm throw. However, the kinematic variable pertaining to stride length revealed $p = .029$ for test session and observed trends indicated increased stride length and hip displacement for all subjects across the four test sessions.

In conclusion, the results indicated that all three instructional strategies assisted the learner in the achievement of a more accurate cognitive representation and the ability to reproduce a more mature overarm throwing pattern. This study revealed the importance of verbal cues which describe the critical transitional positions of the body throughout the coordinated movement. In addition, observing a learning model who demonstrated movement errors was not detrimental to the viewer's learning of a skill.

The Relative Effectiveness of
Three Instructional Strategies on the Learning of
an Overarm Throw for Force

by

Deborah L. Adams

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed January 21, 1994

Commencement June 1994

APPROVED:

Redacted for Privacy

Professor of Exercise and Sport Science in charge of major

Redacted for Privacy

Chair of Department of Exercise and Sport Science

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Date thesis is presented January 21, 1994

Typed by Deborah L. Adams

ACKNOWLEDGEMENTS

I wish to express my gratitude to my committee whose helpful insights and ideas greatly contributed to my completion of the doctoral program at OSU. I appreciate, more than words can say, the advise of my major professor Dr. Debra Rose who helped turn my primitive lines into well-connected thoughts. I am most grateful for her patience and willingness to give of her time to discuss and assist me in solving the various problems that inevitably occur in each step of the research process.

I am also grateful to the faculty and graduate students in the Exercise and Sport Science department at OSU who challenged and encouraged me to keep "pressing on" towards the goal of not just finishing, but finishing "well". I am especially thankful to Dr. Christian Zauner who was extremely helpful during the job search adventures of this PhD candidate.

I would also like to thank my "second family" of friends in Salem, Oregon who faithfully supported me with prayer throughout my graduate school experience. These friends allowed me to be myself and validated the myriad of emotions that accompany success and failure. Their willingness to stop and listen made my journey of reaching a long term goal a shared accomplishment with them. Lastly, I

want to thank my Lord for teaching me, "that in all things God works for the good of those who love him, who have been called according to his purpose".

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CHAPTER 1. INTRODUCTION

Visual demonstrations are considered to be powerful tools used by physical educators and coaches to convey an immense amount of information to learners in a short period of time. Most physical educators and coaches incorporate only a correct or mastery model to teach children a new sport skill. Recently, another instructional strategy incorporating a learning model, a person who is practicing and improving performance, has brought the sole use of correct models into question. While modeling is a widely practiced instructional strategy, little research pertaining to its contribution to the acquisition and retention of motor or sport skills has been conducted (i.e., Gould & Roberts, 1982; McCullagh, Weiss, & Ross, 1989) and even less is know about which type of model should be used.

The role of observational learning in skill acquisition has prompted considerable interest among psychologists since the 1960's (i.e., Bandura 1965, 1977, 1986; Rosenthal & Zimmerman, 1978). One researcher who has contributed much to the theoretical understanding of observational learning is Bandura. Bandura's original social learning theory primarily addressed the acquisition of social skills and behaviors. Observational learning describes a process whereby observers transform visually modeled events into symbolic codes which are cognitively rehearsed for later retrieval and then used to guide overt responses. Four subprocesses are considered to greatly influence what is seen in visual demonstration and, ultimately reproduced in terms of behavior. These subprocesses include attention, retention, motor reproduction, and motivation. Attentional processes involve what is selectively observed and extracted from modeled activities, while the retentional processes involve the manner in which the modeled events are symbolically coded and rehearsed. The successful overt (motor) reproduction of the modeled behavior is dependent on the observer's physical capabilities. Finally, the motivation of the observer determines whether or not the modeled skill will be reproduced.

Absent from Bandura's earlier observational theories (1965, 1977), however, was mention of how developmental characteristics of the observers might influence the relationship between the modeled skill and the reproduction of the skill by the performer. Yando, Seitz, and Zigler (1978) first examined observational learning form a developmental perspective. The theory developed by Yando and colleagues is markedly similar to Bandura's, particularly in reference to the four subprocesses underlying observational learning. Yando et al. address factors such as selective attention strategies, memory and coding capabilities, rehearsal strategies, physical and motor capabilities, and motivational orientation of the observers. However, unlike Bandura, Yando et al. highlight the qualitative differences in each subprocess as a function of the observer's developmental level. This later work has fostered new interest in the investigation of modeling in the physical domain addressed from a developmental perspective (i.e., Feltz; Weiss, 1983; Weiss & Klint, 1987; Weiss, Ebbeck, & Rose, 1992).

One such study applied to the physical domain was conducted by Weiss (1983). A young (4-0 to 5-11 years) and older (7-0 to 8-11) group of children were presented with different model types (i.e., visual, visual & verbal) demonstrating a sequence of familiar motor skills. Weiss found that younger children performed significantly better when exposed to a model who verbalized task components while visually presenting them in comparison to a silent model who only visually demonstrated the skills. In contrast, the older children performed equally as well with a verbal or silent model. Weiss concluded that the addition of verbal cues served to direct the younger children's attention to the relevant aspects of the movement task and, provided verbal labels for facilitating memory recall. Weiss also found that both the developmental characteristics of the children (i.e., selective attention/rehearsal strategies) and that of the model (i.e., silent/verbal model) influenced the behavioral response. It is interesting to note, however, that a later developmental modeling study conducted by Weiss and Klint (1987) and similar to the one conducted by Weiss (1983) did not find cognitive-developmental differences as a function of model type.

A more recent investigation (Weiss, Ebbeck, & Rose, 1992) attempted to both replicate and extend the work of Weiss and Klint (1987) by adding a qualitative measure in addition to the quantitative outcome measure used in earlier studies as well as a two day retention interval to measure more permanent learning effects. The results of the Weiss et al. study did not replicate finding s by Weiss and Klint in that model type effectiveness did depend on the cognitive-developmental level of the observers. Perhaps the contradictory findings between these two studies can be attributed to the addition of a qualitative measure which increased the complexity of the task. This qualitative measure required the children to not only perform the movement sequence in the correct order (quantitative measure), but also to reproduce the criterion form element associated with each skill. The disparate findings of the Weiss and Klint and the Weiss et al. studies underscore the need to use both outcome and process measures to evaluate the effectiveness of different model types.

Model type effectiveness, as it impacts the acquisition of motor skills has been assessed through one or more of the following means: separating performance and learning effect, outcome scores, precess-oriented measures, and through an examination of the quality of the cognitive representation of the skill. A common experimental procedure used to separate learning and performance effects involves a retention period followed by a retention test performed in the absence of knowledge of results. The retention period allows time for the performance-related effects to dissipate (Schmidt, 1988). The outcome measures of a motor skill represent the end product of motor performance and might be expressed in terms of distance traveled, height, or time elapsed. Unfortunately, the use of outcome measures alone provide no information about how the performer's body moved to produce the outcome scores. In order to derive process information it is necessary to employ measures which evaluate technique, form, coordination and/or the timing sequence of a motor skill.

Few modeling studies have assessed modeling effects through a process-oriented approach (i.e., McCullagh, Stiehl, & Weiss, 1989; Weiss, Ebbeck, & Rose, 1992; Wiese-Bjornstal & Weiss, 1992), but instead, have focused on performance outcome. In a comprehensive review article, however, McCullagh, Weiss, and Ross (1989) recommended that researchers interested in observational learning effects should focus more on how the learner reproduces the observed action pattern, namely the form, rather than the outcome of the action. The authors argued that outcome scores and movement form may be differentially affected by modeling. Support for this argument was provided by Feltz (1982), who used both form and outcome measures for subject's performing a Bachman ladder task and found that form ratings were a better indicator of modeling effects than outcome scores. In a later modeling study, McCullagh (1987) also found that form scores were better indicators of group differences.

In recognition of the importance of measuring both outcome and form, investigators (Feltz, 1982; Weiss, Ebbeck, & Rose, 1992; McCullagh, Stiehl, & Weiss, 1990) have begun to incorporate methods of evaluating changes in form as a function of the various model-types. A subjective method of measuring form requires trained judges to rate each subject's performance by assigning scores based on predetermined criteria. Recent advances in biomechanical measurement techniques have also made it possible to evaluate form changes in a more objective manner. Through the use of video cameras, space-time configurations can be derived by marking a performer's body at specific points of interest and then filming the person performing the movement to be measured. The kinematic measurements of the movement are then calculated form the space-time configurations to provide information about movement parameters such as limb displacement, velocity, and acceleration.

A kinematic assessment was a feature of a recent developmental modeling study completed by Wiese-Bjornstal & Weiss (1992). Children were exposed to a correct model demonstrating a modified softball pitch, while verbal performance cues were manipulated by the experimenter. Kinematic were measured in terms of how each subject's form matched that of the model's. Three kinematic variables, stride length, starting shoulder angle, body angle at the moment of ball release over the course of 20 practice trials and repeated exposure to the visual model. More dramatic changes in form were observed when the correct model was supplement with verbal cues.

Although informative, the inclusion of kinematic measurements to evaluate overt changes in form ar still not sufficient to infer the presence or absence of observational learning because, as Carroll and Bandura (1990) argue, "people do not always enact everything they learn" (p. 85). As a means of substantiating this argument, Carroll and Bandura attempted to describe the quality of the cognitive representation (a covert process) believed to guide motor reproduction (an overt response). In several of their more recent studies (i.e., 1982, 1985, 1987, 1990) the motor skill modeled was nine-component-wrist-arm paddle motion. In addition to reproducing this movement motorically, the adult subjects were asked to arrange randomly ordered photographs depicting each of the nine movement components into the correct sequence. The accuracy of the cognitive representation was scored according to the number of pictures placed in the correct sequence. On the basis of the pictorial-arrangement test and motor reproduction form scores, Carroll and Bandura concluded that the more accurate the cognitive representation, the more accurate the reproduction of the movement sequence (1987, 1990). In addition, Carroll and Bandura found that observers often fail to grasp important details of a movement performance simply by watching the model perform the skill. Supplementing the model with verbal cues, however, increased the accuracy of both the cognitive representation and the motor reproduction of the modeled act.

One developmental study investigating modeling effects (Wiese-Bjornstal & Weiss, 1992) in the physical domain also included a measure designed to describe the observer's cognitive representation. In contrast to Carroll and Bandura's use of still photographs to investigate the nature of the cognitive representation. Wiese-Bjornstal and Weiss presented subjects with a dynamic cognitive recognition test. In their study, subjects were asked to select the correct demonstration form four video-taped presentations. Only one of the video-taped presentations showed the correct method of executing the skill while the other three demonstrations were incorrect, with at least one of the key elements of the skill being demonstrated incorrectly. Subjects improved by over 20% in their selection of the correct model as the number of exposures to the model increased. The aforementioned study and other developmental modeling studies (McCullagh, Stiehl, & Weiss, 1990; Weiss, 1983; Weiss, Ebbeck, & Rose, 1992; Weiss & Klint, 1987) have only utilized correct demonstrations of the skill to be learned in conjunction with valuable supplements such as verbal cues, and/or verbal rehearsal.

In recent years, certain motor learning theorist (Adams, 1986; Lee& White, 1990; McCullagh & Caird, 1990; Pollock & Lee, 1992) have begun to question whether a correct/mastery model is the only means of conveying information to the learner/observer attempting to learn a motor skill Lee and White (1990), in particular, have challenged the assumption that the development of an efficient cognitive representation is impaired by watching incorrect performances. In fact, some experimental results (i.e., Lee & White, 1990; Pollock & Lee, 1992) suggest that involving an observer in the cognitive activities of a less skilled or learning model actually facilitates the early learning of a skill. A learning model, or learning sequence model is one who begins the demonstration as an unskilled model but, through practice, continues to improve his/her skill level. Proponents of the use of this model type have suggested that correct/mastery models promote imitation as opposed to an understanding of how the skill is to be performed. This is due to the fact that correct models who demonstrate a mastery of the movement behavior provide little or, no error information for the observer to process. In contrast, a learning model involves the observer in problem-solving activities which develop, among other things, error recognition and correction abilities.

One important limitation of the learning model studies recently conducted (Adams, 1986; Lee & White, 1990; McCullagh & Caird, 1990; Pollock & Lee, 1992) relates to the use of only adult subjects. No studies have yet to be conducted with children of different age groups. In addition, only overt measures of performance have been used to test the effectiveness of such models. It would also be important to investigate the quality of the cognitive representation as a function of model type (learning versus correct) and developmental level. For example, exposure to a learning model at an earlier age may require greater amounts of information to be processed in comparison to exposure to the correct model, and thus result in a poor cognitive representation of the skill and poor skill learning.

To date, studies investigating the relative effectiveness of learning sequence models have used artificially contrived novel tasks in laboratory settings measuring solely the outcome of the motor act without assessing the spatial components of the movement. Perhaps it is time to determine whether the experimental findings can be generalized to the learning of more relevant motor skills performed in more natural settings such as the gymnasium.

According to Scully and Newell (1985), the two questions of greatest interest with respect to the use of visual demonstrations are what is perceived by the observer and what in the demonstration is essential for observational learning? After reviewing the biological motion research incorporating the point-light technique, Scully and Newell concluded that the observer perceives the relative motion or the changes in the relationship between body parts over a period of time (coordination of the action pattern). Observational learning is inferred if the learner's reproduced movements approximate the model's relative motion. Thus, it would be important to model motor skills which incorporate spatial and temporal coordination patterns and then measure the changes in relative motion (kinematics) through biomechanical measurement techniques as a function of exposure to a particular model type.

The study extended the recent research findings related to the role of learning sequence models in the learning of a fundamental motor skill. More specifically, the influence of repeated exposure to a correct versus a learning model and the use of progressive verbal cues were investigated form a developmental perspective. Additionally, the study adopted a multidimensional approach by describing both the overt and covert effects of observational learning. Both form and outcome measures were used to describe the overt changes in the movement pattern while a static pictorial arrangement and dynamic videotaped recognition test will be used to describe the changes occurring in the nature of the cognitive representation developed. This multidimensional approach provided a more comprehensive picture of what was occurring, both overtly and covertly, as a function of observing either a correct or, learning model demonstrate a fundamental motor skill. The motor skill to be demonstrated was the overarm throw for force which demands the coordination of multiple limbs in a given control space.

Statement of the Problem

The purpose of this study was to examine the relative effectiveness of three instructional strategies in the early learning of an overarm throw for force. The three instructional strategies were a correct model plus progressive verbal cues, a learning model plus progressive verbal cues and progressive verbal cues only. Preadolescent girls aged between 8 and 10 years served as the subject in the present study. Both the quality of the cognitive representation and motor reproduction of the skill at various stages of acquisition were analyzed. The key question to be addressed was: what is the effect of model type on the quality of the movement reproduction, performance outcome, and quality of the cognitive representation at various stages of learning?

Research Hypotheses

The hypotheses to be tested in the present study are as follows:

1. At each stage of learning, subjects observing a correct plus progressive verbal cues model will achieve

significantly higher scores on the measures of quality of movement reproduction, quality of cognitive representation and, performance outcome when compared to subjects observing either a learning plus progressive verbal cues model or, receiving progressive verbal cues only.

2. At each stage of learning, subjects observing the learning model plus progressive verbal cues will achieve significantly higher scores on the measures of quality of movement reproduction, quality of cognitive representation, and performance outcome when compared to subjects receiving verbal cues only.

Statistical Hypotheses

The statistical hypotheses are as follows:

M=quality of movement reproduction

O=performance outcome score

R=quality of cognitive representation

L=subjects presented a learning model plus verbal cues

C=subjects presented a correct model plus verbal cues

V=subjects in the verbal cues only group

1.	Ho1:	$CM \leq LM$	Ha1:	$CM > LM$
	Ho2:	$CO \leq LO$	Ha2:	$CO > LO$
	Ho3:	$CR \leq LR$	Ha3:	$CR > LR$
	Ho4:	$CM \leq VM$	Ha4:	$CM > VM$
	Ho5:	$CO \leq VO$	Ha5:	$CO > VO$
	Ho6:	$CR \leq VR$	Ha5:	$CR > VR$
2.	Ho1:	$LM \leq VM$	Ha1:	$LM > VM$
	Ho2:	$LO \leq VO$	Ha2:	$LO > VO$
	Ho3:	$LR \leq VR$	Ha3:	$LR > VR$

Operational Definitions

For the proposed study the following operational definitions were be used:

<u>Cognitive representation</u>: The quality of the cognitive representation is measured by a dynamic (video) cognitive

recognition test and a static pictorial arrangement test to evaluate whether subjects correctly perceived the relevant components of the model.

Correct model: A performer who demonstrates a mature overarm throw (See Appendix A) as described and assessed by Roberton (1978).

Form kinematic of performance: The following kinematic measures reflect the performance form and outcome of the overarm throw for force:

(a) Hip displacement is defined as the total angular displacement of the hip segment (from left to right hip) in relationship to the direction of the throw.

(b) Shoulder angle displacement is defined as the relative angle between the humerus and trunk at the time of achieved minimum elbow displacement.

(c) Relative time is derived from calculating the elapsed time between minimum elbow joint angle achieved at the completion of the preparatory phase and release of the ball, marking the end of the release phase. The elapsed time will be expressed as a percentage of the total throwing time in order to obtain a measure of relative time.

(d) Stride length is defined as the distance between the toes of the rear foot and the heel of the lead foot during the stride in which the ball is released. Stride length is expressed as a percentage of the total throwing time in order to obtain a measure of relative time.

(e) Shoulder angle displacement is defined as the relative angle between the humerus and trunk at the time of maximum angular velocity of the elbow joint.

(f) One kinematic measurement representing performance outcome was also obtained. This value is derived by calculating ball velocity just after release of the ball from the fingers of the throwing hand.

Motor learning: is measured by the ability to perform the overarm throw for force in the absence of a model and or progressive verbal cues following one and two day retention intervals.

Motor performance: is reflected by the physical practice trials of the overarm throw for force immediately following exposure to either of the two model types and/or progressive verbal cues.

Learning model: is a practicing and improving performer who demonstrates an immature overarm throwing pattern at the outset of the experiment. Developmental state of skill is evaluated using Roberton's scale (Appendix A).

Outcome performance: is the measure of the velocity of the ball just after its release from the throwing hand.

Preadolescent: is younger than the average age of menarche (12.79 years).

Progressive verbal cues: are verbal descriptions of the key components of a motor skill stated sequentially.

Assumptions

For the investigation the following assumptions were recognized:

1. Subjects did not rehearse the overarm throw for force between practice sessions.
2. The two measurements used to examine the quality of the cognitive representation were reliable and valid.
3. Three practice sessions, each consisting of 25 physical trials of the overarm throw for force, adequately represented the early stages of learning for this particular motor skill.

Limitations

The limitations of this study are as follows:

1. Subjects have previously observed and, physically practiced the overarm throw for force which may lead to an underestimation of the contribution of modeling to the acquisition of a fundamental motor skill.
2. All subjects are female and therefore the results cannot be generalized to male populations.

Delimitations

The study was limited to preadolescent female performers who ranged in age from 8 to 10 years.

Theoretical Definitions

The following definitions are used throughout this study:

Cognitive representation: is the transformed spatial and temporal features of modeled performances of action patterns into remembered symbolic coding. "The cognitive representation both guides the production of skill action and provides a standard against which to make corrective adjustments in performance." (Carroll & Bandura, 1990, p. 86)

Kinematics: refers to a description of movement without regard to force or mass. Kinematic measures describe movement displacement, velocity, and acceleration.

Learning: "is defined as a change in the capability of a person to perform a skill that must be inferred from a relatively permanent improvement in performance as a result of practice or experience." (Magill, 1993, p. 44)

Model: refers to a demonstration which conveys visual information about how to perform a skill.

Observational learning, vicarious learning, and modeling: are synonyms referring to an observer reproducing the overt actions exhibited by a model (either a real life model or a model symbolized through video tape).

Performance: refers to the execution of a skill at a particular time and in a specific situation (Magill, 1993, p. 43).

Retention: refers to the extent of skill proficiency after a period without practice or assistance from the experimenter.

Verbal cues: refer to verbal descriptions of how to perform important components of a skill.

CHAPTER II. REVIEW OF THE LITERATURE

Historically, most of the theories and studies about observational learning have appeared in the social psychology literature and have been directed to understanding how observational learning influences such variables as attitude, language, and cognitive development. It was not until the late 1970's that researchers interested in motor skill acquisition began looking at the factors which appear to influence observational learning, despite the fact that modeling has been the instructional technique of choice for many years. Researchers of motor behavior have been most interested in examining a variety of modeling research questions including, how developmental factors influence observational learning of a motor skill, what is perceived by the observer, why modeling is more effective in certain situations, and who should model the skill?

In order to systematically address the research literature which is most pertinent to the present study, the chapter is divided into the following sections: (a) observational learning theories and their relationship to motor learning theories and principles, (b) characteristics of the model (i.e., model status and/or correctness of the model), (c) the investigation of modeling and verbal cueing plus or minus rehearsal, (d) augmented feedback and modeling research, (e) a direct perception perspective of modeling, (f) the use of kinematic measures as a determinant of modeling effectiveness, (g) cognitive measures used to describe the nature of the cognitive representation, (h) the task to be modeled in this study, and finally,(i) research implications.

Modeling Theories

Three theoretical perspectives have been proposed in motor behavior literature to explain learning through observation. These theories include Sheffield's symbolic-representational theory (1961), Bandura's social cognitive learning theory (1977, 1986), and a cognitive-developmental theory proposed by Yando, Seitz, and Ziegler (1978).

One of the earliest investigators to systematically investigate the influence of filmed models on instruction and learning was Sheffield (1961). Sheffield, a cognitive psychologist, conducted research on behalf of the United States Air Force in the 1950's in an attempt to identify the best methods of instruction for the learning of complex sequential tasks. Indeed, Sheffield formulated the theoretical frame work on which a number of later studies were designed and analyzed. Sheffield assumes that the overt responses of a serial task are mediated by covert perceptual responses or perceptual "blueprints" which represent the entire sequence of movements in completed form. The development of the perceptual blueprint of an observed motor skill is based on the stimulus-response contiguity theory. In illustration of this theory Sheffield (1961) states that covert perceptual responses are "learned during passive responses to demonstration materials" (p.14).

Unlike Sheffield, Bandura (1977) assigned a more explicit role to the symbolic coding process and emphasized an active rather than passive role for the observer. For example, the observer chooses to selectively attend to certain features of a modeled behavior, applies organization to a rehearsal strategy to remember what was seen and/or heard and, then evaluates his/her reproduction of the modeled behavior. Observational learning plays a central role in Bandura's social cognitive learning theory and is perhaps best reflected in the statement that "virtually all learning phenomena resulting from direct experience occur on a vicarious basis by observing other people's behavior and its consequences for them" (1977,p. 12). By watching others perform a skill, the observer is able to form a visual and/or verbal image of the novel motor skill which is first symbolically coded in memory before being used to guide motor reproduction of the modeled skill. As a result of repeated exposures to a model, an enduring and retrievable image or, cognitive representation of the modeled performance is developed.

While the theories developed by Bandura (1977) and Sheffield (1961) assign different roles for the observer, both theories recognize that viewing a model performing the skill, even on multiple occasions, is not sufficient for complete learning of a complex motor task. Overt physical practice is considered to be essential and some trial-and-error practice inevitable before successful motor reproduction is achieved. An observed mismatch between the symbolic representation of a movement and the motor reproduction become cues for the learner to make the necessary corrections. It is clear that motor skills are not perfected either through observation or, trial-and-error alone, but rather through a combination of demonstration and physical practice.

Bandura's social cognitive theory has dominated the literature, but absent from his earlier theories (1965, 1977) was the developmental differences of the observers which may influence observational learning. While Bandura (1986) was to address the developmental differences in later versions of his theory, Yando, Seitz, and Zigler (1978) were the first to address the role of development on an observers' ability to (a) form mental images, (b) employ language and, (c) physically perform a criterion motor skill. Indeed the type of observational learning possible was considered by the authors to be determined by the learner's current cognitive development. The cognitive abilities considered to be most influential were attention span, memory capacity, and the nature of coding (i.e., imaginal and/or linguistic).

In addition, Yando et al. (1978) included the motivational disposition of the learner as a second factor which determined whether the observed behavior would be reproduced. Both intrinsic and extrinsic rewards are motivational factors which influence the modeling process. Yando et al. suggested that intrinsic rewards serve as motives of competence and the competence factor is realized when a child can solve the problem of performing a sport skill as modeled. The extrinsic motives involve imitating a model for the purpose of gaining rewards or, avoiding punishment. According to Yando et al., both the cognitive abilities and motivational disposition of the child-observer dictate the amount of modeled behavior actually reproduced.

Relating Modeling Theories to Motor Learning Theories

Stages of Learning

According to Bandura (1977, 1986), the symbolically coded image which guides motor reproduction of the modeled skill is most influential in the early and intermediate stages of observational learning. As the motor reproduction begins to look more like that of the model's so too does the cognitive representation become more elaborate and accurate. This perspective can be related to Fitts and Posner's (1967) first two stages of learning a motor skill. In fact, the first stage of learning proposed by Fitts and Posner is called the cognitive stage. This stage is characterized by the learner acquiring some idea of the movement's coordination, often verbalizing, overtly or covertly, the sequence of movements he/she is about to perform. For example, a learner in the cognitive stage might say to him/herself during the first attempts at a forearm tennis stroke: "turn my side to the net, bring the racket back, hit the ball off my front hip, rotate my hips, follow through high". As the learner acquires more information and the errors become less gross through trial-and-error, the learner moves to stage two, the associative stage. During this stage, the developing cognitive representation guides the learner's identification of some of the errors in his/her performance. In this way, the developing tennis player begins to make the appropriate corrections to better approximate the model's actions. Through further observation of a skilled tennis player, the learner begins to attend to the finer aspects of the tennis stroke and the symbolic codes related to the more subtle aspects of the movement are incorporated into the cognitive representation. The third stage of learning is called the autonomous stage and is characterized by skilled movement reproduction which demands little of the performer's attention. Instead, the skilled tennis player can now direct his/her attention to higher-order aspects of the game such as the opponent's position on the court and the intended placement of the next stroke.

Schmidt's Schema Theory

Although Schmidt's (1975) schema theory does not directly address modeling effects, heavy emphasis is placed on the cognitive processes involved with physical performance. The schema in Schmidt's theory is comprised of a set of rules which are used to guide selection and execution of a class of movements. As performance improves, information extracted from actual performance of the skill is incorporated into a set of abstract rules about the skill which can be applied in a variety of circumstances. The types of information incorporated into the schema in an abstract form include: (a) the initial conditions, the position of the limbs and body and the circumstances in the environment, (b) response specifications required for a given situation (i.e., force, speed, and/or direction of the limbs), (c) the sensory consequences associated with performance of the movement and, (d) the response outcome, which is a comparison of the intended outcome to the actual outcome. Schmidt's notion of a schema resembles the cognitive representation and perceptual blueprint postulated in the theories of Bandura (1977, 1986) and Sheffield (1961) respectively.

Model Characteristics

Much of the research related to model characteristics are investigations based on two subprocesses assumed by Bandura to subserve observational learning namely, attention and motivation. In order to examine the extent to which observational learning is a function of attention and motivation, researchers have manipulated such model characteristics as model status and model abilities (Landers & Landers, 1973; Lirgg & Feltz, 1991).

Skilled or Unskilled Teacher/Peer Models

A widely cited study which investigated the influence of model status and model ability on performance of a simple motor skill was conducted by Landers and Landers in 1973. In this study, subjects observed either a teacher or, a peer demonstrate the task in either a skilled or, unskilled manner. The authors hypothesized that subjects who viewed a skillful teacher would perform the best while the observers who viewed an unskilled peer would perform the poorest. The results indicated that the highest performance was achieved by the subjects who watched the skilled teacher; the second highest by those who observed the unskilled peer perform the task; third, by the subjects observing the skilled peer perform; and lastly the group who viewed their teacher as an unskilled performer. Thus, contrary to Landers and Landers' second hypothesis, those who observed the unskilled peer performed better than the subjects observing the skilled peer. Unfortunately, the results may have been influenced by the familiarity of the models' in that subjects (fifth and sixth grade girls) observed either a classmate or the teacher performing the task. The explanation forwarded to account for the surprise finding regarding the performance of those observing the unskilled peer was that the contrasting personalities of the two peer models may have influenced the observer's motivation to perform the task.

More recently, Lirgg and Feltz (1991) attempted to replicate the findings of the Landers and Landers experiment using videotaped models who were not familiar to the subjects being tested. In contrast to the earlier study, these authors found that the subjects viewing a skilled model performed better than those viewing an unskilled model, irrespective of the model's status (i.e., teacher or peer), The results suggest that skill may be more important than the status of the demonstrator, at least when unfamiliar teacher and peer models are involved in demonstrating a motor skill. While the findings of the two studies are contradictory in terms of performance, neither study included a retention test therefore the results and conclusions can be interpreted only in terms of their effects on performance and not learning.

Learning Model

The relative effectiveness of unskilled versus skilled models in observational learning has recently been extended by allowing the observer to watch the unskilled model practice and progressively improve his/her performance. This model type has been called the learning or, learning sequence model and has been incorporated in several recent studies (i.e., Adams, 1986; Lee & White, 1990; McCullagh & Caird, 1990; Pollock & Lee, 1992).

One of the first studies to formally investigate the effects of a learning model was one conducted by Martens, Burwitz, and Zuckerman in 1976. In this study, four experiments were conducted of which one will be discussed. In the first experiment 60 boys with an average age of 8 years and 60 boys averaging 13 years were assigned to one of four experimental groups; Correct Model (CM), Learning Sequence Model (LSM), Incorrect Model (IM) and, no model. The task involved rolling a small ball up an incline to a target area situated three feet from the end of the inclined board. The results indicated that the CM group hit the target with both greater consistency and accuracy when compared to the other experimental groups. It was interesting to note, however, that the LSM group showed consistent improvement across the practice trials. Moreover, both the CM and LSM groups demonstrated significantly better scores than the control and IM groups at least during the first ten trials. The researchers attributed the lack of significance during the later stages of learning to ceiling effects produced by the use of such a simple task.

Adams (1986) also used a learning modeling paradigm but manipulated the amount of knowledge of results given to a learning model. Subjects were randomly assigned to three groups. Group one observed a learning model practice a timing task, but was not allowed to see the outcome scores presented to the learning model after each trial (ONKR). A second group of subjects also viewed a learning model but were provided with the model's KR following each trial (OKR). A third group, serving as the control group, received only a verbal description of the task and their own KR following each practice trial.

The task consisted of moving a control stick through three fixed spatial patterns, each movement phase to be completed in a certain period of time. Group one and two observed the learning model complete 50 trials before physically practicing. The knowledge of results included the absolute error in seconds for each of the three segments plus the overall goal error. All subjects were given KR after each physically practiced trial.

Consistent with Adams' experimental hypothesis, observers in the OKR group exhibited the best performance. Adams proposes the observers in the OKR group were able to form hypotheses related to the model's performance errors and correction of them using the KR presented to the model. Thus, the observer is developing response appraisal and error correction abilities. Since a skilled model was not included in Adams' study, it was not possible to derive any conclusions concerning the relative effectiveness of a learning model. Additionally, Adams did not include a retention test so it was not possible to determine whether the influence of a learning model extended beyond the immediate performance situation.

Despite the limitations associated with Adams' (1986) learning model experiment, the positive findings prompted three additional studies (i.e., Lee & White, 1990; Pollock & Lee, 1992; McCullagh & Caird, 1990). Lee and White applied Adams' experimental paradigm but used different perceptual-motor tasks, namely various computer games, to again test the effectiveness of a learning model. Lee and White found that observers able to watch a model acquire a motor skill demonstrate very large performance gains. Thus, acquiring a motor skill was enhanced by observing a model learn a skill, providing support for the hypothesis that an observer of a learning model become more involved in the problem-solving aspect of learning.

In their 1992 study, Pollock and Lee included a skilled model, hypothesizing that a skilled model may not involve the observer in valuable problem-solving processes because there would be little error to detect from the skilled model. Subjects performed a video game task which involved the sequential pressing of four keys to manipulate a runner moving around a track. The object of the task was to decrease the runner's overall time with each subject being provided with his/her performance time after each practice trial. Fifty-four subjects were assigned to one of two observer groups or to a group of learning models ($n = 18$). The observer groups viewed either the skilled or the learning model. The skilled model was the experimenter and eighteen different pairs of subjects served as the learning model and the observer of the learning model.

On the basis of their findings, Pollock and Lee (1992) concluded that observation was beneficial for performance whether the model was skilled or, unskilled. That is, a learning model facilitates observational motor learning just as well as a skilled model when all observers also receive knowledge of results about their practice trials. The authors demonstrated that a skilled model did not promote better learning, calling into question recommendations made to practitioners concerning the use of skilled models only (Christina & Corcos, 1988; Magill, 1989).

In the three studies mentioned above KR was given to all subjects after each practice trial. McCullagh and Caird (1990) extended Adams' earlier study in two important ways. First, the authors included both an immediate and delayed retention test, making it possible to examine learning in addition to performance. Second, the effects of model type and KR were evaluated separately and in combination.

Subjects were randomly assigned to four groups: (a) physical practice and KR given on 50% of the 60 trials, (b) correct model only, (c) learning model only, (d)learning model with KR about model's correctness of response. Subjects were to knock down 7 wooden barriers in a certain spatial pattern using the criterion time of 2100 ms to accomplish the task. The correct demonstration was performed by an adult male via a videotape of the movement sequence trial performed in 2,100 ms. Learning sequence models were subjects assigned to the physical practice with KR group. Thus, subjects in the learning model conditions were yoked to the physical practice with KR subjects. The subjects, who observed a model, viewed five filmed demonstrations and then performed five trials without KR about their performances. This sequence was repeated for a total of 60 acquisition trials. Upon the completion of the acquisition trials, subjects solved word puzzles for five minutes after which they performed 20 immediate no KR trials. In addition all subjects returned 24 hours later to perform 20 delayed retention trials.

The results of the experiment clearly indicated that observers provided with the opportunity to view a model learning a skill and receiving KR about his/her performance, performed as well as those subjects who physically practiced and also received KR during the acquisition and two retention phases of the study. McCullagh and Caird (1990) concluded that subjects who receive KR about their own performance as they practice or the movement outcome of a model who is learning a skill leads to equally better performance and retention.

Verbal Cues/Rehearsal and Modeling

Verbal cues related to an observed performance of a motor skill represent one means by which a motor skill can be symbolically coded in memory. Symbolic coding of the information gleaned from a modeled performance is assumed to serve as a mediator for later retrieval and motor reproduction (Sheffield, 1961; Bandura, 1969, 1977, 1986). In order for the cognitive representation to develop, the observer must first attend to the demonstration and then discriminate between the distinctive features of the modeled act. Unfortunately, observers often fail to grasp important details simply by watching an entire movement performance. Verbal cues are therefore given by instructors to assist the observer in identifying the critical qualities of a task before he/she attempts to reproduce it. Retention is also enhanced through verbal coding of motor behavior. The verbal cues provided by an instructor assist the observer in transforming modeled information into linguistic codes for rehearsal and retrieval purposes (Bandura & Jeffrey, 1973).

To test the preceding statement Carroll and Bandura (1990) combined multiple exposures to a mastery/correct model and concurrent verbal cues associated with the modeled action pattern, a nine-part sequential task. They found that verbal cueing did, indeed, increase the accuracy of both the cognitive representation and the motor reproduction of the modeled act. It appears that the addition of verbal cues permitted the observers to organize complex visual stimuli into concise meaningful verbal codes to be stored and utilized later to reproduce the correct motor response. Bandura (1977) argues that most cognitive process are coded verbally as opposed to visually. Visual imagery can be helpful, however, for coding a modeled performance when language has not been sufficiently developed or when it becomes difficult to quickly transcribe a motor act into key words.

Developmental Modeling Studies/Verbal Cues and Rehearsal

In response to Yando et al.'s (1978) call for more studies investigating the effects of modeling among younger age groups, several developmental modeling studies have been conducted (i.e., McCullagh, Stiehl, & Weiss, 1990; Weiss, 1983; Weiss & Klint, 1987; Weiss, Ebbeck & Rose, 1992). The studies specifically examined the influence of verbal cues and/or rehearsal on both the immediate performance and later recall of skills.

The Weiss (1983) study investigated the influence of three model types and two types of rehearsal strategies on the behavioral responses of children from two different age groups. The three model types included: a no model control group, a verbal model and a silent model. The verbal model type included verbal cues presented in conjunction with the visual demonstration of a six-part sequential motor task, while the silent model type consisted of only the visual demonstration. In addition, half the subjects randomly assigned to the three model types were trained to verbally rehearse the steps involved the motor skill sequence prior to each performance trial, while the other half were not provided with the opportunity to verbally rehearse. The findings demonstrated that younger children (4 and 5 year old) performed significantly better when a visual model was supplemented with verbal cues compared to the groups provided with either a silent model or, verbal cues only. It was interesting to note, however, that the older children (7 to 8 year old) performed equivalently whether presented with a silent model or, a verbal model. However, an age by model type by verbal self-instruction rehearsal effect was not found and thus, children of both age groups performed equivalently under verbal or no verbal rehearsal. The findings suggest that the effectiveness of viewing motor skill demonstrations depends on both the type of model observed and the age of the observer.

In a later study, Weiss and Klint (1987) examined the influence of various model types and verbal rehearsal on the performance of a six-part motor skill sequence. In this study, the two age groups (5 to 6 year old and 8 to 9 year old) were assigned to either a verbal model or no model condition with or without verbal rehearsal. Each child was required to perform the motor skill sequence until it was completed correctly. A maximum of six trials was provided. Following two incorrect trials, the child received his/her instructional protocol again. The performance of the sequence of skills was scored on the basis of outcome and included four measurements; number of trials required, average number of skills performed correctly per trial, average number of skills performed in the correct sequence per trial, and number of times instructions were required. The results indicated that the older children performed significantly better than younger children on each of the four dependent variables. The results also indicated that the groups who were encouraged to use an overt verbal rehearsal strategy demonstrated superior performance when compared to the group not required to verbally rehearse. Moreover, these findings were consistent for both developmental age groups. The authors, therefore, concluded that prompted verbal rehearsal is an important variable for young children attempting to reproduce a sequence of motor skills.

One important limitation of the Weiss and Klint (1987) study was that only the correct ordering of the sequence was measured and thus the serial recall of the movements was facilitated by the verbal rehearsal strategy. Using the same model types as Weiss and Klint; McCullagh, Stiehl, and

Weiss (1990) extended the earlier study by adding a form measurement to determine if a visual model would also enhance this aspect of the performance. By measuring both the correctness of the sequencing (quantitative) of motor skills and the form (qualitative) associated with each movement, the results revealed that a visual model facilitated better qualitative performance while the addition of verbal cues enhanced sequential task recall. McCullagh et al., concluded that both verbal and visual coding mechanisms may be in operation for quantitative and qualitative aspects of certain motor skills.

The Weiss, Ebbeck, and Rose (1992) study also represented both a replication and extension of the earlier Weiss and Klint (1987) developmental modeling investigation. These authors also added form measurements and a two day retention test for the purpose of measuring performance and learning effects. The authors concluded, in case of younger children (5-0 to 6-11) that verbal rehearsal plus a model who visually and verbally conveys information about successful performance is best for assisting learners correctly sequence the motor skills and also match their own form performance with that of the model. For older children (8-0 to 9-11), a visual model alone was found to be sufficient for both effective performance and learning of a motor skill. While this conclusion contradicts that made on the basis of Weiss and Klint's 1987 findings, a closer examination of the experimental protocol provides some possible explanations.

The Weiss and Klint (1987) study was characterized by two factors: (a) the sequence of skills employed in the demonstration was scored on the basis of performance outcome only and, (b) only immediate performance was measured. That is, no retention test was administered following a period of rest to allow time for the performance-related effects to dissipate. The addition of a retention interval followed by a retention test performed without knowledge of results is the recommended procedure for distinguishing learning from performance effects (Magill, 1993). Thus, it is possible that Weiss and Klint may have found cognitive-developmental differences had both form and performance outcome measures been used, as well as the incorporation of a no KR retention test.

In summary, the developmental modeling studies reveal that the ability of children to reproduce modeled actions is dependent on the observer's cognitive-developmental level, the characteristics of the demonstration (i.e., silent or verbal model, prompted rehearsal), and the characteristics of the task (i.e., form or sequential recall emphasized). While contradictory findings exist in the developmental modeling research, it can be generally concluded that for children older than 8 years, either a verbal model or prompted verbal rehearsal only is sufficient for effective learning of sequences comprised of previously learned motor skills. In addition, research supports the idea that observational learning for both adults and children is facilitated by supplementing modeled motor skills with verbal cues.

Concurrent Visual Feedback and Modeling Research

The focus of this review pertains to feedback provided to the performer on a video monitor in order to expand the visual information about their movement. Carroll and Bandura (1982 & 1985) concluded that concurrent visual feedback enhances observational learning of a novel action pattern which contain segments of movements not normally observable such as the backswing in a tennis serve or golf swing. Carroll and Bandura (1982, 1985) tested the influence of concurrent visual feedback in two studies using a movement pattern consisting of eight movements performed by the right arm while holding a paddle. Angular displacement at the shoulder, elbow, wrist, and paddle occurred during the eight subsequent movements. Subjects were randomly assigned to one of four conditions: (a) vision group, (b) vision-nonvision group, (c) nonvision-vision group, and (d) nonvision group. The movement pattern was modeled six times and subjects performed one trial after viewing each demonstration. Subjects assigned to the vision group or a combination of vision and nonvision group viewed themselves via a video monitor while they performed the eight-part action pattern. The vision group received six trials of visual feedback. The vision-nonvision group received three trials of visual feedback followed by three trials in which visual feedback was omitted. The nonvision-vision group was not provided visual feedback during the first three trials, but received visual feedback on the subsequent three trials. The nonvision group was not given visual feedback during any of the six trials.

Results indicated that vision and nonvision-vision groups produced significantly higher performance scores when compared to the remaining two groups. Carroll and Bandura (1982) concluded that it was necessary for the subjects to develop a cognitive representation before the concurrent visual feedback provided during practice influenced performance. They also concluded that in order to master a skill, more information is needed than can be provided by a model alone.

A second study conducted by Carroll and Bandura (1985) extended the earlier study by manipulating when the visual feedback was to be introduced. Carroll and Bandura proposed that viewing one's motor responses through video monitoring would reveal errors that may otherwise go undetected without such feedback. The two experimenters hypothesized a optimal time for self monitoring was instrumental in enhancing the cognitive representation and the motor reproduction. The optimal time to observe one's enactment of a motor skill was proposed to be concurrently. The same action pattern modeled in the 1982 study was again used in this later study. Thirty male and 30 female undergraduate students were randomly assigned to three treatment conditions. All subjects viewed the model 12 times and practiced the movements sequence once after every two presentations by the demonstrator. Three practice trials were subsequently completed in the absence of a model or, visual monitoring. The three treatment groups consisted of one group that received no feedback, a second group that received concurrent visual monitoring and, a third group of subjects who viewed their actions on the monitor following the completion of the nine-part action pattern.

The study revealed that the group receiving concurrent visual monitoring performed significantly better than the two remaining groups. A possible reason forwarded to account for such an outcome was that delayed feedback makes it more difficult to recall those movements that do not match the model while concurrent feedback may assist the subjects' integration of both visual and kinesthetic sources of information. Carroll and Bandura's experiments contained only skill acquisition trials and thus, it cannot be stated that visual monitoring has an enduring learning effect. Although Carroll and Bandura have shown that concurrent feedback positively influences performance, other studies (Ho & Shea, 1978; Winstein, 1987; Winstein & Schmidt, 1990) have shown the benefits of KR given on each trial to be a temporary effect. Thus, as explained by Schmidt (1988) and

Magill (1993) concurrent information provided on every practice trial becomes a 'sensory crutch', wherein the learner's ignore their own internal sources of error correction information. As a result, once the KR is withdrawn, performance deteriorates.

Direct Perception View of Modeling

In a review of the research pertaining to the direct perception view of observational learning, Scully and Newell (1985) shifted their attention to examining what information is picked up by the observer of biological motion. According to Scully and Newell, previous research in observational learning has been limited by the information-processing framework (i.e., Bandura, 1977; Sheffield, 1961), which emphasizes how visual and verbal cues are coded but not what movement cues are picked up by the observer.

Scully and Newell (1985) concluded from earlier point-light technique studies (Johansson, 1973, 1975, 1976) that the observer gleans the nature of the relative motion patterns from a demonstration. The authors define relative motion as the "transformational information of body and limb position over time" (Scully & Newell, 1985, p. 177). Scully and Newell consider observational learning to have taken place when the observer's performance of a motor skill approximates the modeled relative motion patterns within certain bandwidths.

If a demonstration is to be useful it is the movement pattern or the coordination of the skill that is important to measure in addition to the final outcome. For example, a tennis ball served successfully into the appropriate boundaries can be done without using the most efficient and effective technique. The final outcome of the activity should not be taken as the only indication that the modeled skill has been reproduced successfully by the observer (Scully & Newell, 1985). The majority of observational learning studies have employed outcome scores such as time elapsed, correct sequencing, or error distance from a target. However, if matching the model's movement is the ultimate goal, then objective measures that compare these respective coordination patterns are needed. Kinematic analysis techniques provide one such objective measure.

During the course of their literature review, Scully and Newell (1985) discuss the novelty of the task to be demonstrated. It is generally assumed that a key element impacting the effectiveness of a demonstration is the relative novelty of the task to the performer. Novel tasks are therefore implemented as part of the experimental procedure essential in accounting for the impact of learning variables. While novelty is rarely defined, it generally refers to skills a performer has never attempted before, but this does not seem to be a helpful definition since any movement sequence can be reorganized and considered a new task under the constraints of a skill the performer has never previously attempted (Newell, Morris, & Scully, 1985; Scully and Newell, 1985). For the purpose of this study, a novel task will be defined as "one in which the performer cannot generate the appropriate topological characteristics of relative motion" (Newell, Morris, & Scully, 1985, p.240).

Kinematic Measurements and Modeling Research

Kinematic investigation have primarily provided information about the laws of mechanics applied to the musculoskeletal system. Typically, kinematic investigations have been limited to describing the movement patterns of highly skilled performers (Kroll, 1978). Thus, very little kinematic research exists which documents the kinematic changes in movement characteristics occurring as skill develops.

A recent skill acquisition study using kinematic measurements was conducted by Southard and Higgins (1987). The purpose of their study was to determine if the nature of a performer's movement pattern changed as a function of repeated demonstrations and physical practice. Novice racquetball players were assigned to one of four groups: a control group, demonstration only group, a physical practice group only, and a physical practice plus demonstration group. The demonstration consisted of viewing a 10-minute videotape of a professional racquetball player executing a forehand shot. Kinematic data was collected pre- and post test using high speed cinematography. The differences in angles of the elbow and wrist were evaluated during the arm reversal phase of the stroke to the point of contact. The results of the pretest "showed no significant change in elbow and wrist joint angles from arm reversal to impact with the ball" (Southard and Higgins, 1987, p. 79), which suggested that the arm was being controlled as a single unit. The results of the posttest revealed that both the practice and the practice/demonstration group performed the forehand racketball stroke significantly different than the control and demonstration only group. Both the practice and practice/demonstration groups used greater joint angles during the backswing which leads to a more effective movement pattern. This study in motor skill acquisition employed kinematic measurements to observe and quantify form changes in the existing movements patterns. A knowledge of kinematic measurements can therefore provide a means of objectivity quantifying changes in coordination across the various stages of learning.

Another observational learning study (Wiese-Bjornstal & Weiss, 1992) also included kinematic techniques in order to examine the influences of various model types on skill acquisition. Thirty-six female subjects ranging from 7-0 to 8-11 years of age were randomly assigned to three modeling conditions. The subjects assigned to condition one received a visual model only on the first three blocks, and a visual model plus verbal cues on the fourth block. Subjects in condition two received two blocks of a visual model followed by two blocks of visual model and verbal cues. Subjects in condition three received a visual model on the first block followed by three blocks of the visual model plus verbal cues. Each subject completed five practice throws after four demonstrations of a modified softball pitch provided by an adult female model.

The researchers hypothesized that with increased opportunities to observe the model and with increased physical practice trials, subjects would better physically match the form demonstrated by the model. Wiese-Bjornstal and Weiss also hypothesized that the most significant improvements in physical form matching would occur following the addition of verbal cues to the visual model. From the videotape data of each subject's practice trials, four kinematic variables related to the form of the performance were analyzed. The variables included were starting shoulder angle, stride length, release body angle, and height of the release.

The results of this study supported the first hypothesis in that after 20 trials all subjects regardless of group assignment performed more like the model in stride length, release body angle between trunk and thigh of the stride leg, and starting shoulder angle. The second hypothesis was not supported, since all subjects showed significant linear trends toward performing more like the model in three of the four form kinematic variables. The important aspect of this investigation is that form measures quantified through biomechanical techniques successfully verified the effectiveness of matching the learners' movement to that of the models', with a limited amount of practice trials.

Cognitive Measures and Modeling Research

In addition to use of observable form and outcome measures three methods of measuring the accuracy of the covert cognitive representation have been used in a small number of previous studies. Carroll and Bandura (1982) have defined a cognitive representation as a "conceptual representation constructed by transforming observed sequences of behavior into symbolic codes which are cognitively rehearsed to increase the probability of their retention" (p. 154).

Pictorial Arrangement Test

Carroll and Bandura (1982, 1985, 1987, 1990) tested the cognitive measures using a static pictorial arrangement test. The test required subjects to rearrange nine scrambled photographs into an order that accurately depicted the sequence of components demonstrated by the correct model. The pictorial arrangement test was administered after the correct model demonstrated the action pattern and subjects had practiced the action pattern three times. This procedure was repeated two more times. In each of the three studies (1982, 1985, 1987) in which the pictorial test was used the mean scores obtained by subjects completing the test increased significantly across trial blocks. Carroll and Bandura also found that as the conception of the modeled pattern increased (correctness of cognitive representation as depicted by scores on pictorial arrangement test) the more accurate was the motor reproduction.

Recognition Test

In addition to the pictorial arrangement test, Carroll and Bandura (1987, 1990) also tested cognitive recognition by adding three distractor photographs which depicted incorrect form to the pool of nine photographs viewed. Subjects were once again asked to select only those photographs depicting the correct movements associated with the modeled performance and order them correctly. One point was awarded for each correct response, with the maximum score possible being nine. Unfortunately, this test did not correlate as highly as the pictorial arrangement with the accuracy of motor reproduction in the 1990 study. Correlations between the accuracy of the motor reproduction and the recognition test was, $r = .47$ $p < .05$, or the pictorial arrangement test was, $r = .73$, $p = .001$. Carroll and Bandura concluded that randomizing the order of the nine part sequential task, when combined with distractor photograph, may have diluted the sensitivity of the recognition measure, "because temporal order appears to be an inherent part of the structure of long sequences of movements" (p. 94).

Dynamic Recognition Test

Wiese-Bjornstal and Weiss (1992) used a third type of cognitive representation test in their study which was designed to examine the effectiveness of the various model types during the initial acquisition of a sport skill. The subjects, seven and eight year old children, were shown a videotape of four dynamic performances of the sport skill of which one was demonstrated correctly. The children were asked to identify the correct performance. Following four trial block viewings of the correct model performing the sport skill, subjects were given the dynamic recognition test. This procedure was repeated three more times. The subjects improved by 20% in their ability to select of the correct model across four trial blocks. Intuitively, this method of testing the accuracy of the cognitive representation appears to be perceptually relevant, since the children are asked to recognize the correct performance from videotaped (dynamic) performances, the same type of visual presentation used to present the correct model. Further use of this method is needed however, to ascertain if it measures the conception of the action portrayed by the model as well as the first two methods described. A secondary purpose of this study is to compare the effectiveness of a static cognitive representation test with the more dynamically based test used by Wiese-Bjornstal and Weiss.

Kinematic Analysis of the Overarm Throw for Force

In this present investigation, the task to be employed was an overarm throw for force. Important kinematic descriptive investigations have been conducted to document children's developmental overarm throwing patterns (Roberton, 1977, 1978; Roberton, Halverson, Langendorfer, & Williams, 1979).

Roberton (1978) kinematically analyzed the overarm throw for force across the various stages of development in order to find out if the processes of acquiring a more mature throw proceeds in all body parts simultaneously, as has been described by earlier motor development researchers (Wickstrom, 1977; Wild, 1938). Roberton proposed that development could occur in one part of the throw while no development occurred in another part. Three parts of the overarm throw were described by Roberton and included the humerus action component, the forearm action component, the pelvic-spinal action component. Roberton's (1978) motor development investigation was a longitudinal study, measuring the throwing patterns of 44 children once each year from kindergarten through second grade. Roberton found that little overarm throwing development occurred over the three years in the three action components analyzed. In fact at least half the children were still classified as beginners or intermediates in all three action components at the end of the second grade. Mature throwing patterns were not characteristic of second graders (7-4 to 9-0 years) in this study. Furthermore, the results of Roberton's study confirmed the hypothesis "that the movement components do not develop in a parallel, lock-step fashion" (p.174) as traditionally viewed, but rather development occurred in one part of the throw while no progress occurred in another part of the throw.

In 1979, Roberton, Halverson, Langendorfer, and Williams re-examined the overarm throwing velocity demonstrated by the same children who participated in the earlier longitudinal study. "Although most studies of the overarm throw have used distance thrown as the dependent measure, initial ball velocity is theoretically a better indicator of force production since distance confounds the latter with angle of release" (Roberton et al., 1979, p. 260). Results of this study indicated that boys and girls differed in their yearly developmental progress with girls increasing their average throwing velocity by 2 to 3 feet/second while the boys improved at a rate of 5 to 8 feet/second.

A number of biomechanical principles can be applied to the overarm throw. The overarm throw as described by Kreighbaum and Barthels (1985) is a kinematic chain action, in which the final small distal segment of the hand travels extremely fast due to the sequential acceleration and deceleration of the body segments. The movement sequence progresses from the higher force-producing proximal segments (i.e., legs and trunk) to the weaker but more flexible distal segments (i.e., forearm and hand). Numerous studies (Roberton & Langendorfer, 1980: Halverson, Roberton, & Langendorfer, 1982; Langendorfer, 1980; Leme & Shambes, 1978) describe the most critical kinematic variables of the sequential action of throwing for force as being: (a) preparatory arm backswing; (b) humerus action; (c) forearm action; (d) pelvis-spine action and, (e) foot action. The five variables listed above are described in detail in Appendix A.

Research in biomechanics can provide information about the nature of highly skilled performance and the application of this knowledge will lead to he selection and development of correct models. Also, biomechanical principles can provide the means to quantify the kinematic changes in the movement pattern which occur during the learning process.

2-D and 3-D Recorded Motion Analysis of the Overarm Throw

Cinematographical data collection techniques used to study the overarm throw have included both two-dimensional analysis (Atwater, 1970, 1979), and three-dimensional high speed cinematography (Elliot & Anderson, 1990). In Atwater's (1970) classical study of the overarm throw for force, three camera angles were used (side, rear, and overhead). The film speed used was 64 frames per second and Atwater commented that it was difficult to measure the action of the wrist with less than 100 frames a second. Atwater described her subjects as average and skilled throwers. She utilized the kinematic data to explain the differences in throwing patterns exhibited by the two skill levels. The sequence in which the body segments of the skilled throwers reached their peak angular velocity was pelvis, upper trunk, upper arm (as a unit), forearm, and hand. In contrast the average throwers tended to start moving the entire trunk and arm forward as a unit and then horizontally adducted the arm ahead of the shoulder line. From this position the elbow extended in the sagittal plane to produce a throw that looked more like a fast push. Compared to the skilled throwers, the average throwers moved more slowly and through a smaller angular and linear range.

On the basis of Atwater's study it can be concluded that it is important to ascertain when peak angular velocity occurs for each body segment. The kinetic linked chain should occur in the following order: rotation of the pelvis (hip-to-hip segment), rotation of the upper trunk segment (shoulder-to shoulder segment), followed by the upper arm (as a unit), elbow, and wrist. Finding the sequential summation of the aforementioned body parts would confirm a segmented trunk rotation and a humerus and forearm lag. One component of the throw that was not mentioned is the movement of the non-throwing arm. Intuitively, the opposing action of the non-throwing arm and shoulder seems a very important aspect of the throw in order to gain peak angular velocities at the joints of the throwing arm.

Recently, Elliot and Anderson (1990) used the direct linear transformation to reconstruct a three-dimensional space from two-dimensional images. The overarm throw can be better analyzed three dimensionally, unlike more linear movements such as running or traditional cross country skiing which were more naturally given to two-dimensional analysis. Elliot and Anderson compared their finding with Roberton's diagnostic description of a mature overarm throw for force.

The subjects included the nine best 15 year old boys and the nine best 13 year old boys as nominated by physical educators from two metropolitan public school. In addition an older group (mean age 21) was selected; the nine best throwers as nominated by the State senior cricket coaches and the eight best throwers nominated by the State senior baseball coaches.

All thirty five males were right handed throwers. Two trials were given to each subject with two 16 mm photosonic high speed cameras filming the throwing motion at 200 frames per second and exposure time of 1/2,400 second. Camera one was positioned approximately 1.57 rad (90 degrees) from the plane of motion and camera two.61 rad (35 degrees) from the plane of motion.

The three-dimensional joint angular displacement and three-dimensional angular velocities were calculated. Elliot and Anderson also calculated from the sagittal plane (2-D) the linear and angular displacements and velocities. The maximum resultant two-dimensional linear velocity occurred in the flowing sequential order: the hip joint (angle between trunk and right thigh) at 329 ms prior to release, shoulder 72 ms prior to release, the elbow 58 ms prior to release, and the wrist 9 ms prior to release. At the time of peaked two-dimensional linear velocity, Elliot and Anderson reported that the three-dimensional angular displacement and three-dimensional angular velocity data for the shoulder, elbow, and wrist joint revealed no significant differences between the groups. For example, at the time of maximum linear velocity at the elbow both three-dimensional angular displacement and angular velocity data for shoulder joint revealed no significant differences between groups.

The researchers concluded that 13 and 15 year old children exhibited all the characteristics of the mature throwing pattern as described by Roberton (1978). However, in this study no measurements were calculated relative to the pelvic-trunk rotation, a component of Roberton's developing overarm throw. Additionally, there was no data included pertaining to the action of the non-throwing arm.

Research Implications

Several implications for research emerge from the review of literature related to modeling. First, more empirical evidence is needed that addresses the issue of learning models from a developmental perspective. Introducing younger children to learning models may enhance their ability to detect error and then correct their movement errors. Second, recent learning model studies (i.e., Lee & White, 1990; McCullagh & Caird, 1990; Pollock & Lee, 1992) have emphasized the role of KR and thus, the use of verbal cues and/or verbal rehearsal has not been combined with a learning sequence model. This would appear to be an important variable to study given that a number of developmental studies have shown verbal cues and/or verbal rehearsal to be valuable supplements when viewing a correct model perform motor skills. Third, a motor skill which incorporates spatial and temporal coordination patterns needs to be the modeled skill versus the relatively simple timing tasks performed in a laboratory setting in order to evaluate how closely the observer's reproduced movements approximate the correct form (i.e., technique). Fourth, it appears necessary to supplement outcome measures with process-related measures of performance, either through the use of trained judges who rate and assign scores to a performance or, through biomechanical measurement techniques describing movement location, velocity, and acceleration. Finally, it is important to include an additional retention test phase in order to differentiate immediate performance effects from more enduring learning effects. This proposed study will attempt to incorporate each of these aspects as a means of providing a more comprehensive understanding of the model-observer interaction.

CHAPTER III. METHODS AND PROCEDURES

The purpose of this chapter is to describe the methods and procedures used in the study. The primary purpose of this study was to examine the relative influence of three instructional strategies in the early learning of an overarm throw for force. The three instructional strategies investigated were a correct model plus progressive verbal cues, a learning model plus progressive verbal cues and progressive verbal cues only. Both the quality to the cognitive representation and motor reproduction of the skill at various stages of acquisition were analyzed.

Subjects

The subject sample consisted of 36 females between the ages of 8 to 10 years. Only females were chosen as subjects, since cross-sectional and longitudinal studies have repeatedly shown that males throw further, with greater ball velocity, and using more mature throwing techniques than females at the same age level (Halverson, Roberton, Langendorfer, 1982; Nelson, Thomas, & Nelson, 1991; Nelson, Thomas, Nelson, & Abraham, 1986; Roberton, 1984; Roberton, Halverson, Langendorfer, & Williams, 1979). These differences begin to emerge at 5 years of age and increase progressively through 17 years. The age group was selected on the basis of developmental changes which occur in the use of selective attention and memory control strategies (Gallagher & Hoffman, 1987; Thomas, French, Thomas, & Gallagher, 1988; Siegler, 1991). Children in the 8 to 10 year age range are developing the ability to selectively attend to the salient features of presented information, rehearse without external prompting, and organize information in memory. They do not yet possess mature strategies.

The children were volunteers recruited from the Corvallis and Salem School districts. Only right-handed girls with a level one or two overarm throwing ability in the following three components were selected for inclusion in the study: humerus action, forearm action, and trunk action (see Appendix A). Prospective subjects were first identified by their physical educators and asked to participate in the study. Level of throwing ability was then independently evaluated by two trained judges using Roberton's component rating scale for the overarm throw for force prior to final acceptance in the study. Written permission for the child's participation in the study was then obtained from the school district (Appendix B) and each child's legal guardian (Appendix C). The necessary application for approval of the research project was sent to the human subjects committee at Oregon State University for review and approved prior to the start of the study (Appendix D).

Design

A 3 X 4 (model type by test session) repeated measures factorial design was employed with measures of form and cognitive representation as the dependent variables. A total of 36 girls, between 8 and 10 years of age were randomly assigned in equal numbers to one of three model type groups: a correct model supplemented with progressive verbal cues (CMVC), a learning sequence model supplemented with progressive verbal cues (LMVC) and, progressive verbal cues only (VC). Changes in overarm throwing performance were evaluated across four testing sessions. The second factor of test session is therefore comprised of four levels (See Figure 1).

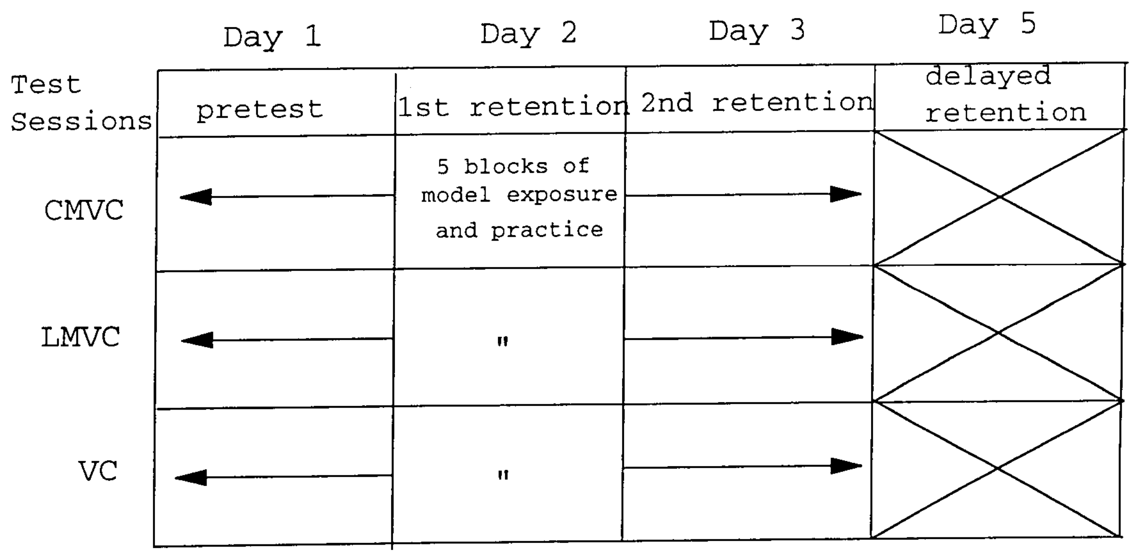

Figure 1. Experimental Schedule

Four dependent variables were used to measure the changes occurring in each of the three independent variables associated with the experimental design. The first two dependent variables measured changes in overarm throwing form across the four test sessions, while the remaining two dependent variables were used to measure the accuracy of the cognitive representation developed as a function of the experimental intervention.

Instruments and Apparatus

The preadolescent subjects were filmed throwing a tennis ball overarm during each of the four test sessions using three video-cameras, each mounted on a tripod and operating at 60 frames/second. One rear and two different side views of the overarm throw for force were filmed simultaneously (See Figure 2). The camera angles were established from several pilot studies (See Appendix E). The focal axis of camera one (Panasonic Ag450), was set to operate at an exposure time of 1/500 sec., stood 3 feet 9 inches above the floor and was positioned approximately 29 feet from the subject in motion and 70 degrees to the plane of motion. The focal axis of camera two (Panasonic Ag170), was set to operate at an exposure time of 1/250 sec., stood 3 feet 3 inches above the floor and was positioned approximately 27 feet from the subject in motion and 90 degrees to the plane of motion. The focal axis of the third camera (Panasonic Ag450), was set to operate at an exposure time of 1/500 sec., stood 4 feet above the floor, positioned approximately 25 feet from the subject in motion and 145 degrees to the plane of motion. All filming was conducted at an indoor gymnasium.

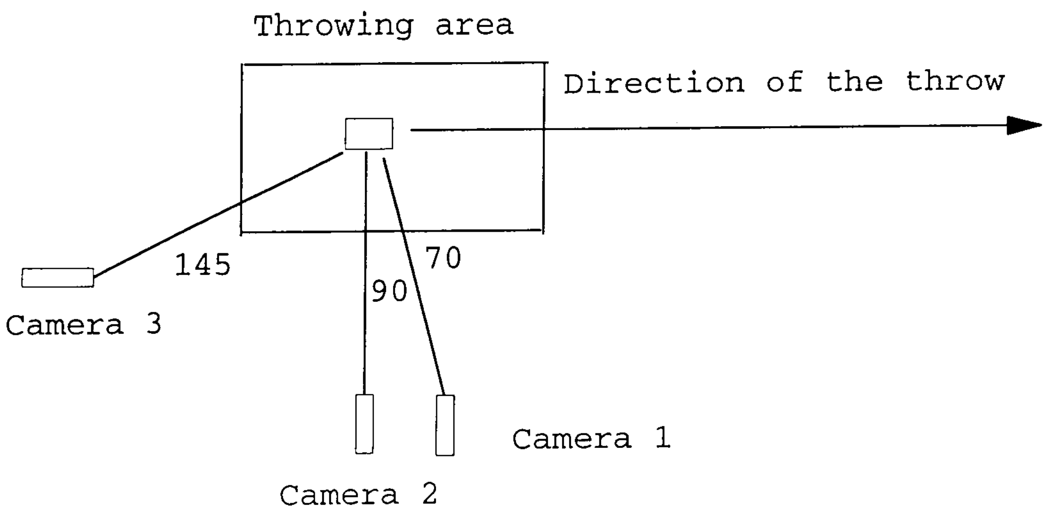

Figure 2. Camera Positions

Video taped data from camera two (i.e., 90 degree side angle) were viewed by two trained judges for the purpose of rating each subject's throwing form according to Roberton's developmental sequence from. The rating form instrument describes the developmental sequences of the overarm throw for force as validated by Roberton et al. (i.e., Roberton 1977, 1978; Roberton & DiRocco, 1981; Roberton & Langendorfer, 1980). The two judges participated in a training session designed to familiarize them with the rating form instrument and to increase response consistency within and between the judges. Judges were presented with a series of throwing trials filmed during pilot studies (Appendix E) and differences in the scores given by the judges were discussed in terms of the criteria described for each score by Roberton's scale. Test-retest and interrater reliability of the identification of levels of throwing patterns for each of the five components of the overarm throw was then established on a sample of 10 subjects. Percentage accuracy was calculated using the following equation to determine intra- and interobserver agreement: Agreements/Agreements + Disagreements X 100 (Cooper, Heron, & Heward, 1987). The proportion of agreement between the two judges across the 10 subjects was .72. The proportion of agreement between the two test sessions across the 10 subjects was .94 (a mean proportion across the two judges). Both judges were blind to the purpose of the study.

Videotaped data obtained from cameras one and three were used to obtain kinematic measurements. The direct linear transformation method of motion analyses for 3-D space construction from 2-D images was used (Walton, 1979). This procedure involved initial filming of a reference structure of known coordinates (i.e., 24 markers) in space, which encompassed the area of movement of the overarm throwing motion (Wood & Marshall, 1986). Both cameras one and three were used to film this structure. The reference structure was then removed from the throwing area prior to the subject being filmed. Six hundred sixty kilowatts of artificial light was used during filming with the aforementioned exposure time and filming speed. This wattage of artificial light was achieved by the use of flood light (Acme-Lite) positioned to the rear of the subject and at a distance of 20 feet from the end of the throwing area.

Videotaped data were reviewed using a videocassette recorder (Panasonic AG 7300) interfaced with a color video monitor (Panasonic BT-M1310-Y) and, a personal computer (IBM-AT) with installed software developed by Peak Performance Technologies, Inc. (Version 5.0.0). The 2-D images of both the reference structure (24 points) and subject were then digitized. The 24 point reference structure was digitized and redigitized, if necessary, until a satisfactory calibration result was achieved (less than 10 mm average mean square error) before analyzing videotaped data from the subject's throwing motion.

Data collected from camera one and three were digitally filtered using a Butterworth 2nd order filter, double pass with a cutoff Frequency of 6 Hz. Three-dimensional angle/segment parameters were established and 3-D angular displacements and angular velocities calculated.

During the course of the experiment sessions, subjects assigned to a visual model (correct or learning) viewed one of the two model types on a color monitor (Quasar Colortrack) interfaced with a Quasar Digitune High Quality videocassette recorder. This same equipment was used when the investigator administered the dynamic cognitive recognition test.

The pictorial-arrangement test was created by photographing the correct model throw four times with a 35mm Camera (Nikon F4) set to take multiple exposures (8 per second). The camera was loaded with ASA 400 film. Ten photos were selected to depict the sequence of overarm throw for force. The 35mm camera was mounted on a tripod positioned approximately 10 feet from the subject in motion and 90 degrees to the plane of motion. A flood light (Acme-Lite) with a wattage of 660 was used during the photo session. The artificial light was positioned approximately 12 feet from the correct model in motion and 90 degrees to the plane of motion.

Procedures

Prerecorded videotapes of each model type performing an overarm throw for force were presented to each designated experimental group throughout the course of the practice sessions. A videotape of an 11 year 11 month old female who exhibited a mature right-handed overarm throwing motion served as the correct model. Two expert judges, trained in the use of Roberton's Developmental Scale, independently evaluated the overarm throwing motion demonstrated by the filmed model to validate the selection of the correct/mastery model.

An 11 year 8 month old female model who demonstrated an immature overarm throwing action served as the learning sequence model. In order to qualify as a learning sequence model, throwing ability was not to exceed level one or two in any one of the three major components associated with the overarm throw for force: humerus action, forearm action, and trunk action (Appendix A). Two expert judges validated the learning model's throwing ability as less than three in all three major components listed above.

The videotape depicting the learning sequence model's demonstrations took three days to develop. During day one and two the learning model heard one of the five progressive verbal cues prior to each view or the correct model's five throwing demonstrations. The progressive verbal cues were derived from two pilot studies (See Appendix E). Before viewing each throw in the first set of five throws, the learning model heard a verbal cue which relates to the type of grip needed and rotation of the trunk and hip. The following statements were used: "Grip the ball with your fingers. As you start the backswing, turn the throwing side of the body away from the direction of the throw with most of your weight on the right foot". Before viewing each throw in the second set of five throws, the learning model heard a specific verbal cue related to the backswing motion in the following form: "During the backswing of the throw, swing the throwing arm below the waist, backward, and upward to bring the ball behind your head". Before viewing each throw in the third set of five throws, the learning model was presented with the following verbal cue related to the position of the non-throwing side of the body: "As you step forward on your left foot, make sure the non-throwing side of your body is facing the direction of the throw and the non-throwing arm is extended and pointed towards the throwing direction". Prior to viewing each throw in the fourth set of five throws, the learning model received the next progressive verbal cue: "Before you move the ball from behind your head, make sure the extended non-throwing arm swings back away from the direction of the throw". Prior to viewing each throw in the fifth set of five throws, the learning model heard the final progressive verbal cue related to ball release: "When you bring the ball from behind your head, quickly extend the throwing arm upward and forward and release the ball with a snap". After the learning model viewed the correct model supplemented with one of the five progressive verbal cues, she performed five physical practice trials. This protocol was repeated four more times during the course of practice session one and two. On day three the presentation of the same progressive verbal cues were scheduled differently. The learning model was given a different progressive verbal cue prior to each view of the correct model's five throwing demonstrations. Thus, at the end of viewing the correct model's five demonstrations the learning model had heard all five progressive verbal cues sequentially. Five blocks of 5 physical practice trials were performed by the learning model on each of three alternate days. The video tape of the learning model showed progressing demonstrations from day one through day three. Based on the judges ratings using Roberton's component rating scale, the learning model's throwing demonstrations progressed from a rated form score of six on day one to a score of nine on day three. The learning sequence model received a total of 75 practice throws throughout the course of the three practice days.

Both the correct model's and the learning model's overarm throwing performance were videotaped using camera two (See figure 2). Subjects randomly assigned to a visual model viewed either the correct model or the learning sequence model performing five consecutive overarm throws for force before the start of each block of physical practice. Only the form demonstrated by either model type were observable from the videotape. The outcome of the throw was not observable and verbal knowledge of results was not provided to the subjects concerning the distance the ball was thrown by the model.

Subjects stood within and to the rear of a 6 by 7 feet throwing area marked on the floor before being asked to throw a tennis ball as hard as they could at a wall approximately 50 feet away. Each child adopted a standardized starting position with both hands on the ball and the body facing the direction of the throw.

In the preceding sections of this dissertation the throw has been named the overarm throw for force to differentiate it from other types of throws. The overarm throwing pattern has been shown to alter within subjects when asked to change from throwing the ball as hard as possible (force) to throwing for accuracy. Langendorfer (1987) found that the mean levels of four of the five components listed on Roberton's rating scale were significantly higher in the force condition. In the remaining sections of this dissertation the term throw or overarm throw will always be assumed to mean an overarm throw for force.

The overarm throw was selected for several reasons. First, it is representative of a fundamental motor skill taught in an elementary physical education setting. Second, authors of widely used elementary physical education texts (i.e., Pangrazi & Dauer, 1992) consider children aged 8 years to be developmentally capable of throwing overarm for force using a mature throwing pattern. Third, the task has been extensively researched and a developmental sequence table describing the five major components of the overarm throw has been validated. Fourth, the task is self-paced and therefore ensures that the performance is under the internal control of the subject.

Qualitative Form Measure

Two expert judges, trained in the use of Roberton's component rating scale for the overarm throw evaluated the overarm throwing form of all subjects filmed during each of the four test sessions. Intra and inter-observer objectivity estimates for the developmental levels of the five major body components of overarm throwing form were obtained. The five components include action related to the backswing (four levels), humerus (three levels), forearm (three levels), trunk (three levels), and feet (four levels). A subject who demonstrates a mature throw would be evaluated at the highest level in each of the five components. A cumulative score of 17 points would be obtained if the subject scored at the highest level in each component.

Quantitative Form Measures

A subgroup of five subjects were randomly selected from each experimental cell group (3) in order to investigate possible kinematic changes in throwing form during the testing phase of each of the four sessions. Kinematic variables related to the form of the overarm throw were analyzed three dimensionally. The filmed data consisted of four sessions of five trials of throwing for force of which two were randomly selected from each session for analysis.

Calculated linear and angular kinematic quantities, based on variables used in previous throwing investigations (Anderson, 1976; Atwater, 1970; Elliot & Anderson, 1990; Roberton, 1977), were accessed and included in the form analysis. Three dimensional joint angles were measured at the right shoulder and right elbow. The degree of trunk rotation was quantified by calculating the total angular displacement of the hip segment throughout the throwing action.

For the purpose of the analysis, the overarm throwing motion was divided into two phases, the preparatory and release phase, respectively. Each subject adopted a standardized starting position with both hands on the ball and the body facing the direction of the throw. The preparatory phase begins when the hands separate and ends at the finish of the backswing, that is, when the elbow joint (included angle between the upper arm and forearm) is at its minimum angle. The start of the release phase begins at minimum elbow angle achieved (end of preparatory phase) and ends when the ball is released form the fingers. Five kinematic form variables were measured. These included stride length, maximum displacement of the hips away from and toward the direction of the throw, the relative time elapsed from the end of the preparatory phase to the end of the release phase, the angle of the shoulder joint at the end of the preparatory phase and, the angle of the shoulder joint at the time maximum angular elbow joint velocity is achieved.

One kinematic measurement representing performance outcome was obtained. The value was derived by calculating ball velocity just after release of the ball from the fingers of the throwing hand.

Cognitive Representation Measurements

In the present study, both a pictorial-arrangement test similar to one used by Carroll and Bandura in previous studies (i.e., 1982, 1985, 1987, 1990) and a series of dynamic video recordings depicting correct and partially incorrect performances (Wiese-Bjornstal & Weiss, 1992) were employed. In the remaining sections of this dissertation the videotaped method will be referred to as the dynamic cognitive recognition test while the pictorial-arrangement of 10 still photographs will be referred to as the static cognitive recognition test. Both tests were used to determine the accuracy of the cognitive representation and were administered during all four test sessions.

All subjects completing the dynamic cognitive recognition test were asked to recognize and identify whether each of the five throws observed represented either a correct or, incorrect throwing action. A score of 1, was recorded for the correct response while a 0, was recorded in the case of an incorrect response. A total of 5 points was possible if all responses were correct. At least one of the five throws observed was correctly demonstrated. In each of the incorrect overarm throws, at least one of the critical elements was performed incorrectly. For example, one incorrect throw was characterized by no trunk rotation and elbow extension which resembled a pushing motion, similar to the release of the shot put. A second incorrect throw consisted of the left arm remaining down at the side of body throughout the entire throwing motion rather than pointing and extending the left arm toward the direction of the throw during the preparatory phase. A third incorrect overarm throw consisted of upper arm horizontal adduction before the shoulders rotate to face the direction of the throw. A fourth incorrect throw depicted the model demonstrating a sidearm instead of an overarm throw. Both the correct and incorrect throwing performances were performed by the correct/mastery model filmed from a 90 degree side angle. Four randomly ordered sequences of five throws were prepared, one for each test session.

The static cognitive recognition test consisted of subjects being presented with ten randomly ordered photographs of the overarm throw sequence. Each subject was required to sequentially order the photographs from left to right. An error was recorded if the subject incorrectly positioned any single photograph in the sequence. The total score recorded was the sum of the error score. Four randomly ordered sequences of the ten photographs were prepared, one for each testing session.

Protocol

Letters of informed consent were sent home to guardians of all children identified as possible participants according to age and overarm throwing ability. After receiving the signed guardian consent form, the children were randomly assigned to one of the three modeling conditions. The three modeling conditions were correct model plus progressive verbal cues (CMVC) condition, learning model plus progressive verbal cues (LMVC) condition, and progressive verbal cues only (VC) condition. The subjects assigned to the VC condition only heard the progressive verbal cues before physically practicing the skill. The same five progressive verbal cues presented during the development of the learning model were presented to all experimental groups. In addition, the same format of presenting the five progressive verbal cues utilized during the development of the learning model was replicated for all experimental groups. One of the three conditions occurred prior to each block of five physical practice trials. Subjects completed five blocks of physical practice each day over a three day period (n = 75).

In order to determine whether any changes occurred in throwing form across the practice sessions each subject performed five physical practice trials of throwing overarm in the absence of either model type and/or progressive verbal cues at the beginning of each session. The static cognitive recognition test and the dynamic cognitive recognition test were also completed by all subjects prior to exposure to models and/or verbal cues. All subjects were videotaped using thee video cameras during the performance of the five throwing trials (See Figure 2). The three tests administered during day one provided the initial performance data while subsequent administration of the tests on days two and three measured stages of learning. Day four was a rest day and on day five the final set of tests, constituting a delayed retention test, was administered (See Figure 1). The order in which the throwing trials and cognitive representation tests were performed was randomized and counterbalanced across subjects and days.

Before completing the static cognitive recognition test, each subject sat in a swivel chair with her back to a set of ten photographs, randomly positioned on a table. The subject was told to turn and face the table while continuing to keep her eyes closed. On the word 'begin' the subject was asked to open her eyes and begin to place the photographs in the correct sequence from left to right.

Prior to administering the dynamic cognitive recognition test, the subject was told that she would see via a T.V. monitor five demonstrations of overarm throws, but not all of the throws would be performed correctly.

After each throw was shown, the subject was asked to identify whether the throw was correctly or incorrectly performed.

Each child was presented the experimental protocol in an individual session. The testing and practice session for each subject lasted approximately 30 minutes. The experimenter explained to each child that she would be helping the researcher understand how children learn particular sport skills. Subjects were instructed to carefully watch the demonstration and/or listen to the verbal cues presented on the video monitor.

Subjects viewing the correct model were told the model is correctly demonstrating how to overarm throw a tennis ball as hard as possible. Each child viewing the correct model were told to focus their attention on the model and the verbal cues provided in order to improve her throwing ability. The subjects viewing the learning sequence model were told that the model is currently learning how to throw a tennis ball as hard as possible, and they are to focus their attention on the model and the verbal cues provided as a means of improving their throwing ability. All subjects presented with either the correct or, learning sequence model viewed each demonstration performed from the side angle only. Each subject given verbal cues only were told to learn as much as they can about how to throw a ball as hard as possible by listening closely to the instructions.

On day 5, after each subject completed the delayed retention tests, she was shown videotape of her performance and provided with feedback. Each subject was then thanked for her participation in the study.

Statistical Analyses

All measures for all variables were recorded during each of the four test sessions. Values were entered into an IBM-PC using the Statistical Package for the Social Sciences (SPSS for Windows, Base System and Advanced Statistics, Release 5.0.1).

A variety of statistical procedures was used to analyze the dependent variables related to both the physical performance and the cognitive representation. First, descriptive statistics were employed to calculate mean and standard deviation values obtained for each dependent variable during each of the four test sessions conducted. Second, a test of sphericity was conducted prior to the use of a DM MANOVA analysis. Third, the intercorrelations among the dependent variables were calculated using the Pearson Product Moment Correlation Coefficient (PPMCC) and it was determined that multicollinearity did not exist. Fourth, a doubly multivariate repeated measures analysis of variance (DM MANOVA) was employed to analyze the 3 X 4 (Model Type by Test Session) factorial design (Schutz & Gessaroli, 1987), with one measure of form (based on Roberton's throwing form instrument) and the scores derived from each of two different types of cognitive recognition tests as the dependent variables. In the case of a significant omnibus F being obtained, follow-up univariate F analysis were conducted in order to determine which dependent variables contributed most to group differences. Trend analyses were also conducted to evaluate the nature of the changes in form and/or quality of cognitive representation from test session one through test session four, while post-hoc procedures helped distinguish among conditions.

In addition to the primary analysis including the data of all 36 subjects tested, a secondary set of analysis was conducted using the kinematic data collected from a smaller group totaling 15 randomly selected subjects, 5 from each instructional strategy group. These analyses were conducted to determine whether changes in overarm throwing form were evident across the four testing sessions using a more objective measure for form. Intercorrelations among the 6 kinematic variables chosen to quantitatively measure changes in throwing form were calculated using the Pearson Product Moment Correlation Coefficient(PPMCC). High correlations were found among four variables and subsequently two kinematic variables were eliminated from further analysis. A 3 X 4 (Model Type by Test Session) ANOVA with repeated measures on the second factor was conducted for each of the four kinematic variables selected after checking for multicollinearity. The degrees of freedom for the within-subject variable, test sessions, was adjusted using the Greenhouse-Geisser method (Dixon, 1983).

CHAPTER 1V. RESULTS AND DISCUSSION

The purpose of this study was to examine the relative effectiveness of three instructional strategies in the early learning of an overarm throw for force among preadolescent females. Subject ages ranged from 8 - 10 years (M = 9 years 1 month). The three instructional strategies were as follows: (a) correct model plus progressive verbal cues (CMVC), (b) learning model plus progressive verbal cues (LMVC), and (c) progressive verbal cues only (VC). Chapter four presents the findings that resulted from the methods and procedures used to investigate the effects of three instructional strategies on the early learning of a fundamental motor skill.

Subject Descriptions

Age and height data were collected on all subjects. Table 1 presents the means and standard deviations for subjects in each experimental group. Subjects in each of the groups were comparable on both age and height.

The correct and learning model were 11 years 11 months and 11 years 8 months of age, respectively. The correct model's height was 146 centimeters and the learning model's height was 145.4 centimeters.

Table 1. Subject Descriptions

	Height(cm) M.	S.D.	Age M.	S.D.
CMVC	138.01	4.42	9.08 yrs	4.94
LMVC	136.36	5.37	9.0 yrs	4.88
VC	138.75	8.63	9.16 yrs	5.30
Total	138.75	6.30	9.08 yrs	4.95

Dependent Variables

Three dependent variables were measured during each of the test sessions conducted on days one, two, and three prior to exposure to either model type and/or the progressive verbal cues. Day four was a rest day. On day five, the three dependent variables were again measured. The dependent variables included (a) an overarm throwing form score, (b) a static cognitive recognition score and, (c) a dynamic cognitive recognition score.

Judges' Interobserver Agreement

Each judge individually rated four sections of videotape, comprised of side-views of 36 subjects throwing using an overarm technique for five trials. When permanent products such as videotaped data are utilized to judge motor performance, it has been recommended that judges' interrater agreement should be a percentage in the high 90's (Cooper, Heron, & Heward, 1987).

To assure a high interobserver agreement and "true" values of overarm throwing form, the investigator reviewed the criteria associated with the rating levels for each component with the judges after each section of tape was judged and scored. Following the review session, the disagreements between the judges on rating levels were, in most cases, reconciled after the observers once again compared the observed values on the coding sheets with the actual behavior patterns on the videotape record. Percentage accuracy was calculated using the following equation to determine interobserver agreement: Agreements/Agreements + Disagreements x 100 (Cooper, Heron, & Heward, 1987). The overall mean interobserver agreement obtained as a result of this review process was 98%.

Statistical Analyses

In order to determine which statistical procedure was the most appropriate to apply to the data, the correlations among the three dependent variables were first reviewed to determine whether multicollinearity was present. The correlations (PPMCC) among the dependent variables, averaged across the four test sessions were as follows: dynamic cognitive recognition test score/static cognitive recognition test score, $\underline{r} = .07$, dynamic cognitive recognition test score/form score $\underline{r} = -.20$, and static cognitive recognition test score/form score $\underline{r} = -.20$. Since the intercorrelations were very low among predictors the importance of the given predictors in the overall relationship were not confounded.

Multivariate Analyses

The DM MANOVA approach, or doubly multivariate approach was chosen based on the recommendations of Schutz and Gessaroli (1987). First, when two or more dependent variables are sampled on multiple occasions, a repeated measures multivariate mixed model (MMM) analysis is considered warranted. Second, Schutz and Gessaroli (1987) suggest using a doubly multivariate approach if the assumption of sphericity is violated. Sphericity refers to the repeated measures, when transformed by a set of orthonormal weights, being uncorrelated with each other and exhibiting equal variance (Schutz & Gessaroli, 1987, p. 134). If the experimental design includes a between-subject factor, then the pooled and group covariance matrices must also be equal in order for the sphericity assumption to be met. This was not the case in the present study as indicated by the findings of the Mauchly Sphericity test conducted (GGI epsilon = .57713). According to Schutz and Gessaroli, "under conditions of nonsphericity, the DM approach will provide a Type I error rate which is much closer to the nominal alpha value than will an MMM procedure" (p. 137). Thus, the DM MANOVA approach was selected.

Model Type by Test Session

Prior to conducting a 3 X 4 (Model Type by Test Session) DM MANOVA analysis, the mean and standard deviation values were calculated for each dependent measure for each of the two factors to be analyzed. These values were then entered into the analysis and are presented in Table 2.

Table 2. Means and Standard Deviations (DM MANOVA)

Variable	Condition	Day 1 M SD	Day 2 M SD	Day 3 M SD	Day 5 M SD
Form	CMVC	8.50/1.56	8.70/ .68	9.25/1.40	8.91/ .99
Scores	LMVC	8.01/1.70	9.20/1.54	9.12/1.17	9.16/1.02
	VC	8.10/1.27	8.75/1.05	8.62/1.06	8.83/1.02
	Total	8.16/1.50	8.88/1.05	9.00/1.12	8.98/ .98
Static	CMVC	4.33/2.49	2.41/1.92	2.08/1.83	2.16/2.40
Cognitive	LMVC	2.75/2.26	2.50/1.50	2.41/1.37	1.83/1.11
Recog.	VC	3.33/3.02	2.83/2.16	2.25/2.09	1.91/2.23
	Total	3.47/2.62	2.58/1.84	2.25/1.74	1.97/1.94
Dynamic	CMVC	2.58/ .99	4.41/ .51	4.33/1.15	4.58/ .51
Cognitive	LMVC	3.08/ .99	3.58/ .79	3.58/1.08	4.25/ .75
Recog.	VC	2.91/ .90	3.41/1.44	4.25/1.13	4.25/ .75
	Total	2.86/ .96	3.80/1.06	4.05/1.14	4.36/ .68

CMVC = Correct Model plus Verbal Cues
LMVC = Learning Model plus Verbal Cues
VC = Verbal Cues Only

The results of the repeated measures DM MANOVA revealed a significant test session main effect only (Wilks Lambda = .226, $\underline{F}(9,25) = 9.40$, $p<.001$). Neither the model type main effect (Wilks Lambda = .890, $\underline{F}(6, 62) = .614$, $p>.70$) nor the model type by test session interaction (Wilks Lambda = .526, $\underline{F}(18, 50) = 1.05$, $p>.40$) were significant.

Follow-up univariate F tests were conducted for each of the dependent variables. All three dependent variables were found to contribute to the significant test session main effect: form scores, $\underline{F}(3,99) = 5.85$, $p<.002$, static cognitive recognition test scores, $\underline{F}(3,99) = 10.15$, $p<.001$, and dynamic cognitive recognition test scores, $\underline{F}(3,99) = 19.84$, $p<.001$.

To determine the nature of the performance changes over test sessions, trend analyses via the use of orthogonal polynomials were conducted for each dependent variable. Significant linear trends were observed for all three dependent variables: form scores, $\underline{F}(1,33) = 8.18$, $p<.008$, static cognitive recognition test, $\underline{F}(1,33) = 73.6$, $p<.001$, and dynamic cognitive recognition test $\underline{F}(1,33) = 14.6$, $p<.002$. Figure 3 displays a plot of the mean values contributing to the significant linear trend for form scores. Irrespective of the type of instructional strategy used (i.e.; verbal cueing, correct or, learning sequence model), each group showed significant improvement in overarm throwing performance between the first and last test session. The average form scores of subjects in each of the

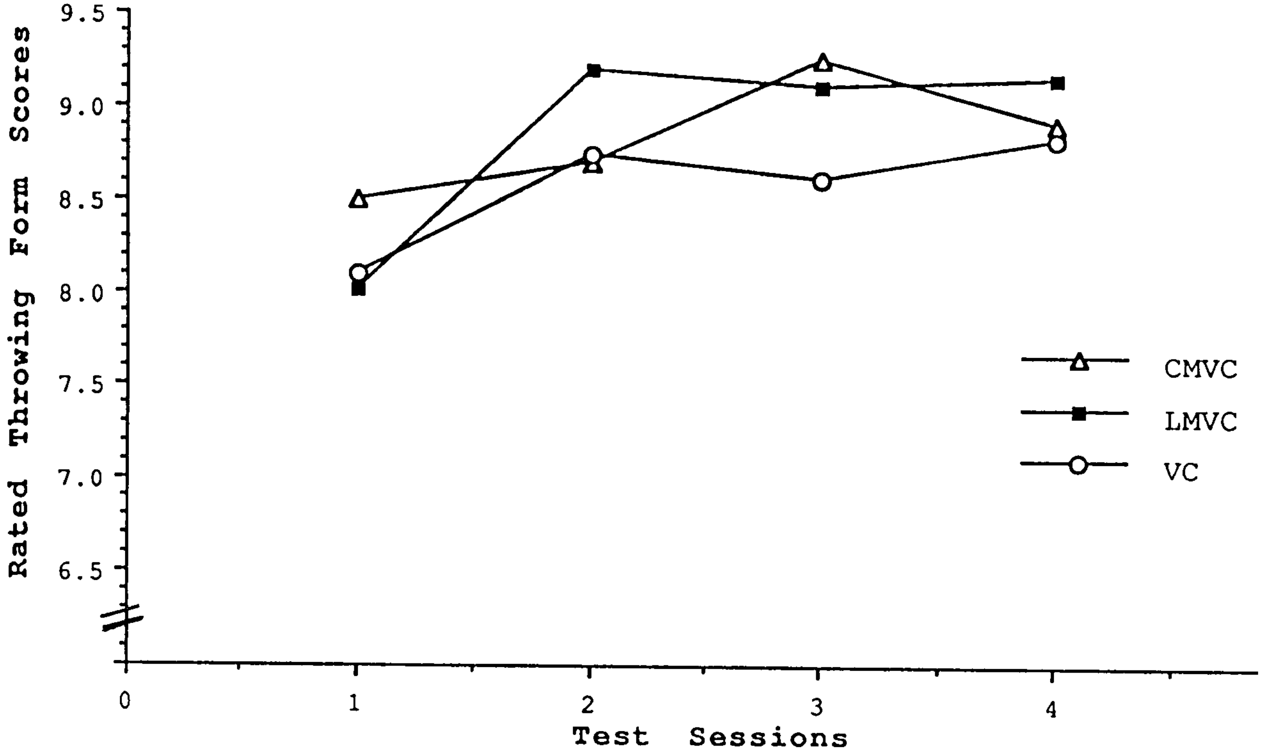

Figure 3. Graph of Mean Rated Throwing Form Scores for the Overarm Throw as a Function of Condition and Test Session. Total possible score is 17

three conditions increased from a mean of 8.16 (SD = 1.50) during test session one to a mean of 8.98 (SD = .98) during test session four. Moveover, the accuracy of the developing cognitive representation, whether it was assessed using a static or dynamic cognitive recognition test, showed significant improvement for subjects who received any one of the three instructional strategies.

The static cognitive recognition task required the subjects to correctly sequence 10 randomly ordered photographs depicting the overarm throwing motion. An error was recorded if the subject incorrectly positioned any single photograph in the sequence. The total score recorded was the sum of the error score. Thus, a score of zero indicated a perfect score. Figure 4 displays the values for the significant linear trend obtained from the static cognitive recognition test results. The graph indicates that an overall trend toward a perfect score was exhibited by subjects in all groups. The mean scores across groups decreased from 3.47 (SD = 2.62) during test session one to 1.97 (SD = 1.94) during test session four.

All subjects completing the dynamic cognitive recognition test were shown five dynamic video recordings depicting correct and partially incorrect overarm throwing performances. Subjects were asked to recognize and identify whether each of the five throws observed represented either a correct or, incorrect throwing action. A score of 1 was recorded for the correct response while a 0 was recorded for

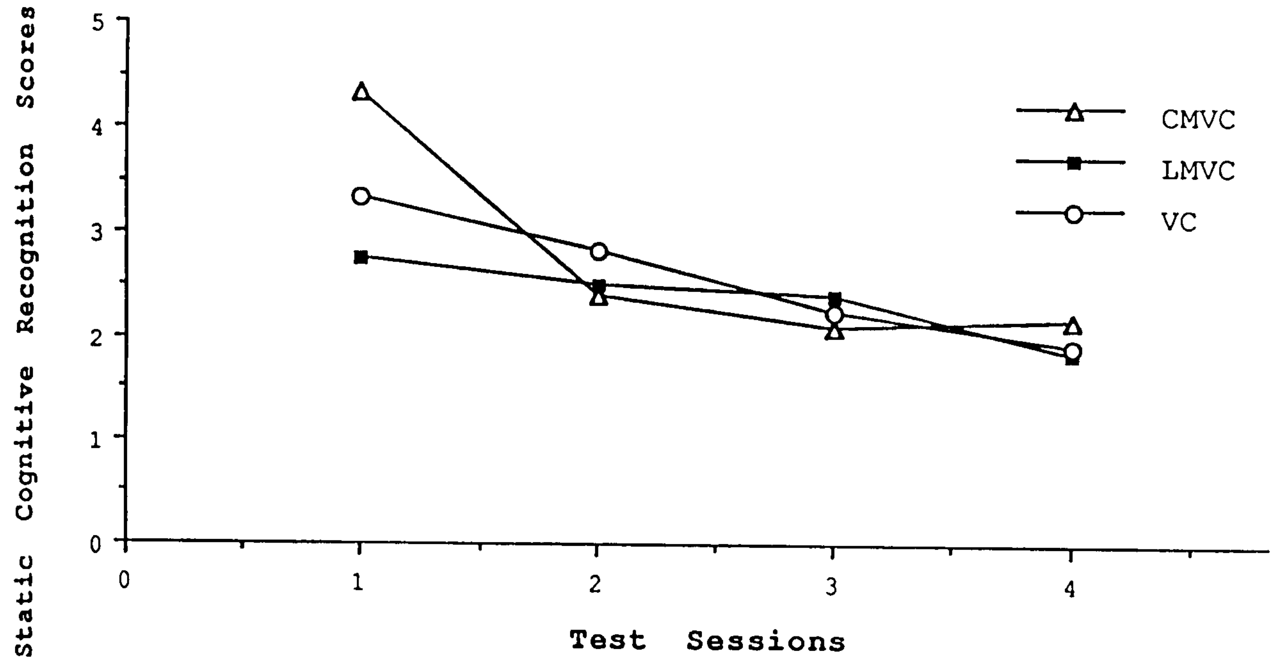

Figure 4. Graph of Mean Static Cognitive Recognition Test Scores as a Function of Condition and Test Session. Zero indicates a perfect score.

an incorrect response. A total of 5 points were possible. In figure 5, the mean values for the dynamic cognitive recognition test are displayed as a function of test session and condition. The mean scores across groups increased from 2.86 (SD = .96) during test session one to 4.36(SD = .68) during test session four.

Analysis of Selected Kinematic Variables

In addition to the cognitive representation data and judges' scores of each subject's overarm throwing form across the four test sessions, changes in important kinematic variables associated with overarm throwing technique were subjected to analyses. Three subgroups comprised of five subjects were randomly selected from each of the three conditions to investigate the kinematic variables related to the form of the overarm throw and one outcome measurement. Two throws were randomly selected from the videotaped data of five throwing trials performed at each of the four test sessions and then digitized. The form-related kinematic variables included: (a) stride length expressed as a percentage of the subject's height, (b) maximum hip displacement away and towards the direction of the throw expressed in degrees, (c) the relative time elapsed from the end of the preparatory phase to the end of the release phase expressed as a percentage of total throwing time, (d) angle of the shoulder joint at the end of

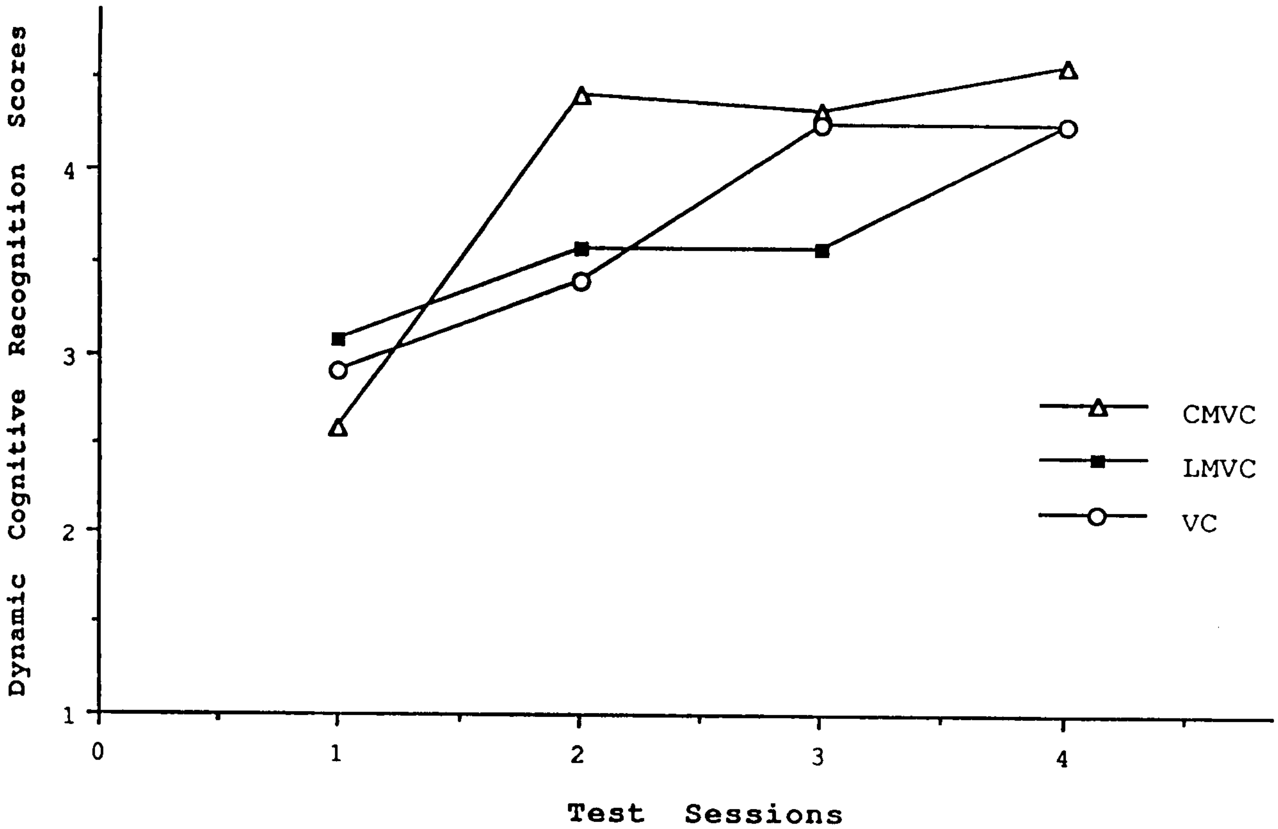

Figure 5. Graph of Mean Dynamic Cognitive Recognition Test Scores as a Function of Condition and Test Session. Five indicates a perfect score.

the preparatory phase expressed in degrees, and (e) angle of the shoulder joint at the time maximum angular elbow joint velocity is achieved expressed in degrees. The single outcome measure selected was the velocity of the ball expressed in meters per second. These particular kinematic variables were chosen based on variables used in previous throwing investigations (Anderson, 1976; Atwater, 1970; Elliot & Anderson, 1990; Roberton, 1977).

Descriptive Statistics

The mean and standard deviations for the two trials selected were calculated for each of the six kinematic variables for each of the four testing sessions. Table 3 contains the descriptive statistics for the variables analyzed and Table 3a contains the descriptive statistics for the variables not analyzed after a review of the correlation matrix.

Review of the correlation matrix constructed for the six kinematic variables revealed a significant correlation ($r = -.69$, $p < .05$) between relative time elapsed from the end of the preparatory phase to the end of the release and the angle of the shoulder joint at the end of the preparatory phase. This correlation indicated that as the angle of the shoulder joint increased at the end of the preparatory phase, the relative time of the release phase decreased.

Table 3. Analyzed Kinematic Variables

Variable	Condition	Day 1 M SD	Day 2 M SD	Day 3 M SD	Day 5 M SD
Stride					
Length	CMVC	24.4/21.3	42.6/13.1	40.8/14.2	45.9/14.7
Expressed	LMVC	44.9/13.7	46.0/20.3	53.5/12.3	51.4/ 9.6
as % of	VC	34.1/15.2	40.1/12.6	40.9/ 9.1	38.8/18.2
height	Total	34.5/19.0	42.9/14.8	45.1/12.7	45.3/14.5
Shoulder					
Joint	CMVC	94.4/16.6	87.7/21.3	82.9/20.9	77.9/15.1
Angle at	LMVC	106.1/24.0	127.5/10.5	125.1/29.0	130.6/25.2
End of	VC	123.0/24.5	108.0/14.8	129.0/24.5	115.0/17.6
Prep.	Total	108.8/23.1	107.7/22.5	112.3/31.7	107.9/29.3
Phase					
	CMVC	95.3/44.2	119.8/55.0	109.2/35.6	128.5/25.8
Total Hip	LMVC	114.0/37.8	115.3/50.6	124.2/44.5	127.3/27.3
Displace.	VC	83.6/65.3	85.9/75.1	109.1/54.2	112.2/71.5
(deg)	Total	97.6/48.5	107.0/58.7	114.2/42.7	122.6/43.8
Velocity	CMVC	11.1/1.3	10.0/1.9	10.2/1.1	10.2/1.3
of Ball	LMVC	11.9/1.0	11.3/ .8	11.5/ .6	12.3/ .7
at Release	VC	11.2/1.7	11.2/1.1	10.2/1.1	10.9/1.6
(m/sec)	Total	11.4/1.8	10.8/1.4	10.7/1.1	11.1/1.4

Table 3a. Kinematic Variables not Analyzed

Variable	Condition	Day 1 M SD	Day 2 M SD	Day 3 M SD	Day 5 M SD
Shoulder	CMVC	133.1/14.7	124.4/19.5	126.6/19.5	137.6/12.5
Angle at	LMVC	145.9/ 8.9	138.3/10.1	143.6/ 7.7	146.1/ 6.7
Max Elbow	VC	143.6/ 8.7	142.2/ 9.6	132.9/ 7.5	141.3/ 4.4
Velocity	Total	140.9/11.7	134.9/15.0	134.3/13.6	141.7/ 8.7
(m/sec)					
Relative	CMVC	23.6/ 5.9	16.7/ 7.0	20.2/ 9.4	22.2/ 6.0
Time of	LMVC	17.3/ 4.4	14.0/ 3.8	19.0/ 5.1	17.6/ 4.6
Release	VC	20.6/ 5.7	20.7/ 6.2	14.7/ 3.6	19.8/ 4.6
Phase	Total	20.5/ 5.6	17.1/ 6.1	18.0/ 6.5	19.9/ 4.6

In addition, a significant positive correlation ($\underline{r}$ = .60, $p<.05$) was found between the angle of the shoulder joint at the end of the preparatory phase and the angle of the shoulder joint at the time maximum angular elbow joint velocity was achieved. Thus, as the angle of the shoulder joint increased at the end of the preparatory phase so too did the angle of the shoulder joint at the time of maximum angular elbow joint velocity. Since significant intercorrelations were found among these dependent variables, two were eliminated from subsequent analyses. The variables eliminated were shoulder joint angle at the time of maximum elbow joint velocity, and the relative time elapsed from the end of the preparatory phase to the end of the release. Four remaining variables were analyzed separately using a 3 X 4 (Model Type by Test Session) repeated measures ANOVA. The four dependent variables analyzed were: (a) stride length expressed as a percentage of the subject's height, (b) maximum displacement of the hips away from and toward the direction of the throw, (c) the angle of the shoulder joint at the end of the preparatory phase, and (d) ball velocity just after release of the ball from the fingers of the throwing hand.

Given that the completion of multiple ANOVA's increases the probability of making Type I errors, a relatively conservative alpha value of .02 was chosen for the second set of analyses. The degrees of freedom for the within-subject variable, test sessions, was also adjusted using the Greenhouse-Geisser method (Dixon, 1983).

Univariate Analyses

A nonsignificant model type by test session interaction was obtained for the kinematic variable angle of the shoulder joint at the end of the preparatory phase $\underline{F}(6, 36) = 2.61$, $p<.05$. A test session main effect was not found to be significant for the angle of the shoulder joint at the end of the preparatory phase. There was, however, a significant model type main effect evident for the angle of the shoulder joint at the end of the preparatory phase $\underline{F}(2, 12) = 7.62$, $p<.01$. A post-hoc Student Neuman-Keuls analysis further indicated that subjects assigned to the CMVC instructional strategy demonstrated significantly smaller shoulder joint angles at the end of the preparatory phase on days three and five when compared to subjects assigned to either the VC or, LMVC instructional strategy. While during day two the CMVC group demonstrated significantly smaller shoulder joint angles at the end of the preparatory phase when compared to the LMVC group only.

A mature throw as described in Roberton's component rating scale is characterized by an upper arm which is horizontally (approximately 90 degrees) in line with the shoulder at the end of the preparatory phase. The subjects assigned to the CMVC instructional strategy demonstrated an average shoulder joint angle of 94.4 degrees at the end of the preparatory phase during the first test session and gradually decreased to 77.9 degrees by the fourth test session. The correct model's shoulder angle at the end of the preparatory phase was 97 degrees. Subjects assigned to the CMVC instructional strategy did not maintain the correct upper arm position and thus, they were not successfully imitating the model across the four test sessions. In Figure 6 it can be seen that the subjects assigned to the LMVC and VC instructional strategy, predominantly positioned the upper arm at an angle above the horizontal line of the shoulder.

Based on the conservative alpha level the kinematic variable of stride length just failed to reach a significant test session main effect, $\underline{F}$ $(3,36) = 4.60$, $p = .029$. Figure 7 displays a plot of stride length mean values as a function

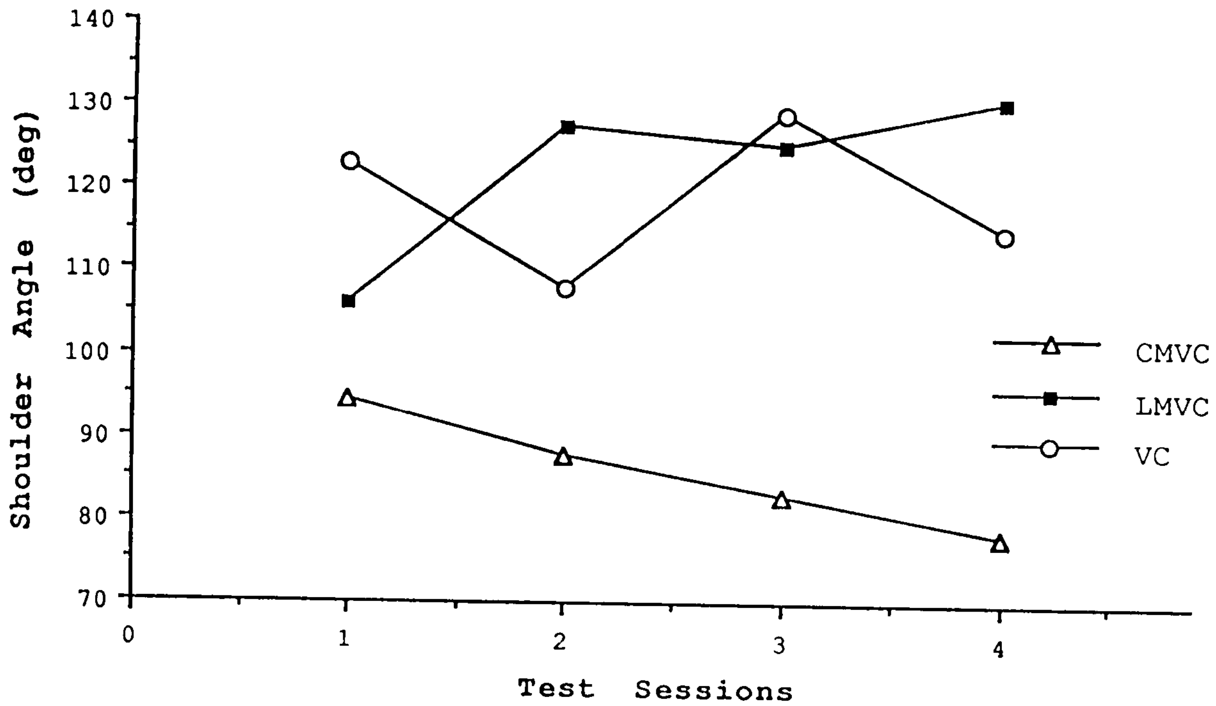

Figure 6. Graph of Mean Shoulder Joint Angle at the End of the Preparatory Phase Contributing to the Condition Main Effect.

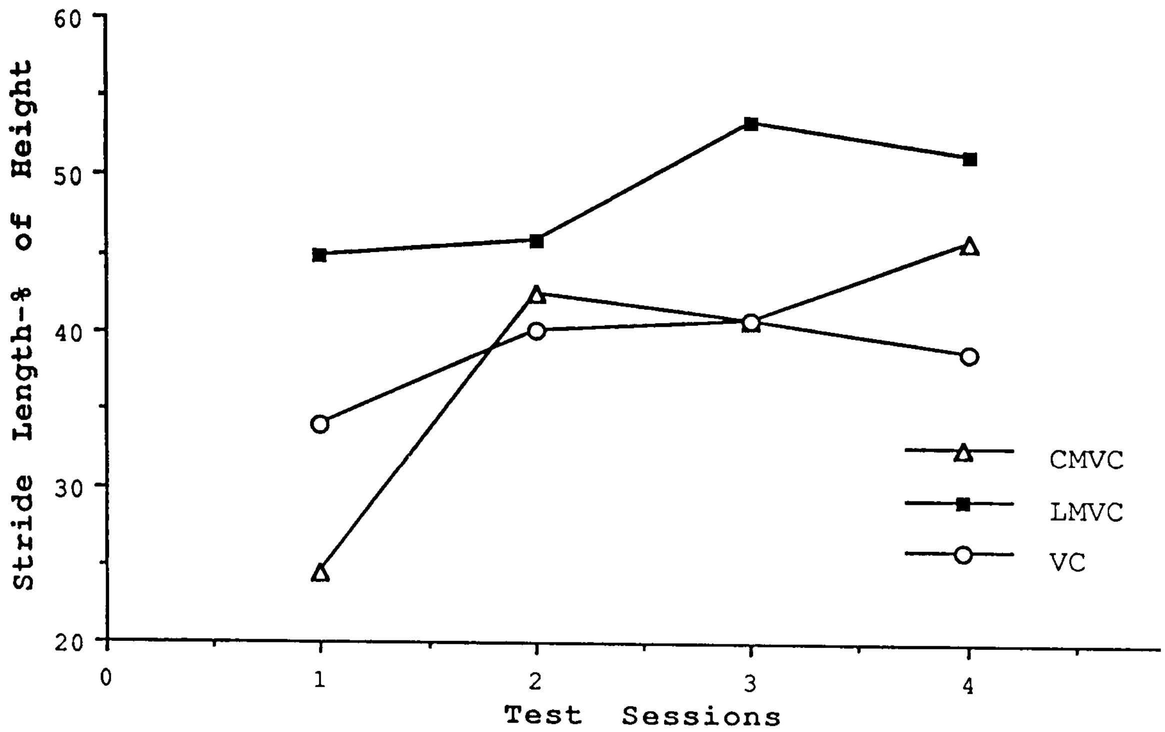

Figure 7. Graph of Mean Stride Length Measures as a Function of Condition and Test Session.

of condition and test sessions. The average stride length of subjects in all three instructional strategies increased from 34.5% (SD = 19) of height during test session one to 45.3% (SD = 14.5) of height during test session four. A mature overarm throw is characterized by a stride length which exceeds 50% of the thrower's standing height according to Roberton's component rating scale. No other significant interactions or main effects were found for the kinematic variables related to total hip displacement or ball velocity.

Discussion

The results of this study do not support the two major hypotheses regarding the effect of model type and/or progressive verbal cues. Hypothesis 1 predicted that subjects assigned to the CMVC instructional strategy would achieve higher scores on the measures of quality of movement reproduction, quality of cognitive representation and, performance outcome when compared to the LMVC or VC instructional strategy on each successive test session.

One measurement reflecting the quality of movement reproduction was throwing form scores based on Roberton's component scale. The quality of cognitive representation was reflected in the dynamic and static cognitive recognition measurements while ball velocity calculated at the time of release constituted the only performance outcome measure. Neither the model type by test session interaction or, model type main effect was significant for any of the three dependent variables analyzed. The DM MANOVA indicates a lack of support for hypothesis 1.

In contrast, a significant multivariate test session main effect indicated that all subjects, regardless of assigned instructional strategy, improved in throwing form based on the judges' ratings. Moreover, all subjects improved in their ability to cognitively recreate the correct throwing form, either by correctly ordering photographs of the overarm throw sequence (static cognitive representation test) or, choosing the correct throwing sequence from multiple performance (dynamic cognitive representation test). Thus, results from the multivariate analyses did not provide support for the first hypothesis.

In addition to the judges' ratings of throwing form, the quality of movement reproduction was evaluated using selected kinematic measures. Four kinematic variables were analyzed. A nonsignificant model type x test sessions interaction and a statistically nonsignificant model type main effect in the repeated measures ANOVA indicated a lack of support for the first hypothesis.

The second hypothesis predicted that subjects in the LMVC instructional strategy would achieve significantly higher scores on the measures of quality of movement reproduction, quality of cognitive representation, and performance outcome when compared to subjects receiving verbal cues only across test sessions. This hypothesis was also not supported given both a model type by test session interaction and a model type main effect in the DM MANOVA were nonsignificant. Moveover, all groups demonstrated significant improvement in the form and cognitive representation measures. No significant group differences were found in the performance outcome measure of ball velocity. The LMVC group's overall ball velocity increased from an initial first session value of 11.9 m/sec to a value of 12.3 m/sec in the final retention session, this small increase was not statistically significant. It is interesting to note however, that the LMVC group was the only group to demonstrate an overall improvement in ball velocity. In addition, a comparison of the three groups' standard deviations for ball velocity revealed that the LMVC group was the most consistent. For example, during test session four the mean ball velocity for the LMVC group was 12.1 m/sec (SD = .7) while the mean ball velocity for the CMVC and VC groups were 10.2 m/sec (SD = 1.3) and 10.9 m/sec (SD = 1.6) respectively.

Form Scores

The form scores, as rated by the judges according to Roberton's component scale for the overarm throw, were found to contribute to the performance changes across time. The actions of five major body components are described in the rating scale and include the backswing (three levels), humerus (three levels), forearm (three levels), trunk (three levels), and feet (four levels). A subject who scored at the highest level in each component received a 17 and a subject who scored at the lowest level in each component received a score of 5. All groups in the present study increased in rated throwing form by approximately one point across the four test sessions (8.16 on test session one to 8.98 on test session four). The subjects in this study did improve their throwing form, but a score of 9 would indicate that they are in the early stages of learning a mature overarm throw according to Roberton's component rating scale.

Kinematic Variables

In addition to judges' ratings of form scores, kinematic variables were analyzed to measure possible performance changes. The results related to the kinematic variable shoulder joint angle at the end of the preparatory phase revealed that subjects in the CMVC group were unable to maintain the correct upper arm (humerus) position while the subjects in the LMVC or VC groups were unable to attain the correct upper arm position. The upper arm component was rated by the judges consistently at a level one (three was the highest score), because the upper arm was positioned at an oblique angle as opposed to being at a right angle to the trunk. The kinematic data (shoulder joint angle at the end of the preparatory phase) reinforced the judges' ratings of this form component. The subjects in the LMVC and VC condition predominantly positioned the upper arm at an angle above the horizontal line of the shoulder while those in the CMVC condition angled the upper arm below the horizontal line of the shoulder. Both the kinematic data and the judges' ratings of the upper arm position indicate that the subjects were in an early stage of learning the upper arm position at the end of the preparatory phase.

The subjects' inability to maintain or attain the correct upper arm position is perhaps partially explained by the exclusion of a progressive verbal cue pertaining to the upper arm position at the end of the preparatory phase. At this time in the throwing action the ball and upper arm are behind the subject's head who now must rely on proprioceptive input from the throwing limb in order to know the position of the upper arm. Thus, it may have been helpful to include a verbal cue to focus the attention of subjects to this portion of the throw. For example, if the experimenter were to say "once the ball is behind your head make sure your elbow is not pointed up or down, but on the same level as your shoulder", then the subject would be reminded to "think" about the upper arm position at the end of the preparatory phase.

All groups demonstrated longer stride lengths across the four test sessions. This variable was perhaps the most visible in the videotape in that it was in view for a longer period of time than the other dynamic form variables concerned with angular shoulder joint angles. In addition, one of the verbal cues directed the subjects to "step forward on their left foot while turning the non-throwing side of their body toward the throwing direction". Turning the non-throwing side of the body toward the direction of the throw allows for a longer foot stride. Easy viewing of the foot stride and/or the verbal directions resulted in longer foot strides during each subsequent test session. A mature throw is characterized by a foot stride that is over fifty percent of the performer's height. The mean stride length for all subjects during test session four was 45.3% of their height and thus a mature throwing pattern was not achieved by the subjects in the foot action component.

Although the kinematic variable, total hip displacement, did not improve significantly, each groups' mean values increased across each of the four test sessions. For total hip displacement, the CMVC and LMVC group displayed greater mean values than the VC group across the four test sessions. The following three separate verbal cues related to hip rotation were presented to the children: "turn the throwing side of the body away from the direction of the throw", "make sure the non-throwing side of your body is facing the direction of the throw", and "make sure the extended non-throwing arm swings back away from the direction of the throw". These cues, in combination with the visual models, appear to have helped the children improve their total hip displacement, albeit not significantly across the four test sessions.

The results obtained from the judges' ratings and the kinematic variables indicate that the children were in the early stages of learning the overarm throw for force across the four test sessions. The early stages of learning have been described as a time when learners are becoming familiar with the spatial aspects of the movement pattern (Gentile, 1972; Marteniuk & Romanow, 1983). The first stage of learning is described by Gentile as getting the idea of the movement. At this stage the learner is getting the idea of the most appropriate movement patterns (spatial components).

The improvements observed in stride length and hip displacement suggest that the children in the present study were focusing on the spatial components of the overarm throw. Once the spatial characteristics of a skill become more accurate and consistent then the timing-based aspects such as velocity and acceleration become increasingly more accurate and consistent (Marteniuk & Romanow, 1983). The only analyzed timing-based performance measurement, ball velocity at the time of release, did not improve significantly. The subjects were in the process of becoming familiar with the spatial aspects of the overarm throw and thus, it is not surprising that ball velocity at the time of release did not increase. The results obtained from the kinematic variables suggest that subjects need more practice in order to achieve more spatially correct overarm throwing patterns.

Furthermore, the mean scores related to ball velocity at release decreased across test sessions for the subjects assigned to the CMVC and VC conditions. It was informally observed that subjects were concentrating more on their body positions at discrete points in time (i.e., spatial aspects), than on the flow and timing of the movement. For example, one of the verbal cues directed the subjects to make sure "the non-throwing arm was extended and pointed towards the throwing direction" and often the subjects would stop the flow of the throw to make sure the non-throwing arm was extended. This interruption to the flow of movement increased the overall time of the throw and thus reduced ball velocity.

A major finding in the present investigation related to the measures of cognitive acquisition. The accuracy of the cognitive representation of the overarm throw improved significantly for all subjects, irrespective of assigned experimental group. Although the accuracy of the cognitive representation improved significantly the final mean score obtained during the final test session, particularly related to the static cognitive recognition test, suggest that the subjects had not attained a completely accurate representation of the overarm throw. A perfect score was a zero and the mean score was 1.97 (SD = 1.94) for all subjects during the last test session. This result indicated that the subjects may have needed further information about the overarm throw related to the correct sequencing of the skill. The dynamic cognitive recognition test in this study further revealed that children who possess immature throwing patterns were able to recognize technical elements of proper form. A perfect score was a five and the mean score for the dynamic cognitive recognition test was 4.36 (SD = .68) for all subjects during the last test session. Just as Scully (1985) found that novice performers could recognize technical elements of correct form so too did this study indicate that children aged 8 to 10 years were able to do the same as they practiced to improve an immature movement pattern.

Theoretical Implications and Past Studies

It was surprising to find that subjects who were not provided with visual demonstrations but received only verbal cues improved in both physical performance and cognitive representation of the overarm throw. To evaluate this outcome it is important to draw upon information provided by observational learning theories (Bandura, 1986) and previous developmental modeling studies in which the researchers utilized verbal explanations of a motor task with or without a model. The findings obtained in this study related to the learning model supplemented with verbal cues are also addressed. In addition, the relative effectiveness of the two tests used to measure the accuracy of the cognitive representation are discussed.

Observational Learning Theory

Bandura proposed that verbal codes presented in conjunction with a visual demonstration are a means of symbolically coding the demonstration in memory. Symbolic coding (cognitive representation) of the information gleaned from a modeled performance is assumed to serve as a mediator for later retrieval and motor reproduction (Bandura, 1977, 1986; Sheffield, 1961). The first hypothesis of this study was based on the assumed importance of observing a correct model to gain a correct cognitive representation and thus a more correct motor reproduction. In the present study the researcher hypothesized that subjects assigned to a correct model plus progressive verbal cues condition would perform better than the subjects assigned to either a learning model plus progressive verbal cues or progressive verbal cues only conditions. All subjects were provided with the opportunity to physically practice. The physical practice provides the performer with sensory information about the movement which can then be compared to the developing cognitive representation of the motor act to identify errors in performance. As learners observe a model and practice a motor skill, the cognitive representation becomes more elaborate and accurate (Bandura, 1986). The degree of observational learning in this study was measured by both motor reproduction and cognitive representation scores. The results of this study indicated that not only did the children who viewed a correct or learning visual model but also the children given only verbal cues were able to develop a more elaborate and accurate cognitive representation. A correct visual model did not appear to be essential in the process of learning a more correct cognitive representation of a familiar coordination pattern. The overarm throw is a skill experienced by all elementary school children and thus, they are somewhat familiar with its coordination patterns.

The action of throwing was measured using a behavioral analysis (trained observer's ratings) and biomechanical techniques to provide further information about form and outcome of the overarm throw. Children demonstrating immature throwing patterns were selected as participants. All subjects' throwing abilities were rated based on Roberton's overarm throwing component scale. Subjects were rated between 6 and 11 points on a 5 to 17 point range scale. The pretest mean values for rated throwing form were as follows: CMVC = 8.5, LMVC = 8.0, and VC = 8.0. All subjects had not mastered a mature coordination pattern of the skill and it was hypothesized that subjects would benefit from visual demonstrations of mature overarm throwing. Indeed, the children in the CMVC condition did benefit from exposure to the correct model but the benefits were as great for those children in both the LMVC and VC conditions. This finding suggests that observational learning may not be the most powerful tool for teaching a motor task when the observers already have some vicarious experience with the task. The movement's coordination pattern is the vital information gleaned from a demonstrated skill (Scully & Newell, 1985) and a correct modeled demonstration would most likely have its greatest influence with a totally unfamiliar movement pattern.

Developmental Modeling Studies

In order to better understand why those children who were only provided with verbal cues improved as well as those children able to watch the skilled model, it is important to draw upon information provided by previous developmental studies. Two previous studies (McCullagh et al., 1990; Wiess et al., 1992) included verbal descriptions alone or, in conjunction with a model. The researchers of both studies also included a measurement of form performance of the motor task.

McCullagh et al. (1990) assigned children, ranging in age from 7-6 to 9-0 years, to a correct model plus verbal descriptions or a verbal description condition. The findings obtained from the McCullagh et al. study revealed that children who were presented with a correct model supplemented with verbal descriptions performed a motor skill sequence with better form than the children provided with verbal descriptions only. In the present investigation, however, all children improved in throwing form regardless of assigned condition, visual models (correct or learning) supplemented with verbal cues and verbal cues only. The difference in findings can be partially explained by examining the nature of the verbal explanations used in the earlier study.

McCullagh, Stiehl and Weiss (1990) provided verbal descriptions that gave information about "what" skills to do, while the present study used verbal cues that provided information about "how" to do the skill. The earlier study used several motor skills (i.e., bow, waist high kick, slide step) to create a sequential task and the verbal descriptions given to the children informed them about "what" skills to perform and in "what" order (i.e, "bow", "kick your right leg"). In the present study children were presented with verbal cues that described "how" the component body parts were to be coordinated to perform an overarm throw (i.e., "During the backswing of the throw, swing the throwing arm below the waist, backward, and upward to bring the ball behind the head."). Perhaps, exposure to descriptions of how to perform a motor skill partially explains why the verbal cues only group did as well as the other two groups.

In the remaining sections of this dissertation the term verbal descriptions will be assumed to mean that subjects were presented verbal explanations of "what" skills to perform and in "what" order. The term verbal cues will be assumed to mean that subjects were presented verbal explanations about "how" to perform the skill(s). Children in previous modeling studies (McCullagh et al., 1990; Weiss et al., 1992) performed already learned skills (i.e., skip, slide, hop) in a sequence and thus, verbal descriptions were sufficient. However, in the present study the children were familiar with the overarm throw, but were unable to perform it with a mature coordination pattern. Thus, verbal cues were provided to describe how to perform the critical components of a mature overarm throw.

In a more recent study (Weiss et al., 1992) children 8 to 10 years of age were placed in one of three instructional conditions, a model plus verbal descriptions, a model plus verbal descriptions and rehearsal, and verbal descriptions plus rehearsal (no model condition). The children assigned to the verbal descriptions and rehearsal group were first presented the verbal descriptions and then recited aloud the correct order of the skill sequence. The task modeled in two of the instructional conditions was a six part skill sequence. The results indicated that any of the instructional strategies equally benefited the learning of the motor task. The Weiss et al. study and the present study obtained similar findings. Regardless of the fact that Weiss et al. presented verbal descriptions and this study presented verbal cues, the groups without a visual model performed as well as the other children exposed to a visual model. Children in the Weiss et al. study were exposed to a demonstration of each skill and a verbal explanation of the form (the "how") that was desirable for each of the skills during a pretest screening of the six component subskills. Perhaps the one time exposure to verbal cues about how to perform the six skills with the correct form account for the similar findings.

To date only one other modeling study (Wiese-Bjornstal & Weiss, 1992) used a sport skill to investigate modeling effects on children's motor skill acquisition. In the 1992 study conducted by Wiese-Bjornstal and Weiss, children 7 and 8 years were assigned to one of three conditions. All subjects viewed a model performing an underhand modified softball pitch before they physically practiced. Verbal performance cues were added to the model during predetermined points in the acquisition phase. The subjects assigned to condition one viewed a model only during the first three blocks, and received a model plus verbal cues on the fourth block. Subjects in condition two received two blocks of a visual model followed by two blocks of a visual model and verbal cues. Subjects in condition three viewed the model on the first block, followed by three blocks of the visual model plus verbal cues. Thus, all subjects were exposed to a correct model plus verbal cues.

Regardless of assigned condition all subjects demonstrated improved matching of form kinematics to the model across the trial blocks. There was some evidence to suggest that two groups presented the verbal cues more often performed better than the group presented the verbal cues only once, albeit not significantly. Wiese-Bjornstal and Weiss (1992) did not include a verbal cue only group therefore comparisons to the present study are somewhat limited.

Earlier experiments with children have not used verbal cues as the sole source of information. Thus, the present study reveals some new information about the use of verbal cues only as an instructional strategy. In this study the verbal cues were presented using a part-whole methodology. For example, during day one and two the first progressive verbal cue was repeated five times followed by physical practice focusing on the first cue. The same procedure was followed for cue two through five. This method of presentation allowed the children to concentrate on one part of the overarm throw during each practice block of five throws. The procedure changed on the third day and all children heard cue one through five sequentially which was then followed by physical practice focused on putting all the cues together (the whole). Therefore, providing children with descriptions of how to perform the overarm throw and using a part-whole method of presentation influenced learning.

Learning Model Studies

None of the past developmental studies mentioned above included a learning model. To date the present study is the only investigation designed to explore the effectiveness of a learning model from a developmental perspective.

The predominant interest in the learning model studies has been the role of knowledge of results, and thus the role of verbal cueing has not been addressed in conjunction with learning models. Only one study has been conducted in which the performers were not given KR about their own performance or KR about the learning model's performance (McCullagh & Caird, 1990). McCullagh and Caird found that adult subjects who viewed either a correct model or, a learning model but did not receive KR about their own movement performed equivalently. However, neither group significantly improved performance. The children in this study who viewed either a correct or learning model, in conjunction with verbal cues not only performed equivalently but both groups demonstrated improved motor reproduction and cognitive representation. In the present investigation knowledge of results and knowledge of performance were not given after physical practice trials and yet significant improvement in performance was noted across test sessions. In addition, the children improved in their cognitive representation of the overarm throw in the absence of feedback from the investigator regarding the correctness of the response.

It has been proposed (Adams, 1986; Pollock & Lee, 1992) that the use of a learning model involves the observer in problem-solving activities which develop, among other things, error recognition and correction abilities. This is due to the fact that the performance of a learning model is not correct and thus discourages imitation. It is reasonable to assume that exposure to a learning model plus verbal cues at a young developmental level may require greater amounts of information to be processed in comparison to exposure to the correct model plus verbal cues. When greater amounts of information need to be processed the possible result is a poor cognitive representation of the skill and poor skill learning.

However, children 8 and 9 years benefited by viewing a learning model supplemented with verbal cues. The children assigned to the LMVC group formed a more correct cognitive representation of the overarm throw and improved physical performance. The children were given a correct verbal cue before the learning model performed the throw. Under this condition the observer can focus attention on one critical component of the throw to see if the learning model demonstrates the component correctly. Perhaps the use of verbal cues in conjunction with the learning model further assisted the children in their problem-solving activities.

Cognitive Representation

Observational learning studies conducted by Carroll and Bandura (1990) and Wiese-Bjornstal and Weiss (1992) included a measurement to describe the accuracy of the cognitive representation (a covert process) which Bandura (1986) assumes guides the motor reproduction (an overt response). Carroll and Bandura used a static cognitive recognition test comprised of nine photographs depicting each component of a nine-part-wrist-arm paddle motion. The subjects were asked to arrange randomly ordered photographs into the correct sequence (pictorial-arrangement test). The accuracy of the cognitive representation was scored according to the number of pictures placed in the correct sequence.

Unlike Carroll and Bandura's use of still photographs, Wiese-Bjornstal and Weiss presented subjects with a dynamic cognitive recognition test. In their study, subjects were asked to select the correct demonstration from four videotaped presentations. Only one of the videotaped presentations showed the correct method of executing the skill while the other three presentations showed partially incorrect demonstrations. The authors' rationale for including the dynamically based test was that this method of testing may be more perceptually relevant when a relatively fast action sport skill is demonstrated by a model. The results of both studies (Carroll & Bandura, 1990; Wiese-Bjornstal & Weiss, 1992) indicated that viewing a correct model and hearing verbal cues increased the accuracy of the cognitive representation.

The present study incorporated both the pictorial arrangement test and the dynamic cognitive recognition test for the purpose of comparing the relative effectiveness of the two measurement tools in describing the conception of a motor skill. In this investigation both tests yielded similar results. The accuracy of the cognitive representation significantly improved for all children, whether it was assessed using a static or dynamic cognitive recognition test.

Practical Implications

In the present study children aged 8 to 10 years performed the overarm throw equivalently whether they observed a learning model supplemented with verbal cues, a correct model supplemented with verbal cues, or heard verbal cues only. From a practical perspective, this finding offers the instructor a choice of instructional strategies which can be employed with children during the early stages of learning a motor skill.

Most coaches and teachers opt to use only a correct model, but another option for teachers is to present verbal cues to a learning model while other children observe. The students who observed could be prompted to become involved in problem-solving activities by deciding whether or not the learning student practicing the skill is performing the critical component correctly as described by the teacher.

The overarm throw is often considered a fundamental motor skill in elementary physical education textbooks (Gallagher, 1987; Thomas, Lee, & Thomas, 1988), but it is a complex task when one considers that children must coordinate many body and limb movements in order to perform a mature overarm throw. When a complex task, like the overarm throw for force is being taught, a part-whole method of verbal cue presentation is one choice of instructional strategy applications. To use the part-whole method of verbal cue presentation, introduce only one verbal cue at a time to prevent information overload. This allows children to focus their attention on one critical component of the skill. Later on in the learning process present all the verbal cues in a progressive order to give children the opportunity to focus on putting all the critical components of the skill together smoothly. The verbal cues could be presented to the children by the teacher or the teacher could use a partner strategy and ask children to present the teacher's "how" to verbal cues to their partner using a part-whole method of presentation.

CHAPTER V. SUMMARY AND CONCLUSION

This study investigated the effectiveness of three instructional strategies: correct model plus progressive verbal cues, learning model plus progressive verbal cues, and progressive verbal cues only. The present study also investigated a real-world sport skill and used both a pictorial-arrangement test and a dynamic cognitive recognition test to describe the quality of the cognitive representation. In addition, the performance of an overarm throw was evaluated using both a behavioral analysis (trained observer's ratings) and biomechanical techniques to provide information about form and outcome. This multidimensional approach described both the overt and covert effects of various instructional strategies.

Subjects in this study were 36 preadolescent female volunteers. Subjects were randomly assigned to one of the three instructional strategies. All subjects heard the progressive verbal cues whether assigned to a model (correct/learning) or no model. The first verbal cue was repeated five times followed by physical practice focusing on the first cue. This procedure was followed for cue two through five. The procedure changed on the third day and all children heard cue one through five sequentially and then physically practiced the overarm throw focusing on putting all the cues together.

In order to determine whether any changes occurred in throwing form across the practice sessions, each subject performed five physical practice trials of throwing overarm in the absence of either model type and/or progressive verbal cues at the beginning of each session. The static and dynamic cognitive recognition tests were also completed by all subjects prior to exposure to models and/or verbal cues. All subjects were videotaped using three cameras during the performance of the five throwing trials. The three tests administered during day one provided the initial performance data while subsequent administration of the tests on days two and three measured stages of learning. Day four was a rest day and on day five the final set of tests, constituting a delayed retention test, were administered.

The results did not provide support for the hypothesis that children assigned to the CMVC instructional strategy would best perform the overarm throw and possess the most accurate cognitive representation of the throw when compared to children assigned to the other two instructional strategies. In addition, the results did not provide support for a second hypothesis that children assigned to the LMVC instructional strategy would perform the overarm throw better and possess a more accurate cognitive representation than the verbal cues only instructional strategy. The researcher found that all three instructional strategies assisted the learner in achieving of a more accurate cognitive representation and the ability to reproduce a more mature overarm throwing pattern.

The results obtained from the kinematic variables failed to show any statistically significant improvement in performance of the overarm throw. This finding can be partially attributed to the small sample size in each group (n = 5) and the small number of throwing trials analyzed at each test session (n = 2). However, the stride length just failed a test session main effect and the trends observed revealed increased stride length and hip displacement for all subjects across the four test sessions, regardless of assigned instructional strategy.

In conclusion, this study revealed the importance of descriptive verbal cues that explain the critical transitional positions of the body throughout the coordinated movement. When the verbal cues are developmentally appropriate and carefully presented in a manner which progressively allows children to focus on the various critical components of a skill, motor skill learning is enhanced. In addition, observing a learning model who demonstrates movement errors is not detrimental to the viewer's learning of the skill. In this study, children who observed a learning model supplemented with critical component verbal cues also demonstrated significantly improved throwing form and cognitive representation of the overarm throw. A learning model facilitates the improved performance of a familiar motor skill when all observers also receive progressive verbal cues, calling into question recommendations made to practitioners concerning the use of skilled models only (Christina & Corcos, 1988; Magill, 1989).

Directions for Future Research

Several lines of future research can be suggested. First, more multidimensional studies are needed that investigate the effects of instructional strategies by assessing motor skill form, outcome and the quality of the cognitive representation of the skill. Second, more studies are needed to look at enduring learning effects. The design of this study employed two 1-day retention tests and a 2-day retention test to allow practice effects to dissipate and test for learning in the absence of modeling and/or verbal cues. Third, it would be important to obtain more information about the observational learning of a motor task with a learning versus a correct model from a developmental perspective. Finally, more studies with progressive verbal cues as the sole source of information need to be conducted with children who are at various stages of development.

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APPENDICES

APPENDIX A

ROBERTON'S COMPONENT RATING SCALE OF THE OVERARM THROW FOR FORCE

Preparatory Arm Backswing Component	
Level 1	No backswing. Ball in hand moves directly forward to release from its position when hand first grasped ball.
Level 2	Elbow and humeral flexion. Ball moves away from intended line of flight to position behind or alongside head by upward flexion of humerus and concomitant elbow flexion.
Level 3	Circular, upward backswing. Ball moves away from intended line of flight to position behind head via circular overhead movement with elbow extended, or oblique swing back or vertical lift from hip.
Level 4	Circular, downward backswing. Ball moves away from intended line of flight to position behind head via circular, down and back motion that carries hand below waist.

Humerus (Upper Arm) Action Component	
Level 1	Humerus oblique. Humerus moves forward for ball's release in plane that intersects trunk obliquely above or below horizontal line of shoulders. Occasionally during backswing, humerus is place at right angle to trunk, with elbow pointing toward target. It maintains this fixed position during throw.
Level 2	Humerus aligned but independent. Humerus moves forward for ball's release in plane horizontally aligned with shoulder, forming right angle between humerus and trunk. By time shoulders (upper spine) reach front facing, humerus (elbow) has moved independently ahead of outline of body (as seen from side) via horizontal adduction at shoulder.

Level 3	Humerus lags. Humerus moves forward for ball's release and is horizontally aligned, but at moment shoulder (upper spine) reach front facing, humerus remains within outline of body (as seen from side). No horizontal adduction of humerus occurs before front facing.

Forearm Action Component

Level 1	No forearm lag. Forearm and ball move steadily forward to release throughout throwing action.
Level 2	Forearm lag. Forearm and ball appear to lag (i.e., to remain stationary behind the child or to move downward or backward in relation to his body). Lagging forearm reaches its farthest point back, deepest point down, or last stationary point before shoulders (upper spine) reach front facing.
Level 3	Delayed forearm lag. Lagging forearm delays reaching its final point of lag until moment of front facing.

Trunk (Pelvis-Spine) Action Component

Level 1	No trunk action or forward-backward movements. Only arm is active in throw. Sometimes forward thrust of arm pulls trunk into passive left rotation (assuming a right-handed throw), but no twist-up precedes that action. If trunk action occurs, it accompanies forward thrust of arm by flexing forward at hips. Preparatory extension sometimes precedes forward hip flexion.
Level 2	Upper trunk rotation or total trunk block rotation. Spine and pelvis both rotate away from intended line of flight and then simultaneously begin forward rotation, acting as unit or block. Occasionally, only upper spine twists away and then twists toward direction of force. Pelvis then remains fixed, facing line of flight, or joins rotary movement after forward spinal rotation has begun.
Level 3	Differentiated rotation of trunk. Pelvis precedes upper spine in initiating forward rotation. Child twists away from intended line of ball flight and then begins forward rotation with pelvis while upper spine is still twisting away.

Foot Action Component	
Level 1	No movement. Child throws from whatever position feet happen to be in.
Level 2	Child steps with foot on same side as throwing hand.
Level 3	Child steps with foot on opposite side from throwing hand.
Level 4	Child steps with opposite foot a distance of over half his standing height.

Table developed by M.A. Roberton and presented in the text "Motor development during childhood and adolescence" (p. 74) edited by J. R. Thomas, (1984), Minneapolis, MN: Burgess.

APPENDIX B

SALEM-KEIZER AND CORVALLIS SCHOOL DISTRICT RESEARCH PROJECTS

1) Describe the purpose of the project, give an estimate of the timeline, and indicate the school(s) and class level(s) to be involved.

The purpose of this study is to examine, through a developmental approach, the influence of observing different types of visual demonstrations on learning an overarm throw for force. The students will be repeatedly exposed to one of two model types, one model will demonstrate the correct method of throwing (mastery model) with as much force as possible and the other model will be learning and demonstrate improving throwing patterns (coping model). The proposed research will incorporate the use of three dimensional film analysis to measure coordination changes as a function of age and exposure to a model type. Preadolescent (8-0 to 10-0 years of age) and adolescent (13-0 to 15-0 years of age) girls who possess an immature throwing pattern will serve as the subjects in the study.

The estimated timeline would involve a child in four half hour sessions over a four day period to take place after school hours in the school's gymnasium.

Physical educators at the following schools have consented to screen and solicit subjects for the study: Bush Elementary, Liberty Elementary, Rosedale Elementary, Wilson Elementary, and Garfield Elementary School.

2) Describe the time, resources, and energies of District personnel who may be involved in the study.

Physical educators will need to evaluate the skill level of the overarm throw for force with Roberton's rating scale and solicit volunteer students. In addition parental consent forms will be given to the students by the physical educator. The researcher will schedule the research sessions for each student at their convenience.

3) Describe the value of the results of such project to the educational goals in general and those of the District in particular.

The value of increased opportunities for students with poor fundamental motor skills to practice and view demonstrations enables them to improve a skill. The overarm throw is a foundational movement skill that forms the cornerstone of many game skills. Furthermore, the ability to throw forcefully with a mature pattern is an underlying skill for more complex sport skills (i.e., the tennis serve, volleyball serve, overhead stokes in tennis, badminton, and racquetball).

4) Describe how the project may serve the needs of the District, particularly in the areas of learning, instruction, leadership, and school facilities.

The project can assist the District in the area of learning by systematically evaluating the effect of model types on different age groups. The instructional strategy of using only a skilled model to demonstrate how to perform a motor skill may be brought into question as a result of this study. In addition, research on observational learning in motor skill acquisition is limited and this project can add to the knowledge base of this subject matter.

The videotapes of the correct and learning models' demonstrations may be useful tools of instruction for the participating school's physical educator. Finally, the physical education teachers involved in this study can take leadership roles by sharing and presenting the findings within the department, the district, and possibly at state conferences in physical education.

5) Describe the degree to which such project would interfere with normal classroom operations.

This project will minimally interfere with classroom operations. The students who volunteer to take part in this research project will be participating outside of classroom time.

Name of Person Requesting Research Project:________________

Mailing Address:____

Phone Number(s):
Date:_________________________________

****

____ Project is accepted ____ Project is not accepted

Building Principal Signature__________________________
Date__________

APPENDIX C

SUBJECT'S CONSENT FORM

Debbie Adams, who is a doctoral student at Oregon State University, has requested my minor child's (ward's) participation in a research study. The title of the research is modeling effects using a standard and a learning model demonstrating an overarm throw for force.

I have been informed that the purpose of the research is to determine the effectiveness of different types of visual demonstrations on learning an overarm throw. The researcher will measure the learning of a forceful overarm throw with a subjective rating form which describes levels of throwing motion maturity. In addition, throwing coordination changes will be measured by using three dimensional film analysis.

My child's (ward's) participation will be supervised by Ms Debbie Adams, a doctoral candidate, and a female research assistant. Participation will involve being filmed by three video cameras simultaneously from various side angles while throwing a tennis ball with as much force as possible in the direction of a gymnasium wall 50 feet away. My child's (ward's) participation in the investigation will involve four separate filming sessions consisting of three 30-45 minute sessions and one 10 minute session according across a five day period. Day four will be a rest day. During the testing procedures my child (ward) will be filmed in the presence of the principal investigator (Debbie Adams) and a female research assistant only.

I have been informed that my child (ward) will be given a five minute warm-up involving jogging and light stretching of muscles pertinent to throwing a ball with as much force as possible prior to each filming session. I have been advised that the research project in which my child (ward) will be participating involves minimal risk or discomfort (i.e., muscle soreness).

I understand that the possible benefits of my child's (ward's) participation in the research is an opportunity to practice and improve a sport skill and it is believed that this study may help towards a greater understanding of motor skill learning.

I understand that in order to maintain confidentiality of my child's (ward's) records, Debbie Adams will assign code numbers to each child. The names and codes will be kept and secured by Debbie Adams, who will be the only investigator to have access to this information. The film of a few selected subjects will be shown at the dissertation defense and professional conferences. Subjects' true names will <u>not</u> be used during the presentations. In the event that my child's (ward's) filmed data is selected, I consent to showing the film of my child (ward) at the dissertation defense and/or professional conferences.

I have been informed that any questions I have concerning the research study, my child's (ward's) rights, or research-related injuries should be directed to Debbie Adams (W: 737-6791 or H: 581-1803).

I have read the above information. The nature, demands, risks, and benefits of the research have been explained to be. I knowingly assume the risks involved, and understand that **I may withdraw my consent and child (ward) from participation at any time** without penalty or loss of benefit to my child (ward).

Parent's or legal guardian's signature____________________

Date________________________________

APPENDIX D

APPLICATION FOR APPROVAL OF THE OSU HUMAN SUBJECTS BOARD

1. SIGNIFICANCE OF THE RESEARCH PROJECT

The purpose of this study is to examine, through a developmental approach, the influence of observing a standard or learning model demonstrate an overarm throw for force. The contribution of progressive verbal cueing alone, or in conjunction with each of the two model types will also be investigated. The learning model will begin the demonstration as an unskilled model, but through practice will improve her performance and thus, the demonstrations progress towards a more correct form of the overarm throw for force. The standard model will possess and demonstrate a mature overarm throw for force. All experimental groups will receive identical verbal cues. The proposed research will incorporate a subjective measurement evaluation based on Roberton's throwing form instrument (Appendix A) and three dimensional film analysis to measure coordination changes as a function of model type. This research expands the current literature in at least two areas: (a) the investigation of motor skill acquisition and retention has never been evaluated through three dimensional film analysis and (b) empirical evidence is needed which addresses the issue of learning models as a teaching aid for improving the motor skills of children.

2. METHODS AND PROCEDURES

A. Developing the Standard and Learning Models

Videotape of the models will be prepared in advance and will be presented to the designated experimental group throughout the course of the practice sessions. The standard and the learning model will be filmed throwing a tennis ball overarm for force at a wall 50 feet away.

A 12 year old female who exhibits a mature right-handed overarm throwing motion will serve as the standard model. The standard model will be filmed until five correct performances can be selected from the model's attempts. The filming session of the correct model will take approximately 30-45 minutes. After standard model's demonstrations are on film, the learning model's demonstrations will be taped.

A 12 year old female who exhibits an immature right-handed overarm throwing motion will serve as the learning model. The learning model will be given different verbal cues prior to each view of the correct model's five throwing demonstrations and then the learning model will be filmed throwing five physical practice trials. This protocol will be repeated four more times. Each day will consist of five practice blocks of five trials (n=25). Three practice sessions will be held across three days and each day of filming will take approximately 30-45 minutes.

Both the standard and learning model's overarm throwing performance will be videotaped using three cameras simultaneously (See Figure D-1). The subjects will view only the form demonstrated by either model type from the videotape recorded with camera two. The videotaped data obtained from cameras one and three will be used to obtained kinematic measurements through three dimensional analysis.

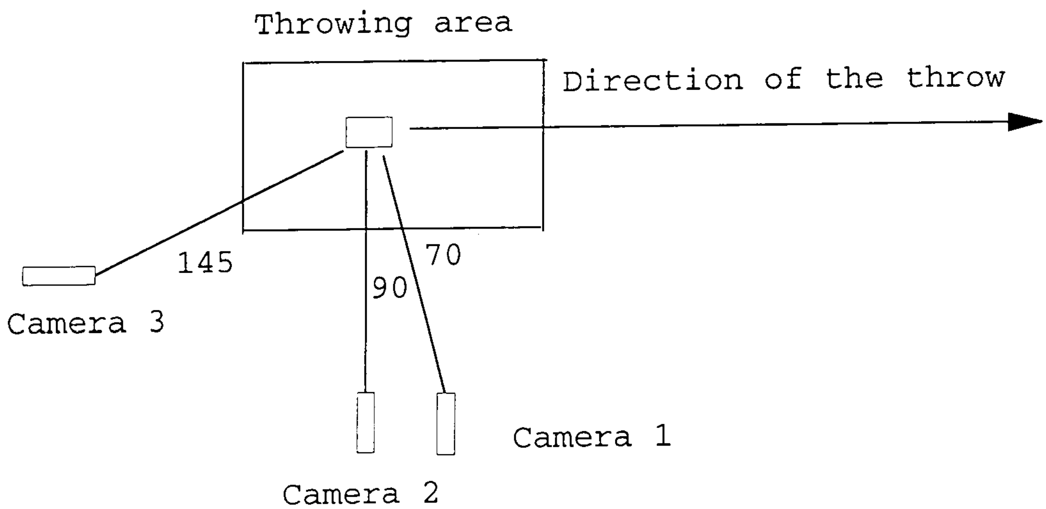

Figure D-1. Camera Positions

B. Experimental Protocol

The subjects will be randomly assigned to either one of the two model types or the verbal cues only group. Before each block of practice trials, the subjects presented either the standard or learning model will view five demonstrated throws and hear the progressive cues, while subjects assigned to the progressive verbal cues condition will only hear the cues. Three practice sessions will be held and each practice session will consist of five blocks of five practice trials. The investigation will take place after school hours and each subject will be dressed for activity.

During physical practice each subject will be throwing a tennis ball with as much force as possible in the direction of the opposite gymnasium wall at least 50 feet from the subject. A warm-up consisting of light stretching activities and three submaximal effort practice trials will be completed before subjects and models are filmed performing maximal effort practice trials. The testing and experimental protocol for each subject will take approximately 30-45 minutes on day one, two, and three with a rest day given on day four. A post-test will be administered on day five taking approximately 10 minutes.

The post-test on day five and pre-tests on day one, two, and three will consist of five throws filmed for later analysis. The subjects will be filmed from a 90 degree angle and this videotape will be utilized by two expert judges to rate each subject's throwing pattern based on Roberton's rating form (Appendix A). In addition, two cameras at 70 and 145 degrees to the plane of the throwing motion will be simultaneously filming the test trials for later three dimensional analysis (Figure D-1).

3. RISKS AND/OR BENEFITS TO SUBJECTS

To ensure that each subject is physiologically ready to perform maximal effort throws; each subject will be guided through a five minute warm-up each day involving jogging to increase the muscle temperature followed by stretching exercises pertinent to the throwing muscles prior to the start of the filming session. Only a female student researcher and a female assistant researcher will be present during the testing procedures. A potential benefit is that the results of the study may provide useful information related to the effects of model proficiency on improvement of a fundamental motor skill.

4. SUBJECTS

A total of 36 female student volunteers from the Corvallis and Salem public schools ranging in age 8 to 10 years will be solicited in order to investigate the effects of observational learning in preadolescent populations. Only right-handed girls with a level one or level two (Appendix A) throwing ability in the following three components will be selected for inclusion in the study: humerus action, forearm action, and trunk action. Each subject will be accessed by their physical educator according to Roberton's component rating scale (Appendix A) for the overarm throw for force. Females were chosen as subjects since heterogeneous distinctions exists between male and female throwing abilities. Both cross-sectional and longitudinal studies have repeatedly shown that males, beginning at age 7

APPENDIX E

PILOT STUDIES

Several pilot studies were conducted to ascertain the optimal protocol for the study. The first three pilot studies were conducted in order to attempt various camera angles, appropriate shutter factors and lighting conditions. From these studies the most critical element was the establishment of optimal camera angles. It is important that the body parts (i.e., elbow of the throwing arm) to be digitized are visible from at least one camera angle throughout the overarm throwing motion. This allows for more accurate digitizing of the selected body markers. The primary decision reached was to place one camera at 70 degrees and the second camera at 145 degrees to the plane of motion. At this position both cameras captured the best view of the throwing arm throughout the motion accept during the follow-through. For this study, the follow-through of the overarm throw was not deemed an important component to analyze.

Two pilot studies were to conducted to test the most effective verbal cues. One set of verbal cues included imagery cues. For example, one of the verbal cues was stated as follows: "during the backswing of the throw spread your arms out like wings". This cue and other similar imagery cues were often misinterpreted by the two subjects (8-0 and 8-9) tested with the first set of verbal cues. To illustrate one of the subjects spread her arms out from her sides while facing the direction of the throw. The subject emphasized bird movement imitation and failed to relate the "spread of wings" image to the position of the arms after turning the non-throwing side away from the throwing direction. A second set of cues were written and tested with two different subjects (8-3 and 8-6). The subjects approximately enacted the instructions presented to them by the experimenter and demonstrated an understanding of each verbal cue. Further questioning by the experimenter revealed that both children comprehended what each verbal cue described. The final verbal cues used in the protocol are listed in chapter three.