

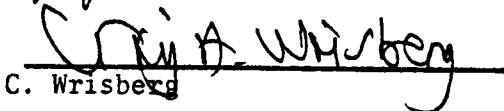
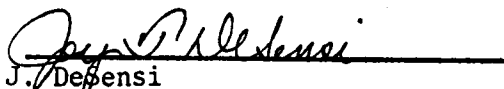
To the Graduate Council:

I am submitting herewith a thesis written by Yon T. Armstrong entitled "The Effects of Forward-Chaining, Backward-Chaining, and Random Feedback on Learning the Tennis Forehand Groundstroke." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Human Performance and Sports Studies.



Patricia A. Beitel, Major Professor

We have read this thesis
and recommend its acceptance:



Accepted for the Council:



Associate Vice Chancellor and
Dean of The Graduate School

**THE EFFECTS OF FORWARD-CHAINING, BACKWARD-CHAINING, AND
RANDOM FEEDBACK ON LEARNING THE TENNIS FOREHAND
GROUNDSTROKE**

**A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville**

**Yon T. Armstrong
May 1997**

**To my parents
Brady and Danute Armstrong,
to my great friends from coast to coast,
and to my music collection,
whose support, encouragement, love,
and confidence have made this pursuit a reality.**

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ABSTRACT

The purpose of this study was to determine the relative effects of sequencing knowledge of performance (KP) feedback on the learning of an applied motor skill, the tennis forehand groundstroke. The KP independent variables were: (a) forward-chaining KP, (b) backward-chaining KP, and (c) random KP. The learning and performance of this motor skill was determined by five movement form measures and one outcome measure. They included the following: (a) ready position, (b) eye contact, (c) hip and shoulder turn, (d) weight transfer, (e) follow through, and (f) outcome score. Thirty-six participants, 19 females and 17 males, ranging in age from 19-42, served as volunteers for this study. A 3 x 5 RMD ANOVA ($p = .05$) was used to investigate the differences between feedback groups and practice sessions in the form of quality (mean) and variability (standard deviation) scores. A Newman-Keuls post hoc procedure ($p = .05$) was utilized to analyze all possible pairwise comparisons for significant main effects and the one significant interaction.

The repeated measures design analysis of variance and post hoc tests indicated the following results: (a) the backward-chaining KP participants had significantly lower variability in their weight transfer form than the forward-chaining KP and random KP groups, (b) no significant differences were found between feedback groups in terms of their quality of performance scores, (c) hip and shoulder turn form improved significantly more under the forward-chaining KP and random KP conditions compared to the backward-chaining KP condition during Sessions 3 and 4, (d) hip and shoulder turn form was significantly better for the random KP group than for the other feedback

groups, (e) for all the movement form measures, there was a significant improvement in their movement form from the first practice session to second practice session, and (f) all the participants significantly improved in the quality of their outcome scores during the retention test as compared to the four preceding practice sessions. Taken together, the three KP feedback methods are comparable for teaching novice students a complex motor skill like the forehand groundstroke. However, specific evidence in this study suggested that using a random KP and backward-chaining KP method might benefit learning more than forward-chaining KP. Therefore, teachers should use integrated methods to instruct complex motor skills.

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CHAPTER I

INTRODUCTION

A student of sport skills learns through practice. The arrangement of practice and the nature of information presented to the performer influences learning (Magill, 1993; Chamberlin & Lee, 1993). An interesting question practitioners and researchers espouse on learning motor skills is which types of performance information should a teacher provide to optimize learning. In the field of motor learning, an important component concerns how information in the form of teacher feedback affects learning (Kernodle & Carlton, 1992). Teacher feedback has been studied in the form of knowledge of results (KR) and knowledge of performance (KP). These feedback variables give the learner information on either the outcome of their movement (KR) or on characteristics of their movement pattern (KP) respectively (Schmidt & Young, 1991). In order to understand how these types of feedback affect learning, one must test the acquisition, retention, and transfer of a particular motor skill.

Several recent feedback studies have revealed that KP improves performance more effectively than does KR (Kernodle & Carlton, 1992; Boyce, 1993; Pellett, Henschel-Pellett, & Harrison, 1994). However, when KP is defined in specific ways such as attention-focusing cues and transitional information cues, the latter seems to be most critical for learning. Thus, it appears that different parts of KP feedback should be identified so that teachers and coaches can implement optimum motor learning environments (Schmidt & Young, 1991).

The nature of KP feedback has been explored in few motor learning studies

(Kernodle & Carlton, 1992). Most of the KP literature examines general feedback techniques such as modeling, kinematics, and videotaping (Pollock & Lee, 1992). Kernodle and Carlton (1992) investigated KP by analyzing two parts of this feedback on throwing. They found significant improvements in throwing distance for learners who received KP in the form of transitional information. This type of KP information would present the learner with, "information about what to change and how to change the next movement" (p. 188).

More recently, the results of three studies supported the effectiveness of utilizing KP feedback in motor learning settings (Boyce, 1992; Pellett, Henschel-Pellett, & Harrison, 1994; Cutton, 1994). Boyce (1992) found enhanced rifle shooting performance from two types of teaching that emphasized KP. These teaching styles had the learner focus on specific characteristics of their movement before and after each performance trial. In addition, Pellet et al. (1994) revealed that KP improved the performance of volleyball skills such as the serve, set, and forearm pass. The KP feedback was measured by examining videotapes of volleyball teachers and recording the amount of specific corrective instruction presented to the students. Also, Cutton (1994) provided evidence for the effectiveness of KP in motor learning settings by demonstrating performance improvements on the tennis forehand groundstroke.

Even though studies on KP seem to indicate the viability of this type of information on motor learning, there is a paucity of research on the nature of this type of feedback. The fact that several research studies have been conducted supporting KP as an effective tool for facilitating the acquisition of motor skills, raises questions about how

this variable should be utilized in the field of pedagogy. It seems that questions concerning the precise effectiveness and presentation of KP need to be pursued. Most of the motor learning studies on KP do not seem to indicate whether this feedback variable needs to change depending on the motor skill. For example, if the skill is open or closed, continuous rather than serial, then perhaps different types of KP would be more effective for learning.

Research in motor learning has offered practitioners several different frameworks explaining how their feedback can be an effective motor learning tool (French, Rink, Rikard, Mays, Lynn, & Werner, 1991). One explanation in the literature is called whole-versus-part teaching method. This method has the teacher analyze the motor skill task in complexity and organization. If the task is complex in terms of its movement and goal, then subdividing the task into simpler parts would be best for learning. A teacher might decide to arrange and structure their feedback according to the complexity level of the motor task. For example, a part-whole teaching method advocated by some tennis professionals is to provide movement pattern feedback on different parts of the complex motor skills of the tennis forehand and backhand groundstrokes (Parks, 1990). Furthermore, the teacher divides these strokes into beginning, middle, and end components, and delivers movement feedback to the novice based on these parts.

A second framework to consider when teaching motor skills is the schema theory (Schmidt, 1975). This theory suggests that motor skills are learned when the student strengthens four sources of information about the movement skill. These sources of information include initial conditions, sensory consequences, response specifications, and

movement outcome. The theory predicts that when students practice a motor skill by using variations of these sources of information, a stronger "schema" or generalized motor program (GMP) will be produced. Thus, if feedback directs the learner's attention towards these sources of information, then motor skill learning should be enhanced (Schmidt, 1975). For example, in tennis teaching environments, it is common for the teacher to direct the learner's attention to variations of sensory consequences and spatial requirements of a movement pattern. Specifically, the teacher might vary the learner's attention from the end parts of their movement (i.e., "focus on freezing and feeling your follow through out in front and above your left shoulder") to middle or beginning parts of their movement pattern (i.e., "focus and feel your shoulders and hips turning") during a series of practice trials in a lesson. Possibly, by delivering this type of KP feedback in these varying ways, the results would lead to enhanced motor learning by developing a stronger GMP.

There has been some anecdotal and laboratory evidence in the motor learning literature that supports the notion of specifying an end location for a movement. (MacNeilage, 1970; Polit & Bizzi, 1978; Schmidt & McGown, 1980; Parks, 1991). Perhaps by selecting an end location for a movement, the learner's muscles may "pre-set" this location in their central nervous system (MacNeilage, 1970). In field settings, many tennis teachers advocate teaching novice students the requisite motor skills by focusing on the end movements first. They structure and deliver their feedback using a practice technique called backward-chaining (Parks, 1990). This involves providing KP feedback to the novice student progressively from the end of their movement to the beginning of

their movement pattern. Possibly, by providing feedback in this sequence, the student is forced to attend to variations of the motor task, enhancing the development of the GMP. Another explanation might be that this sequence of feedback engages the learner in a part to whole progressive process. The learner would be able to piece together the movement over time. More specifically, as the learner performs practice trials, their attention becomes focused on earlier and easier aspects of the movement response, until they have experienced attending to most parts of the movement (Welsh, Fitt, & Thompson, 1994). Thus, at the end of this process, the learner would have a feel for the whole movement.

The inverse of backward-chaining is forward-chaining (Ashe & Holding, 1990). In Ash and Holding's study, the effects of forward and backward-chaining on the learning of piano scores was investigated. They found that students following the forward-chaining method outperformed the students using the backward-chaining method. However, in their investigation, the forward and backward-chaining variables were defined in terms of progressions of difficulty. That is, students would learn a piano score by practicing either an easy-to-difficult order (forward-chaining) or a difficult-to-easy order (backward-chaining). Unfortunately, no studies have examined these variables defined in terms of teacher feedback. This leads to the question of whether the timing and sequence of feedback for a complex movement is relevant to facilitate and optimize learning. Clearly, practitioners in complex motor learning settings seem to follow patterned procedures for beginner level students (Parks, 1990). It seems germane to student achievement in motor skills to determine whether specific teacher feedback, in the form of timing and sequencing, enhances the learning of a novel serial movement.

Another important issue concerning feedback research is that the majority of studies have been conducted using closed motor skills in laboratory settings (Pollock & Lee, 1992; Winstein, Pohl, & Lewthwaite, 1994). This fact concerns practitioners on whether these findings can be applied to their particular physical education classes or sport settings (Wrisberg, Dale, Liu, & Reed, 1995). By differentiating KP into several parts, this study intends to contribute to the future of motor skill pedagogy in more precise, scientifically-based teaching approaches, specifically for tennis.

Statement of Purpose

The purpose of this study was to determine the relative effects of sequencing KP feedback on the learning of an applied motor skill, the tennis forehand groundstroke. More specifically, do forward-chaining KP, backward-chaining KP, and random KP differentially affect the movement performances and results of the tennis forehand groundstroke from a preassigned spot on the tennis court?

Research Questions

After performing the practice trials as well as the post-test performance trials, the following research questions were addressed in this study:

1. Was there a difference among forward-chaining KP, backward-chaining KP, and random KP groups on the tennis forehand groundstroke performance of college participants from a preassigned spot during the acquisition and retention trials?
2. Was there a difference across practice sessions on the tennis forehand groundstroke performance of college participants from a preassigned spot on the tennis court?
3. Would there be an interaction between the KP feedback groups, forward-chaining KP,

backward-chaining KP, and random KP , and the five practice sessions (pre-test, acquisition sessions, and retention session) on the tennis forehand groundstroke performance of college participants?

Definition of Terms

Knowledge of Performance Feedback (KP) - a type of augmented feedback referring to information that describes a movement or parts of a movement pattern that led to a certain outcome of a response (Magill, 1993). For example, a participant in this study would be given KP when told to, “focus on freezing your follow through”. In this study, KP will be provided in the form of verbal movement pattern information in the following three ways.

1. Forward-Chaining KP - a method of giving KP where the instructor progressively delivers information about the performance concerning the early components of the movement to the later components of the movement. For example, the instructor has the student focus on the earliest parts of the movement. Then, the instructor has the student focus on middle parts, and finally the end parts of the movement. In this study, forward-chaining KP was defined by the tennis instructor (Appendix A).

2. Backward-Chaining KP - a method for giving KP where the instructor progressively delivers information about the performance concerning the later components of the movement to the early components of the movement. First, the instructor has the student focus on the end parts of the movement. Then, the instructor has the student focus on the middle parts, and finally on the beginning parts of the

movement. In this study, backward-chaining KP was defined by the tennis instructor (Appendix A).

3. Random KP - a method for giving KP where the instructor administers information about the performance in an unstructured, as needed, and available manner. The instructor selected and offered one of eight movement characteristics that seemed needed at the time for the student (Appendix B).

Motor Skill Learning - a set of processes associated with practice or experience leading to relatively permanent changes in the capability of responding (Schmidt, 1988). In this study, motor skill learning was inferred from performance changes from the first practice session through the last practice session.

Practice Sessions - these were sessions where a skill or task is performed in repetition in order to learn or perfect the skill. In this study, the practice sessions consisted of 40 forehand groundstroke shots from an assigned position on the tennis court for the experimental groups. The acquisition phase consisted of three practice sessions with KP feedback. The pre-test and post-test sessions consisted of one practice session each without verbal KP feedback. Thus, the participants performed during five practice sessions.

Performance - a variable used to measure motor skill learning usually taking the form of scores over a series of trials (Schmidt, 1988). In this study, performance was measured by the means (quality of performance) and standard deviations (variability of performance) of five movement scores and one outcome score for each practice session.

They were defined in the following six ways (Appendix C):

1. Ready Position - this was defined as when the participant had their racket head facing forward and their weight shifted forward.

2. Eye Contact - this was defined as when the participant's eyes were focusing on the contact area momentarily after contact with the ball.

3. Hip and Shoulder Turn - this was defined as when the participant's hip and shoulder was turned perpendicular to the tennis net.

4. Weight Transfer - this was defined as when the participant's weight shifted forward during and after contact of the ball.

5. Follow Through - this was defined as when the participant's follow through finished with their racket high, i.e., head height, or higher.

6. Outcome - this was defined as the result or the behavior of the participant's shot in the Hewitt Tennis Test (Hewitt, 1966). If the ball landed outside the tennis court boundary, then the participant received an outcome score of 0. If the ball landed inside one of five scoring zones on the tennis court by going underneath a restraining line, then the participant received an outcome score of 1 to 5. If the participant's ball traveled over the restraining line, but landed inside the court boundary, then this was an outcome score of ½ point (Appendix D).

Assumptions

The present study was conducted under the following assumptions:

1. All participants were considered capable of performing the tennis forehand groundstroke in this study.
2. The participants performed to the best of their ability during each practice.

3. All participants were healthy and free of any visual problems that would impair their tennis stroking ability.
4. The instructor was fully capable of promoting learning.
5. All participants followed the instructions not to practice outside of the tennis classes.
6. The tennis forehand groundstroke task was representative of the kind of situation encountered in tennis practices and games.

Delimitations

The following were the delimitations of the present study:

1. The participants were volunteer, male and female students at the University of Tennessee, Knoxville, between the ages of 19-42 years.
2. Performance was measured in terms of Likert scale form ratings based on the researcher's viewing of the videotape practice sessions and outcome accuracy.
3. One tennis skill was executed, the forehand groundstroke.

Limitations

The following were the limitations of the present study:

1. Although the participants were randomly assigned to one of three experimental groups, the individual differences among groups could be controlled.
2. There was no control group to compare the performances of the three feedback groups with participants merely practicing the forehand groundstroke with no augmented information.

Significance of the Study

In this study, an attempt was made to provide information on the role of different types of KP feedback in motor skill settings. This study is potentially significant for several reasons. First, this study intends to deepen teachers', coaches', as well as sport and movement scientists' understanding of how three methods of KP feedback, forward-chaining, backward-chaining, and random feedback, affect the learning of an applied motor skill. The motor skills associated with the popular sport of tennis, serves as a strong setting for these types of KP feedback to be investigated. Second, this study sheds light on the relative affects of sequencing KP feedback in the forms of forward and backward-chaining for novices learning a complex motor skill. As a result, this may lead to new studies, theories, and explanations for how and why human beings can learn complex skilled movements. This knowledge can be utilized in motor skill teaching settings commonly found in schools, sport clubs, recreational facilities, and businesses. Third, this study enhances the existing knowledge base of teachers, coaches, and researchers on the complex question of what critical variables optimize motor skill learning. And finally, this information supports and facilitates practitioners' awareness of the importance of giving accurate and precise KP information to students.

CHAPTER II

REVIEW OF LITERATURE

The nature of how individuals learn motor skills is perplexing. Coaches and teachers use many methods to facilitate competent learning of motor skills among their students. In this review of the 1990's, two important areas of motor learning were examined, i.e, augmented feedback and pedagogical research, followed by a summary of how this literature is related to the present study and feedback related research.

Specifically, this review examined research on several important feedback variables (KP and KR) and teaching methods (forward and backward-chaining) in motor learning environments. These feedback variables and teaching strategies are known to be essential to the acquisition of complex motor skills especially in the difficult sport of tennis. A teacher of beginner level tennis students delivers and structures their feedback in a variety of ways during practice so that optimal skills learning results. Thus, the methodology the teacher uses in their classes affects how, when, and in what form the feedback is delivered. It seems important to this study to consider the research conducted on the learning power of different feedback variables as well as attempts to understand different teaching methods used to structure movement information during practice.

Augmented Feedback Research

According to Magill (1993), augmented feedback, "...is feedback provided by a source external to the person's own sensory system"(p. 193). That is, any information given to the learner which does not include sensory or internal characteristics about the movement skill. In the 1990s, there have been several research studies examining an

important augmented feedback variable called knowledge of results (KR). This feedback gives the learner information about the result or outcome of their movement. For example, in tennis instruction settings, a teacher might offer the student KR by saying, “the ball landed two feet out”. This concept has been identified by researchers as one of the most important variables in motor learning (Kernodle & Carlton, 1992). Another powerful augmented feedback variable that has been receiving much recent attention is called knowledge of performance (KP). This type of information describes the characteristics of the movement being performed (Schmidt & Young, 1991). For example, in tennis instruction settings, a teacher might give a student KP by saying, “focus on turning your shoulders and hips”. In this section, current feedback studies were reviewed in the following three areas: (a) knowledge of results (KR) studies, (b) knowledge of performance (KP) studies, and (c) augmented feedback (KR and KP) studies.

Knowledge of Results Studies

Vereijken and Whiting (1990) examined the effects of KR feedback on learning a motor skill. More specifically, they were interested in determining whether discovery learning had an impact on the learning environment. The researchers defined discovery learning as a teaching environment where the nature of the skill can be discovered by the learner without feedback. In this study, the researchers hypothesized that the discovery learning group would perform as well as, or better than, three KR groups.

The researchers reviewed their experiment by describing their method and results in a summarized fashion. They randomly assigned university students into four of the

following experimental groups: discovery learning, no KR, (b) amplitude KR, (c) frequency KR, and (d) fluency KR. Then, all the subjects practiced for four days. On each day, they were pre-tested, given six 1.5 minute practice periods with the subjects' appropriate feedback, and post-tested. For the subjects in the discovery learning, no KR group, instructions to make large amplitude, high-frequency, fluent movements on the ski-simulator task were only provided at the beginning of each practice day. The subjects in the amplitude KR group only received KR feedback given by the size of their oscillating movements in centimeters. The subjects in the frequency KR group received KR feedback in terms of the speed of their movement measured in Hertz. The subjects in the fluency KR group received KR feedback determined by the smoothness of their movements measured by a Z score. Specifically, as their Z score increased, the subjects' movements became smoother. At the end of the practice sessions, the subjects' amplitude, frequency, and fluency were recorded and statistically analyzed.

Vereijken and Whiting (1990) found support for their discovery learning hypothesis. Specifically, the discovery learning group performed just as effectively as the KR feedback groups. Moreover, the dependent measures of amplitude, frequency, and fluency of the ski-simulator task revealed the same amount of improvement in all four experimental groups. Thus, the researchers concluded that discovery learning can be a viable tool for learning a motor skill.

In another KR study, the researchers (Sidaway, Moore, & Schoenfelder-Zohdi; 1991) examined the effects of summary KR on learning a motor skill. Summary KR was defined as giving the subjects their results of their performances after the last

performance trial of a practice block. Specifically, the researchers were interested in testing the guidance hypothesis. This hypothesis states that by summarizing the feedback given to the learner, important cognitive processing occurs which requires the learner to hold critical information in their working memory. By forcing the performer to keep motor skill information in their memory, the skill is processed deeper in their working memory, and therefore, learning results. Thus, Sidaway et al. (1991) hypothesized that the subjects who receive the largest summarized KR would reveal the highest outcome scores during the retention tests.

Sixty subjects were randomly assigned to one of five experimental groups. They were as follows: (a) summary KR for 15 out of 15 trials; (b) summary KR of the last 7 out of 15 trials; (c) summary KR for the last 3 out of 15 trials; (d) summary KR for the last 1 out of 15 trials; and (e) immediate KR for every trial, no summary KR. At the end of each one of these practice blocks, the subjects received summary KR or no summary KR according to their condition. For example, for the summary KR of "15 out of 15" condition, the subjects received KR for all their 15 trials after they finished their practice block. For the "7 out of 15" condition, the subjects received KR for their last seven trials. The other two groups ("3 out of 15" and "1 out of 15") followed this method respectively. All subjects performed a linear slide task for six practice blocks of 15 trials. Then, they rested for ten minutes and completed a retention test with no KR feedback. Next, two days later, all subjects again performed the retention test. Each subject was measured on how accurately they completed the linear slide task goal of 750 milliseconds.

Sidaway, Moore, and Schoenfelder-Zohdi (1991) analyzed their data using a 5 x 2 x 5 (Feedback x Retention Tests x Blocks) analysis of variance statistical procedure. More specifically, they measured the independent variable, frequency of KR, on the dependent variables, acquisition and retention test scores. The experiment revealed no significant difference ($p < .05$) between number of trials summarized in the form of KR and the no summary KR group. In summary, Sidaway et al. (1991) found no support for the guidance hypothesis. Thus, summary KR would not be a strong learning variable for motor skills.

More recently, Winstein, Pohl, and Lewthwaite (1994) conducted a study to investigate the impact of KR and a presentation learning paradigm on motor skill learning. A presentation learning paradigm was described as a physical block or target location for the movement to be directed. Specifically, they were interested in testing the guidance hypothesis proposed by Schmidt (1991). According to this hypothesis, augmented feedback guides the performer to make correct responses by giving him or her information about the outcome of the movement. If too much information is provided, then learning between practice trials is minimized. In this experiment, the researchers hypothesized that the highly guided groups would improve much less than the low guided groups.

Winstein, Pohl, and Lewthwaite (1994) randomly assigned 40 subjects, 31 female and 9 male, ranging from 22-37 years of age into four groups. They were as follows: (a) presentation/high guidance group, (b) presentation/fade guidance group, (c) KR/high guidance group, and (d) KR/fade guidance group. All subjects performed six blocks of

acquisition trials, two retention tests, and a transfer test of an angular positioning task. For the presentation-paradigm groups, a physical block was positioned to aid the learner of the target goal. For the KR groups, the amount of error from the target location was told to these subjects. For both of these groups, feedback was guided in either a high or faded frequency pattern. The high frequency feedback groups received their error score or presentation block during every trial. In contrast, the faded frequency feedback groups received less and less information as the acquisition phase progressed. During all the experimental sessions, the subject error score was recorded and statistically analyzed.

The researchers used a repeated measures $2 \times 2 \times 6$ (Feedback x Feedback Fade x Session) analysis of variance statistical design to analyze the above data. This evaluated the effect of three independent variables (feedback, guidance, and sessions) on the dependent measures (acquisition, retention, and transfer scores). The study revealed, as predicted, a significant difference ($p < .05$) between the feedback groups and the guidance groups for both retention and transfer tests. Moreover, the faded guidance frequency feedback groups outperformed the high guidance feedback groups. Thus, Winstein, Pohl, and Lewthwaite (1994) concluded that guiding feedback, provided in less and less amounts, benefits motor skill learning.

Based on these three recent KR studies, the outcome information of a motor skill may not be the most critical augmented feedback variable for motor learning. This may lead researchers and practitioners to investigate the nature of another important variable in motor skill acquisition, knowledge of performance (KP). In the next section, four recent studies were reviewed that examined KP.

Knowledge of Performance Studies

Another important feedback variable that may affect motor skill learning is KP feedback. This type of augmented feedback provides the learner with movement pattern information either in correct or error descriptions. Boyce (1992) conducted an experiment investigating three types of teaching feedback emphasizing KP on learning a rifle shooting skill. This study delivered the same KP feedback to each group as structured by the teaching strategy. Thus, this study examined how different methods of giving KP feedback affected motor learning. Boyce was interested in testing a teaching notion called the process/product teaching paradigm. Boyce depicted this notion as a teaching environment that involves success in practice, high student expectations, a supportive learning environment, and a high devotion to class content by students. In the present study, Boyce (1992) predicted that there would be a positive difference revealed among three KP teaching styles on their motor performance (rifle shooting).

One hundred and thirty three subjects, 67 male and 66 female, ranging from 18 to 23 years of age were randomly assigned to one of three teaching feedback groups (Boyce, 1992): (a) command style, (b) practice style, and (c) reciprocal style. For the command style group, the subjects received KP feedback entirely from the teacher. In the practice style group, the teacher gave all the KP feedback, but the subjects could make decisions on how they were arranged in their group (i.e., first, third, and fifth for subject one). The reciprocal style group had the subjects assess each other with KP during the practice trials. All subjects received three weeks of rifle shooting introduction practice. At the end of this introduction class, all subjects were pre-tested on a kneeling rifle shooting

task. Then, they performed five sets of acquisition trials with their appropriate teaching feedback style. Furthermore, the subject's performance score was recorded as their accuracy in shooting at a target.

Boyce (1992) analyzed the above data by using a 3 x 6 (Teaching Style x Pre-test/Acquisition scores) analysis of variance statistical procedure. A significant difference ($p < .01$) was found between teaching styles and motor performance scores. More specifically, improvement in all three groups occurred throughout the entire experiment, signifying an overall learning effect due to practice. However, even though all three styles emphasizing KP facilitated skill acquisition, Boyce revealed that command and practice styles were superior to the reciprocal teaching style in shooting accuracy performance. Thus, in a closed skill like rifle shooting, Boyce recommended a teaching style using KP that reflects either command or practice style.

More recently in the KP research, Cutton (1994) examined the role of augmented feedback on the learning of a motor skill, the tennis forehand. Specifically, he explored an active, cognitive learning strategy and KP feedback on learning the tennis forehand. He conducted three experiments. Experiments 1 and 2 were set up in a controlled field setting; however, Experiment 3 was held in an actual tennis class. Cutton hypothesized that the cognitive learning strategy group and KP feedback groups would outperform the control groups in movement form and outcome scores.

In Experiment 1, Cutton (1994) randomly assigned 44 subjects into four groups: (a) performer self-cuing, (b) advanced organizer, (c) control with sports background, and (d) control without sports background. For the performer self-cuing group, each subject

learned a sequence of cues on how to hit a tennis forehand. For example, they were told, "ready, ball, turn, hit, follow through" at the appropriate time while executing the tennis forehand. The advanced organizer group was provided with cues relating to their particular sport background that applied to tennis. For example, the critical components of a baseball swing were compared to the critical components of the forehand groundstroke. For the control groups, the subjects received a standard introduction on how to perform the tennis skill test. One of these groups had experience playing another sport such as racquetball, badminton, or baseball. The other control group had no previous sport background. All subjects performed 50 forehand trials on a pre-test, post-test, and for each of the three days of practice. The outcome scores, where the ball landed on the tennis court, and the movement sequence patterns were measured for each subject. The movement sequence pattern was measured by breaking the forehand groundstroke into five critical components and rating whether the subjects' correctly executed each part.

In Experiment 2, 44 subjects were randomly assigned to one of four groups: (a) performer self-cuing, (b) performer self-cuing with KP feedback, (c) KP feedback, and (d) a practice only control group. For the KP feedback groups, the experimenter gave movement pattern cues every fifth trial during the acquisition trials. Similar to Experiment 1, all subjects performed 50 trials of the forehand during the pre-test, post-test, retention-test, and for each of the five days of acquisition phase.

The third experiment was conducted (Cutton, 1993) in a physical education tennis class. Seventy-two subjects were randomly assigned to one of three feedback groups.

They were: (a) a performer self-cuing group, (b) a performer self-cuing with KP group, and (c) a KP group. Seven experimental sessions were held. These sessions followed the form of one session each for a pre-test and post-test, and five sessions of practice under the subjects' appropriate feedback condition. Cutton's last two experiments measured the subjects' outcome scores as well as their movement pattern.

The results of these experiments (Cutton, 1994) revealed a significant effect ($p < .05$) between feedback groups on motor skill performance. More specifically, Experiments 1 and 2 demonstrated that the self-cuing learning strategy was the most effective method for performing the tennis forehand correctly. However, in Experiment 3, the physical education tennis class, no significant differences were found between the self-cue and KP groups in terms of outcome scores. Furthermore, Cutton (1994) found the self-cuing group outperformed the KP group on the movement pattern measure in the tennis class. Cutton (1994) concluded that self-cuing and KP are powerful feedback tools which seem to facilitate the motor learning process.

Most recently, Pellett, Henschel-Pellett, and Harrison (1994) conducted a study which demonstrated the effectiveness of KP feedback. They selected 68 female seventh and eighth graders and had them perform three volleyball skills. All the subjects were pre-tested and post-tested on AAHPHERD's serve and set, and forearm pass test. All subjects were divided into low and high skill levels. Then, the subjects participated in eleven volleyball lessons that were videotaped and rated for teacher KP feedback.

Although Pellett, Henschel-Pellett, and Harrison (1994) did not manipulate any independent variables, they found an overall improvement from pre-test to post-test on all

three volleyball skills. Specifically, the videotape analysis revealed that the low skill volleyball players improved twice as much after the teacher provided corrective, specific knowledge of performance feedback. Also, the highly skilled players improved just as much as the low skill level players for all volleyball skills. Thus, Pellett et al. (1994) concluded by recommending three implications from the study: (a) motor skill teachers need to provide specific, corrective feedback to their students; (b) teachers need to be adept in timing and identifying when to give corrective feedback; and (c) teachers need to plan in advance what KP feedback they will provide.

Augmented Feedback Studies (KP and KR)

Two studies were reviewed that examined both KP and KR. First, Kernodle and Carlton (1992) conducted an experiment on the viability of information feedback on motor skill learning and performance. In particular, they examined the effect of KR and KP on a multiple-degree-of-freedom task (i.e., throwing). Furthermore, the researchers studied two aspects of KP which were described as transitional information and attentional focusing cues. Transitional information includes instructions provided to the performer on how to produce the next movement, i.e., "extend your left arm as you release the ball" (Kernodle and Carlton, 1992, p. 190). Attention focusing KP is information about a specific aspect of a previous movement, i.e., "focus on the hips during your throwing phase". In the present experiment, Kernodle and Carlton (1992) hypothesized that KP with attention focusing cues and transitional information should reveal higher performance scores than KR feedback.

Kernodle and Carlton (1992) randomly divided 48 subjects into four experimental

groups: (a) KR, (b) KP, (c) KP with transitional information, and (d) KP with attention focusing cues. All the subjects practiced a throwing task for 600 times, for 12 sessions, three times a week, for four weeks with their nondominant arm. The researchers measured the performer's movement form and the distance the ball was thrown. The KR group was told the distance thrown after each trial. In the KP conditions, however, no KR was given, but each subject viewed his or her throwing movement pattern immediately following each practice trial. In addition, the KP groups viewed a model throwing the ball with correct biomechanics every 10th practice trial. A trained instructor gave the second KP group transitional information based on 15 fundamental corrections. Moreover, the instructor gave the third KP group attention focusing cues described by 10 important body parts. During each practice session, the subjects were tested on 10 practice throws. The results of these tests were then statistically analyzed.

An analysis of variance $4 \times 2 \times 2$ (Practice Feedback $\times$ Performance $\times$ Form) was calculated for the above data. A significant effect ($p < .05$) was found between feedback groups and their resulting performance. Kernodle and Carlton (1992) found support for their hypothesis that KP feedback facilitates motor skill learning. Specifically, KP with transitional information and KP with attentional focusing cues revealed the highest performance scores and the highest biomechanical form measures. Furthermore, the KR group and the KP groups showed a decrease in the amount of improvement in both categories. Thus, these results supported the notion that KP and KR alone are less effective motor skill feedback factors than KP given with additional information.

Another recent augmented feedback study explored the effects of a cognitive

strategy and visual aid strategy on the acquisition of a motor skill (Wrisberg, Liu, & Reed; 1995). The researchers were interested in clarifying two issues concerning teacher feedback on student learning. One contention states that the student should be forced to actively problem solve the task situation, whereas, another view claims that the teacher should provide essential augmented information. More specifically, they analyzed different types of feedback a teacher may supply to a learner. These include verbal instruction, demonstration, manual guidance, cognitive strategy, and information feedback based on the learner's previous attempts. In this experiment, Wrisberg et al. (1995) hypothesized that the cognitive and visual aid groups would outperform the control group (no augmented feedback group).

The researchers randomly assigned 60 subjects, 30 female and 30 male, ranging from 17-22 years of age, to one of three experimental groups to perform a space maze motor skill game: (a) a cognitive strategy group, (b) a visual aids group, and (c) a control, no feedback group. The cognitive strategy group was provided with information an expert uses to complete the task. For the visual aids group, performance relevant targets were visually displayed throughout the maze. The control group simply played the game without augmented information feedback. Next, all the subjects' performances were measured in the form of four types of scores during an acquisition phase (first day), relearning phase (second day), and transfer phase (second day). They include trials to first successful performance, time per-hole to first success, trials to reach criterion following first success, and time per hole to reach criterion following first success. Furthermore, all subjects were queried about what cues they used during their

performance.

Wrisberg, Dale, Liu, and Reed (1995) used a 3 x 3 (Group x Phase) multivariate analysis of variance statistical procedure for the above data. There was no significant effect found between the feedback groups and the performance phases. However, the statistics revealed that all three experimental groups attended to cues in different ways. Specific maze game board cues were used more often by the visual aid and cognitive strategy groups than by the control group. Moreover, the researchers' hypothesis that the visual aid and cognitive strategy groups would outperform the control group was not found. Furthermore, all these groups improved equally in terms of their performance scores. Thus, Wrisberg et al. (1995) concluded by questioning whether humans have a "preferred road map" for optimum motor learning.

Pedagogical Research

Similar to feedback, practice structure is an inextricable aspect of motor skill learning. Teachers, instructors, and coaches need to understand not only what kind of feedback to provide students, but they need to know how to structure their motor skill information so that optimum learning will occur. Several recent motor skill pedagogy studies have been conducted that examine the effectiveness of forward and backward chaining, and teacher refining on learning complex movements. The "chaining studies" were primarily interested in whether the sequence of motor skill information would optimize motor learning. The teacher refining study was interested in determining whether augmented information given to the learner about critical aspects of their motor skill affects learning. In this section, two "chaining" studies and one "refining motor

task” study were reviewed.

Forward and Backward Chaining Studies

Ash and Holding (1990) conducted an experiment exploring the effects of part-whole practice on learning a motor skill, keyboard music. Specifically, they were interested in two types of practice-part methods called forward and backward-chaining. These part-whole methods must be used with a complex motor skill that has a clear beginning and end. Teaching a skill by using part-whole method is defined as breaking a particular complex skill into component parts. By learning these parts of the skill, the whole skill becomes much easier to understand and perform. Ash and Holding were testing whether there would be a difference in performance among three practice structure groups. These groups were as follows: (a) whole training group, whole difficult task performed; (b) backward-chaining group, learned difficult piece then easy piece; and (c) forward-chaining group, learned easy piece then difficult piece. Sixty-one beginner piano players were randomly assigned to one of these aforementioned groups. All subjects performed three musical segments on a piano keyboard. Each subject practiced under their specified practice structure for five training sessions. Then, all subjects performed a retention test of a difficult musical segment. The subjects were measured for melodic error, rhythm, consistency, and accuracy of the musical piece.

Ash and Holding (1990) analyzed this data by using a one-way analysis of variance. They evaluated the affect of practice structure on music segment performance. Furthermore, the results indicated a significant difference between practice groups and music performance. Specifically, the piano students in the part-whole practice groups

outperformed the students in the whole practice group. Moreover, the students in the forward-chaining group revealed the best music performances on the retention test. Thus, Ash and Holding (1990) concluded that the forward-chaining part-whole practice method may enhance the learning of complex motor skills.

Another recent study examined the effectiveness of teaching forward-chaining and backward-chaining teaching strategies on learning a complex dance sequence (Welsh, Fitt, & Thompson, 1994). Similar to the part-whole method of teaching motor skills, the researchers reasoned that "chaining" a movement sequence would allow the learner to piece together the motor skill. Forward-chaining had the learner begin learning the movement sequence from the beginning of components to the end of the components. The inverse of this method was called backward-chaining. The researchers were interested in determining whether there was a difference in the number of movement errors made by the dance students under these two teaching methods.

Welsh et al. (1994) selected six subjects, ranging in age from 19 to 23 years, to participate in a modern dance class. All the subjects participated in two dance classes. The first class involved learning three axial sequences and three locomotor sequences in either a forward-chaining or backward-chaining teaching method. For example, under the forward-chaining condition, the students were taught part 1 of the movement sequence first, then parts 1 and 2, and finally parts 1, 2, and 3. The backward-chaining group were taught one these dance sequences by learning part 3 first, then parts 2 and 3, and finally 1, 2, and 3. During the second dance class, the six students were measured by trained observers on their dance performance. Their performance measures included errors of

sequence, timing movement path, missing movements, and movement quality.

A multielement experimental design was used to analyze each student's performance under the forward-chaining condition as compared to their performance under the backward-chaining condition. Welsh et al. (1994) found five of the six students performing fewer errors under the forward-chaining condition. Also, when the researchers asked which method was preferred, three students favored the forward-chaining method, two students made no distinction, and one student reported that all the methods were "very enjoyable". Taken together, these findings suggested that forward-chaining might be a more effective teaching strategy than backward-chaining.

Refining Task Teaching Research

A recent study investigated how teachers provide and structure information in a motor learning environment. Specifically, Rink, French, Werner, Lynn, & Mays (1991) examined the nature of part-whole practice by exploring the effectiveness of extending and refining the progression tasks of learning two motor skills. These motor tasks would be implemented into a particular practice progression that would focus the students on a fundamental aspect of the task, e.g., "Class, get your toss to the side and in front of your body (p.142). Rink et al. (1991) predicted that the progression groups with refining tasks would outperform the other groups.

Fifty-nine subjects were randomly assigned to one of five experimental groups to practice the volleyball serve and set. One group, the final test group, practiced the final test for both volleyball skills with refining tasks. Another group, the final test with

motivation group, practiced the final test for both skills and only received motivation statements about their performance. A third group, the four-step progression group, practiced a simple to complex ordered progression on both skills. The fourth group, the same four-step progression was practiced with refinement tasks added. The refinement tasks were defined as critical performance information given by trained teacher after every five trials of practice (e.g. "focus on getting your toss to the side and in front of your body"). Finally, a fifth group, the control, practiced in a physical education class, but not in volleyball. All subjects were pre-tested and post-tested on AAHPERD's volleyball skills test and were appropriately assigned to either a low or average skills group. In addition, all subjects practiced 60 trials for each skill, the volleyball serve and set, for six days.

Rink et al. (1991) analyzed the performance scores by utilizing a 5 x 2 x 2 (Practice Group x Skill Level x Pre and Post Test) analysis of variance statistical method. The results indicated a significant interaction ($p < .01$) between type of practice, skill level, and the pre to post test on volleyball performance. Specifically, both low and high skill subjects who trained under both progression groups had higher scores than the non-progression groups. Specifically, the low skill students in the combination group (progression and refinement task group) improved on their final test more than the progression group. However, this difference was not statistically significant. Moreover, the progression group with refinement tasks performed the best overall. Furthermore, the results found no significant differences in improvement between low and average skill performers. However, Rink et al. (1991) suggested that this experiment provides

evidence that progressive practice with focusing on the critical elements of the motor task facilitates learning.

Summary

The research concerning augmented feedback and pedagogy has revealed several results on the nature of feedback in motor learning. First, based on the current studies on KR, KP, and augmented feedback, the structure of how, when, and what form this type of information should follow remains unknown. The KR studies demonstrated the following points: (a) discovery learning rather than providing KR feedback might optimize motor learning (Vereijken & Whiting, 1990); (b) the type of summary KR to provide is unclear (Sidaway, Moore, & Schoenfelder-Zohdi, 1991); and (c) providing guiding target information instead of KR feedback might be beneficial to motor learning (Winstein, Pohl, & Lewthwaite, 1991). The KP studies indicated that this movement information significantly enhances skill acquisition. However, these studies suggested that how a teacher presents this movement pattern information might be paramount to learning. For example, Boyce (1992) found that different styles of teaching emphasizing KP might diminish learning. She demonstrated that providing KP with a command and practice style of teaching yielded the best rifle shooting performances. Cutton (1994) and Pellett et al. (1994) confirmed that providing KP improves performances for complex, open motor skills such as the tennis forehand groundstroke and the volleyball serve, set, and forearm pass. The augmented feedback studies (combining KP and KR) revealed that providing certain types of movement form information to the learner may optimize motor skill learning, i.e., KP with transitional information (Kernodle & Carlton, 1992).

Also, one study conducted by Wrisberg et al. (1995) found no difference between feedback and learning groups on performing a maze game. They suggested that this finding might mean that humans attend to critical skill information and cues in unique ways.

A second main point on the organization of movement information was depicted in the pedagogical research. This research seemed to indicate a preference for sequencing the learning of complex motor skills emphasizing movement pattern information in a forward-chaining manner (Welsh, Fitt, & Thompson, 1994; Ash & Holding, 1990). Also this research suggested that when breaking a complex motor skill into parts, the teacher should emphasize refining task information. That is, information emphasizing critical aspects of the performance of the motor skill (Rink, French, & Werner, 1991).

Taken together, based on the research reviewed, feedback in the form of KP, or movement pattern information, seems to enhance the learning of motor skills. However, it is yet to be determined, how, when, and in what form this information should follow. It seems prudent that more field-setting studies should be conducted to resolve whether there is a preferred information path for learners. Specifically, this review seems to identify the need for further research examining the sequencing, timing, and nature of augmented feedback and motor skill information.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to determine the relative effects of sequencing knowledge of performance (KP) feedback on the learning of an applied motor skill. More specifically, do forward-chaining KP, backward-chaining KP, and random KP differentially affect the movement performances and outcome results of the tennis forehand groundstroke? The following sections describe the participants, rationale, practice environment, procedures, practice phases (acquisition phase and retention phase) and data collection for this study.

Participant Selection

Seventeen male and nineteen female student volunteers, ranging in age from 19 to 42 years, from the University of Tennessee, Knoxville campus, served as participants for this study. A letter (Appendix E) was distributed to each student containing an explanation of the purpose of the study as well as a description of the test to be administered. The letters were distributed during the Spring semester 1996, one week prior to the beginning of the study. All the experimental procedures were held on the University tennis courts. The 35 participants signed and returned the informed consent statement (Appendix F) and completed an information sheet (Appendix G) prior to the onset of the study.

Rationale

The measures used in this study to determine performance form and outcome results were composed from Cutton's dissertation (1994) and the Hewitt Tennis Test

(1966). The movement performance for the tennis forehand groundstroke was separated into five fundamental movement form components. They included the ready position, eye contact, hip and shoulder turn, weight transfer, and follow through (Cutton, 1994; Groppe, 1980). These form measures were obtained by having an observer rate the videotape practices of each one of these above movement characteristics on a Likert scale from 0 to 2. For example, a score of 0 would have indicated that the participant did not correctly execute this movement characteristic; a score of 2 indicated that the participant correctly executed this movement characteristic; and a score of 1 indicated that the participant executed the movement characteristic in a satisfactory manner (Appendix C). As described by these experts (Cutton, 1994; Groppe, 1980), this measure seems to assess the movement performance of the forehand groundstroke.

For the outcome measure, the Hewitt Tennis Test (1966) was used which required the participants to attempt 40 forehand groundstroke shots into one of the five marked scoring zones (Appendix H). A restraining line was strung above the tennis court net at seven feet. In order for the participants to score 1 to 5 points, they had to hit a forehand groundstroke over the net and underneath the restraining line. If they hit their shot over the line and into the tennis court boundary, then they received a $\frac{1}{2}$ point. This test was selected because it has logical validity of the motor task in tennis. The tennis test has a reliability level of .75 for the forehand groundstroke. Also, the validity coefficient for beginners of this test is .73 (Hewitt, 1966). One assistant or the researcher quietly marked each participants' outcome scores (Appendix D) and recorded all their forehand groundstroke movements with a video camera (Appendix H).

Practice Environment

Fifty yellow Wilson tennis balls were used during the pre-test, acquisition, and retention sessions. All balls were pressurized with approximately the same air pressure. In order to evaluate the outcome of each practice hit white chalk was used to mark the tennis court into 5 scoring zones as specified by the Hewitt Tennis Test (Hewitt, 1966). The first four zones began at the baseline marked at 4'6" apart. The fifth zone covered the entire forecourt (Appendix H). Each zone was clearly marked with the numbers - 5, 4, 3, 2, and 1 respectively. A restraining line, 50', was strung across two wood poles, 7' x 2" x 2", located at each net post. A measuring tape was used to demarcate each scoring court zone and to verify the height of the restraining line.

The experiment was set up as shown in Appendix H. A starting spot for all participants was located directly north of the center mark on the tennis court. After each trial, the participants re-positioned themselves back to the center mark. The instructor was located at the intersection of the center-line and service-line, 58' 6" from the student. Each trial ball was fed from this location by a ball machine. This was performed to minimize the variance of speed, spin, and arc on each fed ball. The ball machine fed balls that were "flat" (no spin) and easy-paced. The ball traveled through the air at approximately 10-15 mph. The researcher determined from direct observation whether the fed ball behaved with the appropriate speed, spin, and arc. If the fed ball was inappropriate, then the practice trial was repeated. Since all of the participants were novice tennis players, easy-paced fed balls seemed most appropriate.

Two trained assistants stood next to the west net post, videotaping and recording

the outcomes of each trial performance on the data sheets (Appendix D). The outcome data sheet was placed on a chair near the assistant, who recorded all of the performer's outcome shots. The assistant checked with the researcher after each shot to make sure the attempt was acceptable. An unacceptable attempt would involve a fed ball that did not adhere to the researcher's condition of an easy-paced fed ball. Furthermore, a trial attempt was repeated if the participant was not ready. For example, if he or she was turned in the wrong direction or was distracted in some way during the ball feed, the trial was repeated. Another responsibility for the assistants was to clear any balls that remained on the performer's side of the court. This was to ensure safety and alleviate any distraction to the participant. Also, the assistant monitored the video camera at the beginning, middle, and end of each participant's practice session. At the beginning of the participant's session, the assistant focused the camera on the participant, and pressed "Record" just before the onset of the first trial. Before the participants began their practice session, the researcher displayed a 8.5" x 11" sheet of paper for the camera indicating the practice and participant number.

The participant's outcome data on the Hewitt Tennis Test were calculated in the form of total score, mean score, and standard deviation. All pre-test, acquisition, and retention trials were videotaped and then evaluated by the researcher at a later time for the movement form measures (Appendix C).

Procedures

The pre-test, acquisition period, and the post-test took place between February and May during the Spring semester of 1996. The pre-test and three acquisition practice

periods measured acquisition performance, and the post-test assessed the retention performance. For each of the four practice periods, a pre-test and three acquisition sessions, each participant performed 40 forehand groundstroke attempts. Thus, each participant performed a total of 160 practice strokes during their acquisition period. Also, 40 forehand groundstrokes were performed during the fifth session, the retention test.

Pre-test

After the first practice period, the pre-test, skill level was analyzed by grouping the participants based on their mean outcome score into three levels: high (49 - 28), medium (27 - 14), and low (11.5 - 1). Then, for each skill level, the participants were randomly assigned into one of the three feedback groups, i.e., forward-chaining KP, backward-chaining KP, and random KP. For each feedback group at each skill level, gender was balanced as much as possible. Prior to beginning instructions with feedback, a one-way ANOVA by group was calculated for the pre-test outcome scores. The results indicated that the Forward-chaining ($\bar{M} = .66$, $s = .45$), Backward-chaining ($\bar{M} = .66$, $s = .42$), and Random ($\bar{M} = .54$, $s = .33$) groups were not significantly different ($p > .05$) at the start of the acquisition period.

Acquisition Phase

All participants performed the forehand groundstroke from the center mark on four different practice days. The participants arrived at the court individually and received instruction on how to perform the forehand groundstroke skill (Appendix J). In order to keep the basic instructions standardized, a script was used by the teacher during each practice session (Appendix J). This was to ensure that all participants in all

respective groups received the same information about the skill. A certified United States Professional Tennis Association tennis professional served as the teacher and introduced the critical components of the tennis motor skill. During the first practice session, the participants were given basic instructions, and a 40 trial pre-test. Then, for three subsequent practices, all participants again received basic instructions, and performed 40 practice trials with appropriate group feedback on each day. All participants performed a total of 160 practice shots.

During the three acquisition sessions, verbal feedback from the instructor was given using eight relevant movement characteristics of the forehand groundstroke (Groppel, 1980). The instructor followed a feedback script for each group (Appendix I). The participants assigned to the forward-chaining KP, backward-chaining KP, and random KP groups received their appropriate feedback once every five trials during the latter three practice sessions. This feedback was sequenced for each group by following a feedback script (Appendix B). The verbal feedback groups received a total of 27 feedback statements, 9 per day, for three practice sessions.

Retention Test

One post-test without KP feedback was administered to all 36 participants for retention. Once the participants completed their 40 shots, they were thanked for participating in the experiment, debriefed, and asked if they would like to receive a copy of the results. The participants were debriefed by being explained the three different feedback groups and which one they were in for the study.

Movement Form Measure

The videotape movement form analysis on the tennis forehand groundstroke was developed from a similar method constructed by Cutton (1994). He used five basic components of the forehand groundstroke depicted in a tennis instruction book (Groppel, 1980). These components included the ready position, eye contact, hip and shoulder turn, weight transfer, and follow through. According to Cutton (1994) and Groppel (1980), these five components assess the tennis forehand groundstroke movement pattern (Appendix C).

A VHS video camera was used to record each participants' movement form for all the trials throughout the experiment. A VHS video player was used to replay the pre-test session, the three acquisition sessions, and retention session in order to evaluate the movement form ratings. The above data were recorded on a movement performance scoring sheet (Appendix I). This scoring sheet indicated the participant's number, and their experimental groups representing one of three feedback conditions (FKP, BKP, and RKP).

An intraobserver reliability measure was determined by analyzing a pilot participant's movement form on all five performance variables. The researcher scored the movement patterns of the pilot participants, and then scored the same pilot two more times on separate days. The number of correct observations were divided by the total observations which yielded the intraobserver reliability for this study. A reliability measure of 91.5 percent was achieved. This indicates a high level of intraobserver reliability.

An interobserver reliability measure was determined by having another United States Professional Tennis Association certified tennis teacher and the experimenter evaluate two pilot participants' movement form performances. For each movement form category, the number of agreements were divided by the total number of observations between the researcher and tennis teacher. An interobserver reliability of 82.5 percent was achieved. This interobserver comparison indicates an acceptable level of reliability for scoring performance from the video tapes.

These two forms of reliability were achieved prior to the researcher's viewing of the 36 participants' practice sessions. Following the collection of all the data, the researcher rated the videotape recordings of the participants' movement form. The movement form scores were determined by marking 1 of 3 possible characteristics for each of five defined movement parts of the forehand groundstroke (Appendix C). Each part of the skill was worth two points; thus a maximum score for the whole skill was 10. For example, a participant was rated on five movement segments of the forehand groundstroke, i.e., ready position, eye contact, hip and shoulder turn, weight transfer, and follow through. Each one of these movement features was scored from 0 points (incorrect) to 2 points (correct) on the movement form data sheet. If a participant received a "1" for ready position, a "1" for eye contact, a "2" for hip and shoulder turn, a "2" for weight transfer, and a "2" for follow through, then for this particular trial, the participant received a movement form score of "8", or a mean score of "1.6". This would be considered a very strong score since a perfect score for each trial was "10", and a perfect mean movement score was "2". All trials for each participant were measured in

this manner. Then, the session means and standard deviations for all the movement form categories were calculated for each participant.

CHAPTER IV

RESULTS

This study explored the relative effects of sequencing three information feedback conditions on the learning of an applied motor skill, the forehand groundstroke. These conditions included three different arrangements of knowledge of performance (KP) feedback. Participants were given either backward-chaining KP, forward-chaining KP, or random KP. In addition to these conditions, all the participants received results of their shot by viewing how the ball traveled, underneath or over the restraining line, and where the ball landed in the tennis court. This information was not specifically given by the experimenter, it was determined by the learner's viewpoint of their performance. The performances and learning demonstrated by the participants were measured by movement form scores and outcome scores across five practice sessions. These scores were presented as the quality (session mean) and variability (session standard deviation) of the performance for each variable. These data were analyzed utilizing a 3 x 5 (Feedback Group x Session) RMD analysis of variance with subjects nested in group. A Newman-Keuls post hoc pairwise test was performed to find all possible comparisons in the significant main effects and the one significant interaction. This test was selected because it is a moderately liberal design and the majority of the overall differences were in the main effects.

The data for the 36 participants in this study were collected during the spring of 1996. The research findings for this study were arranged and analyzed by six dependent variable categories: (a) ready position, (b) eye contact, (c) hip and shoulder turn, (d)

weight transfer, (e) follow through, and (f) outcome. Each variable was discussed first in terms of the quality of performance and then followed by the variability of performance.

Ready Position

In order to explore the effects of KP feedback on the movement form dependent variable of ready position, two 3 x 5 (Feedback Group x Sessions) RMD ANOVAs with subjects nested in feedback group were calculated. The dependent variables were quality of performance and variability of performance.

Quality

The main effect for group was not significant, but the main effect session was significant ($p = .0003$). The Feedback Group x Session interaction was not significant (Table 1). Furthermore, the descriptive statistics were calculated for the main effects and interaction for the quality of performance of ready position (Table 2).

A Newman-Keuls post hoc test was calculated for the significant main effect for session. The results indicated that the participants' ready position form was significantly poorer in session 1 than in the other sessions. Specifically, in Sessions 2, 3, 4, and 5, the subjects had better ready positions than in Session 1 ($p = .028$).

Variability

The main effect group was not significant, but the main effect session was significant ($p = .0086$). However, the Feedback Group x Session interaction was not found to be significant (Table 3). The descriptive statistics were calculated for the main effects and interaction for the variability of performance of ready position (Table 4).

Table 1. Group x Session (2 x 3) RMD ANOVA for Quality of Ready Position.

Source	df	F	p
Between Group	2	.69	.5068
S (Group)	33	-	-
Within Session	4	5.72	.0003
Group x Session	8	1.28	.2581
Error	132		

Table 2. Group x Session Descriptive Statistics for Quality of Ready Position.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	1.69 (.55)	1.86 (.28)	1.97 (.08)	2.00 (.02)	1.98 (.07)	1.90 (.30)
FKP	1.94 (.20)	1.99 (.02)	1.98 .07	2.00 (0.00)	2.00 (0.00)	1.98 (.09)
RKP	1.82 (.36)	1.91 (.27)	1.93 .27	1.93 .25	1.94 .22	1.91 (.27)
Total Sessions	1.82 (.39)	1.92 (.23)	1.96 (.17)	1.97 (.15)	1.97 (.14)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Table 3. Group x Session (2 x 3) RMD ANOVA for Variability of Ready Position.

Source	df	F	p
Between Group S (Group)	2 33	1.16 -	.3271 -
Within Session	4	3.56	.0086
Group x Session	8	.86	.555
Error	130	-	-

Table 4. Group x Session Descriptive Statistics for Variability of Ready Position.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.13 (.21)	.12 (.21)	.07 (.18)	.02 (.07)	.04 (.13)	.08 (.17)
FKP	.04 (.14)	.02 (.08)	.05 (.15)	0.00 (0.00)	0.00 (0.00)	.02 (.10)
RKP	.09 .16	.03 (.11)	0.00 (0.00)	.02 (.07)	.03 (.10)	.03 (.10)
Total Sessions	.09 (.17)	.05 (.14)	.04 (.13)	.01 (.06)	.02 (.09)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP
 FKP - Forward-Chaining KP
 RKP - Random KP

A Newman-Keuls post hoc test was calculated for the significant main effect for session. The results revealed that Session 1 was significantly higher in form variability than the other sessions. In particular, Sessions 2, 3, 4, and 5 were lower in form variability than Session 1 for the ready position ($p = .01$).

Eye Contact

To determine the relative effects of KP feedback on movement form, the dependent variable eye contact was evaluated during practice of the forehand groundstroke. This measure was examined utilizing a 3 x 5 (Feedback Group x Session) RMD analysis of variance. Both quality of eye contact and variability of eye contact were analyzed.

Quality

The findings revealed that the main effect of group was not significant, however, the main effect session was significant ($p = .0001$). Even further, the Feedback Group x Session interaction was not significant (Table 5). Descriptive statistics were calculated for the main effect and interaction for quality of performance of this dependent variable, eye contact (Table 6).

A Newman-Keuls post hoc test was performed for the significant main effect of session on eye contact. The results indicated that eye contact during Session 1 was significantly poorer than during the other sessions ($p = .04$). In addition, eye contact was significantly poorer during Session 2 than during Sessions 3, 4, and 5, but significantly better than in Session 1 ($p = .04$).

Table 5. Group x Session (2 x 3) RMD ANOVA for Quality of Eye Contact.

Source	df	F	p
Between Group S (Group)	2 33	.16 -	.8539 -
Within Session	4	13.55	.0001
Group x Session	8	.69	.702
Error	132	-	-

Table 6. Group x Session Descriptive Statistics for Quality of Eye Contact.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	1.08 (.35)	1.18 (.34)	1.31 (.37)	1.31 (.32)	1.34 (.39)	1.24 (.36)
FKP	1.01 (.25)	1.23 (.14)	1.37 (.28)	1.42 (.33)	1.36 (.32)	1.28 (.30)
RKP	1.09 (.31)	1.19 (.20)	1.24 (.27)	1.28 (.28)	1.30 (.29)	1.22 (.28)
Total Sessions	1.06 (.30)	1.20 (.23)	1.30 (.30)	1.33 (.31)	1.33 (.32)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP
 FKP - Forward-Chaining KP
 RKP - Random KP

Variability

The main effect for group was not significant, but the main effect for session was significant ($p = .0015$). The Feedback Group x Session interaction revealed no significant differences (Table 7). In addition, descriptive statistics were calculated for the main effects and interaction for variability of eye contact (Table 8).

To determine the contrasts between feedback group and session, a Newman-Keuls post hoc test was calculated for the variability of eye contact. This test revealed a significant main effect for session. Specifically, the results indicated that subjects had significantly lower variability at Session 1 than during all other sessions ($p = .02$).

Hip and Shoulder Turn

In order to examine the effects of KP feedback on the form of hip and shoulder turn, a 3 x 5 (Feedback Group x Session) RMD ANOVA was used. This analysis explored both the quality and variability of hip and shoulder turn form.

Quality

The main effect for group was not significant (Table 9), however, the main effect for session was significant ($p = .0001$). In addition, the results indicated that the Feedback Group x Session interaction was significant ($p = .0001$). Also, descriptive statistics were calculated for the main effects and interaction for quality of performance for hip and shoulder turn (Table 10).

Table 7. Group x Session (2 x 3) RMD ANOVA for Variability of Eye Contact.

Source	df	F	p
Between Group	2	.51	.6056
S (Group)	33	-	-
Within Session	4	4.68	.0015
Group x Session	8	.40	.9179
Error	130	-	-

Table 8. Group x Session Descriptive Statistics for Variability of Eye Contact.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.33 (.17)	.44 (.09)	.44 (.21)	.49 (.07)	.33 (.18)	.41 (.16)
FKP	.38 (.13)	.50 (.15)	.49 (.13)	.46 (.12)	.40 (.12)	.44 (.13)
RKP	.33 (.17)	.46 (.11)	.44 (.15)	.45 (.17)	.42 (.22)	.42 (.17)
Total Sessions	.35 (.16)	.46 (.12)	.45 (.17)	.46 (.13)	.39 (.18)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP
 FKP - Forward-Chaining KP
 RKP - Random KP

Table 9. Group x Session (2 x 3) RMD ANOVA for Quality of Hip and Shoulder Turn

Source	df	F	p
Between Group S (Group)	2 33	2.27 -	.1191 -
Within Session	4	36.28	.0001
Group x Session	8	.88	.0001
Error	132	-	

Table 10. Group x Session Descriptive Statistics for Quality of Hip and Shoulder Turn.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	1.27 (.49)	1.48 (.41)	1.72 (.46)	1.80 (.29)	1.72 (.54)	1.60 (.47)
FKP	1.29 (.57)	1.81 (.31)	1.93 (.13)	1.99 (.03)	1.89 (.29)	1.78 (.40)
RKP	1.33 (.43)	1.85 (.23)	1.91 (.21)	1.95 (.12)	1.98 (.05)	1.80 (.34)
Total Sessions	1.30 (.48)	1.73 (.35)	1.86 (.30)	1.91 (.19)	1.87 (.35)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

A Newman-Keuls post hoc test was calculated to evaluate the contrasts of the main effect for session. The results indicated that subjects had significantly poorer hip and shoulder turns during Session 1 than in the other sessions ($p = .05$). Furthermore, the test revealed that subjects were significantly poorer at Session 2 than during Sessions 3, 4, and 5, but significantly better than during Session 1 ($p = .05$).

To determine the significant effects for the Feedback Group x Session interaction, a Newman-Keuls post hoc test was performed. The results indicated that there were no group differences for Session 1. However, the subjects in the forward-chaining and random feedback groups had better hip and shoulder rotations during Session 2 than did the subjects in the backward-chaining feedback group during Session 2 (Table 10). Moreover, for the forward-chaining and random feedback groups during sessions 3 and 4, subjects had significantly better hip and shoulder turn scores ($p = .05$) than the backward-chaining group at Sessions 3 and 4. Furthermore, the hip and shoulder rotation of the subjects in the random feedback group, on Session 5, was significantly better ($p = .05$) than the subjects in the forward and backward-chaining feedback groups during Session 5 (Table 10).

The results of the Newman-Keuls post hoc analysis also revealed that subjects in the backward-chaining feedback group performed significantly better ($p = .05$) hip and shoulder rotations during Sessions 3, 4, and 5 than during Sessions 1 and 2 (Table 10). For the forward-chaining feedback group, the subjects performed significantly better ($p = .05$) hip and shoulder rotations during Sessions 3 and 4 than during the other sessions. Furthermore, in this group, the subjects during Sessions 2 and 5 performed significantly

better ($p = .05$) hip and shoulder rotations than the subjects during Session 1. The findings also revealed that the subjects in the random feedback group had significantly better ($p = .05$) hip and shoulder rotations during Sessions 3, 4, and 5 than during Sessions 1 and 2 (Table 10). Moreover, the subjects in this group performed significantly better ($p = .05$) during Session 2 than in Session 1 on this dependent variable.

Variability

The main effects for both group ($p = .0415$) and session ($p = .0001$) were significant. However, the Feedback Group x Session interaction was not significant (Table 11). The descriptive statistics were calculated for the main effects and interaction for the variability of hip and shoulder turn form (Table 12).

A Newman-Keuls post hoc test was also performed for the significant main effect for group. The results indicated the subjects in the backward-chaining feedback group were significantly more variable ($p = .05$) during their hip and shoulder rotations than were those in the forward-chaining and random feedback groups. Post hoc tests were calculated by utilizing the Newman-Keuls procedure for the significant main effects for session. The results indicated that subjects at Session 1 had significantly higher variability than at Session 3, 4, and 5 ($p = .02$). In addition, the findings revealed that at Session 2, subjects were significantly more variable than during Sessions 3, 4, and 5 ($p = .02$).

Table 11. Group x Session RMD ANOVA for Variability of Hip and Shoulder Turn.

Source	df	F	p
Between Group	2	3.52	.0413
S (Group)	33	-	-
Within Session	4	15.26	.0001
Group x Session	8	.43	.9035
Error	130	-	-

Table 12. Group x Session Descriptive Statistics for Variability of Hip and Shoulder Turn.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.40 (.17)	.36 (.21)	.26 (.20)	.17 (.19)	.21 (.21)	.28 (.21)
FKP	.33 (.20)	.24 (.21)	.14 (.20)	.04 (.10)	.07 (.14)	.17 (.20)
RKP	.27 (.24)	.20 (.21)	.14 (.26)	.11 (.17)	.08 (.14)	.16 (.19)
Total Sessions	.33 (.21)	.26 (.22)	.18 (.19)	.11 (.16)	.12 (.17)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Weight Transfer

The form of weight transfer was evaluated using two 3 x 5 (Feedback Group x Session) RMD ANOVAs to measure the quality of performance and variability of performance for this movement variable.

Quality

The main effect for group was not significant (Table 13), but the main effect for session was significant ($p = .0001$). Furthermore, the Feedback Group x Session interaction was not significant. The descriptive statistics were calculated for the main effects and interaction for the quality of weight transfer (Table 14).

A Newman-Keuls post hoc test was performed to determine the specific location of the significant main effects for session. The results revealed that subjects performed significantly poorer at Session 1 than during the other sessions ($p = .05$).

Variability

The main effect of group was significant ($p = .0407$), however, the main effect of session was not significant. Moreover, a Feedback Group x Session interaction was not significant (Table 15). Descriptive statistics (Table 16) were calculated for the main effects and interaction for variability of weight transfer.

To determine the variability of performance contrasts for weight transfer, a Newman-Keuls post hoc test was utilized for the significant main effect of group. The results revealed that the subjects in the backward-chaining feedback group had significantly less variability ($p = .05$) in their weight transfer performances than did those in the forward-chaining and random feedback groups (Table 16).

Table 13. Group x Session (2 x 3) RMD ANOVA for Quality of Weight Transfer.

Source	df	F	p
Between Group	2	.96	.3915
S (Group)	33	-	-
Within Session	4	10.08	.0001
Group x Session	8	.54	.8261
Error	132	-	-

Table 14. Group x Session Descriptive Statistics for Quality of Weight Transfer.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	1.23 (.59)	1.35 (.54)	1.45 (.34)	1.46 (.43)	1.44 (.41)	1.38 (.46)
FKP	1.29 (.36)	1.50 (.28)	1.60 (.26)	1.75 (.26)	1.61 (.21)	1.55 (.31)
RKP	1.22 (.41)	1.45 (.35)	1.55 (.34)	1.55 (.27)	1.64 (.24)	1.48 (.35)
Total Sessions	1.24 (.45)	1.43 (.39)	1.53 (.32)	1.58 (.33)	1.57 (.30)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Table 15. Group x Session (2 x 3) RMD ANOVA for Variability of Weight Transfer.

Source	df	F	p
Between Group	2	3.53	.0407
S (Group)	33	-	-
Within Session	4	.56	.690
Group x Session	8	1.15	.3336
Error	130	-	-

Table 16. Group x Session Descriptive Statistics for Variability of Weight Transfer.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.41 (.10)	.29 (.21)	.37 (.08)	.34 (.14)	.30 (.17)	.34 (.15)
FKP	.38 (.16)	.43 (.18)	.43 (.18)	.33 (.16)	.44 (.08)	.40 (.16)
RKP	.43 (.14)	.34 (.17)	.38 (.19)	.42 (.09)	.41 (.10)	.40 (.15)
Total Sessions	.41 (.14)	.36 (.19)	.39 (.16)	.37 (.13)	.39 (.13)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Follow Through

To evaluate the effects of KP feedback on the follow through, two 3 x 5 (Feedback Group x Session) RMD analyses of variance were employed. One ANOVA was calculated for quality of performance and one for variability of performance.

Quality

The main effect of group was not significant, however, the main effect session was significant ($p = .0001$). Moreover, the Feedback Group x Session interaction was not significant (Table 17). Descriptive statistics were calculated for the main effects and interaction for quality of performance for follow through (Table 18).

A Newman-Keuls post hoc test was conducted to analyze the contrast of performance across sessions. First, the results indicated that subjects had significantly poorer follow through during Session 1 than in all other sessions ($p = .05$). Furthermore, subjects had significantly poorer follow throughs in Session 2 than in Sessions 3, 4, and 5 (Table 18).

Variability

The main effect of group was not significant, but the main effect of session was significant ($p = .0001$). In addition, the Feedback Group x Session interaction was not significant (Table 19). Descriptive statistics were calculated for the main effects and interaction for variability of follow through (Table 20). A Newman-Keuls post hoc test revealed no significant pairwise contrasts between session means.

Table 17. Group x Session (2 x 3) RMD ANOVA for Quality of Follow Through.

Source	df	F	p
Between Group	2	.08	.9219
S (Group)	33	-	-
Within Session	4	16.15	.0001
Group x Session	8	.86	.5539
Error	132		

Table 18. Group x Session Descriptive Statistics for Quality of Follow Through.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.98 (.36)	1.21 (.44)	1.43 (.29)	1.40 (.28)	1.22 (.34)	1.25 (.37)
FKP	1.05 (.41)	1.12 (.23)	1.26 .343	1.29 (.34)	1.28 (.36)	1.20 (.34)
RKP	.96 (.32)	1.15 (.41)	1.33 .35	1.40 (.36)	1.31 (.36)	1.23 (.38)
Total Sessions	.99 (.35)	1.16 (.37)	1.34 (.33)	1.36 (.33)	1.27 (.35)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Table 19. Group x Session (2 x 3) RMD ANOVA for Variability of Follow Through.

Source	df	F	p
Between Group	2	1.82	.1784
S (Group)	33	-	-
Within Session	4	8.29	.0001
Group x Session	8	1.58	.1380
Error	130	-	-

Table 20. Group x Sessions Descriptive Statistics for Variability of Follow Through.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.14 (.13)	.39 (.13)	.41 (.16)	.40 (.13)	.40 (.16)	.36 (.17)
FKP	.32 (.15)	.42 (.13)	.39 (.15)	.40 (.09)	.35 (.15)	.38 (.14)
RKP	.24 (.20)	.37 (.14)	.34 (.15)	.31 (.17)	.29 (.18)	.31 (.17)
Total Sessions	.24 (.18)	.39 (.13)	.38 (.15)	.37 (.14)	.34 (.17)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Outcome

To determine the effects of knowledge of performance feedback on motor skill learning, a result oriented dependent variable called outcome was analyzed by utilizing a 3 x 5 (Feedback Group x Session) RMD ANOVA. This analysis was calculated for both quality of outcome and variability of outcome.

Quality

The main effects for quality of outcome between the 3 x 5 (Feedback Group x Session) RMD ANOVA with subjects nested in group was calculated (Table 21). The main effect of group was not significant, but the main effect of session was significant ($p = .0001$). Also, the Feedback Group x Session interaction was not significant (Table 21). Descriptive statistics were calculated for the main effects and interaction for quality of outcome (Table 22). A Newman-Keuls post hoc test revealed that subjects had significantly better outcome scores in Session 5, the retention trials, than in all other sessions ($p = .05$).

Variability

The main effect of group was not significant, however, the main effect of session was significant ($p = .0011$). Moreover, the Feedback Group x Session interaction was not significant (Table 23). Descriptive statistics (Table 24) were calculated for the main effects and interaction for variability of outcome. A Newman-Keuls post hoc test indicated that subjects had significantly more variance in their outcome scores during Session 5 than during all the other sessions ($p = .05$).

Table 21. Group x Session (2 x 3) RMD ANOVA for Quality of Outcome.

Source	df	F	p
Between Group	2	.53	.5909
S (Group)	33	-	-
Within Session	4	10.94	.0001
Group x Session	8	1.06	.3946
Error	132	-	-

Table 22. Group x Sessions Descriptive Statistics for Quality of Outcome.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.51 (.35)	.52 (.40)	.67 (.46)	.72 (.48)	.90 (.49)	.66 (.45)
FKP	.53 (.39)	.57 (.43)	.67 (.42)	.58 (.29)	.95 (.47)	.66 (.42)
RKP	.48 (.31)	.51 (.33)	.57 (.35)	.51 (.33)	.65 (.36)	.54 (.33)
Total Sessions	.51 (.34)	.53 (.37)	.63 (.40)	.60 (.37)	.82 (.45)	

* Means are located in the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

Table 23. Group x Session (2 x 3) RMD ANOVA for Variability of Outcome.

Source	df	F	p
Between			
Group	2	.35	.7107
S (Group)	33	-	-
Within			
Session	4	4.89	.0011
Group x Session	8	.71	.6834
Error	130	-	-

Table 24. Group x Session Descriptive Statistics for Variability of Outcome.

Group	Session 1	Session 2	Session 3	Session 4	Session 5	Total Group
BKP	.86 (.59)	.84 (.57)	1.07 (.55)	1.08 (.53)	1.28 (.46)	1.03 (.54)
FKP	.91 (.50)	.93 (.62)	1.13 (.57)	1.01 (.49)	1.81 (2.02)	1.16 (1.05)
RKP	.90 (.41)	.89 (.56)	1.03 (.50)	1.08 (.54)	1.20 (.40)	1.02 (.49)
Total Sessions	.89 (.48)	.89 (.56)	1.07 (.52)	1.06 (.51)	1.41 (1.16)	

* Means are located on the first line of every block and Standard Deviations are indicated in the parentheses, N = 36.

Key

BKP - Backward-Chaining KP

FKP - Forward-Chaining KP

RKP - Random KP

CHAPTER V

DISCUSSION

The learning of motor activities depends on the information feedback presented. Even though this seems clear to practitioners, teachers, and researchers, the nature of how this information should be arranged, organized, and sequenced is perplexing. Much research has been conducted on an augmented feedback variable commonly known as knowledge of results (KR). Few studies, however, have explored an augmented feedback variable known as knowledge of performance (KP). More recently, this variable has been the subject of investigation among motor learning researchers (Schmidt & Young, 1991). This type of feedback describes some part of the movement pattern of a given motor skill, i.e., the forehand groundstroke. The literature suggests that very few field studies have been performed to determine what movement form variables lead to effective motor learning. Specifically, it is puzzling, how, when, and in what form this feedback should be structured and provided to optimize learning in motor skill settings.

This study examined the relative effectiveness of sequencing three conditions of knowledge of performance feedback on the learning and performance of a sport oriented motor skill, the forehand groundstroke. These three conditions included backward-chaining KP, forward-chaining KP, and random KP feedback. These conditions are common teaching styles used in motor learning settings for complex motor skills. This chapter is organized to discuss the quality and variability of performance and results in the following manner: (a) the presentation of feedback group findings, (b) the presentation of findings across practice sessions, (c) the presentation of significant

Feedback Group Session interaction findings, and (d) the presentation of summary, conclusions, and implications.

Feedback Group Findings

In order to determine feedback group differences among the three conditions, backward-chaining, forward-chaining, and random knowledge of performance, a 2 x 3 RMD analysis of variance was calculated. Among all the movement form measures - ready position, eye contact, hip and shoulder turn, weight transfer, and follow through, there were no significant differences between the three experimental feedback groups except for the variability measures for the form of hip and shoulder turn and weight transfer. The hip and shoulder turn findings are discussed in the interaction analysis later in this chapter.

Participants who received backward-chaining feedback throughout the experiment had significantly lower variability in their weight transfer than did those in the forward-chaining and random feedback groups. Since all the groups performed this movement characteristic relatively well (Table 12, page 54), this finding suggests that backward-chaining might be a stronger learning variable for students to achieve sound weight transfer. Perhaps, by first having the learners focus on the end components of their movement, the learner is initially forced to feel their weight shifting forward. By introducing this aspect of the forehand groundstroke in each feedback session, the learner experiences a shift in their weight first which might have an enduring effect (Malone, 1990).

There were no significant differences between these feedback groups for the outcome measures. Taken together, these results imply that all three feedback methods were similar in their effectiveness as tools for learning the quality of the movement pattern and achieving a comparable outcome goal for the forehand groundstroke.

The literature review failed to find any studies that examined the sequencing of KP feedback on the learning of an open, complex motor skill. However, one study conducted by Welsh, Fitt, and Thompson (1994) investigated forward-chaining and backward-chaining teaching strategies on the learning of a sequence of complex dance movements. They found that teaching a dance sequence through forward-chaining was more effective in producing fewer errors than backward-chaining. Although this study utilized a "forward" and "backward" method of teaching, the researchers did not sequence their movement pattern feedback for each movement pattern of the dance sequence. Thus, it seems impossible to compare the feedback group findings of this study with the results of any other studies. Therefore, the findings of the five movement form variables and one outcome variable were discussed in terms of their significance by session and the interaction with feedback groups.

Practice Session Findings

These results supported a notion called the practice effect (Thomas & Nelson, 1990). That is, all the performance variables improved significantly across the five practice sessions. Since there was no control group (without feedback), the power of the feedback compared to just practicing the motor skill was not clear. In this section, the

practice session significant results are discussed for the quality and variability of the following components of movement form: (a) ready position, (b) eye contact, (c) hip and shoulder turn, (d) weight transfer, (e) follow through, and (f) outcome.

Ready Position

As the results indicated, ready position significantly improved initially for all of the participants. That is, the subjects were able to begin their movement pattern with the racquet head forward and have their weight shifted forward (Appendix C). The findings revealed that the participants improved their ready position significantly from the pre-test to the first practice session with feedback. After the second session, the participants leveled off and maintained a high ready position score for the rest of the acquisition sessions and the retention session. One explanation for this finding might be that the novice participants were going through a cognitive stage of learning (Fitts & Posner, 1967). That is, the participants were implementing many mental strategies in which they were adjusting, changing, or dismissing solutions to the motor skill problem. For example, some participants might have been adjusting to the speed of the delivered ball from the ball machine. After the first practice session, the participants might have learned to begin preparing with their eyes, racquet, and feet, several seconds before each ball delivery.

Another explanation for this finding might be that the participants achieved this stable movement score through a primacy effect. Since the participants were experiencing the same stimulus very frequently (being on the tennis court, seeing the ball

machine, practicing the forehand groundstroke), their responses of ready position were becoming necessary, repetitive, and habit forming (Watson, 1930). A third explanation might be that the feedback, regardless of the chaining conditions during Sessions 2, 3, and 4, functioned as a guiding tool for the participants to initiate their ready position.

The results also indicated that the participants' ready positions became significantly less variable from the first practice session compared to Sessions 2, 3, 4, and 5. The least amount of variability occurred during Session 4 (Table 4, page 45), but it was not significantly different from Sessions 2, 3, and 5. This finding seems to support the aforementioned theory of practice. Thus, as learners begin to understand the requirements of the motor task, their responses become more consistent.

Eye Contact

Similar to the findings of ready position, eye contact movement improved across the five sessions. Specifically, the participants had poor eye contact during the first session as compared to the other sessions. Also, the participants had much better eye contact during the second session than during the first session, but significantly less eye contact compared to Sessions 3, 4, and 5. This finding was expected because three KP feedback statements were given to the forward-chaining and backward-chaining KP participants, and possibly to the random KP participants during Sessions 2, 3, and 4 (Appendix B) that emphasized how their eyes should be focusing. For example, one of these middle of the movement feedback statements was, "focus on watching the ball into your strings, your contact point." Thus, the present data might support the use of eye

focusing KP feedback for skill acquisition when eye-hand coordinating motor skills are being learned. However, this is not clear, since there was no control group (no feedback condition) in this study. Another interesting finding was that the participants maintained a consistent level of eye contact across Sessions 3, 4, and 5. They never achieved a high level of eye contact ($\underline{M} = 1.5$ to $\underline{M} = 2.0$). But they achieved consistent above average eye contact mean scores ($\underline{M} = 1.3$ and $\underline{M} = 1.33$). This suggested that the participants were beginning to focus in a relatively successful manner with their eyes. Nevertheless, it was unclear, based on this study, what germane middle of the movement, KP feedback statements contributed to this finding.

The results also indicated the significantly lower variability of eye contact scores during Session 1 than during the other sessions. This finding might seem unusual to the stages of practice notion which suggests that when novices learn a motor skill, they perform with high variability at the beginning trials, and less variability during their later practice trials. Thus, the learner would problem-solve until finding a successful solution to the motor task. An explanation for the high variability after Session 1 might be that the participants consistently achieved very little eye contact at the beginning of the sessions, and slowly, across the other four sessions, began seeing the ball. Therefore, the participants may have been responding consistently at interspersing watching the ball and monitoring other factors in the environment..

Hip and Shoulder Turn

Across the five practice sessions, participants during Session 1 had significantly worse hip and shoulder turns than during the other sessions. Also, the participants in Session 2, performed the hip and shoulder turn significantly better than their performances in Session 1, but significantly worse than during Sessions 3, 4, and 5. Although this movement was critical to an efficient execution of the forehand groundstroke, it was not clear when this feedback should be given. One of the feedback statements provided for this particular movement was, "focus on turning your shoulders and hips." These findings might suggest that this type of movement information was critical to successful hip and shoulder performances. But further research should examine whether this beginning of the movement feedback should be offered in any type of structure or just delivered in an "as needed" manner for learners. According to Kernodle and Carlton's study (1992), transitional information on the movement pattern of throwing, revealed increased performances compared to attention focusing movement information. That is, movement information based on what to change and how to change the next movement as compared to information directed at a body part. Even though this was not distinguished in the present study, transitional knowledge of performance feedback might be similar to saying, "focus on turning your shoulders and hips as the ball approaches you." Attention focusing feedback might take the form of, "focus on your shoulders and hips when hitting." It would be interesting to study how these two types of movement information variables affect performances of motor skills found in various other sport and

movement activities.

For Session 1, the participants had significantly higher scores of variability in their hip and shoulder turn scores than in Sessions 2, 3, 4, and 5. As expected, the participants during Session 2 had significantly higher hip and shoulder turn scores than in Sessions 3, 4, and 5, but significantly lower variability in their hip and shoulder turns from their performances during Session 1. As discussed earlier, this follows the pattern described in the theory of practice (Thomas, & Nelson, 1990) The participants hip and shoulder turns became more and more consistent across the practice sessions. The largest performance variance occurred in Session 3 ($\underline{M} = .18$), whereas, Sessions 3 and 4 had equitable performance variability ($\underline{M} = .11$ for Session 4 and $\underline{M} = .12$ for Session 5). Even though all three feedback groups received this information in different order, these findings suggest that this KP feedback might be effective irrespective of its sequence (Appendix B).

Weight Transfer

Similar to the aforementioned findings, the participants during Session 1 significantly transferred their weight more poorly compared to all the other sessions. Since performing this movement characteristic correctly involves the learner shifting their weight forward with their feet (Appendix C), the KP feedback given in this study does not offer this information directly to the learner (Appendix B). It seems unclear what feedback components influenced the learning of this movement. Perhaps, weight transfer could be linked to the middle of the movement and end of the movement feedback. For

example, this variable might be affected when the experimenter said to the learner, "focus on making contact with the ball in front of you, near your front foot, with a firm grip" (middle of movement). Furthermore, this variable might be affected when the experimenter said, "focus on finishing your follow through above and out in front of your non-dominant shoulder and feeling it there momentarily after you hit the ball" (end of movement). Since these two feedback statements had the learner shift their weight to accomplish the movement pattern of the forehand groundstroke, these feedback statements might be directly affecting this movement variable. Further study is needed to identify what forms of KP feedback influence specific performance movement variables of a complex motor task.

An interesting finding in this study was that the participants' weight transfer variability scores did not change across sessions. The scores were consistently high from Session 1 to Session 5. Perhaps, the participants were learning how to transfer their weight while coordinating their balance throughout all the sessions. Thus, the participants were problem-solving with their weight transfer during all the sessions. Since the participants had a relatively small amount of practice attempts, it would be intriguing to extend the study another five sessions to determine whether these variability scores level off and change between different feedback groups.

Follow Through

Participants during Session 1 performed their follow through significantly poorer than during all the other sessions. Also, significant improvements in follow through

scores were revealed during Sessions 3, 4, and 5, compared to Session 2. These session findings for follow through movement score clearly describe a practice effect.

Furthermore, its possible that the end of the movement feedback was functioning during Sessions 2, 3, 4 and 5 with a strong performance and learning effect. For example, during the last feedback session (Session 4), the participants had their best follow through scores ($\bar{M} = 1.36$). Then, during the final session (retention test), the participants maintained a high follow through score, slightly less but not statistically different than Session 4 ($\bar{M} = 1.27$). As indicated by all the participants' improvements across the sessions, these findings suggest that the KP feedback on the end of the movement might be functioning as a strong learning variable. As discussed earlier, further research with a control group is needed.

The 3 x 5 RMD analysis of variance for the participants' variability of performance on the follow through revealed significant findings ($p = .02$). However, no significant pairwise contrasts were demonstrated by the post hoc test. Based on the descriptive statistics, the participants had lower variability during Session 1 than during all the other sessions. As described previously, this finding would be expected to be the opposite. Specifically, as the participants practiced more, their movement scores would become more consistent. The participants would be finding solutions to the movement task problem. In this case, the participants during the later practice sessions (Sessions 2, 3, 4, and 5) became more varied in their follow through movement scores. An explanation for this finding could be that the participants were trying to apply the

feedback on the end components of their movement, but were having outcome success without following through properly. For example, a good outcome score (i.e., the tennis ball lands inside the tennis court boundary) can be achieved when the learner makes contact with the ball and stops soon after contact. This movement phenomenon can lead many tennis students away from developing efficient, biomechanically sound groundstrokes (Groppel, 1980). Thus, the participants' high follow through movement variability scores might have been influenced by this common movement difficulty found in many real-world tennis settings (Groppel, 1980).

Outcome

The participants during Session 5, the retention session, had significantly higher outcome scores than in all the other sessions. Furthermore, the participants during Sessions 1 through 4 scored similarly in their outcome measures. One reason for this occurrence might be that the participants during the acquisition trials were attempting to qualitatively learn the movement pattern. Thus, the outcome of their trials were not pertinent until they were being post-tested during Session 5 when no movement form feedback was given. This finding was congruent with motor learning theorists, who advocate providing beginning students with high amounts of qualitative feedback (movement form) not quantitative feedback (outcome) when teaching a motor skill (Landin & Cutton, 1990). These results also imply that the feedback delivered in all three groups enhanced the outcome performances of participants learning the forehand groundstroke. Moreover, this study did not ascertain what specific KP feedback might

have attributed to such a strong outcome retention test finding. Further work is needed to investigate this question.

Furthermore, a 3 x 5 RMD analysis of variance conducted on the participants' session variability of performance found that Session 5 was significantly more variable than all the other sessions. As discussed earlier, this was an unexpected result. It might be reasoned that the nature of the Hewitt Tennis Test could create spurious variance in the participants' outcome scores. For example, the experimenter noted that a sound biomechanically hit ball would be scored a 1 or 2 on the outcome score sheet when the shot was just as good as a shot scored a 3 or 4. Therefore, in the present study, the high variability found in the Session 5 outcome scores might have resulted because the participants scored well in varied ways.

Feedback Group x Practice Session Interaction

For Hip and Shoulder Turn

According to teachers, coaches, and biomechanics experts, one of the most critical movement patterns to achieve in order to execute an efficient forehand groundstroke is the hip and shoulder turn (Groppel, 1980). This movement allows the learner to utilize linear and angular momentum to optimize their swinging pattern into the contact point with the ball (Groppel, 1980). In this study, significant interaction results were found between feedback groups and practice sessions for the hip and shoulder turn. Participants in forward-chaining and random knowledge of performance feedback groups achieved their hip and shoulder turns significantly better than did those in the backward-chaining

group during Sessions 3 and 4. Also, during Session 5, the retention test, the participants in the random knowledge of performance feedback group performed their hip and shoulder turns significantly better than the forward and backward-chaining groups. These findings imply that the random feedback method might be preferable to the other feedback groups. Since random KP was given in an, "as needed" manner, it is possible that these students received more KP statements on their hip and shoulder turn than for other movement characteristics. However, there were no other dependent variables in this study where random feedback was more effective than forward and backward-chaining feedback. Further research should be pursued in this area.

Another interesting finding was that each feedback group had significant interactions within the practice sessions for hip and shoulder turn form. The participants in the backward-chaining feedback group had significantly better hip and shoulder rotations during Sessions 3, 4, and 5 than in Sessions 1 and 2. Perhaps, the participants were beginning to piece together the movement for the forehand groundstroke after their first feedback trial (Welsh, Fitt, & Thompson, 1994). For the forward-chaining group, the participants performed the hip and shoulder turn significantly better during Sessions 3 and 4 than during all the other sessions. Also, the participants in this feedback group significantly executed their hip and shoulder turns better during Session 2 and 5 than during Session 1. Moreover, for the random feedback group, the participants were similar to the backward-chaining group. They executed their hip and shoulder turns significantly better during Sessions 3, 4, and 5, than during Sessions 1 and 2. In addition,

these participants scored significantly higher hip and shoulder turns during Session 2 than during Session 1; and both of these groups revealed much higher retention test (Session 5) hip and shoulder turn scores than the forward-chaining group. These findings might imply that backward-chaining and random knowledge of performance feedback groups are stronger learning feedback tools. Since these findings only pertain to the hip and shoulder turn measure and not the other dependent measures in this study, it would be erroneous to generalize on the learning power of one of these feedback groups.

Summary

The purpose of this study was to determine the relative effects of sequencing knowledge of performance feedback on the learning of a motor skill, the forehand groundstroke. Knowledge of performance feedback (KP), kinematic feedback, or movement pattern feedback has been described by many researchers as the most appropriate information to provide to the learner in order to optimize skill learning (Kernodle & Carlton, 1992). This study examined three knowledge of performance variables - backward-chaining KP, forward-chaining KP, and random KP. Performance was measured using five movement form variables and one outcome variable across five practice sessions. The performance oriented form variables were as follows: (a) ready position, (b) eye contact, (c) hip and shoulder turn, (d) weight transfer, and (e) follow through. The outcome score was a point score determined by location of the ball landing. All the participants performed five sessions in a pre/post-test format. Taken together, the results suggested that all three KP feedback methods are effective learning

tools in teaching an open, complex motor skill such as the forehand groundstroke.

However, the results do not support a preferred sequence of KP feedback that would optimize motor learning for novice learners. If there is a preferred framework for giving KP feedback, then it is yet to be discovered.

Several motor learning theorists may have shed light on why coaches, teachers, and practitioners choose one of these three methods for giving KP feedback to novice performers. One notion is called the schema theory which suggests that a learner becomes skilled with a motor task when he/she is exposed to four types of information. These include the initial conditions, the response specifications, the sensory consequences, and the outcome consequences of the motor task (Schmidt, 1975). Once the student experiences these four characteristics, then the student begins to learn the movement task. Another framework that might explain the use of these feedback methods is called part-whole teaching. This is a very common teaching notion found in many physical education settings. It simply advocates breaking a complex motor skill into parts. This enables the learner to easily understand each component of a motor skill and then eventually put the movement together into a “whole” form (French, Rink, Rikard, Mays, Lynn, & Werner, 1991). A third notion that might offer credence for the “chaining” methods investigated in this study is termed target or endpoint hypothesis (MacNeilage, 1970; Polit & Bizzi, 1978; Schmidt & McGown, 1980). These researchers suggest that endpoint locations for motor tasks may enhance the learning of a movement.

The results of the present study suggested:

1. (a) The backward-chaining KP participants were significantly less variable in their weight transfer ability than the other two feedback groups.

(b) There were no significant differences among the three feedback groups for the participants quality of performance measures and outcome scores.

2. (a) The participants significantly improved their ready position ability from the first practice session to the second practice session.

(b) The participants all became more consistent, less variable, at establishing their ready positions after the first practice session.

3. (a) All the participants had superior eye contact with the ball during practice Sessions 3, 4, and 5 as compared to practice Session 1 and 2.

(b) All the participants had consistently low eye contact with the ball during the first practice session as compared to the other four sessions.

4. (a) All the participants had superior hip and shoulder turns during practice Sessions 3, 4, and 5.

(b) All the participants became more consistent at correctly turning their hips and shoulders across the five practice sessions.

(c) All the participants became proficient at turning their hips and shoulders after the second practice session.

5. (a) All the participants were transferring their weight significantly better after the first practice session.

(b) All the participants transferred their weight inconsistently across all five

sessions.

6. (a) All the participants significantly improved their follow through from the first and second practice sessions as compared to the other three practice sessions.

(b) All the participants had significantly lower variability in their follow through during the first practice session as compared to the other four practice sessions.

7. (a) All the participants had superior outcome scores during the fifth session as compared to all the other preceding practice sessions.

(b) All the participants had significantly higher variability in their outcome scores during the last practice session as compared to the other practice sessions.

8. (a) The participants in the forward-chaining and random KP feedback groups had significantly better hip and shoulder turn ability than the backward-chaining group during practice Sessions 3 and 4.

(b) The participants in the random KP feedback group had superior hip and shoulder ability during Session 5 as compared to the backward and forward-chaining groups.

Conclusions

Based on these findings, the three KP feedback methods are comparable for teaching a novice student a complex, serial motor skill like the forehand groundstroke in tennis. However, the results provide a small amount of evidence for supporting random and backward-chaining methods over the forward-chaining method. This contradicts evidence supporting a forward-chaining teaching method for learning a complex dance

movement (Welsh, Fitt, & Thompson, 1994). Therefore, teachers, coaches, and researchers should utilize these results to encourage practitioners to emphasize kinematic information using all three teaching methods, perhaps with an emphasis on random and backward-chaining.

Implications

This study has demonstrated that exploring the effects of sequencing knowledge of performance feedback on the learning of a motor skill is complex. Also, it has provided evidence for a closer examination of this variable in real-world settings. Furthermore, there are a vast number of other variables that need to be incorporated in order to have a more complete understanding of this construct. The following recommendations are offered for future research on how KP feedback influences motor skill learning.

1. Reexamine the sequencing of KP feedback. For example, it would be interesting for researchers to create an experiment where several more movement skill characteristics would be added. Conduct a similar study, but sequence and control for KP information in transitional and attention-focusing ways.

2. Conduct the present study by sequencing kinematic feedback over a series of practice sessions. That is, the learner would be introduced to early parts of the movement during the first session, middle parts of the movement during the second session, and later parts of the movement during a third session. This condition could be altered and structured for different chaining and teaching methods.

3. Conduct this study by having the students achieve a criterion movement goal before progressing to the next movement criterion goal under the same conditions. For example, a learner would achieve a satisfactory level of the end of the movement for the forehand groundstroke before practicing another component of the movement. This might shed light on which method is more effective in optimizing motor learning.

4. Conduct a similar study with a different complex, serial motor skill such as a backhand groundstroke or a golf drive. In order for any of these teaching methods to be effective, they must be studied in other movement and sport settings.

5. Conduct a similar study, but include the variables of previous sport experience, self-confidence, spatial visualization ability, and a stimulus cuing feedback group. Many other factors seem to be affecting why a student learns a motor skill. Investigating some of these above variables would help researchers, teachers, and coaches understand what enhances motor learning.

6. Conduct the present investigation and assess the effects of gender and a control group with no KP feedback. By researching the effects of a control group without feedback, the viability of utilizing different types of KP feedback on teaching a complex motor skill might be revealed. Possibly, gender might be a factor when a teacher provides feedback. It could be reasoned through sociological and physiological predispositions that gender may affect how, when, and in what form the feedback should be given. Perhaps, novice male or female students of a complex motor skill might have a preferred movement information path.

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APPENDICES

APPENDIX A: FEEDBACK SCRIPTS

1. **FKP**: Forward-Chaining knowledge of performance feedback will emphasize the beginning of the movement for the first three feedback statements (1. "Concentrate on turning your shoulders and hip, and pointing your racket to the back fence, before the ball bounces"). Then, for the next three feedback statements, the instructor will emphasize the middle of the movement (2. "Watch the ball into the contact point, make contact out in front of you, near your front foot"). Finally, the last three feedback statements, the instructor will emphasize the end of the movement (3. "Focus on finishing your follow through above and out in front of your non-dominant shoulder, hold it and feel it there momentarily after you hit the ball").

2. **BKP**: Backward-Chaining knowledge of performance feedback will emphasize the above feedback but in opposite order. Thus, the movement feedback will be given emphasizing the end of the movement first (3), then the middle of the movement (2), and finally the beginning of the movement (1).

3. **RKP**: The instructor will give random feedback based on the above feedback scripts, depending on what the student needs at each feedback delivery. That is, after a series of five trials, the feedback information will be based on the most relevant correction for the stroke problem occurring.

APPENDIX B: FEEDBACK ATTENTION FOCUSING CUES SCRIPT

A. BEGINNING OF MOVEMENT (B)

1. Concentrate/focus on turning your shoulders and hip.
2. Concentrate/focus on pointing your racket to the back fence.
3. Concentrate/focus on turning, and pointing your racket back before the ball bounces.

B. MIDDLE OF THE MOVEMENT (M)

4. Concentrate/focus on watching the ball into your strings, your contact point.
5. Concentrate/focus on making contact with the ball in front of you, near your front foot, with a firm grip.
6. Concentrate/focus on keeping your eyes momentarily at the contact point after you hit the ball.

C. END OF THE MOVEMENT (E)

7. Concentrate/focus on finishing your follow through above and out in front of your non-dominant shoulder and feeling it there momentarily after you hit the ball.
8. Concentrate/focus on freezing your follow through momentarily, and then return to ready position.

SEQUENCE OF FEEDBACK/ATTENTIONAL INFORMATION

TRIALS	FKP	BKP	RKP
1 - 5	1	8	B,M,E
6 - 10	2	7	B,M,E
11 - 15	3	6	B,M,E
16 - 20	4	5	B,M,E
21 - 25	5	4	B,M,E
26 - 30	6	3	B,M,E
31 - 35	7	2	B,M,E
36 - 40	8	1	B,M,E

Before beginning each feedback statement, the director will provide positive affective feedback such as, "Good", "Nice Job", or "Well Done", etc. Also, to avoid having the participants receive a final feedback statement following the last trial of the practice session, the experimenter will deliver the first feedback statement after their first trial. Furthermore, at the end of the last trial for the practice session, the experimenter will thank the participant for coming to the lesson, and remind him or her of their next scheduled time.

APPENDIX C: MOVEMENT FORM KEY

Ready Position (RP): 0 = racket head down, weight not forward
1 = racket head facing forward, weight not forward
2 = racket head facing forward, weight forward

Eye Contact (EC):

- 0 = eyes not tracking ball into contact area, ball missed
- 1 = eyes tracking ball into contact area, but averted upon contact
- 2 = eyes focus on contact area momentarily after contact

Hip and Shoulder Turn (HS):

- 0 = both hips and shoulders stay parallel to the net
- 1 = both turn 45 degrees to the net
- 2 = both turn perpendicular to the net

Weight Transfer (WT):

- 0 = no weight shift
- 1 = weight evenly distributed between both feet or parallel to net
- 2 = weight shift forward

Follow Through (FT):

- 0 = racket head stops immediately upon contact
- 1 = follow through forward, below shoulder level
- 2 = follow through high, head height or higher

APPENDIX D: OUTCOME SCORING SHEET

Participant #:

Date:

Time:

Session #:

Scoring Procedures:

1) 5, 4, 3, 2, 1, marked if ball lands in.

2) Balls hit over 7' line into scoring
zones score $\frac{1}{2}$ point.

3) Ball hit out, wide, net score 0.

TRIALS PER PRACTICE SESSION

1.	0	1	2	3	4	5	$\frac{1}{2}$	26.	0	1	2	3	4	5	$\frac{1}{2}$
2.	0	1	2	3	4	5	$\frac{1}{2}$	27.	0	1	2	3	4	5	$\frac{1}{2}$
3.	0	1	2	3	4	5	$\frac{1}{2}$	28.	0	1	2	3	4	5	$\frac{1}{2}$
4.	0	1	2	3	4	5	$\frac{1}{2}$	29.	0	1	2	3	4	5	$\frac{1}{2}$
5.	0	1	2	3	4	5	$\frac{1}{2}$	30.	0	1	2	3	4	5	$\frac{1}{2}$
6.	0	1	2	3	4	5	$\frac{1}{2}$	31.	0	1	2	3	4	5	$\frac{1}{2}$
7.	0	1	2	3	4	5	$\frac{1}{2}$	32.	0	1	2	3	4	5	$\frac{1}{2}$
8.	0	1	2	3	4	5	$\frac{1}{2}$	33.	0	1	2	3	4	5	$\frac{1}{2}$
9.	0	1	2	3	4	5	$\frac{1}{2}$	34.	0	1	2	3	4	5	$\frac{1}{2}$
10.	0	1	2	3	4	5	$\frac{1}{2}$	35.	0	1	2	3	4	5	$\frac{1}{2}$
11.	0	1	2	3	4	5	$\frac{1}{2}$	36.	0	1	2	3	4	5	$\frac{1}{2}$
12.	0	1	2	3	4	5	$\frac{1}{2}$	37.	0	1	2	3	4	5	$\frac{1}{2}$
13.	0	1	2	3	4	5	$\frac{1}{2}$	38.	0	1	2	3	4	5	$\frac{1}{2}$
14.	0	1	2	3	4	5	$\frac{1}{2}$	39.	0	1	2	3	4	5	$\frac{1}{2}$
15.	0	1	2	3	4	5	$\frac{1}{2}$	40.	0	1	2	3	4	5	$\frac{1}{2}$
16.	0	1	2	3	4	5	$\frac{1}{2}$								
17.	0	1	2	3	4	5	$\frac{1}{2}$								
18.	0	1	2	3	4	5	$\frac{1}{2}$								
19.	0	1	2	3	4	5	$\frac{1}{2}$								
20.	0	1	2	3	4	5	$\frac{1}{2}$								
21.	0	1	2	3	4	5	$\frac{1}{2}$								
22.	0	1	2	3	4	5	$\frac{1}{2}$								
23.	0	1	2	3	4	5	$\frac{1}{2}$								
24.	0	1	2	3	4	5	$\frac{1}{2}$								
25.	0	1	2	3	4	5	$\frac{1}{2}$								

APPENDIX E: LETTER TO THE PARTICIPANTS

Dear Participant,

As a graduate student currently enrolled in the Sport Psychology Master's Degree Program at the University of Tennessee-Knoxville, my thesis research compares the effectiveness of different types of instructor feedback on the learning of tennis skills.

In order to complete my thesis project, 36 students who are beginning tennis players will be needed as participants.

The testing period will be during the spring semester 1996 at the University of Tennessee-Knoxville recreation tennis courts, and will consist of four practice sessions and one post-practice session. Both practice and post-practice sessions will last approximately 15 minutes. The times of practice will be scheduled at a time set by you and me. The 36 participants will be divided in three experimental groups, and will practice a tennis skill with different amounts and kinds of feedback. All the participants will take an equal number of practice shots (160 shots during practice and 40 shots during the fifth practice period).

Your cooperation is important and appreciated for the successful completion of my research. With your cooperation, this study will provide additional information for teachers and coaches in real-life instructional situations. It will provide insight to physical educators and coaches on how to teach sport and skills so that learning occurs more effectively.

On the back of this letter, there is an informed consent statement that you need to sign, and a demographic sheet you must complete. I will be present at your next physical education activity class. Please return these two forms to me at this time. If you request, I will mail the results and conclusions of the study to you.

Thank you for your cooperation with my research.

Sincerely,

Yon T. Armstrong
M.S. Candidate

Dr. Patricia A. Beitel
Professor

Cultural Studies Unit
The University of Tennessee
Knoxville, TN 37996-2700
Phone: (423) 974-5111

APPENDIX F: INFORMED CONSENT

I understand that the purpose of this study is to learn more about how instructor feedback affects the performance of tennis skills.

I confirm that my participation as a participant is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

I understand that my participation has no effect on my grade or standing in my physical activity class.

I understand that I may withdraw my consent and terminate my participation at any time during the investigation.

I have been informed of the procedures that will be used in the study and understand what will be required of me as a participant.

I understand that the results of this study will remain completely confidential. In particular, no names will be attached to any of the data and only group results will be reported.

I understand that all my performance attempts will be videotaped and will remain confidential.

I understand that the study involves my participation in five sessions and each one will last approximately 15 minutes.

I wish to give my consent to serve as a subject in this study.

Signed

(participant)

(witness)

(address)

(telephone number)

(date)

For further information to answer any questions, please contact:

Yon T. Armstrong
M.S. Candidate

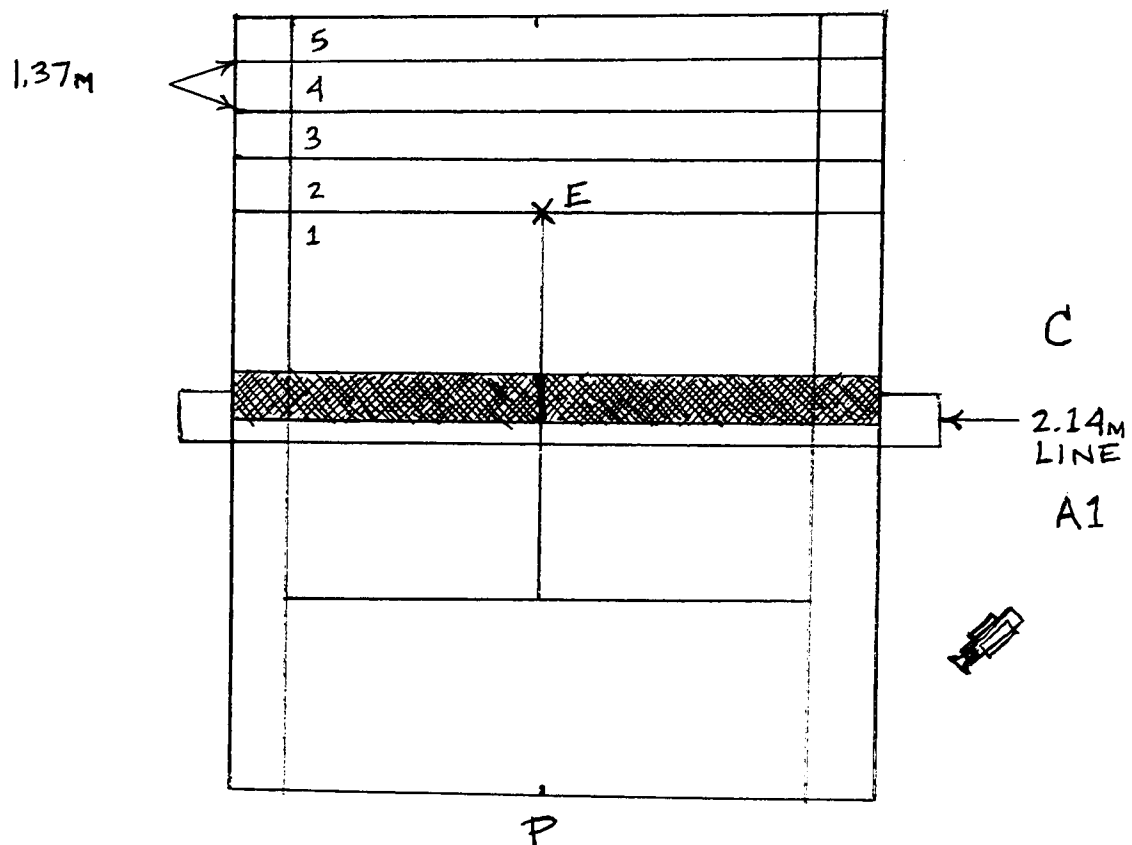
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1. Left-hand 2. Right-hand

APPENDIX H: THE TENNIS COURT LAYOUT (Hewitt, 1966)**KEY**

- E - Instructor and ball machine, with hopper of 50 tennis balls
- C - Chair for data sheets
- A1 - Assistant one assigned position
- P - Participant starting position



APPENDIX I: MOVEMENT FORM SCORING SHEET

Participant # _____

Date: _____

Session# _____

TRIALS PER PRACTICE

	Ready Position			Eye Contact			Hip and Shoulder			Weight Transfer			Follow Through		
	RP			EC			HS			WT			FT		
1.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
2.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
3.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
4.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
5.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
6.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
7.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
8.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
9.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
10.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
11.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
12.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
13.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
14.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
15.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
16.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
17.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
18.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
19.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
20.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
21.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
22.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
23.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
24.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
25.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
26.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
27.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
28.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
29.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
30.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
31.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
32.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
33.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
34.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
35.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
36.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
37.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
38.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
39.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
40.	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2

APPENDIX J: TENNIS FOREHAND SCRIPT

1. The ready position consists of the eastern forehand grip, a handshake grip with:
(a) a V formed from the thumb and index finger on the top bevel of the racket grip, (b) a trigger index finger and (c) the thumb pointing straight down on the back plate of the grip. Additionally, the feet are shoulder width apart, with knees slightly bent, weight is forward on the balls of the feet, and the racket is held in front of the body.
2. The hip and shoulder turn means turning the hips and shoulders perpendicular to the net: (a) pivot on and transfer weight to the rear foot while bringing the racket back, (b) bring the racket back with a firm wrist until the head points to the rear fence.
3. The weight transfer is the transfer of weight from the rear foot to the foot closest to the net (front foot) by stepping forward at a 45 degree angle, after hip and shoulder turn.
4. Keeping your eyes on the contact area is also important. Upon transfer of weight to the front foot, contact ball opposite the front foot at around waist height. Keep the wrist firm upon contact, while watching the ball make contact with the racket.
5. Finally, the follow through is the completion of your swing. Following contact the racket swing finishes at least head height on the non-dominant arm side of the body.

VITA

Yon Tomas Armstrong was born in Baltimore, Maryland, on May 16, 1969. He spent his entire childhood in Baltimore, attending and graduating from the Friends School in June 1987. He attended Virginia Commonwealth University where he was a member of the varsity tennis team, the club lacrosse team, and the National Honor Society for psychology. He graduated in 1992 with a Bachelor of Science degree in psychology with a minor in philosophy. From the fall of 1992 until the beginning of 1995, he taught, coached, and organized tennis programs for adults and junior players in Albuquerque, New Mexico. In 1995, he began his graduate course work in sport psychology at the University of Tennessee. While studying for his Masters of Science degree, he taught and coached tennis at the Cedar Bluff Racket Club and the Holston Hills Country Club. In the fall of 1996, he was hired as the sport psychology consultant for the Smoky Mountain Tennis Academy. He currently coordinates, plans, and implements mental training programs for the students at this academy. He received the Master of Science degree with a major emphasis in sport psychology/motor behavior in May 1997. He will continue to be employed by the Smoky Mountain Tennis Academy in Knoxville, Tennessee.