The effects of subject-generated verbal strategies on the learning of a novel motor skill

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Abstract

The main purpose of the present study was to determine the effects of subject-generated verbal strategies (VS) on the learning of a novel skill. The second purpose of the study was to determine the effects of knowledge of performance (KP) on the learning of a novel motor skill. The third purpose of the study was to examine the interaction effects of knowledge of results (KR) and KP on the learning of a novel motor skill.

The study consisted of three testing phases, the Acquisition phase, the Immediate Retention phase, and the Retention phase.

Study subjects were eighty college-aged students (mean age = 19) enrolled in physical education courses at Middle Tennessee State University. The subjects were randomly assigned to one of four groups. Each of the four groups had 20 subjects. A three-factor analysis of variance (ANOVA) was used to analyze the results. The independent variables measured were VS, KP, and Trials (Blocks).

Subjects who completed the novel task using VS performed, on average, with less error than subjects without VS during Acquisition phase. A VS main effect was

found. Subjects in all four groups improved performance, on average, over trial blocks with practice, during Acquisition. Statistical evidence supported this observation with a main trial block effect for Absolute Error (AE).

During Retention phase, subjects who completed the novel task using VS performed, on average, with less error than subjects without VS. No significant differences were found between these. However, a trial block by VS interaction was obtained.

The present findings support the importance of providing feedback for the acquisition and retention of a novel motor skill. The findings of the present study suggested that VS was beneficial for performance and for learning of a novel motor skill.

Future research is recommended to investigate the effects of subject-generated VS when experimenters provide information on how to verbally strategize using KR or KR and KP as reference.

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I have to thank God for giving health to me and my family.

Dedication

I want to dedicate this dissertation to mi familia (Papi, Mami, Soli, Nany and fam., Charo and fam., Maru, Paco, and Nini) and my loved one, Heather. Thank you for your love, your patience, and the support you have always given me and that have been needed since day one. Love you very much.

TABLE OF CONTENTS

Page

List of Tables....i

List of Figures....ii

List of Appendices....iii

CHAPTERS

I. Introduction....1

Problem Statement....4

Hypotheses....6

Assumptions made in this Study....7

Limitations of this Study....8

Significance of this Study....8

Definition of Terms....10

II. Review of Literature....12

Motor Learning Definitions....12

Motor Learning Theories....13

Background on Motor Learning Research....16

Knowledge of Results (KR)....17

Effects of High-frequency KR....20

Knowledge of Performance (KP)....26

Verbal Descriptions (self-talk)....29

Summary....33

III. Method....36

Subjects.....36

Study Design.....36

Treatment Conditions.....38

Apparatus and Task.....40

Procedures.....45

Data Collection.....48

Data Analysis.....48

IV. Results.....50

Description of Subjects.....50

Acquisition Phase.....51

Immediate Retention Phase.....57

Retention Phase.....60

V. Discussion.....67

Summary.....67

Acquisition Phase.....68

Immediate Retention Phase.....69

Retention Phase.....70

Conclusions.....71

Verbal Strategies (VS).....71

Knowledge of Performance (KP).....72

Treatment Conditions.....73

Recommendations.....76

Appendices.....77

References..101

List of Tables

Table Page

1. Mean and Standard Deviation (SD) for Absolute Error (AE) for VS during Acquisition....51
2. Mean and SD for AE for KP during Acquisition....54
3. Mean and SD for AE for Groups during Acquisition....54
4. Mean and SD for AE for VS during Immediate Retention....57
5. Mean and SD for AE for KP during Immediate Retention....57
6. Mean and SD for AE for Groups during Immediate Retention....60
7. Mean and SD for AE for VS during Retention....63
8. Mean and SD for AE for KP during Retention....63
9. Mean and SD for AE for Groups during Retention....65

List of Figures

Figure Page

1. Picture that shows wall placed between PA and T.........43

2. Picture that shows T and A2 measuring AE........................44

3. Mean for Absolute Error (AE) for VS during Acquisition...52

4. Mean for AE for KP during Acquisition...................................53

5. Mean for AE for Groups during Acquisition.........................55

5a. Trial blocks mean for AE for Groups (Acquisition)....56

6. Mean for AE for VS during Immediate Retention..............58

7. Mean for AE for KP during Immediate Retention..............59

8. Mean for AE for Groups during Immediate Retention.....61

9. Mean for AE for VS during Retention.......................................62

10. Mean for AE for KP during Retention.......................................64

11. Mean for AE for Groups during Retention..............................66

List of Appendices

Page

Appendix

A. Consent form presented to Subjects..77

B. Institutional Review Board Approval.....................................80

C. Types of verbal feedback provided through KR, KP, and possible VS...82

D. Study protocol procedures...84

E. Random selection procedures...88

F. Teaching criteria used to teach the golf putt..................90

G. Score sheet 1 (Acquisition and Immediate Retention phases)...93

H. Score sheet 2 (Retention phase)...95

I. Process used for data collection...97

J. Results of SPSS, during Immediate Retention for VS........99

Chapter I

Introduction

Learning movement skills is essential to our everyday adaptation to the environment (Carnahan, Vandervoort, & Swanson, 1996). The process of learning a motor skill commonly involves physical practice accompanied by instruction feedback from a teacher or coach (Hall, Moore, Annett, & Rodgers, 1997). Feedback is known as information provided to a learner as a result of performance as well as the information provided by the various sense organs and is almost without dispute considered critical for learning new motor acquisitions (Salmoni, Schmidt, & Walter, 1984).

The role of feedback in performance of motor skills has been well documented, as seen in the works of Adams (1971), Salmoni et al. (1984), and Schmidt (1975). According to Weeks and Kordus (1998), feedback is known to have two different categories: intrinsic feedback or extrinsic feedback.

Intrinsic feedback is sensory information that normally occurs when individuals produce movements; it can come from sources that are outside (exteroception) or inside the body (proprioception) (Schmidt & Wrisberg, 1999, p.257). The individual could make use of intrinsic feedback in two different ways: 1) mental imagery or 2) verbalization (self-talk). The use of mental imagery (imagination of performing a motor skill without overt movement) in skill performance has been well documented (Wulf, Hortsmann & Choi, 1995). Recent reviews by Driskell, Copper, and Moran, (1994) and Hall, Buckolz, and Fishburne (1992) showed the importance of mental imagery for performance of a motor skill and how often it is used by experienced athletes. Adams (1971) suggested that individuals use verbalization during the early stages of learning. Adams (1971) also suggested that the motor system is controllable by verbal systems. However, few researchers in motor learning have studied verbal description or labels (Hall et al., 1997; Shea, 1977).

Schmidt and Wrisberg (1999) defined extrinsic feedback, sometimes referred to as augmented feedback, as sensory information provided by an outside source and in addition to that which normally occurs when individuals produce movements (i.e., intrinsic feedback). Augmented feedback has been known as an important variable for motor skill learning (Thorndike, 1927) and has been classified into two broader categories: knowledge of results (KR) and knowledge of performance (KP) (Weeks & Kordus, 1998).

Unlike verbalization, KR and KP are delivered by someone other than the person performing the motor skill.

Salmoni et al. (1984) have defined KR as extrinsic feedback. Extrinsic feedback is usually terminal information given in a verbal form (or at least is able to be verbalized) that tells the learners something about the success of their actions with respect to the intended environmental goal (Schmidt & Wrisberg, 1999). Schmidt and Wrisberg explained that KR could be the information provided by a coach, "You missed the shot" or a music teacher who tells the student, "That note was flat." KR is also known to be an important factor for the performance and learning of motor skills (Adams, 1971; Salmoni et al.; Schmidt, 1975).

KP provides information about the movement pattern that the individual has produced when performing a motor skill. It is sometimes referred to as kinematic feedback (Gentile, 1972; Schmidt & Wrisberg, 1999, p. 260), and has been shown to have learning benefits for performance and learning motor skills, as well as KR (Brisson & Alain, 1996). Research has shown that KP was beneficial to learning (Carroll & Bandura, 1987, 1990; Newell, Carlton, & Antoniou, 1990) in studies that used an optimal movement pattern, which was either identified or implied, as the criterion to be achieved.

Carroll and Bandura (1987, 1990) had subjects perform a complex action pattern with movement of the arm, wrist, and paddle. The optimal movement was implied through a model shown on a video. Subjects were asked to perform the movement pattern as performed by the model shown on video. Each trial was recorded and then played, frame by frame, over the video with the model.

Newell et al. (1990) utilized an identified pattern to draw a circle on an unmarked white table as the optimal movement pattern. The identified pattern was a circle with a radius of 10.5 cm. After the subject performed the task, a circle with the identified pattern was placed on top of the pattern created by each subject.

The findings obtained by Carroll & Bandura (1987,1990) and Newell et al. (1990) suggested that KP is most beneficial for learning a motor skill if the goal was achieved through the use of implied or identified movement patterns or if the goal was an isomorphic movement such as a gymnastics routine or a springboard dive.

Problem Statement

The present study focused on three different types of feedback used in skill acquisition. First, the study evaluated the effects of high-frequency KR on the learning of a novel motor skill. High-frequency KR has been shown to block the processing of intrinsic sources (Salmoni et al., 1984; Swinnen, S. P., Schmidt, R. A., Nicholson, D. E., & Shapiro, D. C., 1990). Second, the present study investigated the effects of KP, using KR as reference (calibration), on the learning of a novel motor skill that is not isomorphic. Brisson & Alain (1996, 1997) suggested that KP augments the information about the movement pattern, used to perform a motor skill, with the reference provided by KR through the calibration strategy. Third, the study focused on combined KR + VS and KR + KP + VS to determine the combined effects on the learning of a novel motor skill. Adams (1971) suggested that the motor system is controllable by the verbal system during the early stages of learning (verbal-cognitive stage).

The present study had three purposes. The main purpose of the present study was to determine the effects of subject-generated verbal strategies (VS) on the learning of a novel motor skill. The second purpose of the present study was to determine the effects of KP on the learning of a novel motor skill. The third purpose of the present study was to examine the interaction effects of KR and KP on the learning of a novel motor skill.

Hypotheses

During the Acquisition phase:

1. Subjects in the groups generating verbal strategies (VS) will perform with less error than subjects in the groups that did not generate VS.
2. Subjects in the groups receiving knowledge of performance (KP) will perform with less error than subjects in the groups not receiving KP.
3. Subjects in the group under treatment condition-4 (TC-4) will perform with less error than subjects in the groups TC-2, TC-3, or TC-1.
4. Subjects in the group TC-2 will perform with less error than subjects in the groups TC-3 or TC-1.
5. Subjects in the group TC-3 will perform with less error than subjects in the group TC-1.

During the Immediate Retention phase:

1. Subjects in the groups generating VS will perform with less error than subjects in the groups that did not generate VS.
2. Subjects in the groups receiving KP will perform with less error than subjects in the groups performing without receiving KP.

3. Subjects in the group under treatment condition-4 (TC-4) will perform with less error than subjects in the groups TC-2, TC-3, or TC-1.

4. Subjects in the group TC-2 will perform with less error than subjects in the group TC-3 or TC-1.

5. Subjects in the group TC-3 will perform with less error than subjects in the group TC-1.

<u>During the Retention phase</u>:

1. Subjects in the groups generating VS will perform with less error than subjects in the groups that did not generate VS.

2. Subjects in the groups receiving KP will perform with less error than subjects in the groups performing without receiving KP.

3. Subjects in the group under treatment condition-4 (TC-4) will perform with less error than the subjects in the groups TC-2, TC-3, or TC-1.

4. Subjects in the group TC-2 will perform with less error than subjects in the groups TC-3 or TC-1.

5. Subjects in the group TC-3 will perform with less error than subjects in the group TC-1.

Assumptions made in this Study

1. All subjects provided accurate and honest information.

2. All subjects had the same skill level.
3. All subjects maintained the same level of concentration throughout the study.
4. All subjects performed to the best of their abilities.
5. None of the subjects had previous experience with putting a golf ball.
6. Data collection procedures have reliability and validity.

Limitations of this Study

1. Study participants were limited to college-aged students (ages 18-25).
2. The study was conducted at one university setting.
3. Students were enrolled in physical education activity classes, which they have selected.
4. Only right-handed students were included.
5. The study took place in an empty classroom.

Significance of this Study

There are two main reasons for the significance of this study in improving the teaching of motor skills. First, in a large size class, it is difficult to constantly provide feedback to all students during time consuming supervised practices. Chen and Singer (1992) suggested that it is not sufficient for an instructor or coach to impart some skills or strategies to students or learners. The ideal scenario is that the learners are able to implement strategies under their own control as appropriate for the performance context and situational demands. Hardy and Nelson (1988) explained that, by actively involving the learner in the learning process, the retention of crucial information was significantly enhanced. With the findings from the current study the instructor can be confident that his/her students are obtaining positive benefits for learning by generating their own verbal strategies during practice that is either supervised or not supervised. Second, the present study was an attempt to identify, through subject-generated verbal strategies, what subjects are actually doing and/or thinking while they practice a motor skill. Newell and McDonald (1992) suggested that the majority of motor learning researchers emphasize their findings toward the relative amount of change in movement outcome scores that occur as a result of practice conditions and ignore the search strategies used by subjects during actual performance of the skill in various situations.

Definition of Terms

1. Absolute error (AE)-The distance from outside the target area to the farthest point on the golf ball (measured in inches).
2. Calibration-The use of KR as a reference for KP to generate the best movement possible during the performance of the task.
3. Descriptive feedback-Information that describes the errors the individual makes during the performance of the skill.
4. Guidance hypothesis-Information provided to the subject (feedback) that is thought to have guiding properties that have both beneficial and detrimental effects on motor learning.
5. Knowledge of Performance (KP)-Information provided to the subject by the experimenter. Information related to the motion, movement patterns (e.g., "You need to shorten the length of your backswing").
6. Knowledge of Results (KR)-Information provided by Assistant 2 (A2) about the environmental goal (e.g., "You were ten inches past the target").

7. Prescriptive feedback-Information that the learner can use to make more effective corrections in the subsequent movement.

8. Verbal Strategy-Subject generated information based on the information received through KR, KP, or KR + KP (e.g., "I need to reduce the length of the backswing").

Chapter II

Review of Literature

In an attempt to provide the reader with the necessary information to understand the purpose of the present study, definitions, theories, and background of motor learning research have been presented. These definitions and theories may help explain the acquisition of motor skills. Although many variables considered important determinants of motor learning have been studied (feedback, modeling, demonstrations, mental practice, part-to-whole practice) (Winstein, 1991), the general purpose of this review of literature was to show two areas affecting skill acquisition. First, this review focused on the effects of high-frequency KR on learning a novel motor skill. Second, it provided information to investigate if the effects of high-frequency KR could be improved by providing learners with either KP or verbalization (self-talk).

Motor Learning Definitions

The study of motor learning originated as a branch of experimental psychology and was labeled accordingly in order to distinguish it from what was once called verbal learning (Newell, 1991). Schmidt (1988) suggested that motor learning has four characteristics. They are: 1) the learning process of acquiring the capability for producing motor skills, 2) learning occurs as a direct result of practice or experience, 3) the learning process occurs on the basis of the changes in behavior that can be observed, and 4) learning is assumed to produce relatively permanent changes in the "capability" for skilled behavior.

Gallahue (1989, p. 18) stated that learning is an internal process that results in consistent changes in behavior seen as evidence of its occurrence. Learning is the result of experience, education, and training interacting with biological processes. The authors suggested that learning is a phenomenon in which experience is prerequisite, whereas development is a process that may occur relatively independently of experience. Motor learning, then, is that aspect of learning in which movement plays a major part. These definitions suggested that motor learning is relative permanent changes in movement behaviors caused entirely by experience and practice.

Motor Learning Theories

Different theories have been presented in the past in attempts to explain the acquisition of motor skills. The present review of literature focused attention on the theories of Adams (1971), Keele (1968), and Schmidt (1975).

Keele (1968) attempted to explain motor learning through the motor program, which he described as a set of muscle commands that are structured before a movement sequence begins. This process allows the sequence to be carried out uninfluenced by peripheral feedback. This theory proposes the concept of central programs that control the human movement and suggests that movements are controlled by the central nervous system and there is no need of feedback for learning to occur.

The motor learning theories of Adams (1971) and Schmidt (1975) suggest the gradual build-up, over practice, of the strength of perspective memory constructs for motor control (Newell, 1991). Adams (1971) proposed the closed-loop theory. This theory of motor learning suggests that motor response is primarily driven by feedback. The closed loop theory of motor learning presents two traces for self-paced movements. Newell explained that during the first trace, memory trace, the learner selects and initiates a movement and during the second trace, perceptual trace, a correction is made based upon prior experience of the sensory consequences (exteroceptive and proprioceptive) of action. The closed-loop theory proposes that for skill learning to occur KR is a necessary type of information that must be provided to the learner (Magill, 1994).

Schmidt (1975) presented the schema theory, which kept the principles of the open-loop theory. Schmidt proposed that learners do not learn specific movements. Learners do develop generalized motor programs (GMP) from which they can learn to produce different movements based on the parameters already established for those movements. In his theory, Schmidt (1988) presented two schemas: 1) Recall schema (relates outcomes to parameters) and 2) Recognition schema (relates expected sensory consequences of a movement to the movement's outcome).

Newell (1991) explained that Schmidt (1975) was concerned about two problems in previous theories: 1) the storage problem of the open-loop system, how many representations of motor programs can the central nervous system store? and 2) the novelty problem, how could a given motor program in a one-to-one memory framework generate new movement configurations? Newell stated that the strengths of the recall and recognition schemata are postulated to be build-up over practice trials and feedback.

Magill (1994) explained that Schmidt (1975), with the schema theory, supported the necessity of KR for skill learning. Both Adams (1971) and Schmidt (1975) suggested that there is a need for feedback on learning motor skills.

Background on Motor Learning Research

Motor learning literature shows that most early research was performed with simple laboratory tasks, mainly those requiring arm movements with few degrees of freedom (Wulf, Shea, & Matschiner, 1998). Winstein and Schmidt (1990) explained that motor learning literature has been consistent in showing that KR was beneficial for learning motor skills during the practice phase (acquisition) using simple laboratory tasks.

Wulf et al. (1998) suggested that nearly any variation that increases the amount, precision, or frequency of information feedback benefits performance of motor skills and increases the rate of improvement over trials. This interpretation may lead us to believe that increased levels of feedback (high-frequency feedback) during practice would benefit learning.

Salmoni et al. (1984) explained that, other than using simple tasks, most of the early findings on the effects of KR and learning motor skills, were obtained in studies measuring performance during an acquisition phase. They suggested that not including a retention test in those studies make the findings of motor learning questionable. Winstein and Schmidt (1990) supported Salmoni et al. and explained that earlier findings failed to consider the important distinction between performance and learning, which has been defined by most behavioral researchers as a relatively permanent change in the underlying capability of responding (Winstein & Schmidt, 1990; Schmidt & Wrisberg, 1999).

Winstein and Schmidt (1990) suggested that motivation is a reason for changes during performance of a motor skill when feedback is present. Schmidt and Wrisberg (1999) explained that extrinsic feedback could serve as motivation because it provides information about the progress the learners are making to achieve the goal. Schmidt and Wrisberg suggested that when individuals are making progress toward achieving the goals they have set for themselves their motivation is further increased. If feedback is not provided to the learner, as on a no-feedback retention test, motivation may not be present. Therefore, it is suggested by the experimenter that any progress or changes toward achieving the goal, during a no-feedback retention test, could be considered learning.

Knowledge of Results (KR)

Throughout the years the research on feedback has focused attention on the role of KR, which is considered by many to be a critical variable influencing the learning of a motor skill. Historically, KR has been shown to be beneficial for performance and learning of motor skills (Gable, C. D., Shea, C. H., & Wright, D. L., 1991), aside from practice itself (Bilodeau & Bilodeau, 1958; Schmidt, 1988).

Early motor learning researchers suggested that there is no learning without feedback (Bilodeau & Bilodeau, 1958; Throwbridge & Cason, 1932). Bilodeau and Bilodeau blindfolded subjects performing a simple lever-pulling task to examine four different conditions. The subjects received KR about the distance and direction of position error. This information was provided at 10%, 25%, 33%, and 100% of the trials. The authors maintained KR absolute frequency constant between groups at 10 trials, and the distribution of KR trials was equal across practice. No differences were demonstrated due to relative frequency suggesting that learning is related to the absolute frequency. These findings suggested that the more frequent KR is presented to the learner, the more he/she will benefit in learning a novel motor skill.

In an earlier study of KR and learning motor skills, Throwbridge and Cason (1932) also used blindfolded subjects. Their task was to draw a line 3 inches long. The subjects did not receive any type of feedback. The findings showed that the subjects had no improvement in their performance over time suggesting that no learning of motor skills took place without feedback. Schmidt and Wrisberg (1999) explained that it was not surprising that no learning took place without KR on a study that prevented learners from detecting their own errors.

Sparrow and Summers (1992) explained that over the years reviews have systematically summarized studies purporting to show how factors such as precision KR, KR delay, frequency of KR, and activity during the post-KR period affect learning. Anderson, Magill, and Sekiya (1994) explained that a primary concern for motor skill learning has been to determine the effects of these KR schedules and to understand the mechanisms related to their effects. Recent studies have directed their attention toward different frequencies of KR as well as to their effects on learning of a motor skill. These studies suggested that less frequency KR (50%, 33%, 25%) is more beneficial for learning than high-frequency KR (100%) (Gable et al., 1991; McCullagh & Little, 1990; Nicholson & Schmidt, 1991; Schmidt, Young, Swinnen, & Shapiro, 1989; Swinnen, et al., 1990; Weeks & Sherwood, 1994; Winstein & Schmidt, 1990; Wulf, et al., 1995).

Effects of High-frequency KR

Many researchers in motor learning have focused attention on the use of high-frequency feedback to improve learning of a motor skill, as seen in the works by Salmoni et al. (1984). Based on the findings of motor learning literature, that focused attention on high-frequency KR, Salmoni et al. presented the guidance hypothesis. The guidance hypothesis suggests that high-frequency KR has two different effects on the learner: 1) beneficial; or, 2) detrimental.

It is suggested that high-frequency KR have a beneficial effect in that it may guide the learner to obtain the goal movements by receiving information about the error. The learner may use the information about the error to correct that error. The ability of the learner to detect errors and correct them for better performance has been shown to be important in learning of a motor skill (Swinnen et al., 1990; Winstein and Schmidt, 1990).

Study results by Swinnen et al. (1990) and Winstein and Schmidt (1990) supported the guidance hypothesis on the detrimental side. Their findings suggested that high-frequency KR has a detrimental effect because it allows the learner to continue its use as a guide. The constant guidance of high-frequency KR may allow the learner to become dependent on it. Swinnen et al. explained that high-frequency KR interferes with learning, perhaps by degrading the acquisition of error detection capabilities.

Winstein and Schmidt (1990) suggested that, when feedback is always available during practice, it actually becomes part of the task, so when it is withdrawn, the learner will suffer. They also suggested that the dependency on high-frequency feedback produces interference with, or prevention of, other important task-related operations such as those involved in error-detection. Wulf et al. (1998) explained that another negative side of high-frequency KR is that it might provide too much facilitation in the planning of the subsequent response, thereby reducing the participant's need to perform memory retrieval operations.

Lavery, (1962), Schmidt, et al. (1989), Weeks and Sherwood (1994), and Wulf et al. (1995) have also shown support for the guidance hypothesis as their findings suggest that high-frequency KR is detrimental to learning during no-feedback retention tests.

Lavery (1962) investigated the effects of different types of feedback on learning of a simple task. Subjects had to strike a small ball with a special hammer and send it up a ramp towards a target. The study investigated three different treatment conditions. During the first day of the experiment, all groups performed the task without feedback. The next five days, the participants performed the task under their treatment condition: 1) feedback after every trial, 2) summary feedback after 20 trials, and 3) feedback after every trial and after 20 trials. In a study comparing high frequency KR and summary KR, the findings suggest that KR was beneficial to performance, during acquisition, but detrimental to learning when using a no-feedback delayed retention test.

Schmidt et al. (1989) found that subjects receiving high frequency KR (1-trial summary) performed better during acquisition than the summary group (every 15 trials). However, during the no-KR retention test, the summary group (every 15 trials) had the smallest error while the 1-trial summary group had the greatest error. Schmidt et al. (1989) explained that the subjects in the 1-trial summary group might have become dependent on immediate KR. The authors suggest that KR may block other information-processing activities that could result in the capability to perform this response when feedback is withdrawn on a retention test. These findings supported the guidance hypothesis as it was found that high-frequency KR was beneficial for performance but detrimental for learning.

Swinnen et al. (1990) had subjects perform a task that simulated batting in baseball. They used a timing task with two reversals in direction as well as with a coincidental-timing task. The subjects were divided into two groups under different treatment conditions. One group received instantaneous feedback after every trial and the other group received delayed feedback. They found that, relative to delayed feedback, instantaneous KR degraded learning as measured on delayed retention tests without feedback. The authors explained that the instantaneous feedback group performed more poorly than the delayed feedback group, during the no-feedback retention tests, because instantaneous feedback might have prevented the subjects from processing their own response-produced feedback.

Weeks and Sherwood (1994) had subjects perform an abrupt pull with the left arm by briefly statically contracting elbow flexor muscles. Each subject performed 75 acquisition trials and they were divided into three groups under different treatment conditions: 1) high frequency KR, 2) summary trial group (KR after 5 trials, about all of the 5 trials), and the average group (KR every 5 trials, as an average of all 5 trials). The findings showed that the high-frequency KR group had the largest performance decrement as measured during a no-KR retention test. The authors suggested that receiving KR after every trial might motivate the learner to constantly make changes. Many of these changes, they say, may likely result in overcompensation.

Winstein and Schmidt (1990) also suggested that high-frequency KR is detrimental for learning. During experiment 2 of their study, subjects had to perform a goal movement pattern. The subjects, while seated at the table, grasped a lever handle with the right hand and rested the forearm on the foam pad. Subjects began the movement from 0 degrees of lever rotation (approximately 100 degrees of elbow flexion) with the lever and forearms in the subjects' frontal plane. The subjects had to move the lever to the predetermined goal within 800ms. The subjects received augmented feedback in the form of KR through the use of a computer terminal after the movement was completed. The information showed the subject's performance superimposed with that of the goal movement. The subjects also received KP about the movement pattern used to produce the response.

The experimental groups were 100% KR (receiving KR in all practice trials) and 50% KR (receiving KR after half of the practice trials). The 50% KR group received KR after every trial for the first 22 trials and then received KR after 8, 7, 4, 3, and 2 trials. The authors found that the 50% KR group performed with 35% less error than the 100% KR group, during a no-KR retention test. They also found that the 100% KR group exhibited higher error than the 50% KR group during a KR retention test. These findings, the authors explained, challenged the specificity theory, which suggests that subjects performing under certain experimental conditions will perform better than other groups under different experimental conditions, when tested under the experimental condition of the former group.

Wulf et al. (1995) compared mental practice (MP) and physical practice with and without information feedback (IF). They hypothesized that if MP functions like physical practice without IF, practice conditions interspersed with MP or with no visual feedback (less frequency) should produce more effective learning than practice with IF after every trial (high frequency KR). The task was to putt golf balls into three different target zones. The subjects had to putt, in order, to zones 1, 2, and 3. Learning, the authors explain, was measured by a delayed retention test without IF. The results obtained during the no-IF retention test showed that the 50% IF condition produced more effective learning than both the 100% IF and 50% MP conditions. These results also showed that subjects in the high-frequency KR (100% IF) condition had higher scores, measured as absolute error (AE), than the subjects in less-frequency KR (50% IF). These findings supported previous findings suggesting that high-frequency KR is detrimental to learning of a novel motor skill.

Knowledge of Performance (KP)

KP provides information about the movement pattern the individual has produced sometimes referred as kinematic feedback (Gentile, 1972; Schmidt & Wrisberg, 1999) and has been shown to have learning benefits as well as KR (Brisson and Alain, 1996). Research findings have suggested that KP was beneficial to learning (Carroll & Bandura, 1987, 1990; Newell, et al., 1990) when an optimal movement pattern was used. This movement pattern was either identified or implied, as the criterion to be achieved. These findings suggested that KP could only be beneficial if the goal is an isomorphic movement such as a gymnastics routine or a springboard dive. However, Brisson and Alain (1996) found that KP could contribute to learning, without identifying optimal movement pattern characteristics as a reference for KP. The authors suggested that subjects could use KR as a reference to calibrate the movement pattern used with the task outcome and that learning can result from this calibration strategy. The calibration strategy involves modifying the movement from trial to trial until the movement pattern that produces the best result is discovered (Brisson & Alain, 1997).

Brisson and Alain (1996) had participants swing a lever to the left and then to the right past the light emitting diode (LED). The participants had to move the lever according to the speed of the LED. The authors explained that the degree convention was with 0 [degrees] position to the left of the participants, the 180 [degrees] position to the right of the participant, and both positions in the seated participant's frontal plane.

Three different conditions were tested: 1) KR-only, 2) KP-only, and 3) KP + KR. The findings showed that both KP groups performed better (higher scores) than the KR-only group. According to the authors, the calibration effect can be seen in that KP + KR performed better than KR-only and KP-only, and KP-only was not significantly higher than KR-only. The calibration effect undertaken by participants in KP + KR group may have been better for learning as they generated greater velocity and used longer backswings than the other groups.

Brisson and Alain (1997) had subjects produce a right-arm lever movement in which four targets had to be reached with a prescribed amplitude and time. Each target was at a specific distance (45, 12, 70, and 20 degrees). Subjects needed to reach those targets in specific times of 280ms, 550ms, 820ms, and 1073ms, respectively.

They found that the KP + KR group outperformed both the KR-only and KP-only groups on the timing aspect of the task, the parameter of overall timing, and the learning of the most efficient generalized motor programs (GMP) for performing the task. The authors explained that additional KR enhanced performance and learning over KP alone. These findings supported the view that when KR is provided as a reference, subjects probably adopted a calibration strategy to learn the task.

In a different type of study, involving KP and learning motor skills, Kernodle and Carlton (1992) had subjects perform a throwing task. The subjects had to throw a "nerf" ball as far as possible with the nondominant hand. They tested four different conditions: 1) KR-only, 2) KP-only, 3) KP with cue, and 4) KP with transition.

The findings showed that both KR-only and KP-only performed similarly in response outcomes and movement forms. KR-only was expected to perform better in response outcome while KP was expected to perform better in movement forms based on the type of information either group received. KP with cue and KP with transition performed better than KR-only and KP-only on both response outcome and movement forms. It is assumed that both the cues and the transition information helped the learner to focus on the most relevant aspect of the feedback provided. The authors stated that a combination of KR and KP would have facilitated learning, but they did not run this condition. Brisson and Alain (1996, 1997) did target the combination of KR + KP and its effects on learning a novel motor skill. The investigation of the effects of KR + KP on learning a motor skill is one of the purposes of the present study.

Verbal Descriptions (self-talk)

Verbal descriptions and mental imagery are two frequently used rehearsal strategies for learning-remembering motor skills (Hall et al., 1997). They are also considered learning strategies used in physical education known as cognitive tools. These tools are used to systematically manage the thought process associated with knowledge and skill acquisition (Anderson, 1997).

Adams (1971) suggested that the human learning of a motor act involves, during the verbal-motor stage, influence of non-motor response classes. This assumes that response systems interact and that the motor system is controllable by the verbal system. Gentile (1972) stated that in the verbal-cognitive stage, the learner has to get a general idea of the movement. Learners in this stage spend a lot of time talking to themselves about what they are going to do and thinking about strategies that might work (Schmidt & Wrisberg, 1999).

However, very little research has focused attention on the effects of verbal strategies on learning a motor skill. Research has focused attention on the effects of self-talk and learning and performance of motor skills (Highlen & Bennett, 1983; Mahoney & Avener, 1977; Ziegler, 1987) but attention is mostly focused on the effects of positive or negative self-talk on performance of a motor skill (Dagrou, Gauvin, & Zinsser, 1992; Gould, Hodge, Peterson & Giannini, 1989; Kendall, Hrycaiko, Martin, & Kendall, 1990; Schill, Monroe, Evans, & Ramanajah, 1978; Van Raalte, Brewer, Lewis, Linder, Wildman, & Kozimor, 1995).

Hall et al. (1997) investigated the effectiveness of mental imagery, verbal mediators, and a combination of both on the retention of movement. The study involved a presentation of movement patterns and a free recall test. Subjects were randomly assigned to one of eight groups. Half of the participants were blindfolded and guided through the movement pattern. The other half observed how a model was guided through the movement patterns. The subjects were told to focus on the shape (form) of the movement as well as on both the starting and ending points of the movement.

The findings obtained in the study, for the learners' performance of the task and questionnaire, showed that the subjects in the verbal label and imagery condition and in the verbal label only condition performed better than the subjects in the other six groups. These subjects had to give a meaningful verbal label or brief description of the pattern as quickly as possible.

The authors explained that it is not clear why having a verbal description for a movement would improve the quality of recall for that movement. They stated that the description might relate (describe) the movement shape and aid in the actual production of the movement.

Van Raalte et al. (1995) used dart throws as the task for the subjects to perform during their study of self-talk and skill acquisition. Using a regulation board located six feet from the floor, the subjects had to throw darts from seven feet away. The board was covered with paper and only showed the center of the board ("bulls eye"). Error was measured from the "bulls eye" to the location of the darts. The subjects were assigned to one of three conditions, 1) control, 2) positive ("You can do it"), and 3) negative ("you cannot do it"). Each subject performed

15 practice trials and 15 trials under their assigned condition. The findings suggested that self-talk is an important variable in sport performance. Subjects in the positive self-talk group performed better than the subjects in the other two groups.

Ziegler (1987) wanted to investigate the effects of a self-directed stimulus cueing technique on the skill acquisition of beginning tennis players. Subjects had to perform both forehand and backhand strokes. They were randomly assigned to one of three groups (A, B, and C). Criteria were presented for both tennis strokes. Subjects completed two sets of 30 balls each for a total of 32 observations. The subjects were to vocalize the word "ball" when they saw the ball fired from the machine. They had to vocalize the word " bounce" as the ball contacted the surface of the court. Then the word "hit" as they made contact with the ball on the racquet. The word "ready" was vocalized to prepare physically for the next ball. The intervention for Group A began after the fifth set of balls. The intervention for Group B started after Set 10. Group's C intervention began after Set 16. Group A had the earliest intervention and was the group with the most improvement. Group B had the second highest improvement followed by Group C.

Ziegler (1987) reported that the findings demonstrated a functional relationship in beginning tennis between the introduction of stimulus self-cueing when hitting the ball and successfully performing both the forehand and backhand strokes into the backcourt area of a tennis court. He suggested that the strength of self-cueing might be in accelerating initial skill acquisition.

Summary

The role of high-frequency KR on learning of a motor skill has been well documented (Adams, 1971; Salmoni et al., 1984; Schmidt, 1975). Early researchers suggested that there is no learning without KR (Bilodeau & Bilodeau, 1958; Throwbridge & Cason, 1932). Salmoni et al. demonstrated concerns about the designs of these studies because the designs used by Bilodeau and Bilodeau (1958) and Throwbridge and Cason (1932) may have prevented the subjects from detecting their own errors.

Other studies investigated learning by using only an acquisition phase (Salmoni et al., 1984). Earlier researchers failed to consider the important distinction between performance and learning (Winstein & Schmidt, 1990). Based on these earlier findings, Salmoni et al. developed the guidance hypothesis. This hypothesis suggested that high-frequency KR is both beneficial and detrimental. High-frequency KR is beneficial in that it guides the learner to obtain the goal movements by receiving information about the error. High-frequency KR is detrimental to learning because the learner may become dependent on it. It could also become part of the task if it is always available during practice, so when it is withdrawn, the learner will suffer (Winstein & Schmidt, 1990). It may also provide too much facilitation in the planning of subsequent response, thereby reducing the participant's need to perform memory retrieval operations (Wulf, et al., 1998).

Recent studies have suggested that high-frequency KR is beneficial for performance but detrimental for learning (Lavery, 1962; Schmidt et al., 1989; Swinnen et al., 1990; Weeks & Sherwood, 1994; Winstein & Schmidt, 1990; Wulf et al, 1995).

KP has been shown to be beneficial for learning of motor skills that require a movement pattern that is either identified or implied (Carroll & Bandura, 1987, 1990; Newell et al., 1990). These studies suggested that KP is only beneficial for skills such as a gymnastics routine or a springboard dive.

Brisson and Alain (1996, 1997) suggested that KP could also be beneficial with non-isomorphic skills. Subjects can use the information provided through KR as a reference to calibrate the movement pattern used with the task outcome. They suggested that learning could result from this calibration strategy.

Hall et al. (1997) explained that verbal descriptors and mental imagery are two strategies frequently used for learning-remembering motor skills. Adams (1971) suggested that during the early stages of learning (verbal-motor stage) the motor system is controllable by the verbal system. During this stage, learners spend a lot of time talking to themselves about what they are going to do and thinking about strategies that might work (Schmidt & Wrisberg, 1999).

Researchers focused their attention on the effects of self-talk (Highlen & Bennett, 1983; Mahoney & Avener, 1977; Ziegler, 1987) but mostly on the effects of positive and negative self-talk (Dagrou et al, 1992; Gould et al., 1989; Kendall et al., 1990; Schill et al., 1978; Van Raalte et al., 1995). These findings suggested that positive feedback is beneficial for learning and performance of a motor skill. However, literature shows that no previous research has directed the attention to the investigation of the effects of subject-generated verbal strategies and the effects on learning a motor skill.

Chapter III

Method

The methods section is divided into seven sections. These sections are: 1) subjects, 2) study design, 3) treatment conditions, 4) apparatus and task, 5) procedures, 6) data collection, and 7) data analysis.

Subjects

The subjects were eighty college-aged (ages 18 to 25), right-handed students with no previous experience playing golf or practicing a golf putt. The subjects were volunteers enrolled in physical education courses offered at Middle Tennessee State University (MTSU) and required for all students through the general education core. Informed consent (see Appendix A) was obtained prior to their participation in the study. University IRB guidelines were followed to perform the current study (see Appendix B).

Study Design

The study consisted of three testing phases; Phase 1, Acquisition; Phase 2, Immediate Retention; and, Phase 3, Retention. This design was selected based on the recommendations presented by Winstein and Schmidt (1990), which recommended the study of temporary performance changes (motivation, information) from those relatively permanent changes associated with longer-term retention and learning.

The subjects were randomly assigned to one of four groups. Each of the four groups had 20 subjects. Within groups, each subject performed the task during his/her randomly assigned turn. A detailed explanation of the randomization process is presented in the Procedures section of this chapter. The experimenter randomly assigned turns for each group on both days of testing.

On the first day of testing, subjects had to perform the first two phases of the experiment. These two phases had a total of 60 trials. The first phase (Acquisition) consisted of 40 trials. During this phase the subjects received feedback according to their experimental condition. The second phase (Immediate Retention) took place two minutes after the acquisition phase. During this two-minute break, the subjects received instructions regarding procedures during the immediate retention phase. In the Immediate Retention phase, the subjects performed 20 trials without feedback of any kind. The third phase (Retention) took place 48 hours after the first day of testing. This phase consisted of 20 trials in which the subjects also performed without feedback of any kind.

Treatment Conditions

The four treatment conditions (TC) used in the study were: 1) KR-only (TC-1), 2) KR + VS (TC-2), 3) KR + KP (TC-3), and 4) KR + KP + VS (TC-4).

The subjects in each of the four TC received verbal KR about absolute error (AE) after every trial. AE is the distance, measured in inches, from the outside of T to the farthest point on the golf ball. KR was presented specifically based on the position of the ball in relation to the target (e.g., "The ball was 10 inches short of the target.").

Subjects in TC-1 received verbal KR-only. The subjects received verbal KR from Assistant 2 (A2).

Subjects in TC-2 received verbal KR and then provided VS, using KR as reference, to help them find the proper way to perform the task to obtain the goal (hitting the golf ball into T or near it). Using the example presented for KR, the strategy expected from the subjects in the group TC-2 was "I need to hit the ball harder" (see Appendix C). This was expected based on the information the subjects received, KR-only.

Subjects in TC-3 received both verbal KR and verbal KP (information about the performance of the skill) after every trial. KP was provided to the subjects by the experimenter. The experimenter used the information provided by A2, in the form of verbal KR, as reference (see Appendix C). The way KP was presented to the subjects was adapted from Kernodle and Carlton (1992). The intention was to provide KP as prescriptive feedback. Prescriptive feedback provides information that the learner can use to make more effective corrections in the subsequent movement. Using the previous example, the instructor was expected to provide KP such as "Focus on the length of your backswing. It was a short backswing."

Subjects in TC-4 received both verbal KR and verbal KP and then generated their own VS using both KR and KP as references to develop their strategies until the goal was attained. The subjects in the group TC-4 were expected to provide a more specific and detailed strategy about their putts. Using the same example, the subjects were expected to verbalize, "I need to increase the length of my backswing." This type of strategy was expected based on the information that was provided to the subject by both A2, in form of KR, and by the experimenter, in form of KP.

Subjects in TC-2 and TC-4 received instructions to use KR and KR + KP, respectively, as references for the verbal strategies. They were instructed to generate their verbal strategies based on answering the question "How can I putt better?"

Apparatus and Task

This section includes a description of the apparatus and task used in the present study as well as a detailed explanation of the testing area (TA).

The apparatus used in the present study is a Dunlop Finale FS-3 putter for right-handed players. Regular size golf balls of the same brand and type were used.

The task for the study was to putt a golf ball to a target fifteen feet away from the subject. The putt is considered: a) a discrete skill (one that has a definite beginning and end), b) a closed skill (every aspect of the environment is stationary except for the movements of the performer), and c) a not-isomorphic skill (goal can be obtained with different movement patterns). Two other factors contributed in the selection of this motor skill as the task for the study. First, this task was selected to approach the objective of using a more complex and realistic task in a situation between a laboratory and a normal situation, as it was the intent of Zubiaur, Oña, and Delgado (1999) in their study with a volleyball serve. Second, a non-isomorphic task allows for different movement patterns to be used in order to achieve the same outcome (putting the golf ball into the target) not to reproduce a specific movement pattern. Brisson and Alain (1997) explained that a good type of task would be a golf shot. The authors suggested that many different patterns of swinging the club could be used so the ball hits in the same place. Pace (1986, p.84) suggested that there are almost as many different putting styles as there are putter designs.

The distance of 15 feet, as measured with a Lufkin white steel tape of 50 feet, was selected based on previous golf literature. Pace (1986, p. 85) stated that from a range of 12 feet or less one should make a high percentage of one's putts. Outside that range, the odds of making the putt get proportionally worse. The distance of 15 feet was selected by the experimenter because it is considered a difficult distance from which to make a putt. It is suggested by the experimenter that from this distance the subject would need information feedback of some kind to improve and learn how to putt with less error. The distance and the location of the target remained the same during all phases and was the same for all four groups.

The testing area (TA) was an empty classroom with carpeted floor, to simulate the "green's" surface on a golf course. TA was cleaned and vacuumed prior to testing. TA was divided into two smaller areas: 1) putting area (PA); and 2) target area (T).

PA is the area where the subjects stood while performing the task. PA was located 15 feet away from the true center of T, as measured from the center of the mark (M) on PA. M consisted of a golf ball-like size dot, where the golf balls were placed.

A barrier made of wood was placed between PA and T. Two pieces of wood (8' x 4') were placed to block the subjects from viewing T. It was located three feet from M towards T. The barrier was placed to avoid providing the subject with visual feedback of T (results of their putts). In their study, Zubiaur et al. (1999) explain that on many occasions, KR could be redundant information, because the subjects can normally see the results. One of the wood panels elevated from the floor to its height of eight feet. The other wood panel elevated from six inches off the floor to a height of eight feet, six inches. The six inches between the floor and the wood panel allowed for the golf balls to roll underneath (see Figure 1).

The wood barrier was located three feet from M towards T. T consisted of a circle (target), six inches in diameter, in the center. The target had four bigger circles that surrounded it (see Figure 2).

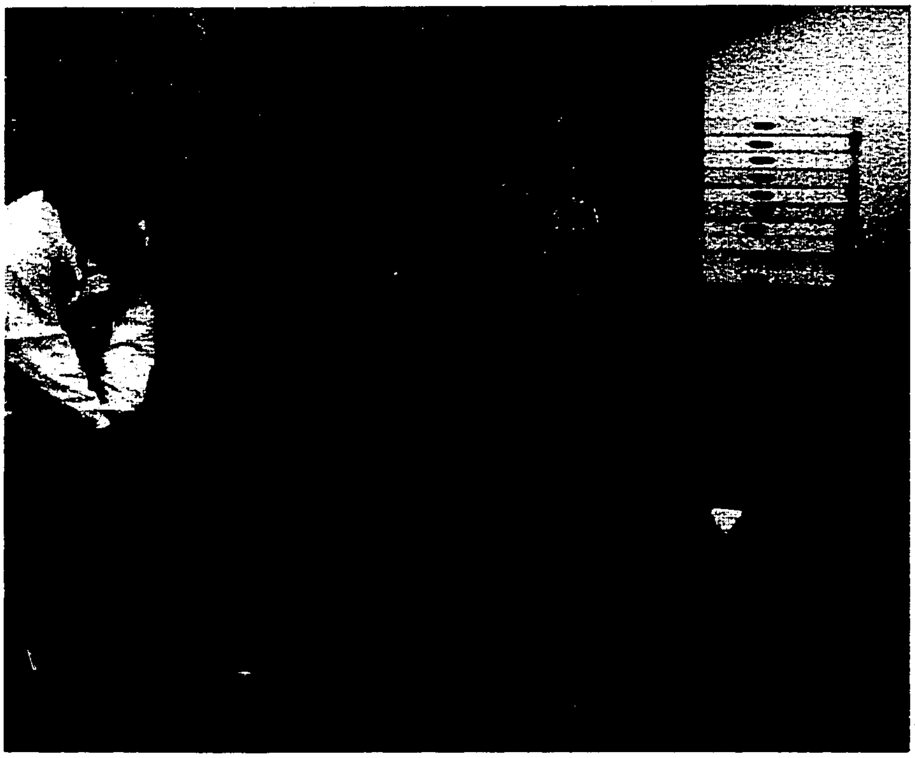

Figure 1. Picture that shows wall placed between PA and T

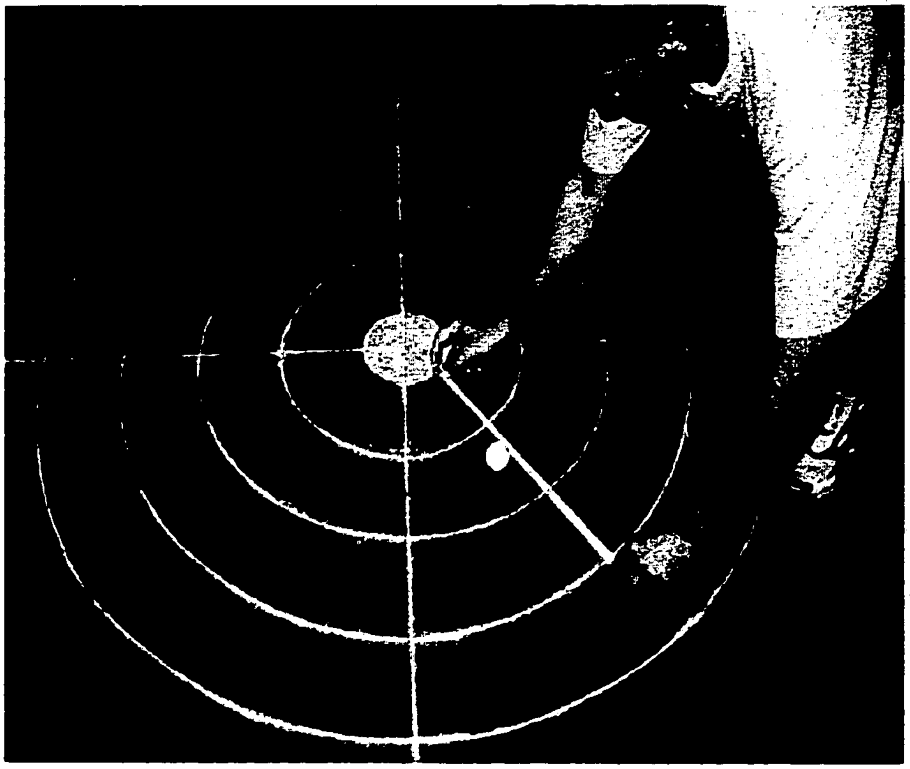

Figure 2. Picture that shows T and A2 measuring AE

These circles were one foot in diameter greater than the previous one. T covered an area of four feet and six inches in diameter. This size for T was selected after a pilot study. All the measures for distance (absolute error, AE) were made from the outside of T. AE was measured, in inches, from the outside of T to the farthest point on the golf ball (see Figure 2).

Procedures

The procedures section is divided in two sections. First, it demonstrates the protocol for conducting the research. Second, it shows how the subjects from each of the four groups were instructed to perform the task (see Appendix D).

Each group was divided into two groups of ten subjects. Subjects were called for their turn to perform the task at their assigned turn. The 10 subjects sat outside TA. Each one of the subjects was given a number of 1, 2, 3, etc, up to number 20, for each one of the four groups (e.g., TC-1, 1). The experimenter of the study randomly assigned turns to perform the task, based on the numbers given to the subjects (see Appendix E).

When indicated by the experimenter, assistant 1 (A1) (see Appendix D) called the subjects, one at a time, by the number assigned to them before the subjects entered TA. This process was applied to all four groups.

Once a subject was called into the TA, the experimenter taught the golf putt (putt). The experimenter taught the putting stroke following the techniques outlined by Pace (1986) (see Appendix F). The experimenter emphasized that the goal of the task was to putt the ball into T. After the teaching and demonstration by the experimenter was completed the subjects had time to get familiar with the apparatus (putter). Once familiar with the putter the subjects performed 4 practice trials. During these practice trials feedback was provided to the subjects just as it would be provided during the acquisition phase. The subjects in groups TC-2 and TC-4 had the opportunity to practice their verbal strategies. After the practice trials were performed the subjects proceeded with the acquisition trials. There were no practice trials prior to the Retention phase.

Each subject putted from PA. Prior to every trial the Assistant 1 (A1) placed a golf ball on M. A1 had a total of 20 golf balls. Each subject putted the golf ball as soon as he/she was ready. As the golf ball rolled to a complete stop, A2 measured AE. A2 also collected the golf balls. After the subjects finished putting all 20 balls, A2 brought the golf balls to A1 (see Appendix D).

Subjects in the group TC-1 received verbal KR from A2 after every trial. After receiving KR the subjects performed the next putt. The subjects in the group TC-2 also received verbal KR from A2 after every trial. After A2 provided KR, each subject provided him/herself intrinsic feedback in the form of VS. After both types of feedback were provided the subjects performed the next putt. The subjects in the group TC-3 also received verbal KR from A2 after every trial. Following KR, the experimenter provided verbal KP. After receiving both types of feedback the subjects performed the next putt. The subjects in the group TC-4 received verbal KR from A2 after every trial. Following KR, the experimenter provided verbal KP. After both types of augmented feedback were provided the subjects provided their own intrinsic feedback on the form of VS. Following all three types of feedback the subjects performed the next putt.

During both, the Immediate Retention (2 minutes after acquisition) and the Retention trials (48 hours later) the subjects performed the task under a no-feedback condition. As in the first day of testing, all groups were randomly assigned turns to perform the task during the Retention phase. Within groups, the subjects were randomly assigned turns to perform the task (see Appendix E).

Data Collection

Every obtained score for AE was written on a score sheet. Each subject had two score sheets, which had both the subject and group number. Score sheet 1 (see Appendix G) had 60 empty spaces, divided into two sections, 1) the Acquisition phase (40 spaces) and 2) the Immediate Retention phase (20 spaces). Score sheet 2 (see Appendix H) was used for the Retention phase and had only 20 empty spaces. The scores were written on the empty spaces by the experimenter (see Appendix I).

The scores written on both score sheets were entered into a spreadsheet on the Excel computer program by the experimenter. Different spreadsheets representing the three phases of the study were used for the scores of all four groups. The scores were saved and then transferred into the SPSS 10.0 statistical analysis program. After the scores were transferred, the experimenter performed the statistical analysis for the study on a Dell computer available in one of the computer laboratories at MTSU.

Data Analysis

A three-factor analysis of variance (ANOVA) was used to analyze the results. The variables measured were VS, KP, and Trials (Blocks). There were two levels for both VS and KP. VS present or absent (VS, yes; VS, no) as well as KP present or absent (KP, yes; KP, no).

For the analysis of all scores for AE, from all three phases, the trials were divided into blocks (every four trials). The Acquisition phase had 10 blocks. The Immediate Retention phase as well as the Retention phase, each had 5 blocks. For the Acquisition phase, a 3-factor (2 x 2 x 10) (VS x KP x Blocks) ANOVA, with repeated measures on the third factor, was performed. For both the Immediate Retention and the Retention phases a 3-factor (2 x 2 x 5) (VS x KP x Blocks) ANOVA, with repeated measures on the third factor, was performed.

Chapter IV

Results

The main purpose of the present study was to determine the effects of subject-generated verbal strategies on the learning of a novel skill. The second purpose of the study was to determine the effects of KP on the learning of a novel motor skill. The third purpose of the study was to examine the interaction effects of KR and KP on the learning of a novel motor skill. The present chapter is divided into four sections. The sections are: 1) Description of Participants, 2) Acquisition phase, 3) Immediate Retention phase, and 4) Retention phase.

Description of Subjects

Data were collected on 80 college-aged students (mean age = 19) enrolled in physical education courses at MTSU. Sixteen subjects (20%) were not present for the second day of testing and were not included in the statistical analysis. The total group sample size for statistical analysis purposes was 64 (80%) subjects.

The following is a description of the number of subjects per group. The four groups under treatment conditions had the following number of subjects: a) TC-1 had 17 subjects, b) TC-2 had 15 subjects, c) TC-3 had 16 subjects, and d) TC-4 also had 16 subjects. The groups generating VS had a total of 31 subjects and the groups that did not generate VS had 33 subjects. The groups receiving KP had a total of 32 subjects and the groups that did not receive KP had 32 subjects.

Acquisition Phase

Subjects who completed the novel task using VS performed, on average, with less error than subjects without VS (see Table 1). A VS main effect was found. There was a statistically significant difference with $F(1, 60) = 4.614$, $p < .05$ (see Figure 3).

Table 1

Mean and Standard Deviation (SD) for Absolute Error (AE) for VS during Acquisition

Variable	VS, yes (KR+VS, KR+KP+VS) n=31 Mean(SD)	VS, no (KR-only, KR+KP) n=33 Mean(SD)	P value
AE	25.3(8.5)	28.2(9.7)	< .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

Subjects who completed the novel task receiving KP performed, on average, with less error than subjects without KP (see Table 2). However, no significant differences were found with $F(1, 60) = .006$, $p > .05$ (see Figure 4).

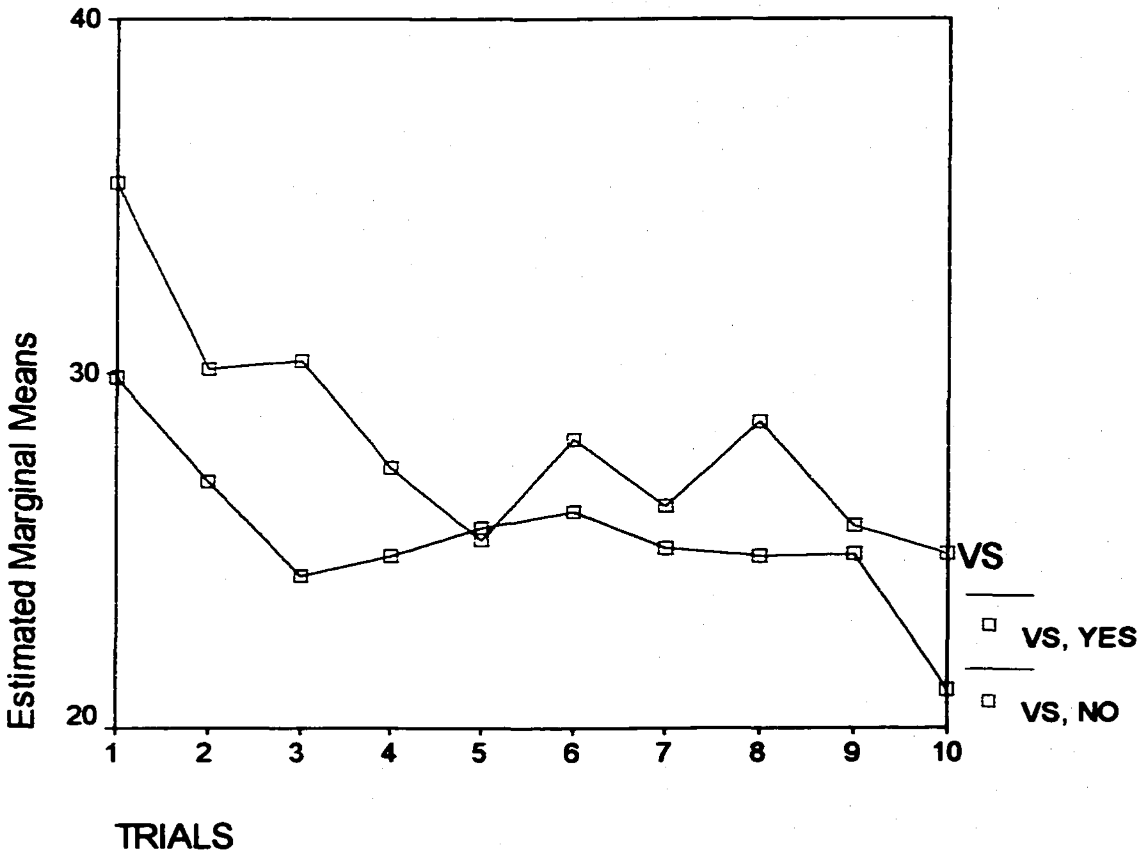

Figure 3. Mean for Absolute Error (AE) for VS during Acquisition

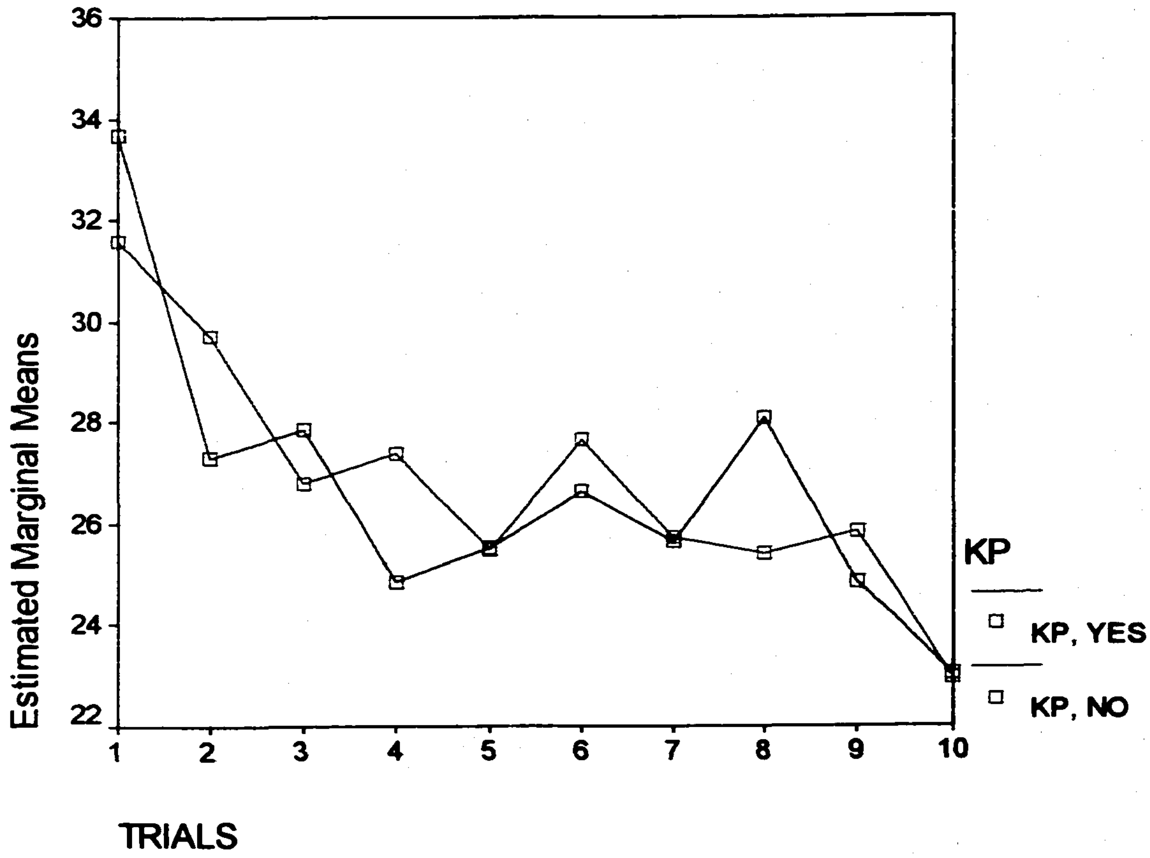

Figure 4. Mean for AE for KP during Acquisition

Table 2

Mean and SD for AE for KP during Acquisition

Variable	KP, yes (KR+KP, KR+KP+VS) n=32 Mean(SD)	KP, no (KR-only, KR+VS) n=32 Mean(SD)	P value
AE	26.7(8.7)	26.8(9.8)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

Subjects in all four groups improved performance, on average, over trial blocks. Statistical evidence supported this observation with a main trial block effect for AE with $F(9, 1000) = 6.286$, $p < .05$. Subjects in the group TC-4 performed, on average, with less error than subjects in the groups TC-2, TC-3, or TC-1 (see Table 3). Subjects in the group TC-2 performed, on average, with less error than subjects in the groups TC-3 or TC-1. Subjects in the group TC-3 performed, on average, with less error than subjects in the group TC-1 (see Figures 5 and 5a).

Table 3

Mean and SD for AE for Groups during Acquisition

Variable	KR-only n=17 Mean(SD)	KR+VS n=15 Mean(SD)	KR+KP n=16 Mean(SD)	KR+KP+VS n=16 Mean(SD)	P value
AE	27.6(10.8)	26.0(8.7)	28.8(8.4)	24.6(8.4)	< .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

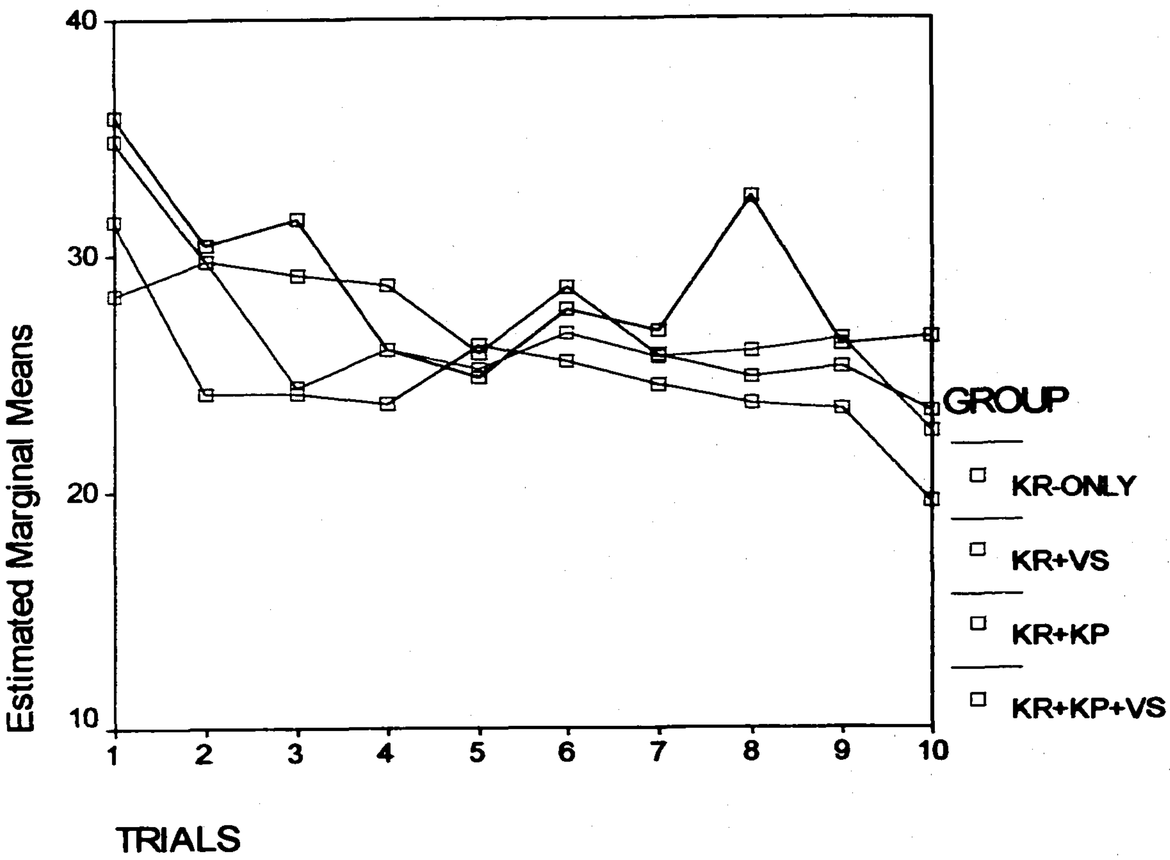

Figure 5. Mean for AE for Groups during Acquisition

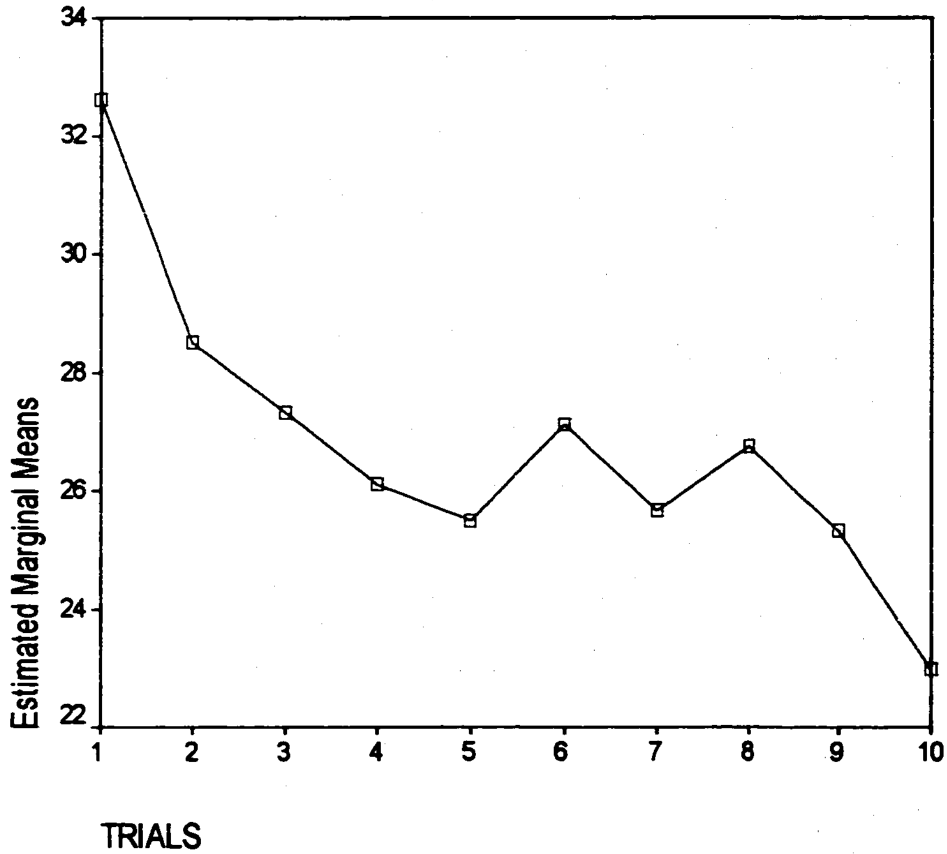

Figure 5a. Trial blocks mean for AE for Groups during Acquisition

Immediate Retention Phase

Subjects who completed the novel task using VS performed, on average, with less error than subjects without VS (see Table 4). No significant differences were found with $F(1, 60) = 2.864$, $p > .05$ (see Figure 6).

Table 4

Mean and SD for AE for VS during Immediate Retention

Variable	VS, yes (KR+VS, KR+KP+VS) n=31 Mean(SD)	VS, no (KR-only, KR+KP) n=33 Mean(SD)	P value
AE	24.6(8.2)	27.2(10.5)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

Subjects who completed the novel task receiving KP performed, on average, with less error than subjects without KP (see Table 5). No significant differences were found with $F(1, 60) = .549$, $p > .05$ (see Figure 7).

Table 5

Mean and SD for AE for KP during Immediate Retention

Variable	KP, yes (KR+KP, KR+KP+VS) n=32 Mean(SD)	KP, no (KR-only, KR+VS) n=32 Mean(SD)	P value
AE	25.3(8.8)	26.4(10.2)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

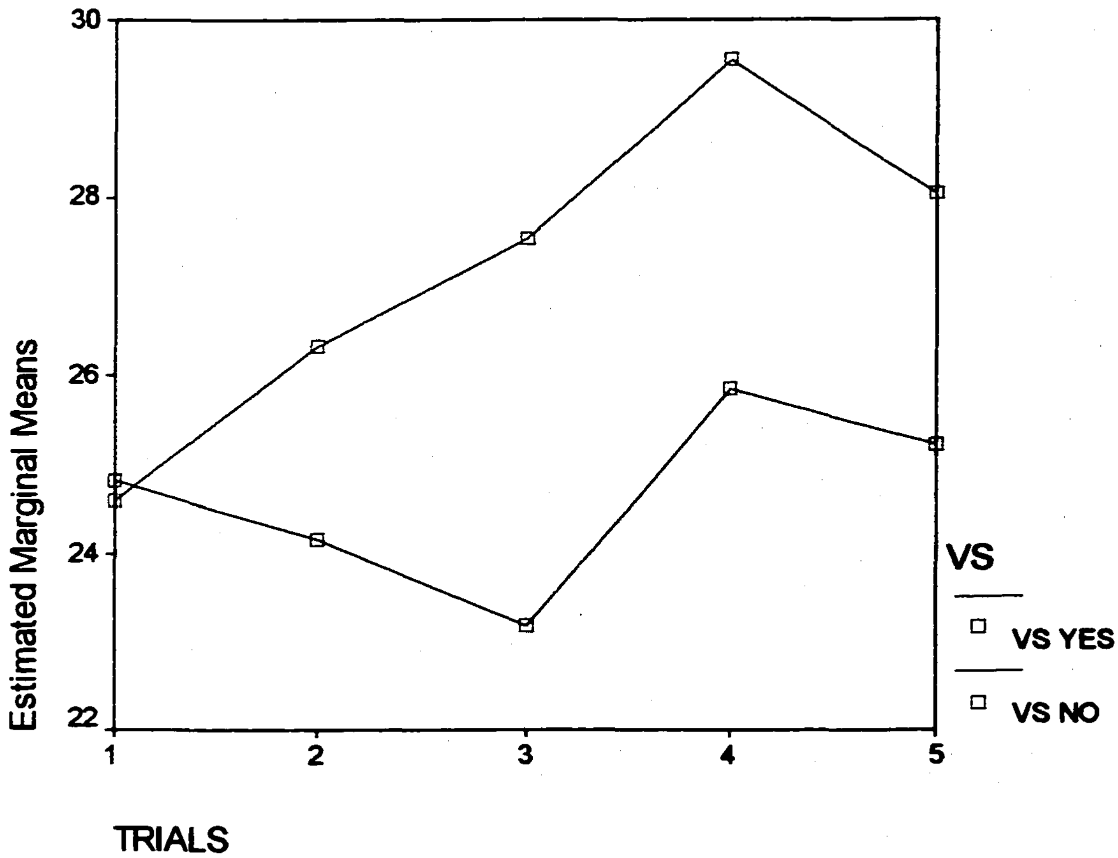

Figure 6. Mean for AE for VS during Immediate Retention

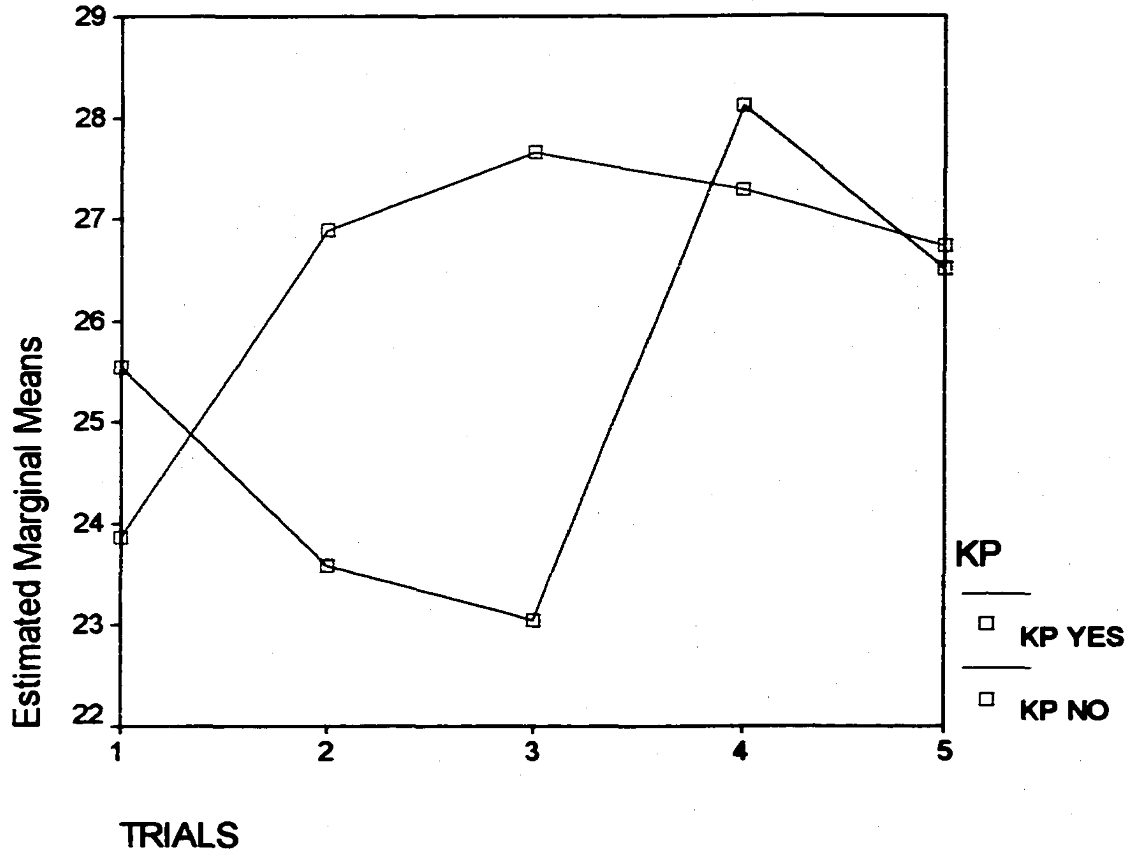

Figure 7. Mean for AE for KP during Immediate Retention

Subjects performing in the group TC-4 performed, on average, with less error than subjects in the groups TC-2, TC-3, and TC-1 (see Table 6). Subjects in the group TC-2 performed, on average, with less error than subjects in the groups TC-3 and TC-1. The hypothesis that TC-3 would perform with less error than TC-1 during the Immediate Retention phase was not supported. Subjects in the group TC-1 performed, on average, with less error than subjects in the group TC-3. No significant differences were found between groups $F(3, 60) = 1.922$, $p > .05$ (see Figure 8).

Table 6

Mean and SD for AE for Groups during Immediate Retention

Variable	KR-only n=17 Mean(SD)	KR+VS n=15 Mean(SD)	KR+KP n=16 Mean(SD)	KR+KP+VS n=16 Mean(SD)	P value
AE	26.6(11.7)	26.3(8.0)	27.8(8.8)	22.9(8.1)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

Retention phase

As shown in Table 7, subjects who completed the novel task using VS performed, on average, with less error than subjects without VS. No significant differences were found with $F(1, 60) = 3.293$, $p > .05$ (see Figure 9). However, a trial block by VS interaction was obtained with $F(4, 1000) = 3.757$, $p < .05$.

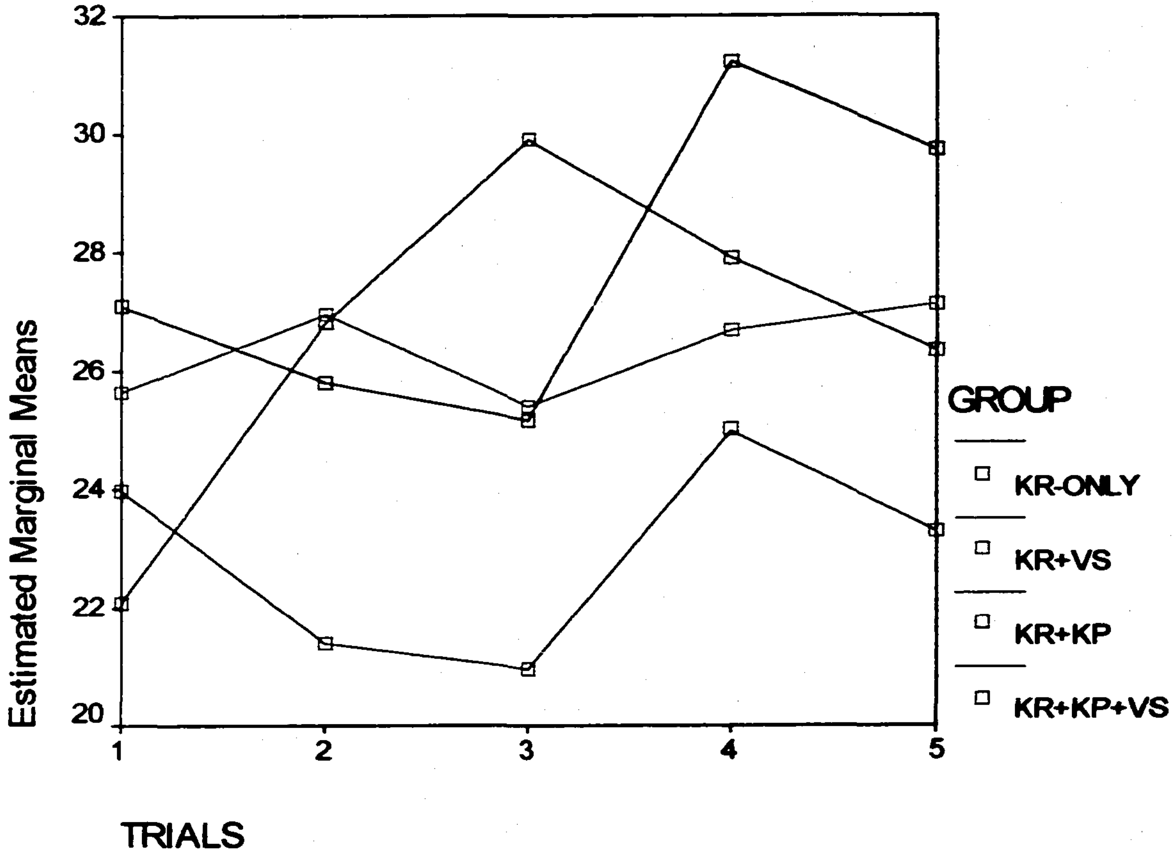

Figure 8. Mean for AE for Groups during Immediate Retention

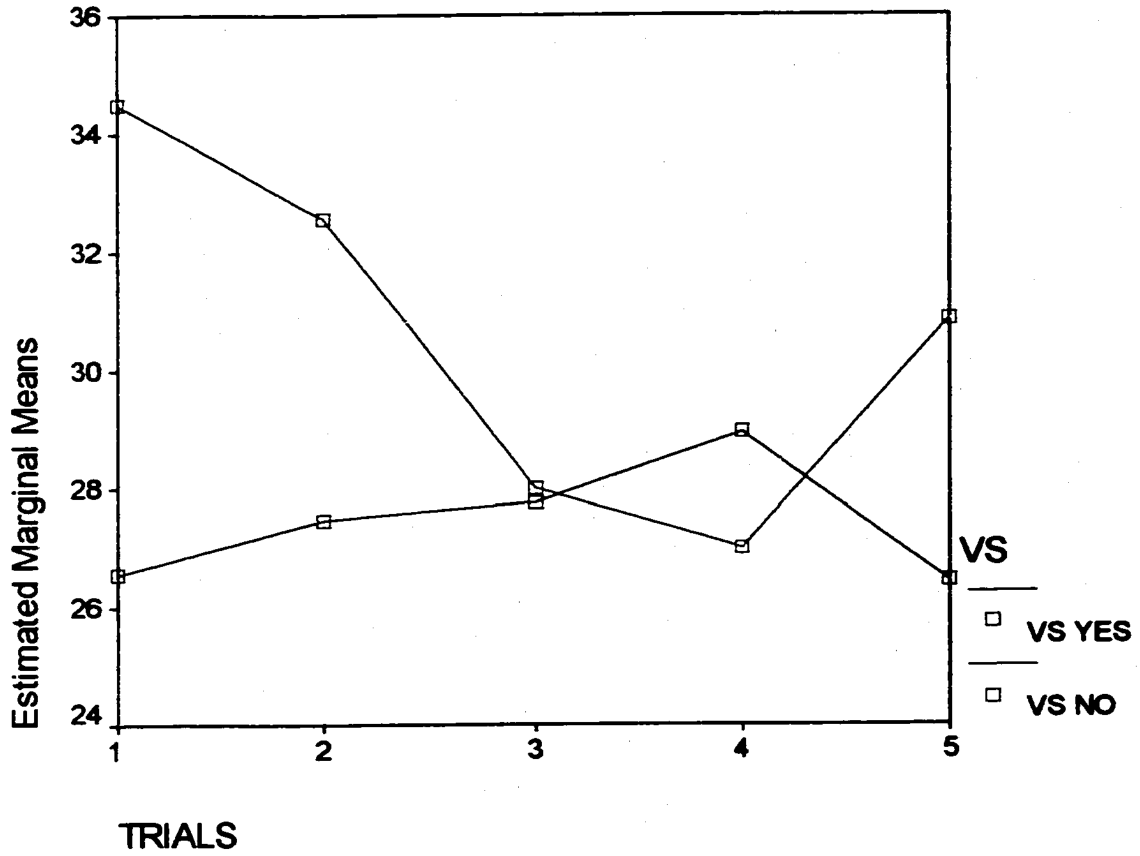

Figure 9. Mean for AE for VS during Retention

Table 7

Mean and SD for AE for VS during Retention

Variable	VS, yes (KR+VS, KR+KP+VS) n=31 Mean(SD)	VS, no (KR-only, KR+KP) n=33 Mean(SD)	P value
AE	27.4(9.8)	30.5(9.9)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

Subjects who completed the novel task receiving KP performed, on average, with less error than subjects without KP (see Table 8). No significant differences were found between these groups with $F(1, 60) = .237$, $p > .05$ (see Figure 10).

Table 8

Mean and SD for AE for KP during Retention

Variable	KP, yes (KR+KP, KR+KP+VS) n=32 Mean(SD)	KP, no (KR-only, KR+VS) n=32 Mean(SD)	P value
AE	28.5(9.2)	29.4(11.0)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

AS shown in Table 9, subjects performing in the group TC-4 performed, on average, with less error than subjects in the groups TC-2, TC-3, and TC-1. Subjects in the group TC-2 performed, on average, with less error than subjects in the groups TC-3 and TC-1. Subjects in the group TC-3

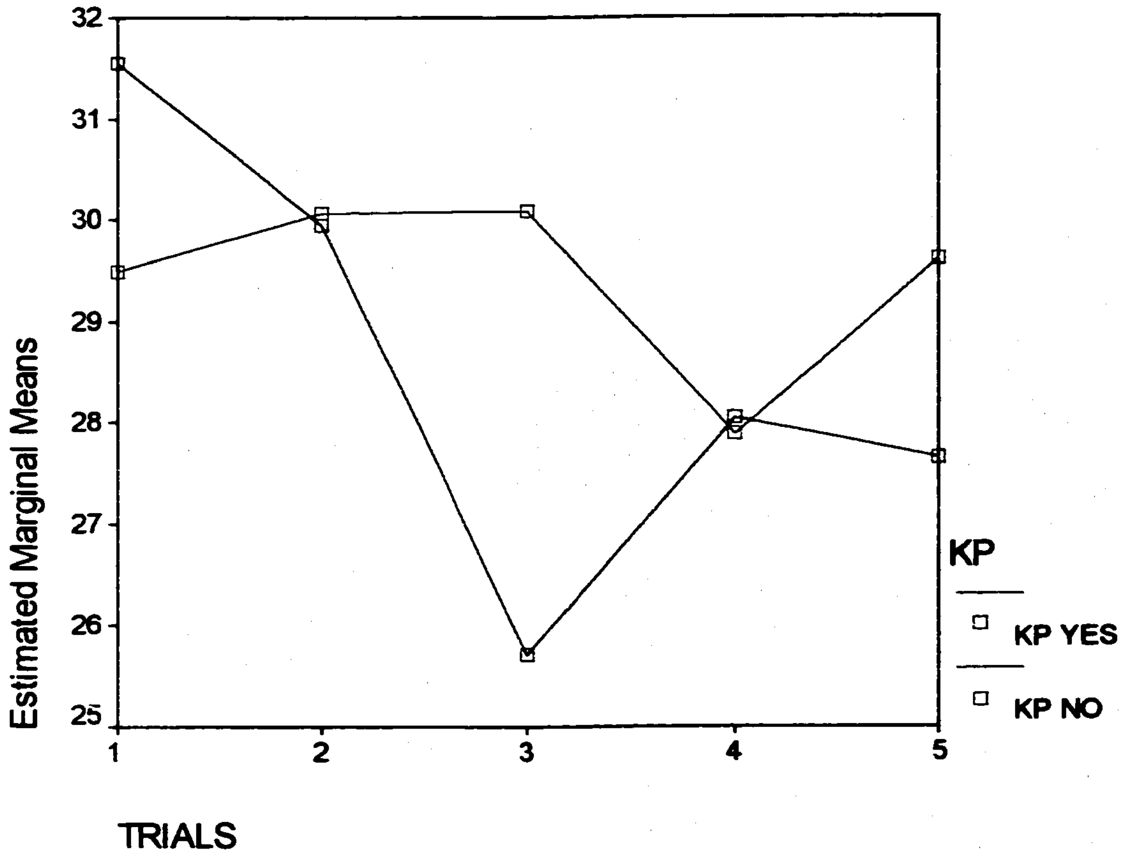

Figure 10. Mean for AE for KP during Retention

performed, on average, with less error than subjects in the group TC-1. No significant differences were found with $F(3, 60) = 1.347$, $p > .05$ (see Figure 11).

Table 9

Mean and SD for AE for Groups during Retention

Variable	KR-only n=17 Mean(SD)	KR+VS n=15 Mean(SD)	KR+KP n=16 Mean(SD)	KR+KP+VS n=16 Mean(SD)	P value
AE	31.5(11.1)	27.2(10.2)	29.5(8.9)	27.5(9.3)	> .05

Note: AE was measured in inches from the outside of T to the farthest point on the golf ball.

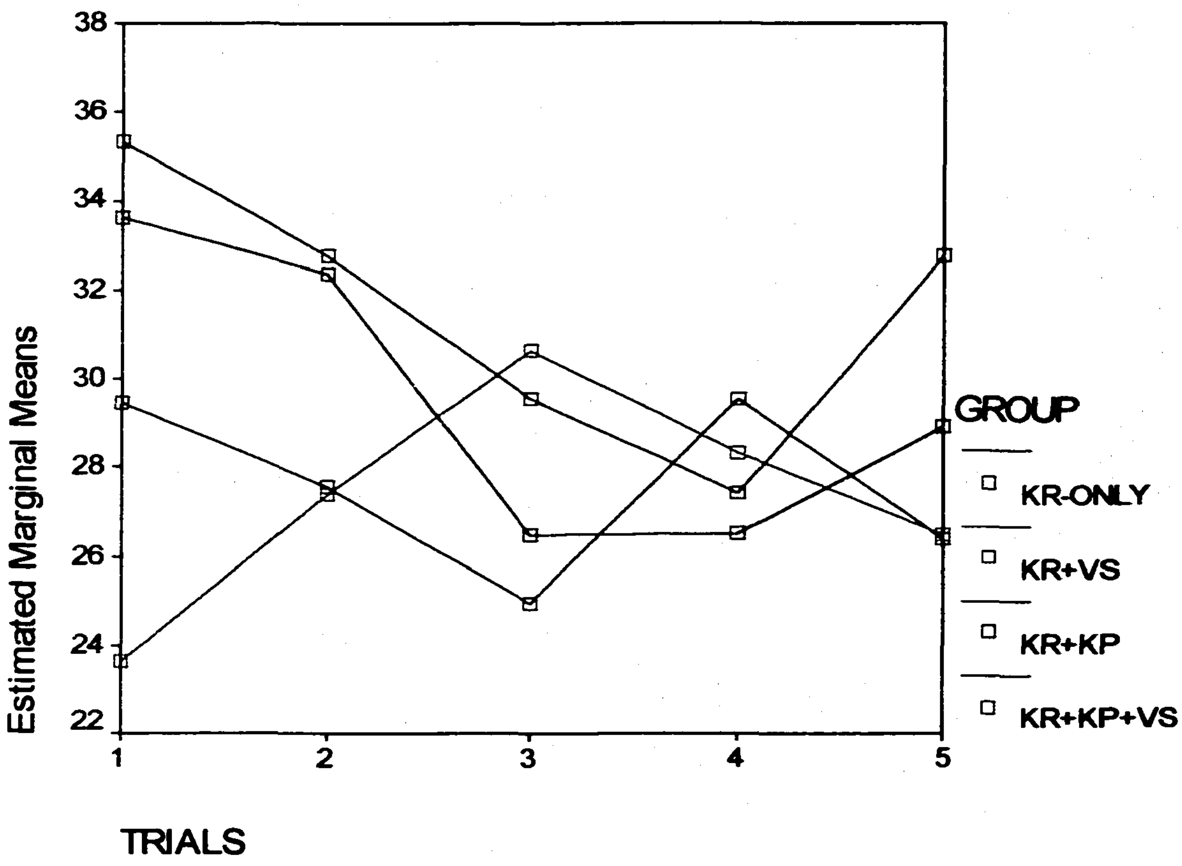

Figure 11. Mean for AE for Groups during Retention

Chapter V

Discussion

The main purpose of the present study was to determine the effects of subject-generated verbal strategies on the learning of a novel skill. The second purpose of the study was to determine the effects of KP on the learning of a novel motor skill. The third purpose of the study was to examine the interaction effects of KR and KP on the learning of a novel motor skill.

Chapter V is divided into three sections. The sections are: 1) Summary, 2) Conclusions, and 3) Recommendations. The Summary section provides a summary of the results obtained during the three phases of the present study, which were presented on Chapter IV. The Conclusions section presents conclusions warranted based upon the findings of the study. The Recommendations section presents recommendations, made by the experimenter for future research and instruction of a novel motor skill using verbal strategies, based on the results obtained from the present study.

Summary

The present findings support the importance of providing feedback for the acquisition and retention of a novel motor skill.

Acquisition Phase

All four groups performed with less error over trials during the Acquisition phase as indicated by a significant main effect of block of trials found for AE. Although small, all subjects seem to have obtained gains in performance of the golf putt over trials. The experimenter suggested that all subjects benefited from the informational properties of KR. KR tells the learner what errors were made and what to do next, providing a strong guidance function for future performance (Salmoni et al., 1984). Subjects in all four groups may have also benefited from the motivation-like properties, thought of as temporary phenomena. Salmoni et al. explained that these properties could dissipate with a short rest or change in conditions. Similar performances were obtained in both the Immediate Retention and Retention phases.

Subjects in the groups generating VS performed, on average, with less error and were significantly better than subjects in the groups that did not generate VS. Subjects in the groups receiving KP performed, on average, with less error than subjects in the groups that did not receive KP but were not significantly better. Subjects in the group TC-4 performed, on average, with less error than subjects in the group TC-2, TC-3, or TC-1. Subjects in the group

TC-2 performed, on average, with less error than subjects in the group with condition TC-3 or TC-1. Subjects in the group TC-3 performed, on average, with less error than subjects in the group with condition TC-1. No significant differences were obtained between these groups.

Immediate Retention Phase

Subjects in the groups generating VS performed, on average, with less error but were not significantly better than subjects in the groups that did not generate VS. However, when comparing both groups on trial blocks 2, 3, 4, and 5, the results showed significant differences (see Appendix J). Subjects in the groups without VS may have benefited from the motivation-like properties discussed earlier, during the first trial block. As the condition was changed and a short period of time had passed, those properties may have dissipated. Subjects in the groups that did not generate VS performed with greater error over trial blocks (see Figure 6).

Subjects in the groups receiving KP performed, on average, with less error than subjects in the groups that did not receive KP but were not significantly better. Subjects in the group TC-4 performed, on average, with less error than subjects in the group TC-2, TC-3, or TC-1. Subjects in the group TC-2 performed, on average, with less error than subjects in the group TC-3 or TC-1. Subjects in the group with condition TC-3 did not perform with less error than subjects in the groups with condition TC-1, as was expected and presented in the Hypotheses section of Chapter I. Subjects in the group TC-1 performed, on average, with less error than subjects in the group TC-3. No significant differences were found between groups.

Retention Phase

Subjects in the groups generating VS performed, on average, with less error but were not significantly better than subjects in the groups that did not generate VS. Subjects in the groups receiving KP performed, on average, with less error than subjects in the groups that did not receive KP but were not significantly better. Subjects in the group TC-4 performed, on average, with less error than subjects in the group TC-3 or TC-1 but did not perform with less error than subjects in the group TC-2, as was expected and presented in the Hypotheses section of Chapter I. Subjects in the group TC-2 performed, on average, with less error than subjects in the group with condition TC-4, TC-3 or TC-1. Subjects in the group TC-3 did perform, on average, with less error than subjects in the group TC-1. However, no significant differences were found between groups.

Conclusions

Verbal Strategies (VS)

The findings of the present study suggested that VS was beneficial for performance and for the learning of a novel motor skill. The findings supported the hypothesis that, during Acquisition phase, subjects in the groups generating VS will perform with less error than subjects in the groups that did not generate VS.

Subjects generating VS performed with less error and were significantly better than subjects in the groups that did not generate VS during the Acquisition phase. These results were also obtained in both the Immediate Retention and Retention phases. However, differences obtained were not statistically significant. A trial block by VS interaction during the Retention phase suggests that VS was beneficial for the learning/retention of a novel motor skill.

These findings suggested that subjects in the groups generating VS might have benefited from VS in that the motor system is controllable by verbal systems (Adams, 1971). VS was probably not the only reason for the effectiveness of combined KR + VS and KR + KP + VS, but it seems to have an advantage to actually executing the golf putt when compared to no VS. Subjects could have benefited from KR and/or KP as well as previous sport related experiences. Another reason for their advantage might have come from the possible use of mental imagery. It is known that verbalization and mental imagery are frequently used rehearsal strategies for learning-remembering motor skills, (Hall et al., 1997). Hall et al. also explained that participants who were instructed to use verbal labeling, an effective rehearsal strategy for remembering movements (Shea & Zimny, 1988), also reported use of mental imagery, doing so to about the same extent as participants instructed to use mental imagery as their rehearsal strategy.

Knowledge of Performance (KP)

Subjects in the groups receiving KP performed with less error than subjects in the groups that did not receive KP but were not significantly better. The subjects in the groups receiving KP might have benefited from KP because it was presented as prescriptive feedback, which provides information that the learner can use to make more effective corrections in the subsequent movement. Subjects could have used KP to focus on the important part of the movement pattern required to putt the golf ball.

These findings are consistent with those obtained by Brisson and Alain (1997) and Kernodle and Carlton (1992).

Brisson and Alain (1996) also obtained similar results with significant differences between groups.

The same results were obtained during both the Immediate Retention and Retention phases. Brisson and Alain (1996, 1997) obtained significant differences between groups during the Retention phases of their studies.

The findings of the present study suggested that KP could be beneficial for the performance of a novel motor skill that is neither isomorphic nor requires a specific movement such as gymnastics routine or a springboard dive, as found by Brisson and Alain (1996, 1997). However, the findings of the present study were not statistically significant.

<u>Treatment Conditions</u>

As mentioned earlier, the experimenter suggested that all subjects benefited from the informational properties of KR. KR tells the learner what errors were made and what to do next, providing a strong guidance function for future performance (Salmoni et al., 1984).

Subjects in the group with condition TC-4 (KR + KP + VS) performed with less error than those in the groups with conditions TC-2 (KR + VS)(except on the Retention phase), TC-3 (KR + KP), and TC-1 (KR-only) in all three phases of the study.

Subjects in the group TC-2 performed with less error than TC-3, TC-1. It is suggested by the experimenter that subjects in the groups generating VS might have benefited from a combination of external and internal feedback. The use of VS, intrinsic feedback, may have helped subjects not to become dependent on KR and allowed them to develop some error detection mechanisms. The ability of the learner to detect errors and correct them for better performance has been shown to be important in learning of a motor skill (Swinnen et al., 1990; Winstein and Schmidt, 1990).

Subjects in the group TC-3 performed with less error than subjects in the group TC-1 (except on the Immediate Retention phase). The experimenter suggested that subjects in the group TC-3 might have benefited from the use of the calibration strategy. The calibration strategy is the use of KP with KR as reference to improve performance (Brisson & Alain, 1996, 1997). Subjects in the group TC-3 benefited from the guiding properties of high-frequency KR and from KP, presented as prescriptive feedback, to make more effective corrections in the subsequent movement.

Subjects in the group TC-1 improved their performance over trials during Acquisition, as did every other group. These findings are aligned with what Salmoni et al. (1984) stated as certainly the most fundamental finding in motor learning. They referred to the positive relationship between the absolute frequency of KR and performance in acquisition. Subjects in the group TC-1 also performed with less error than those in the group TC-3 during the Immediate Retention phase. The former group might have benefited from motivation-like properties, as mentioned earlier when discussing the results obtained during the Immediate Retention phase between group with VS and groups without VS.

Four main conclusions can be drawn from the findings of the present study. First, VS is an important tool for the acquisition and learning of a novel motor skill when used in combination with KR or KR and KP as reference. Second, KP is an important tool for the acquisition of a novel motor skill that is not isomorphic, using KP as reference. Third, the group with the greatest success in the present study, performing, on average, with less error, was the group with all three types of feedback (KR + KP + VS). Fourth, high-frequency KR is beneficial for the acquisition of a novel motor skill but was detrimental for learning. Subjects could have become dependent on high-frequency KR (Salmoni et al., 1984) degrading the development of error-detection capabilities (Swinnen et al., 1990).

Recommendations

As a result of the findings obtained in the present study, the following recommendations are presented:

a) Replicate the study using smaller groups (five subjects per group instead of ten) to reduce the waiting time prior to performing the task.

b) Replicate the study using subjects from different departments and/or from a different university.

c) Replicate the study and provide subjects with an introduction and explain to subjects how to generate verbal strategies using KR or KR + KP as reference.

d) Replicate the study using a different type of closed, discrete motor skill (e.g., bowling, darts, free throws) to determine the effects of VS on the learning of these novel motor skills.

e) Include an introduction, by instructors, on how to generate verbal strategies as part of their lesson when introducing a novel motor skill.

f) Provide learners with KP as prescriptive feedback, by instructors, to help them focus on the main aspect of the movement pattern that needs improvement.

Appendix A

Consent form presented to Subjects

You are being asked to take part in a research study, which evaluates your performance on a novel motor skill, the golf putt.

The study will take place in the Murphy Center at Middle Tennessee State University (MTSU). Testing will take place in two different days. During the first day, you will perform the task 60 times. The first day of testing is divided into two sessions. One session has 40 trials (acquisition phase) and the other session has 20 trials (immediate retention phase). The second day of testing is 48 hours later. During the second day of testing, you will perform 20 trials (retention phase) of the same skill.

There are no immediate risks to you while performing the task. You will perform a discrete, closed motor skill in a controlled environment.

As an undergraduate student who volunteered to participate as a subject in the study, you are expected to provide honest and correct information. You are expected to be present during both days of testing at the assigned time. You are expected to perform the task to the best of your abilities. You are expected not to share any information or knowledge about the study during the two-day period of testing.

You will benefit from participating in the study by learning how to properly perform the motor skill. You may also benefit from the techniques taught to you, during the study, as a way to improve motor skill performance.

If you have any questions about the study, you should feel free to communicate with the experimenter prior to becoming a volunteer in the study. You are encouraged to ask questions about the procedures used in the study or the results of the tests. If for some reason (questions, concerns, etc.) you need to contact someone regarding this study, you can call Adolfo R. Ramos (849-6918) or Dr. Peggy O'Hara-Murdock (904-8358).

Your permission to participate in the study is voluntary. You are free to stop participation at any point if desired without any consequences. You can feel confident that your test results will not be made public at any time. Your performance on this test will have no effect on your grade in the course in which you are enrolled. You should keep in mind that this study takes considerable time commitment. Your cooperation is greatly appreciated.

I have read this form and I understand the test procedures that I will perform. Knowing the procedures and having had the opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this test.

______________	______________________________
Date	Signature of Subject
______________	______________________________
Date	Signature of Witness

Appendix B

Institutional Review Board Approval

on-campus memo:

TO: Adolfo R. Ramos
Dr. Peggy O'Hara-Murdock

FROM: Dr. Dellmar Walker *Dellmar Walker*
IRB Representative
College of Education and Behavioral Science

Subject: "The effects of subject-generated verbal strategies on learning motor skills"

DATE: November 30, 2000

The project has been reviewed and approved. This approval is granted for one year only and must be reviewed by the committee on an annual basis if the project continues beyond the next twelve months. Any changes in the protocol (materials, design, etc.) require resubmission of your project for committee approval.

Best of luck on the successful completion of your project.

Appendix C

Types of verbal feedback provided through KR, KP, and possible VS

The following are possible types of KR, KP and VS that could have been presented based on different types of situations, after the subject performs a trial.

Based on a putt that rolled to a complete stop 18 inches passed the target, a subject in group TC-1 (KR-only), may receive:

a) KR from the experimenter, "You were 18 inches past the target."

Based on a putt that rolled to a complete stop 10 inches short of the target, a subject in group TC-3 (KR + KP), may receive:

a) KR from A2, "You were ten inches short of the target."
b) KP from the instructor, "You need to focus on the length of your backswing. It was a short backswing."

Based on a putt that rolled to a complete stop 18 inches passed the target, a subject in group TC-2 (KP + VS), may receive:

a) KR from A2, "You were 18 inches past the target."
b) After receiving KR, the subject may verbally strategize "I need to hit the ball softer next time."

Based on a putt that rolled to a complete stop ten inches short of the target, a subject in group TC-4 (KR + KP + VS), may receive:

a) KR from A2, "You were ten inches short."
b) KP from the experimenter, "You need to focus on the length of your backswing. It was a short backswing."
c) After receiving both KR and KP, the subject may strategize verbally, "I need to increase the length of the backswing."

Appendix D

Study protocol procedures

Experimenter to subjects…Hello! Glad you could make it! Thank you.

The first thing we are going to do is to select orders to perform the task. Every subject has a number. I'll draw the numbers from this box. You will wait in this room until one of my assistants comes to get the next subject to perform the task."

Once your number is called, you will go inside the testing area (TA). There you will go to the putting area (PA). There, the experimenter will teach you how to perform the golf putt. After the experimenter teaches you how to putt, you will have four trials to get familiar with the instrument (putter) and with the task. The task is to putt golf balls into the target (T). The target is located 15 feet away from the PA. Sorry, you cannot see it! You will receive feedback during the four practice trials.

During the first day of testing you will perform the task 60 times. The first 40 trials are part of the acquisition phase. The other 20 trials are part of the immediate retention phase. During the acquisition phase you will perform the task based on the treatment condition (TC) that was randomly assigned to your group. During the immediate retention phase, two minutes after the acquisition phase, you will putt when ready. No feedback will be provided neither during immediate retention nor retention phases.

<u>During the acquisition phase</u>:

a) Subjects assigned to group under treatment condition 1 (TC-1) will receive verbal KR from A2 after each trial during the acquisition phase. Each subject is instructed to wait until KR is provided prior to performing the next trial. Once KR is provided, each subject can perform the next trial.

b) Subjects assigned to group TC-2 will receive verbal KR followed after every trial during the acquisition phase. After KR is provided, each subject is instructed to provide a verbal strategy to answer the question, "How can I putt better?" Each subject is instructed to use the information provided through KR as a reference for the verbal strategy. Once the verbal strategy is provided, each subject may perform the next trial.

c) Subjects assigned to group TC-3 will receive verbal KR after every trial. Each subject will also receive knowledge of performance (KP) from the experimenter. Each subject is instructed to wait for both types of feedback prior to performing the next trial.

d) Subjects assigned to group TC-4 will receive both KR and KP after every trial. Each subject is instructed to provide a verbal strategy after both KR and KP have been provided. The subject is instructed to use the information provided through KR and KP as reference to generate a verbal strategy to answer the question "How can I putt better?" Once the verbal strategy is provided, the subject may perform the next trial, until all 40 trials of the acquisition phase are completed.

<u>During the immediate retention phase</u>:

Each subject performs 20 trials without feedback of any kind two minutes after the acquisition phase. After performing all 60 trials you will leave the building and are not to say anything to anybody about the test.

During the second day of testing, 48 hours later, you will perform 20 trials as part of the retention phase. You will be given a turn to perform the task. Again, once your number is called you come into the TA and perform the 20 trials. Just as during the immediate retention phase you will not receive feedback of any kind.

Once you are done with the 20 trials of the retention phase you will leave the building and are not to say anything to anybody about the test. Again, thank you for your participation in the study.

Description of Staff and Instructions

The staff for the present study is composed of three people. They are: 1) the experimenter, and 2) two assistants (Assistant 1, A! and Assistant 2, A2).

The experimenter is in charge of assigning the subjects to one of the four groups through randomization. The experimenter also assigns turns to perform the task by group as well as by subjects within groups.

The experimenter is in charge of teaching each subject, of all four groups, the golf putt prior to the acquisition phase. The experimenter also demonstrates how to perform the golf putt. After teaching the golf putt, the experimenter provides knowledge of performance (KP) to the subjects in the groups TC-2 and TC-4 during the acquisition phase. KP is provided to each subject by the experimenter right after A2 provides KR.

The experimenter also collects the data into the score sheets (score sheet 1 and score sheet 2) during all three phases of the study.

A1 is in charge of guiding the subjects to the putting area (PA). After guiding the subject to the PA, A1 sits in front of the PA. A1 places a golf ball on M for each one of the trials of each subject. A1 will place golf balls for every trial of each subject during all three phases of the study.

A2 is in charge of measuring the absolute error (AE). A2 is sitting near the target area (T) but far enough to avoid interfering with the roll of the golf balls. Once the golf ball rolls to a complete stop, A2 measures AE. AE is the distance, measured in inches, from the outside of T to the farthest point on the golf ball. A2 then tells the experimenter the score for AE. An example of this measure is "The ball stopped 10 inches from the target." The experimenter will use this information to provide the subject with KP.

After measuring AE, A2 collects the golf ball and places it inside a box. Once the subject has performed all the trials of each phase, A2 takes the golf ball to A1, who is in the PA.

Appendix E

Random selection procedures

Each subject was assigned a number by the experimenter. A copy of each number was placed inside a box. The experimenter drew a number from the box. Each subject was assigned to one of the four groups, under different treatment conditions (TC), following the order TC-1, TC-2, TC-3, and TC-4. After each fourth subject the selection starts with group TC-1 and follows the order again. Each subject was assigned to one group at a time.

Random selection of turns for groups

A paper with the number indicating each group, TC-1, TC-2, TC-3, and TC-4, was placed inside a box. The experimenter drew a number at a time to determine the order in which the groups will perform the tasks. This random selection was done for both days of the study.

Random selection of subjects'

Each subject was given a number to identify them from other subjects within their group. A copy of the numbers was placed inside a box prior to both the acquisition and retention phases. Each subject was called to perform the skill based on the selection made randomly by the experimenter.

Appendix F

Teaching criteria used to teach the golf putt

The following presents the criteria used for teaching the golf putt as the task in the study. The experimenter only taught the basic needs to perform the golf putt. The experimenter taught the subjects about the grip, stance and set-up, aligning the clubface, and the stroke.

The grip is known as the reverse overlap. For this grip place the handle of the club (putter) along the callus line of the hand (right hand) and wrap the last three fingers around the handle. The subjects should feel holding the club in the fingers of the right hand. The right thumb should ride down the center of the handle.

The left hand keeps the putter blade on the same swinging path throughout the stroke. It helps in controlling the direction of the putt. For the left hand, place the handle of the club between the thumb and pad so the handle runs nearly through the center of the palm. The right hand goes on top of the left hand and the index finger of the left hand wraps the fingers of the right hand.

The stance and set-up will be with the golf ball closer to the left foot. Place both feet on a slightly open stance. The ball should be an inch or two from the heel of the left foot. The weight of the body should be placed more on the left foot than on the right foot.

During the set-up, stand with back bent forward and arms hanging in front of body. The putter should be an extension of your arms. Where the putter ends, that is the distance between the subject's feet and the placement of the golf ball.

During the stroke the backswing and follow-through should be identical. A good balance provides a smooth, evenly paced stroke. The putter head should be accelerating the clubhead through impact with the ball. The length of the backswing determines how far the ball will go, provided that the follow-through is the same.

For the stroke, the path of the club should go straight back and straight through. The clubhead should rise during both the backswing and the follow-through. Do not make an attempt to raise the clubhead.

The stroke takes place on the shoulders. Do not break or hinge the wrists. It will create putt more inconsistent because it is hard to control the clubhead.

The contact with the ball should be on the center of the blade of the club.

Appendix G

Score Sheet 1 (Acquisition and Immediate Retention phases)

Score Sheet

Subject________ Group__________

Trials		Acquisition		Immediate Retention	
1		21		41	
2		22		42	
3		23		43	
4		24		44	
5		25		45	
6		26		46	
7		27		47	
8		28		48	
9		29		49	
10		30		50	
11		31		51	
12		32		52	
13		33		53	
14		34		54	
15		35		55	
16		36		56	
17		37		57	
18		38		58	
19		39		59	
20		40		60	

Appendix H

Score Sheet 2 (Retention phase)

Score Sheet

Subject___________Group___________

Trials Retention

Trials	Retention
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Appendix I

Process used for data collection

There was one type of data collected in this study. It was absolute error (AE). AE is the distance from outside of the target area to the farthest point on the golf ball (measured in inches)

The scores for AE were recorded on either score sheet 1 (see Appendix E) during acquisition and immediate retention phases, or on score sheet 2 (see Appendix F) during retention phase. Each subject performed the trials and was recorded for each trial.

The experimenter received the measurement of AE from A2 and wrote the score inside the box corresponding to each one of the trials for each one of the subjects. Each subject had his/her own score sheet 1 and score sheet 2. Both score sheets were stapled together.

Appendix J

Results of SPSS, during Immediate Retention for VS

Immediate Retention Phase: Trials 2-5 for the VS variable

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	175466.079	1	175466.079	1062.177	.000
VS	705.555	1	705.555	4.271	.043
Error	10242.079	62	165.195		

Immediate Retention Phase: Trials 1-5 for the VS variable

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	214163.958	1	214163.958	1150.877	.000
VS	542.020	1	542.020	2.913	.093
Error	11537.429	62	186.088		

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