A TEST OF THE VARIABILITY OF PRACTICE HYPOTHESIS: THE ACQUISITION OF A GROSS MOTOR SKILL.

By

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ABSTRACT

The sport of golf presents the constant challenge of a novel movement problem with every succeeding shot. A novel movement, in this instance, being a new and different movement experience (Schmidt, 1975).

The purpose of this study was to test the Variability of Practice Hypothesis (Schmidt, 1975) in a gross motor skill learning situation. More specifically, to assess the effectiveness of varying the initial conditions of a practice method, which was designed to facilitate the transfer of an expanded range of skills to the actual playing situation.

32 adult male and female golfers, who possessed a handicap between 12 and 24 strokes were assigned to one of two experimental groups according to their scores on a pre-practice administration of a criterion golf accuracy performance test.

The experimental group undertook a variable practice schedule incorporating a stance simulator which presented a differing lie and elevation on each stroke, whereas, the control group was presented with a constant practice schedule which had every ball played from the same location and lie.

The criterion test was administered four times in total, throughout the course of the six week experiment and required each subject to play three 120 yard approach shots from each

of six different fairway locations and lies, to a slightly uphill target area (flag stick).

The radial error values of each subject were analyzed by a 2 (groups) X 4 (tests) X 6 (positions) ANOVA with repeated measures on the 2nd and 3rd factors. A Chi square test was conducted from scatter plot graphs of each subject's shots, to determine shot pattern similarities. The comments from each subject's self analysis checklist reports were recorded and classified to detect any cognitive activity that reflected action plan recostruction

The variable practice group's performance showed a significant improvement in golf shot accuracy, from each of the 6 test locations, in comparison to that of the constant practice group. When the test positions were categorized, in terms of severity of lie, an interaction effect was observed revealing that the variable practice group improved performance on the less severe lies as well as the severe lies, whereas the constant practice group had no significant improvement in performance.

The Variability of Practice Hypothesis was tested whilst manipulating the initial conditions of practice. Variable practice in this practical field study found definite support for Schmidt's Hypothesis. From a practical point of view the results from this study illustrate the benefits of variable practice in a practice schedule adding strength to the position that the Variability of Practice Hypothesis should be considered as a important guideline to the structure of practice experiences.

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CHAPTER I

INTRODUCTION

Researchers and practitioners who are involved in the study of the acquisition and retention of motor skills are concerned with determining the optimal design of practice conditions (Shea & Kohl, 1990). Such practice conditions should then be able to produce maximum test performance, whether the test condition is a competition or an evaluation situation in which the practiced skill must be performed. Specifically, the question for coaches and athletes alike is, under what conditions should we practice in order to facilitate maximum transfer to the performance or competition setting?

The sport of golf presents the constant challenge of a novel movement problem with each shot. A novel movement being defined as a new and different movement experience (Schmidt, 1975). Traditionally, skill acquisition procedures in golf have involved practice on a driving range with the repetitive hitting of a large number of shots, usually with the same club. Unfortunately, this type of practice schedule does not adequately represent the task demands of actual golf play.

Golf's self paced, open skill situations, present ever changing environmental conditions thereby making it virtually impossible to create practice conditions that represent exact environmental fidelity. Of concern here is the need to be able to produce successful actions in a variety of novel situations, that is, a way to generalize specific practice to the many novel variations that will be encountered in the game situation.

Spriddle (1991) determined that of all iron shots played during a round of golf, only 17 percent were played from what could be regarded as a level lie. Consequently, it can be said that the nature of the game of golf and the typical terrain that it is played upon would suggest that practice upon flat lies has limited value. The problem, from a theoretical perspective, involves the need to create and test practice conditions that provide for a variety of lies (change of initial conditions) for each stroke (same class of movement) and thereby requiring actual course stance and stroke adaptations.

Schmidt (1975), motivated by earlier work on schema theories of learning (Bartlett, 1932) and by the limitations of existing motor learning theories (Adams, 1971) proposed his schema theory. To explain how a correct response could be produced for an action not previously experienced, he proposed that a fundamental aspect of motor skills learning involved the acquisition of a schemata that defines relationships among the information sources involved in the production and evaluation of motor responses within a class of actions.

Adams (1971) Closed Loop Theory explanation was limited to slow, limb positioning movements. Schmidt (1975) suggested that individuals do not store the exact specifics of each movement to be performed in memory but rather, a general rule or schemata for each movement class. Basically, when an individual makes a movement that attempts to satisfy some goal, four pieces of information are abstracted: the initial conditions, the response specifications, the sensory consequences of the response and the outcome of that movement. A motor response schema develops for a particular class of movements, within a generalised motor plan, and provides situation specific characteristics to the action.

In order for individuals to move effectively, information is required about the pre-response state of their body and the environment in which they are to move (Keele, 1968; Pew, 1974). These initial conditions consist of the information received from the various receptors prior to the response, such as proprioceptive information about limb and body positions in space, as well as visual and auditory information about the state of the environment. The response specifications are stored after the movement and serve as a record of the specifications of that movement produced. The third type of information stored after the movement is response produced sensory information. The sensory consequences information consists of actual feedback stimuli received visually, auditorily, and proprioceptively and are a representation of the information provided on the response. The fourth source of information stored after the movement is the success of the response in relation to the outcome that was originally intended. The actual outcome of the movement is stored, not the desired outcome. The response outcome information arises from information the subject receives after the movement, and consists of knowledge of results and subjective reinforcement that the subject obtains from other sources of feedback. The accuracy of the outcome information is thus a direct function of the amount and accuracy of the feedback information. When a number of different movements have been made, the subjects begin to abstract the information about the relationship between these four sources of data. The strength of the relationship among the four stored elements increases with each successive movement of the same action class and increases with increased accuracy of feedback information from the response outcome. This relationship is the generalized motor program or schema for the movement type under consideration and is more important to the subject than any one of the stored information sources (Posner & Keele, 1970).

When an individual is required to make a response of a type for which he/she has a schema already developed, he/she begins by determining the desired outcome for the movement and the initial conditions (Schmidt, 1975). From the existing relationship between the past outcomes and response specifications the individual then estimates the set of specifications that will achieve the desired outcome (recall schema). The subject need never have produced those specifications previously, as they are determined from a combination of initial conditions and an outcome that might never have been experienced previously. At the same time that the subject uses the schema to generate the response specifications, he/she also anticipates the expected sensory consequences of the movement (recognition schema). These expected sensory consequences are compared with the respective in-flow of sensory information (the proprioceptive and exteroceptive feedback) and the difference in the expected and actual sensory consequences produce an error message that is fed back to the schema providing KR of the outcome of the response produced (subjective reinforcement). The following diagram (Figure 1) shows how these sources of information are associated to form the schemata. One of Schmidt's major predictions was that within a class of movements, the more the varied practice or previous experiences had been, the better the performance would be on a novel task. This support for the notion of the schema was suggested from the fact that subjects could produce movements of a given class that they had never performed previously. The example cited by Schmidt (1975) was the basketball player who shoots from various places on the floor with great accuracy. The notion is that the varied previous shooting experiences led to increased schema strength, providing a basis

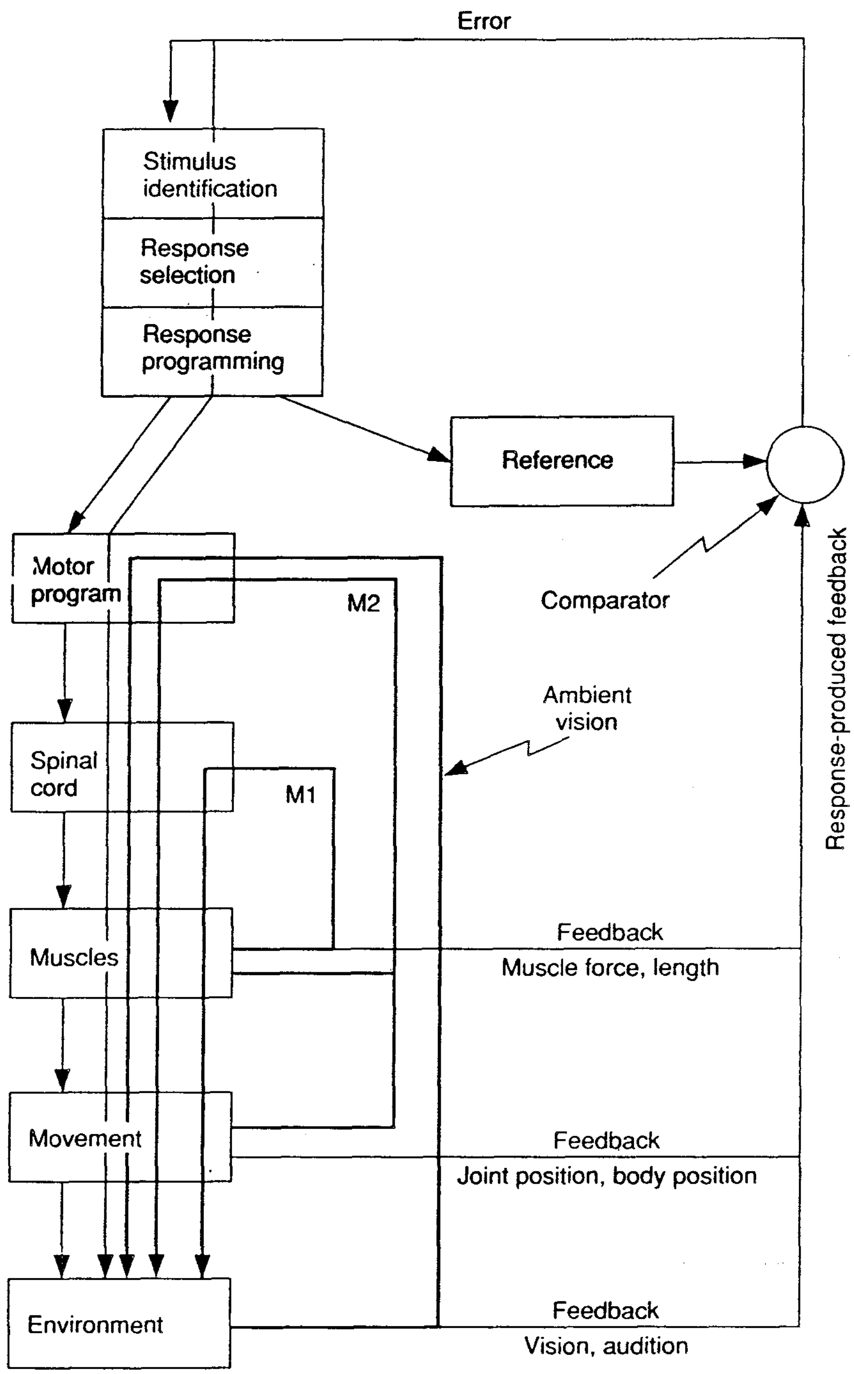

Figure 1. The Recall and Recognition Schema in relation to various sources of information (Schmidt 1991).

for generating novel movements of that same class. This position became known as the variability of practice hypothesis.

Since the proposal of the Schema Theory (1975), numerous researchers have attempted to test the variability of practice prediction in a variety of movement experiences. Most designs (Bird & Rikli, 1983; Husak & Reeve, 1979; Lee, Magill, & Weeks, 1985; Margolis & Christina, 1981; McCracken & Stelmach, 1977; Pigott & Shapiro, 1984; Wrisberg & Ragsdale, 1979) compared variable practice groups with a constant practice group. McCracken and Stelmach (1977), employing a rapid-timing task, where the movement time was fixed and movement distance was varied, used a variable practice group which practiced at four distances, a constant practice group and a blocked practice group that practiced at only one distance for less than half the number of trials of the other two groups. When transferred to a novel distance, the variability practice group performed with significantly less absolute error than the other groups. It was concluded that the high variability practice group had less error in a transfer test.

Pigott and Shapiro (1984) discovered that there was an optimal way to structure a variable practice session. Subjects tossed a weighted bean bag to a fixed target location. Three groups experienced variability in practice with four bean bags of varying weights (3, 4, 5, and 6 oz.), and the trial by trial presentation of each weight was different for each group. One group received a random presentation of each weight from trial to trial while another experienced random presentations of a weight for blocks of three trials. The third variability group received blocked practice with six trials per block for each weight. All variability groups experienced the same amount of practice at each weight. A constant practice group experienced only a single weight. Following 24 practice trials, all subjects were required to transfer their performance outside the range of previous experience, receiving three trials with one of two possible test weights (2 oz. or 7 oz.). The results indicated that the variability group practicing with blocks of three trials at each variation led to superior transfer performance to novel variations of the task.

Wrisberg and Ragsdale (1979) used a tracking task to test the hypothesis. In their experiment, subjects practiced an anticipation timing task in which they were to depress a button to be coincident with the illumination of the target (last) lamp in a series of lights on a runway 29.5 cm long. Variability of practice conditions were developed for both stimulus and response characteristics of the task. The high stimulus, high response variability group practiced for 40 trials with velocities of 22.35, 31.29, 49.17, and 58.12 cm/sec. The high stimulus, low response variability group observed the same four speeds for 40 trials but did not make an overt response.

The low stimulus, high response subjects overtly responded to a constant stimulus speed of one of the four speeds used for the high stimulus variability group. Finally, the low stimulus, low response group only observed a constant speed for 40 trials. All subjects were then required to respond to a novel speed of 40.23 cm/sec. The results of the experiment confirmed that on the novel speed task, the subjects who were required to make an overt response and who had practiced the four different stimulus speeds were more accurate in responding to the novel speed.

Lee, Magill, and Weeks (1985) used a two movement rapid timing task, with subjects learning to control their actions under one (constant) or four (variable) parameters, with variable practice conducted under either a blocked or randomized schedule. The error (variable and absolute) was significantly less in the random-variable practice group lending strong support for the schema theory prediction. It was suggested that the results indicated that random practice conditions promoted better retention and transfer because a more effective interference (forgetting) situation was established relative to blocked conditions.

Margolis and Christina (1981) used a rapid aiming response task while wearing prism glasses to test the variability of practice hypothesis. The glasses enabled the subjects to view the target, but not their responding limb or the outcome of the movement. The groups with variable target practice had less error on all transfer tests to a novel target, than the groups with non variable target practice.

Bird and Rikli (1983) used an angular positioning task involving 48 right handed male and female college volunteers to test the schema theory. The task was accomplished by extending the forearm in a clockwise direction from the starting point to a specified target location. Twelve subjects were randomly assigned to each of four conditions, with equal male and female subjects per group. Within the two levels of practice (variable/ constant), half of the subjects were exposed to a model (visual information only), while the other half was assigned to a control group. The control manipulation consisted of physical movements executed in the absence of vision. During the acquisition phase, all subjects heard verbal knowledge of results after each trial. All subjects received 60 knowledge of result acquisition trials prior to transferring to a different no knowledge of results location for 20 trials. During the blindfolded, 20 no knowledge of results trials, all subjects aimed at a new target located outside of their range of previous practice. It had been proposed that subjects observing a model who employed a practice variability strategy would be superior to subjects who observed a model who practiced under constant conditions. This prediction was supported by the data analysis, which showed that the variable-modeling condition had significantly less error during no knowledge of result transfer than did the constant modeling condition. It is important to note that, regardless of whether practice took place through modeling or through voluntary physical movements, the direction of the means was consistently in favour of practice variability.

Other research studies (Doody & Zelaznik, 1988; Johnson & McCabe, 1982; Newell & Shapiro, 1976; and Zelaznik, 1977), involving more limited variability of practice failed to support the hypothesis. Newell and Shapiro (1976), used two experiments to test predictions of the variability hypothesis. Rapid linear timing movements were employed to operationally separate the recall and recognition of a subsequent transfer to another task. This rapid-timing task with fixed movement distance, allowed subjects to practice at either one movement time (constant) or two movement times (variable) and then to transfer either inside or outside the range of their previous response variations. For absolute error, there were no differences between the constant and variable groups when transferred inside the range of the variable group. However, when transferred outside of their previous range of experiences, the variable group had significantly less error on the slower transfer task than the constant group, providing partial support for the schema theory.

Doody and Zelaznik (1988) found that when subjects transferred outside of their range of previous experiences, subjects using constant practice performed the transfer task with less error than the variability group. The subjects" task was to learn to execute a movement which resembled a left handed backhand movement (such as in tennis) so that a distance, visible at all times, was covered in 200ms. The movement was executed from a sitting position. The results of the transfer portion of the experiment suggested that when subjects transferred outside of the range of their previous experiences the subjects who performed the transfer task with less absolute error were the constant practice subjects. The constant practice group had more practice at a task similar in nature (40 cm distance - 47.5 cm) to the criterion test than did the variable group who experienced a greater variety of practice although none similar to the test situation.

Zelaznik (1977) used a rapid-timing task where movement time was fixed and movement distance was varied. Zelaznik trained a variability group at three distances and a constant group at only one distance. This constant group practiced closer to the transfer target than did the variability group. The transfer data demonstrated that the group experiencing variability of practice was not significantly different in absolute error from the constant group on the novel task. In addition, the group means were ordered contrary to the schema prediction, with the variability group demonstrating higher error than a constant group.

Johnson and McCabe (1982) used a ballistic positioning task with subjects sliding a ball bushing to rebound off a bumper located at the end of a trackway so that it would stop at a designated target. Subjects in a variability group practiced 50 trials at random distances of 210, 230, 250, 290, and 310 cm. Three practice groups practiced with a constant schedule of 50 training trials at distances of 230, 270 and 310cm, respectively. The final group was a control group with no practice experience. It was concluded from the results that the variable practice group did not perform with significantly less absolute error than groups experiencing only one distance, which did not support Schmidt's variability of practice hypothesis.

In summary, a number of experiments were conducted to test the Variability of Practice Hypothesis. The effect of variable practice schedules were studied via a variety of movement tasks which varied distance requirements within a fixed time period or varied the number of movements within rapid timing requirements. In addition, the timing of movements under anticipation response conditions, as well as, aiming response accuracy while visually limited, were explored. In all situations, the degree of transfer to the novel task, or retention test, setting was significantly enhanced by a variable practice schedule.

Limited support of the Variability of Practice Hypothesis was found in experiments that examined the effects upon transfer outside the range of the practice schedule. A rapid linear timing movement study revealed support only at the slower speeds, whereas, a fixed time and distance requirement benefited more from a constant practice schedule. Two other studies, one involving varied distance requirements within a fixed time period and the other involving ballistic positioning, found no significant differences in results between variable and constant practice schedules. As the design of these studies incorporated a criterion test that resembled the constant practice schedule, it is suggested that they did not provide a suitable test of the Hypothesis, that is, the transfer tests did not appear to be novel. None of the previous studies have looked at the effect of varying the initial conditions, with respect to the recall schema, of each practice trial in a practical field based study. The initial conditions consist of the information received from the senses prior to the desired response, such as proprioceptive information about the positions of the limbs and body in space, as well as visual and auditory information about the state of the environment (Schmidt, 1975).

Simulators

For the game of golf the changing nature of the response requirements in every situation makes it essential to vary the relevant stimuli related to performing the skill in the learning setting. Providing this type of variability during practice enables the performer to acquire the repertoire of motor patterns that match the possible responses that may be required (Gentile, 1972). An important requirement of practice, therefore, is that it provide a variety of experiences related to the skill being learned, that is, practice schedules and practice environments should be manipulated to present or simulate a variety of performance specific situations.

The overall goal of any simulation situation is for the transfer of learning on a particular simulator to the criterion task. For example, the use of ball serving or pitching machines in tennis or baseball is based upon the assumption that skill gained as a result of practice with the machines will positively transfer to the real situation (Magill, 1989).

Schmidt (1982) concluded that, during the early stages of learning, simulators were excellent for teaching procedural details and could save considerable time and money, compared to that involved with training on the actual equipment.

Kolers and Roediger (1984) have argued that what accounts for transfer between practice and test or between two skills is the similarity of the procedures required by the two situations or skills. In fact, they argued that many transfer effects in motor learning could be accounted for by invoking this "procedures" explanation. Even though the majority of studies concerning the use of simulators have shown their results to be, at best, equal with those achieved on the real task there is evidence that simulators provide a more efficient training medium. The Weitzman et al (1979) study indicated that the use of a simulator for training helicopter pilots was able to provide a greater diversity of situations than the real task and was, therefore, move effective. In this study, a helicopter simulator was used to train 36 helicopter pilots in instrument flight. The results showed that pilots trained in the simulator were better prepared for instrument flight than the pilots trained solely in the helicopter.

A meta-analysis of flight simulation research was conducted by Hays, Jacobs, Prince, and Salas (1992) to identify those characteristics associated with the effectiveness of simulator training. The major finding was that the use of a simulator combined with aircraft training consistently produced improvements in training for jets compared to aircraft training only.

Minaert (1950) discovered a significant difference when ski simulation training was compared to no practice at all on skiing ability. The study looked at the effect that dry land ski simulation had on 32 college women learning the snow plow, snow plow turn and stem turn. The results showed that the amount of time needed to master the skill on the hill was significantly less for the dry land simulation group than for subjects who had no practice at all.

Past research in areas of swimming, bowling, and golf instruction for beginners has shown that the use of simulation did not have an advantage over equivalent practice time on the real task (Chui, 1965; Nixon & Locke, 1973). Chui (1965) discovered that golf performance of beginners showed no significant difference when using a simulated golf practice device (Golf-O-Tron) as compared to the conventional driving range method. In this study the conditions of practice varied for each successive trial. The golf-o-tron was a video representation of a golf course and after each stroke the screen moved to show the result of that previous stroke as well as what confronted the player on their next stroke. Thus, the player although playing from the same location for every shot, was required to select a different club and face different course distances and directions. In physical activities, the use of simulators have become important when the skill to be learned is expensive or dangerous (e.g., pilot training), where facilities are limited (e.g., the golf course), or where real practice is not feasible (Schmidt, 1991).

Previous research, testing the application of the variability of practice hypothesis in real world settings, has not addressed the effects of manipulating the "initial conditions" element of the recall schema development. In golf, to allow practice from a variety of different lies without using the golf course itself, a course lie simulator would allow the initial conditions of each practice trial to be easily changed, thereby permitting the creation of a variety of different lies during a practice session.

The Golf Course Lie Simulator

The overall goal of any simulation situation is for the transfer of learning on a particular simulator to the criterion task (Magill, 1989). For the purpose of this study, a Golf Course Lie simulator (GCLS) was designed and built to provide the necessary game specific requirements for practice (see Figure 2, and for details of the design and construction see Appendix 1). In light of the nature of the game of golf and the realities of golf course management, access to game like locations for practice purposes are virtually impossible. Consequently, the only alternative available for course like practice conditions was the GCLS platform.

Purpose

Using the GCLS, this study was designed to examine the effects of varying the practice conditions (variable initial conditions vs constant initial conditions) in golf "practice sessions" upon performance on the golf course. Schmidt (1975) stated that the relationship between the "initial conditions" and the desired outcome of the movement create the new and more accurate response specifications. Therefore, it was hypothesized that by changing the initial conditions on every trial (via the GCLS) an extended schemata would develop and thus performance in novel task situations would improve. The real world setting selected to test the hypothesis was a 120 yard approach shot to the green on the 17th hole at the University Golf Course in Vancouver, B.C.

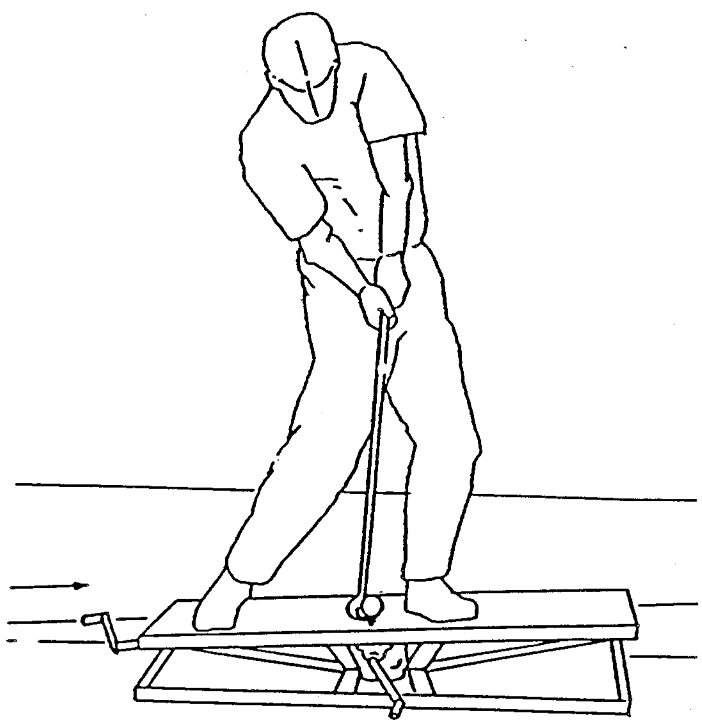

Figure 2. An illustration of the Golf Course Lie Simulator

CHAPTER II

METHODOLOGY

Subjects

32 adult male and female golfers, who possessed a handicap between 12 and 24 strokes were assigned to one of two practice groups according to their scores on a pre-practice administration of the criterion performance test. Attrition factors reduced the group size by five subjects, thus 13 subjects (n= 8 males, n= 5 females) completed the study as the experimental group (EG) and the remaining 14 subjects (n= 10 males, n= 4 females) made up the control group (CG). These pre-practice scores were also used to establish a baseline measure for the determination of the extent of any performance changes which may have occurred during the course of the experiment. The subjects, whose ages ranged from 19 to 34 years ($\bar{X}$ = 22.4, SD = 2.5), were naive as to the experimental hypothesis.

Apparatus

Experimental Group (EG)

A GCLS (see Figure 2, and for details of design and construction see Appendix 1) was designed to be capable of replicating most of the reasonable lies or elevations that may be encountered on a golf course (e.g., uphill, downhill, and sidehill lies or any combination thereof). The simulator permitted the presentation of a variety of lies from the same location during shot production sessions, that is, a variable random practice schedule.

Control Group (CG)

The CG's shot production sessions occurred while standing on a conventional flat driving range surface, that is, a constant practice schedule.

Performance Test

The performance test was a target acquisition task which required each subject to play 18 approach shots to a designated spot (the hole on the green) with the intention of getting their ball to finish as close to the hole as possible. The par 5, 17th hole at the University Golf Club (Vancouver), was selected as it presented many subtle variations of lies from the 120 yard approach area. The test required all golfers to play 3 strokes from each of six different lies, all with the same club. The club used for both warm up, practice and test was a 7 iron for the female subjects and a 9 iron for the male subjects. The choice of the 7 and 9 irons were prescribed by a jury of six Canadian Professional Golfers' Association professionals as being the appropriate club for female and males, respectively, to play a shot to a target 120 yards away.

Performance Test Procedures

Before each of the four performance test sessions (see Table 1), each subject "warmed up" by hitting 10 balls from a specified non-test location in preparation for the test. Then each of the 27 subjects played three rotations of one ball from each of the six test positions for a total of 18 test shots. The order of trials was the same for every subject and for every test session. A shot from position 1 was always followed by a shot from position 2 and then 3 until all six positions had been played from, three times each.

The distance that the ball finished from the target was recorded using a yard wheel. A direct line was taken from the test location to the hole and the measure that was recorded reflected the error distance long or short of the target. A perpendicular line was then taken to the ball to find the error distance left or right of the intended target. With the resultant error vectors forming a right angled triangle,the radial error distance that the ball finished from the hole was calculated using Pythagoras' theorem.

The six test positions were selected to represent the most frequent lie conditions with which players must contend during their third strokes on a typical par 5 hole (see Appendix 2). The angles of the test positions were determined by calculating the value of the tangent of the horizontal and vertical distances at each of the six test positions. A spirit level

Table 1. Test and Practice Schedule

Week	1	2	3	4	5	6
Practice Days		M W Th	M W F	M W Th	M W F	
No. of Balls		90	90	90	90	
Test	T1 (18)*		T2 (18)		T3 (18)	T4 (18)

*number of balls in test

and two yardsticks were used to measure the perpendicular height created by each angle of the test positions. From these two distances the precise angle of elevation was determined geometrically.

The six test positions, which remained the same throughout the study, included two downhill lies, two uphill lies, and two sidehill lies. The angles of each position were : downhill 10 degrees (position 1), downhill 3.5 degrees (position 2), uphill 4 degrees (position 3), sidehill 7 degrees above feet and 3.5 degrees downhill (position 4), sidehill 4 degrees below feet and 2.5 degrees downhill (position 5), and uphill 8 degrees (position 6) (See Table 2).

Practice Procedure

The EG and CG hit 30 practice shots three days per week (n = 3 x 30 = 90 shots) for four consecutive weeks (n = 360 shots), over the 12 session duration of the six week study. Both groups practiced with the investigator present and were hitting towards a target flag located at a distance of 120 yards. Each EG practice session of 30 balls started with the subject facing a 2 degree downhill lie with each of the subsequent 29 shots being played from a different position. The first 20 balls were hit in groups of five (from the angles of 2, 5, 9, 13, and 18 degrees, respectively) with the first group off a downhill lie, the second group off an uphill lie, the third off an uphill and above the feet lie and the final group off a

Table 2. Summary of strokes taken from each Test Location during Practice and Test sessions.

	Angles in Degrees			
Location	Practice (30)		Test (18)	
Sidehill				
Above/Uphill	2	(3.5/9,11/5.)		
Below/Uphill	2	(2/10,7.5/3.)		
Above/Downhill	3	(2.5/4,5/2,9/5.)	3	(7/3.5.)
Below/Downhill	3	(6/2,9/3,9.5/5.5.)	3	(4/2.5.)
Downhill	5	(2,5,9,13,18.)	6	(3.5,&10.)
Downhill/Below	5	(2,5,9,13,18.)		
Uphill	5	(2,5,9,13,18.)	6	(4, & 8.)
Uphill/Above	5	(2,5,9,13,18.)		

The lies are shown in parentheses.

Example

3.5/9 - a sidehill location, 3.5 degrees above feet and 9 degrees uphill.

2,5 - two locations, one at 2 degrees downhill and one at 5 degrees downhill.

downhill and below the feet lie. The final 10 balls were played from varying sidehill angles (below/downhill then above/downhill, below/uphill, and finally above/uphill). The range of practice lies selected exceeded the test range but did not replicate any of those lies. Each practice session took place at the same time each day. The EG practiced one at a time at the University playing fields with each practice session lasting approximately 15 minutes. The CG also practiced one at a time but at the University Golf club driving range. The EG practices were referred to as a variable random practice schedule whereas the CG practice was regarded as a constant practice schedule. All subjects agreed that they would not participate in any golf related activity during the course of the six week study. It was confirmed at the end of the study that none of the subjects had any other contact with golf, other than the study during that time.

Instructional Control and Self Analysis

As the study did not provide formal instruction or teacher generated feedback of any kind, all subjects were required to monitor and regulate their own performance. In order to ensure that the self guided development of stroke production was within an acceptable performance framework, the use of a Self Analysis Checklist (SAC) (developed by Owens & Bunker, 1989, see Appendix 3) was incorporated. This checklist consisted of key fundamentals of the golf swing in sequential order. The SAC was presented, and it's use explained by the investigator, to every subject prior to the first week of practice. Each subject was required to complete a Self-Analysis Checklist Report (SACR) after every practice session and to review that analysis immediately prior to the warm up period preceding each subsequent practice session. The report was an opportunity for the subjects to make notations upon their performance during their practice sessions. The subjects were reminded, by review of their SACR, of the basic fundamentals of the golf stroke and, following each practice session, they used the SAC to update their SACR about performance and technical points which may otherwise have been forgotten from session to session. No KR was provided to any of the subjects by the investigator thus controlling the availability of augmented information. As in the actual golf situation, the general information available from the movement and the KR feedback visually available from the flight and resting location of the ball on the target surface were the only information sources available to the performer.

Data Collection

Quantitative

The Performance Test was initially conducted at the beginning of week 1 of the study to determine group allocation and to identify baseline or pre test measures (see Table 1). The data collected were the radial error measures of each ball in terms of it's resting distance from the designated target. At the conclusion of the second week of practice, after 6 sessions of 30 practice shots, each, the Performance Test was re-administered. Following the fourth and concluding week of practice, after 6 more sessions of 30, a post experiment administration of the Performance Test was completed. A final week of no practice was permitted to elapse and then a Retention Performance Test was conducted.

Qualitative

Each subject's Self Analysis Report represented a chronicling of personal anecdotal data which summarized their after practice thoughts throughout the study. These data were scrutinized in terms of a stroke production vocabulary and then categorized in terms of the five fundamental golf performance components (Hogan, 1957) which provide a basis for determining the correctness of a movement.

Statistical Analysis

A 2 x 6 x 4 (Practice Methods x Lie Positions x Tests) ANOVA with repeated measures on the last two factors, with the radial error (absolute distance from target) of the performance as the dependent variable, was conducted in order to test the proposed hypotheses. A supplementary Chi-

Square test (log-linear procedures) analysis was performed to determine the independence of the pattern of final resting postions of the strokes, between the two groups. This was done in light of the possibility that subjects with the same radial error values could have produced different stroke patterns. Although it may not be practically important in golf, the pattern of stroke clusters would be valuable information from an instructional point of view. In order to obtain this stroke pattern information the green was first divided into two concentric circles from the center of the green, and then segmented into four equal quadrants which were aligned from the practice lie location. This design yielded a 2 x 4 frequency table for each group. A frequency count in this contingency table was subjected to a chi-square test to compare the distribution of the stroke patterns between the two groups and thus determined degrees of similarity that may have existed between the two groups in terms of the direction and clustering of the strokes.

CHAPTER III

RESULTS AND DISCUSSION

Quantitative Results

The following section presents the results of the statistical analyses in conjunction with the corresponding discussion.

1. Comparison of Practice Methods and of Test Lies

The results of a 2 (Practice Methods) by 6 (Test Lies) by 4 (Tests) ANOVA, with repeated measures on the second and third factors are presented in Table 3. Descriptive statistics for the dependent variable (the radial error) were also given in Tables 4, 5, and 6, each using a specific, or combination of, independent variables.

Practice Method

As can be seen in Table 3, a significant main effect was found for Practice Method, $F(1,25) = 8.41$, $p < .05$. Comparing the marginal means between the two groups indicated that the EG (37.2) outperformed the CG (44.8), collapsed across the four Tests and the 6 Test Lies. In addition, there was a significant Method by Test interaction effect, $F(3,75) = 3.78$, $p < .05$ as well as a significant Test main effect, $F(3,75) = 10.22$, $p < .05$. When the mean value between the two groups across the 4 tests were compared (collapsed over Test Lies), it was evident

Table 3. Results of ANOVA for Method X Test X Test Lie Locations.

Source	MS	df	F	p
Practice Method	9450.7	1	8.41	<0.05
Error	1123.8	25		
Tests	1602.2	3	10.22	<0.05
Tests X Method	593.1	3	3.7	<0.05
Error	156.7	25		
Test Lie	1651.5	5	8.3	<0.01
Test Lie X Method	76.8	5	0.4	>0.05
Error	197.9	125		
Test X Test Lie	311.4	15	2.25	<0.05
Test X Lie X Method	197.2	15	1.42	>0.01
Error	138.7	375		

that the performances improved over the duration of the Test period. For example, the mean radial error for CG decreased from 45.9 to 43.2 showing little improvement from Test 1 to Test 4. The error score of the EG was almost the same (43.4) as that of the CG at Test 1, but was substantially reduced (i.e., 31.5) in test 4, indicating a greater improvement over the same period (see Table 4, Figure 3.). Furthermore, a non-significant 3-way (Method by Test Lie by Test) interaction effect ($p > .10$) suggests that the pattern of the Method and Test interaction is consistent across all six Test Lies.

These results indicate that the variable practice schedule was more effective than the constant practice schedule in the improvement of the accuracy of the subjects' golf strokes, measured by the radial error. From this result it appears that the subjects who participated in the variable practice (GCLS) schedule were able to adapt more effectively to the actual course requirements than those whose schedule consisted of constant practice from a traditional flat surface. This finding is in agreement with the results of Shea and Morgan (1979) who found that subjects who practised randomly arranged trials showed greater retention and better transfer of training than did the subjects who practiced blocked trials.

Test Lie Locations

With respect to the effect of Test Lies on the test performance, there was a significant Test Lie main effect, $F(5,125) = 8.34$, $p < .01$. This result is evident when the

Table 4. Summary of the Mean and Standard Deviation scores of the Radial Error measures for each Test for both groups during the study averaged over the 6 Test Lie Locations

	n	T1	T2	T3	T4	$\bar{X}$
EG	(13)	43.4	38.2	35.7	31.5	37.2
s		18.6	14.4	9.0	7.1	
CG	(14)	45.9	46.3	43.9	43.2	44.8
s		16.1	17.1	11.4	11.2	

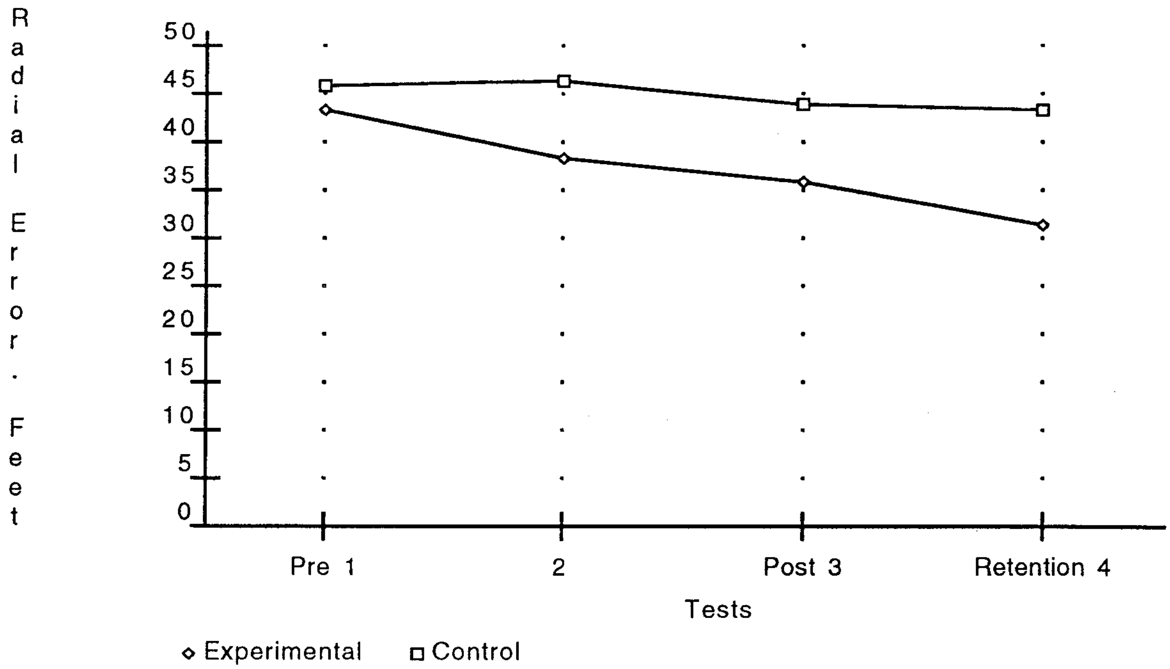

Figure 3. A graph of the Radial Error Means for EG and CGs averaged over 6 Test Lie Locations.

marginal means for the Test lie factor are examined. For example, as seen in Table 5, the marginal means ranged from 38.54 at lie location 2 to 49.00 at lie location 4, indicating a substantial performance difference between lie locations. Tukey's post hoc pairwise comparison test (see Table 6) confirmed this result, which produced a critical difference value of 10.5 thus identifying significant differences between Lie 4 and Lies 2 and 5. In addition, the differences between Lie 4 and Lies 1 and 3 approached significance. This result confirmed that approach shots played from downhill and uphill lies produced greater accuracy than approach shots played from a combination of locations and sidehill locations. Lie location 4 (sidehill and above/downhill) appeared to be the most difficult location from which to play an approach shot. The tendency from this type of lie is to produce a shot with a severe right to left flight path which typically tends to have a topspin applied to the ball due to the action of the clubhead during the stroke. The tendency from a downhill lie is for the ball to travel with a left to right trajectory due to the cutting action of the clubface on the ball. The cutting action imparts a side spin to the ball which thus flies from the left to the right. The tendency from an uphill lie is for the ball to travel from the right to the left. The clubface travels in a semi-circular manner contacting the outside of the ball. As the club travels

Table 5. Summary of the Mean and Standard Deviation scores of the Radial Error measures of both groups from each Test Lie Location

	n	L1	L2	L3	L4	L5	L6
EG	(13)	35.75	36.05	35.70	44.30	34.30	37.03
s		13.03	10.63	10.88	11.98	13.70	10.50
CG	(14)	44.25	40.85	44.30	53.38	42.80	43.35
s		16.13	13.10	13.55	15.65	12.35	13.03
$\bar{X}$	(27)	40.20	38.50	40.20	49.00	38.70	40.30

Table 6. Pairwise comparison between Test Lie means.

Lie	1(40.2)	2(38.5)	3(40.2)	4(49.0)	5(38.7)	6(40.3)
Lie 1	-	1.7	0.0	8.8	1.5	0.1
Lie 2	*	-	1.7	10.5	0.2	1.8
Lie 3	*	*	-	8.8	1.5	0.1
Lie 4	*	*	*	-	10.3	8.7
Lie 5	*	*	*	*	-	1.6
Lie 6	*	*	*	*	*	-

past the ball the action of the clubhead causes the spin and thus flight path.

Furthermore, a non-significant Method by Test Lie interaction effect ($p>.5$) indicates that the EG, when averaged over the 4 tests, consistently outperformed the CG at all 6 Test Lies. It may be worth noting that the EG which practiced with varied lie conditions for each trial and each Lie, still showed substantial improvement on all six Test Lies over the test period. This result supports the variability hypothesis (Schmidt, 1975, 1976), that is, practice variations about the criterion task leads to better performance on the subsequent criterion task retention test. Variable practice, in other words, enhances the development of a class of movement's, or performance generalizability, and allows the performer to apply learning to situations and actions not specifically experienced in practice. It appears that the EG acquired a set of rules to accommodate each practice situation requirement which transferred as a schema to fit the differing parameters of a new task, in this case, the criterion test.

Test Lie Locations over the 4 Tests

Finally, a significant Test Lie by Test interaction effect, $F(15,375) = 2.25$, $p < .05$ indicates that the trend of the performance improvement over the test period was not the same across the six Test Lies. The reason for this interaction is clear when the mean value of the radial error across the test period was examined (see Table 7). For example, the means for the Lie locations 1, 4, and 6 ranged from 44.3 to 56.2 at Test 1, but substantially reduced at Test 4, ranging from 34.0 to 42.1. On the other hand, the mean of the lie locations 2, 3, and 5 at Test 1 was considerably lower and changed marginally over the test period. This is a somewhat expected result as the six lie locations during the performance tests varied in terms of angle of lie and direction of the lie to the target. The lie locations 1, 4, and 6 had a similar, but severe degrees of lie angle, while the other three (locations 2, 3, and 5) all had a lie angle close to flat. This suggests that all subjects, regardless of teaching method, would have more difficulty at the first test in performing an approach shot from a severe lie angle than they would from a less severe lie. However, as the test progressed, this challenge was overcome, resulting in a more improved performance from the severe lies than from the less severe lies. The greater improvement from the severe lies would be expected as the Test 1 results indicated a higher error score and thus greater chance to improve. As the less severe lies produced a higher level of performance at Test 1 increased improvement would be less evident from these locations.

From a coaching point of view the results indicate the need for a more realistic practice routine. Both the schedule and the amount of practice should be emphasised to create a

Table 7. Summary of the Mean scores of the Radial Error Measures from each Test Lie Location during the four Tests.

	Tests				
	T1	T2	T3	T4	$\bar{X}$
Location 1	49.7	41.4	35.6	34.0	40.2
Location 4	56.2	50.6	47.1	42.1	49.0
Location 6	44.3	44.0	36.3	35.4	40.3
Location 2	38.0	36.4	41.1	36.4	38.5
Location 3	39.8	42.4	39.4	39.0	40.2
Location 5	40.2	39.5	38.9	37.5	38.7

more effective and game useful practice plan. As the results demonstrate, more variation in practice, in this case created by changing the initial conditions of each trial, produced a positive transfer of practice results to the criterion task or game situation. Practice should reflect the nature of the task that the practice is designed for. In golf, seldom are shots from varying lies practiced, generally they are confronted in the game itself for the first time. A varied practice schedule would allow players to perform effectively in these new situations without actually ever having attempted them previously.

2. Comparison of stroke clusters

The analysis was performed using log-linear procedures (Chi-Square Test) in the BMDP statistical program to determine whether the pattern of the 2 x 4 (Distance by Direction) contingency table for EG was actually different from that of CG. A 2 x 2 x 4 (Group by Distance by Direction) contingency table was constructed for Tests 1 and 4 at Test Lie location 1, from the scatter plot graphs (see Figure 4.). This location was selected as subjects showed most improvement over the test period at this postion, thus, if an analysis of results was to reveal a difference in the stroke pattern between the two groups, it would occur here. The log linear procedure did not reveal a significant difference between the two group's stroke clusters, therefore, further analyses with remaining lie locations were not performed. Table 8 presents the pattern of

Table 8. Table of the Proportion of Stroke Clusters observed at Test Lie 1 for Test 4, only.

Group	Distance	Direction				Frequency
		Short/ Straight	Right	Long/ Straight	Left	
EG	<30 ft.	29.6	22.2	33.3	14.8	27.0
	>30 ft.	58.3	16.7	16.7	8.3	12.0
Totals		38.5	20.5	28.2	12.8	39.0
CG	<30 ft.	23.1	53.8	7.7	15.4	13.0
	>30 ft.	72.4	10.3	10.3	6.9	29.0
Totals		57.1	23.8	9.5	9.5	42.0

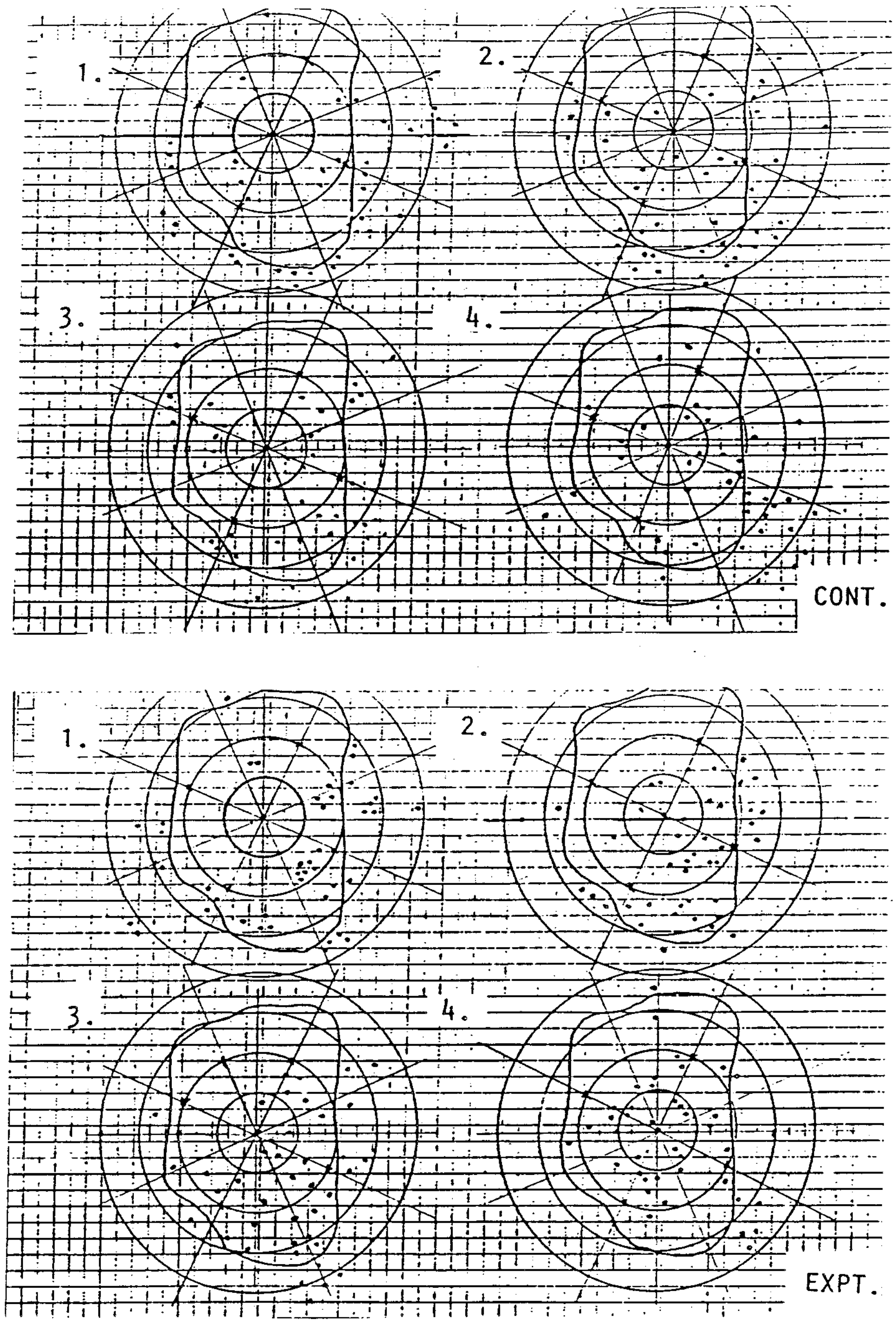

Figure 4. Scatter Plot graph for both EG and CG from Test Lie Location 1 over the four Tests.

proportions in each cell with marginal frequency counts for test 4 only, for both groups. Similar results, as expected from homogeneous groups, were obtained in the analysis of the Test 1 results. The statistical result indicated that the association between Distance and Direction (i.e., two-way marginal table) was significant, X^2 (3) = 14.05, p < .01 (see Table 9). This indicates that the pattern of strokes, averaged over the two groups, was not statistically independent of each other. This is apparent from the table which shows incongruency in cell proportions. However, a non-significant 3-way association (Group by Distance by Direction), X^2 (3) = 2.41, p > .45, suggests that the pattern of the stroke clusters in terms of direction and distance shown in the above 2-way interaction was similar for both groups. That is, the EG and CG were both as likely to miss their intended target to the left or right, short or long. This result was further supported by a non-significant Group by Direction interaction, X^2 (3) = 5.72, p > .10, averaged over the Distance factor. Furthermore, although only part of the data was actually analyzed, the resulting significant Group by Distance marginal interaction (X^2 (1) = 12.16, p < .01) confirmed the significant Practice Method main effect revealed by the ANOVA results. That is, the EG strokes were more likely to finish within 30 feet of the target (69 % or 27/39), in terms of radial error, than were the strokes of the CG (31 % or 13/42).

Table 9. Chi Square Table with Partial and Marginal Association.

		Partial			Marginal	
Effect	df	X^2	Prob.	df	X^2	Prob.
Direction	3	23.28				
Distance	1	0.01				
Group	1	0.11				
Dir x Dist	3	12.20		3	14.05	$p<0.01$
Dir x Group	3	3.86		3	5.72	$p>0.01$
Dist x Group	1	10.30		1	12.16	$p<0.01$
Dir x Dis x Grp	3	2.41	$p>.45$			

From a coaching point of view, it is worth noting that the majority of strokes in this study were short of the target because the majority of these strokes were mishit. A mishit occurs when a stroke has not been contacted correctly by the golf club and thus the ball travels a lesser distance than normal. From the various lie locations in this study there is a greater likelihood of mishit strokes due to the unusual slope of the ground, uncharacteristic feet placement and uncertainty of the stroke. It is also worth noting that due to the nature of the lie the ball tends to fly, upon contact with the club face, with different spin and therefore different direction. The coach or instructor will find this information useful when deciding upon strategies to play the course in terms of club selection and the likelihood of achieving the desired outcome of the stroke.

Qualitative Results

The purpose of collecting this information was to monitor the nature of the performers' thoughts during practice sessions to determine if any evidence was available to confirm cognitive activity that reflected motor plan formation or action plan reconstruction.

Anecdotal Data

The comments made by each subject in their Self Analysis Checklist and Report (SACR) were reviewed and categorised into the five general golf performance areas of Alignment, Distance, Swing Techniques, Position of Feet, and

General Comfort (Hogan, 1957). The information taken from each subject's SACR provided an insight into the process involved in the refining of the stroke mechanics (see Table.10).

Control Group

The limited comments from the CG were general in nature. After session 3, at the end of the first week, the only comments made by the CG were concerned with matters of alignment and swing techniques. The CG maintained the same thoughts throughout the study period. The CG were initially concerned with a square aim and straight ball flight. The comments from the CG promptly decreased after the sixth practice session when it became apparent that their performance and their comments had not really altered. The main alignment comments suggested the great need to be aiming at the target prior to the start of the backswing. Swing technique comments were reminders to swing the golf club head towards the target in question. An analysis of the nature of the CG's comments revealed that they appear to have, at an early time in the practice period, determined that the task did not require a change from their current procedures. The CG's SAR comments reflected the generation of performance related, cognitive activity during practice sessions 1 to 4, and any action plan reconstruction (Goode & Magill,1986) that was deemed necessary appeared to be completed by the end of practice session 4. It is feasible to conclude that practices 5

Table 10. Number of Comments in Categories from Self Analysis Report.

Practice Session	No. of Comments	Align.	Dist.	Swing	Feet Pos.	Comfort
1 Expt.	*1 (48)	16	14	07	11	00
2 Expt.	(39)	14	02	11	08	04
3 Expt.	(37)	17	00	09	07	04
4 Expt.	(36)	11	02	13	05	05
5 Expt.	(26)	10	00	13	03	00
6 Expt.	*2 (22)	09	00	07	06	00
7 Expt.	(18)	09	00	02	07	00
8 Expt.	(16)	09	00	04	03	00
9 Expt.	(17)	10	00	05	02	00
1 Control	*1 (38)	22	04	02	00	10
2 Control	(26)	14	01	06	01	04
3 Control	(24)	16	00	07	01	00
4 Control	(13)	10	00	02	01	00
5 Control	(13)	04	00	09	00	00
6 Control	*2 (07)	05	00	02	00	00
7 Control	(06)	03	00	03	00	00
8 Control	(06)	04	00	02	00	00
9 Control	(05)	04	00	01	00	00

Sessions 10,11,12 no new comments.

*1 = Test 1.

through 12 were completed with little attention to the details of the swing, as all adjustments that the subjects felt were needed had been made.

Experimental Group

Prior to Test 2, comments were quite varied and general in scope. The main focus for the EG appeared to be associated with stance alignment to the changing lies presented by the simulator. Most subjects, it would appear, were unsure of how the ball was going to fly from all the varying elevations as a total of 27 comments reflected a concern with alignment and foot position factors. The general alignment from each position during practice session 1, accounted for the majority (33%) of initial comments . 15% of comments were concerned with swing techniques and 23% were concerned with where the ball position should be in relation to their feet. The remainder of comments revealed feelings about both distance factors and comfort feelings. Following each practice session the comments became noticeably more focused on the mechanics of the actual stroke from each different lie. For example, several subjects commented that the stroke was more successful when their body was angled at the same angle as the lie from which they were attempting to play. The majority of SARs produced comments that revealed a concern with remembering what and focusing upon that which had been successful to them in prior situations. After the fourth practice session thoughts concerning feet position were seldom recorded. Most SARs indicated that the subjects had reached the conclusion that uphill lies required the ball to be moved to the front of the feet and downhill lies had the ball placed back in the stance. Sessions 5 and 6, just prior to the second test, saw the subjects primarily focusing upon the correct alignment and swing technique. Comments that were used included "swing with the slope down the target line" and "do not always swing with the lie of the ground". Other swing technique centred comments were "stay balanced and still over the ball", and "choke up and down the clubs" were associated with the severity of lies. Alignment comments included such cue words as "aim left" for downhill and "right" for uphill shots. Nearly 82% (39 of 48) of all comments on sessions 5 and 6 were concerned with technique and alignment, a shift from 61% (98 of 160) in sessions 1 through 4. The nature of the comments had shifted from those expressing general concerns about all five performance components to brief "cue words" specific to two technical components of performance, thus indicating that the subjects' general movement experimentation had concluded and that they were selectively attending to factors associated with shot accuracy. There appears to be an association between the reported thought patterns of the EG and their improvement in the Test performance.

After six practice sessions the EGs' comments were becoming more concentrated on two key areas (swing technique, alignment). It appears that after six or seven practice sessions the EG's reconstruction plans were representative of the motor stage as they appeared to be becoming less concerned with the general actions of the movements and were consciously focusing on fewer performance factors. The EG had formulated a motor plan but were required to briefly attend to the movement because of the continuously changing lies.

CHAPTER IV

SUMMARY

Schmidt's Variability of Practice Hypothesis states that within a class of movements, the more varied the practice or previous experiences, the better performance would be on a novel task.

This field based study was conducted in order to determine the effects of the variability of practice, (specifically varying the initial conditions), on the accuracy of the approach shot in golf. Two groups took part in the study, an experimental group which practiced from a Golf Course Lie Simulator and experienced a different lie for each trial, and a control group which practiced from a flat driving range surface and experienced the same lie on each trial. Each group hit 360 balls over the course of 12 practice sessions.

The criterion Test for each of the 27 subjects involved playing approach shots toward an actual golf hole to a target 120 yards away. The 18 test strokes were made up of three rotations of one ball from each of the six Test Lie locations. There were four tests throughout the course of the six week study.

From the results it appears that the subjects who participated in the variable practice schedule were able to transfer more effectively to the actual golfcourse test situation, than those whose schedule consisted of constant practice from a more traditional flat surface.

The EG, which participated within a random variable practice schedule, significantly improved approach shot accuracy on the golf course over a six week period, hitting 360 golf balls from a variety of lies from the Golf Course Lie Simulator. This improvement held for all Test Lie locations presented by the criterion test.

As the study did not provide formal instruction or teacher generated feedback of any kind, all subjects were required to monitor and regulate their own performance. In order to ensure that the self guided development of stroke production was within an acceptable performance framework, the use of a Self Analysis Checklist Report was incorporated. This checklist presented the key fundamentals of the golf swing in sequential order and was reported on by each subject after every practice session.

Each subject's Self Analysis Checklist Report (SACR) represented a chronicling of personal anecdotal data which summarized their after practice thoughts throughout the study. These data were scrutinized in terms of a stroke production vocabulary and then categorized in terms of the five fundamental golf performance components (Hogan, 1957) which provide a basis for determining the correctness of a movement.

The qualitative results gained from the SACR suggested that the EG were involved actively in an action plan reconstruction stage well through the practice sessions as the varying lies and changing locations during practice appeared to have generated a considerable amount of cognitive activity. As Lee and Magill (1983) suggested, this active processing is primarily to reconstruct an action plan on the next trial for a particular variation, because the action plan developed for the previous trial of that skill is partially or completely forgotten. This pattern continued for most of the practice sessions although laterly the EG were becoming less concerned with the general actions of the movements and were consciously focusing on fewer performance factors.

The CG maintained the same thoughts throughout the study period. The comments from the CG ceased after the sixth practice session when it became apparent that both their performance and their comments showed minimal change. The SACR comments reflected the generation of performance related cognitive activity during practice sessions 1 to 4, but any action plan reconstruction that was deemed necessary appeared to be completed by the end of practice session 4.

From a coaching point of view the results indicate the need for a more ecologically valid practice routine. Both the schedule and the amount of practice should be emphasized to create a more effective and game like practice plan which should reflect the nature of the task that the practice was designed for.

A practice session which deals with sidehill severe positions and variations of all other types of lies (as with the EG in this study) would better prepare players for the demands of the eventual game (or criterion test in this study). In golf seldom are shots from varying lies practiced, generally they are confronted in the game itself for the first time. A varied practice schedule would allow performers to attempt these new situations without actually ever having attempted them previously. As was seen, more variation in practice by changing the initial conditions of each trial, permitted an enhanced degree of transfer to the game or criterion task. As Schmidt (1975) suggested " increased amount and variability (of practice) will lead to the development of an increasingly strong recall schema, so that when the subject is transferred to a novel situation governed by the schema, he will be able to determine more effectively the appropriate response specifications, given the desired outcome and the initial conditions".

The Variability of Practice Hypothesis has been tested whilst manipulating the initial conditions of practice. Variable practice in this practical field study found definite support for

Schmidt's Hypothesis. From a practical point of view the results from this study illustrate the benefits of variable practice in a practice schedule. The Variability of Practice Hypothesis should be used as a guideline to structure practice. This will lead to more effective practice and thus improved performance in the criterion situation.

Recommendations

1. The first recommendation would be to increase the length of the study from six to ten weeks with follow up retention trials to be conducted to better assess the permanence of learning.

2. Increasing the number of subjects would give greater validity to the results, however, practically it may not be realistic to expect so many golfers to forego playing over the extended duration of the study.

3. The addition of a random practice group and a no practice group would be useful to permit a comparison with the existing groups.

4. Future studies may want to use the same methodology but increase the distance of the criterion task. A situation where two clubs could be incorporated into the practice sessions could yet further relate practice to the actual game.

5. It is important to have the subject groups as homogeneous as possible and this may not always be true

when handicaps are the criterion for group selection. The pre-test should dictate the composition of the groups.

6. The use of video analysis would provide another data source that would permit a more specific analysis of the nature of the changes in stroke mechanics which occurred during practice.

7. Have all subjects practice off the same simulator surface to account for Hawthornes effect. The control group would practice with the simulator in a horizontal position.

8. The criterion test should include a position outside the range of positions practiced by the experimental group.

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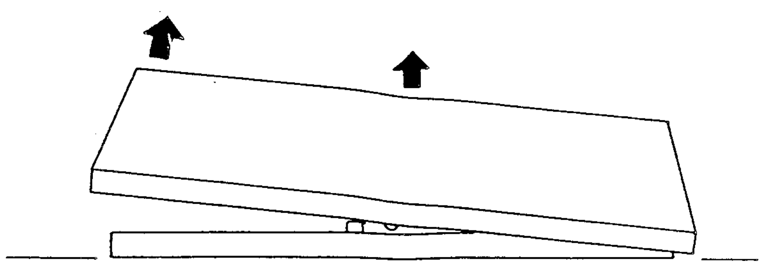
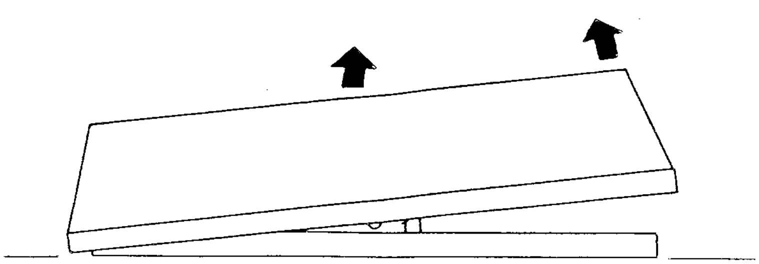
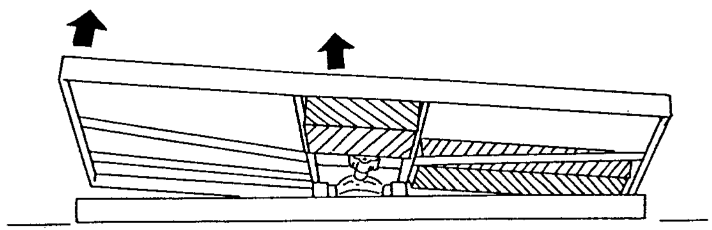
Appendix 1. Golf Course Lie Simulator- design and construction details.

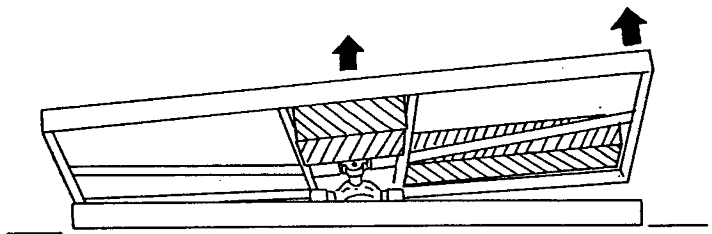
A portable, aluminum GCLS provides a golf practice device for use in simulating all typical uneven lies from which a golfer may hit practice shots. The practice platform, when horizontal, is located 12 inches above ground level in order to permit the tilting of the surface to simulate any reasonable course lie desired. The platform's base is adapted to provide stability and houses two hydraulic jacks which are manipulated to create the desired slope. The hydraulic jacks are self contained and operate with a valve which is closed when the desired lie position has been found. Hydraulics were used so that stability of the GCLS was ensured. The device weighs approximately 150 lbs, and is 52 inches X 52 inches square.

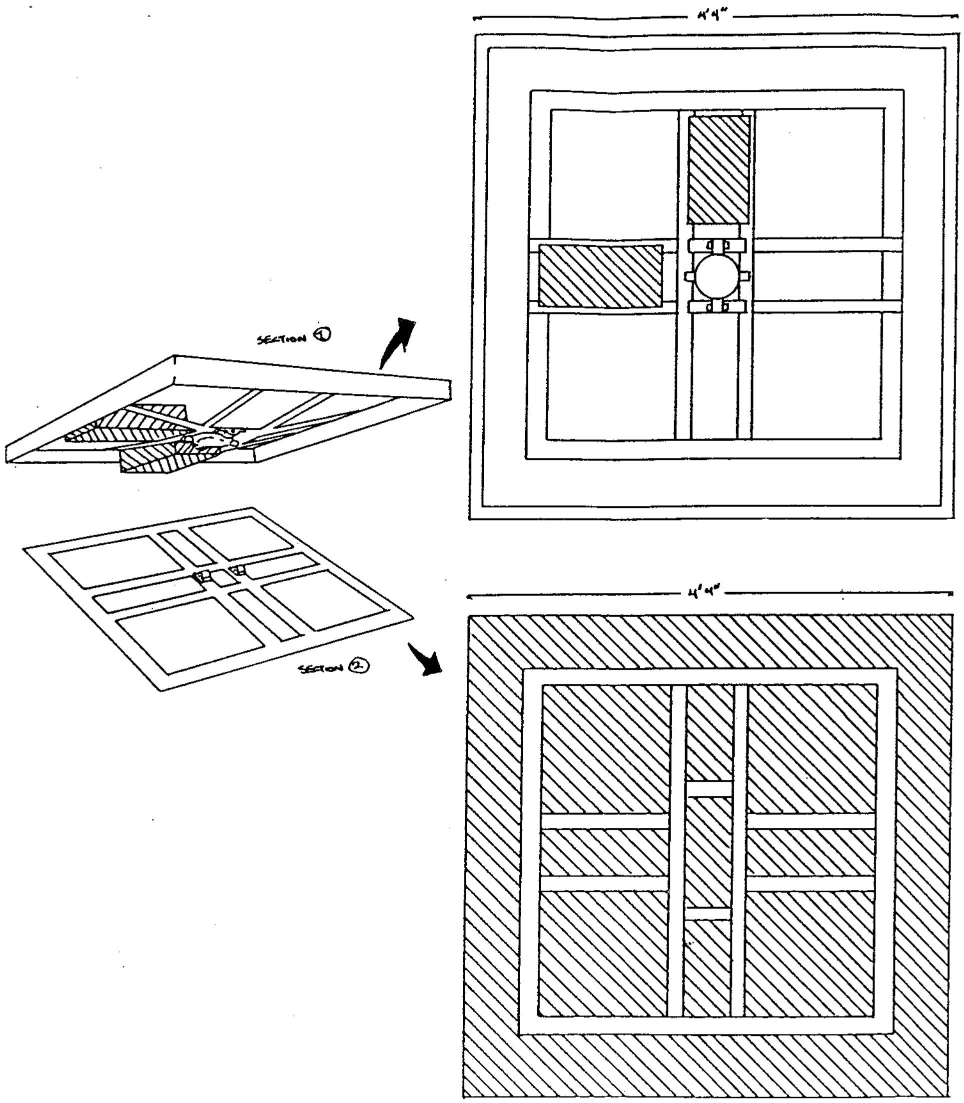
Diagrams:










4'4"
SECTION ①
SECTION ②
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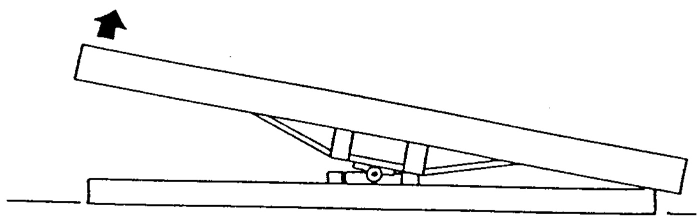
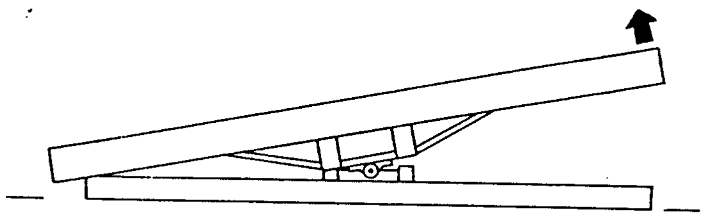
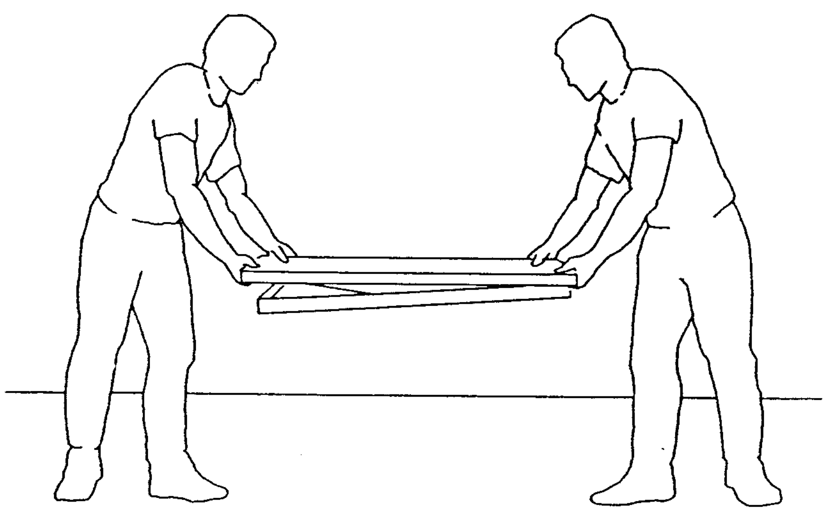
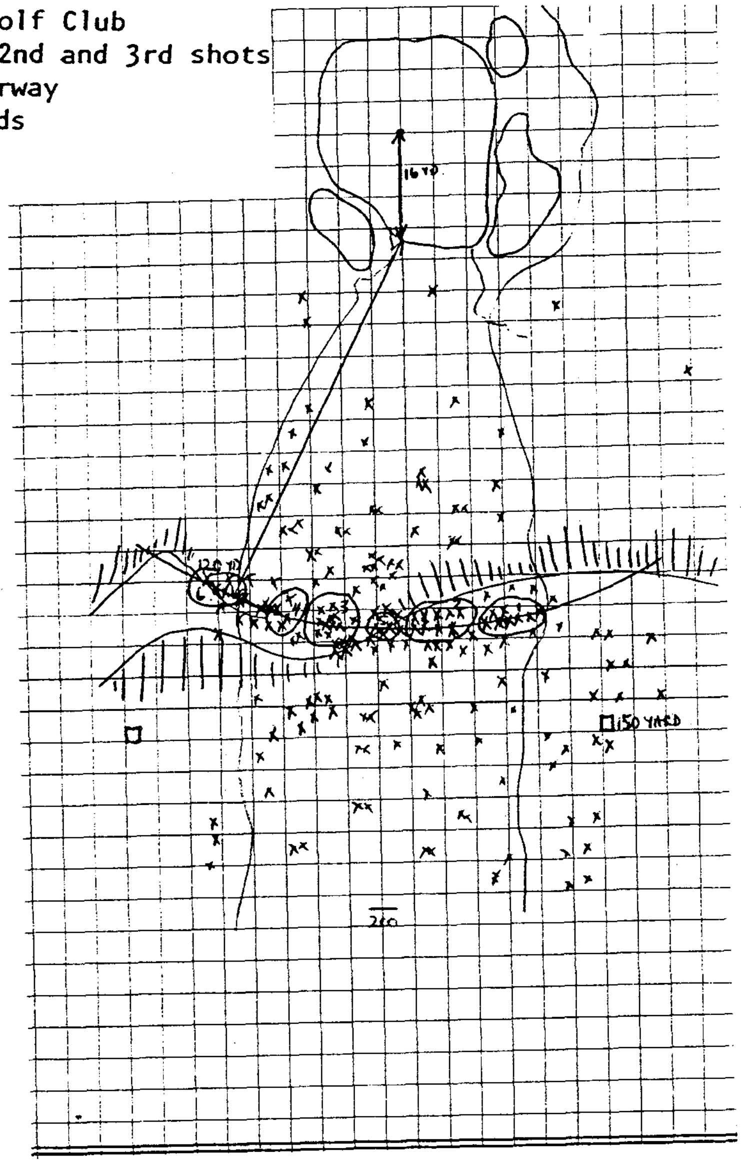




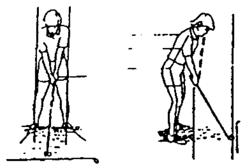


Appendix 2. Typical Par 5 hole

Par 5
17th hole
University Golf Club
Position of 2nd and 3rd shots
from the fairway
From 120 yards

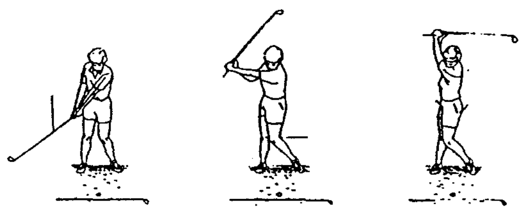


Appendix 3. Self Analysis Checklist



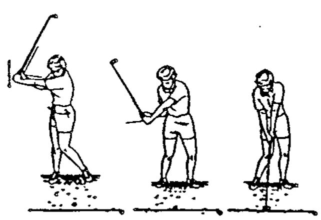
- ____ Grips club in neutral position (Vs in grip pointing to rear of chin)
- ____ Feet shoulder width apart
- ____ Weight evenly distributed
- ____ Foot alignment square to target line
- ____ Hips square to target line
- ____ Shoulders square to target line
- ____ Posture with flat back and eyes over hands
- ____ Weight forward, midstep to balls of fe
- ____ Ball position with irons: near center of stance; with woods: target side of center
- ____ Blade of club square to target

Backswing

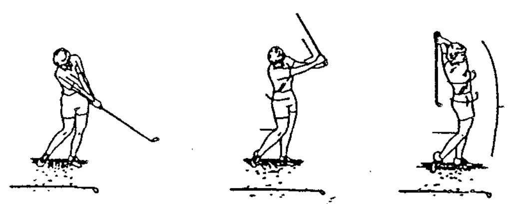


- ____ Arms, hands, and club swing back as unit
- ____ Weight shifts to rear (target knee touches rear knee)
- ____ Wrists cocked at hip level
- ____ Hips turn to rear (belt buckle back)
- ____ Backswing length 5
- ____ Heel of target foot off ground slightl
- ____ Hands over rear shoulder in full turn
- ____ Club parallel to ground
- ____ Back to target

Forwardswing



- ____ Weight shifts to target side
- ____ Target heel down
- ____ Target knee toward target
- ____ Hips return to square
- ____ Arms, hands, club swing down
- ____ Wrists uncocked at hip level
- ____ Arms, club, hands extended at contact with ball
- ____ Rear knee turns towards target knee



- ____ Swing continues smoothly; wrists recock at hip level
- ____ Arms, hands, club continue until hands are higher than target shoulder
- ____ Hips face target
- ____ Forwardswing length 5
- ____ Chest to target
- ____ Holds position at end to check for balance
- ____ Weight on target side (rear knee touches target knee)