COLBY, Marilyn Fairfax, 1938-
THE AMOUNT OF INFORMATION FEEDBACK ESSENTIAL
TO ERROR CORRECTION IN PUTTING.

The Ohio State University, Ph.D., 1971
Education, physical

University Microfilms, A XEROX Company, Ann Arbor, Michigan
THE AMOUNT OF INFORMATION FEEDBACK ESSENTIAL
TO ERROR CORRECTION IN PUTTING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Marilyn Fairfax Colby, B.S., M.S.

* * * * *

The Ohio State University
1971

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ACKNOWLEDGMENTS

Many people have been involved in the conception and execution of this study. In particular, the writer appreciates the assistance of Dr. Anthony Greenwald for suggestions on structuring the study, and Dr. L. Delyte Morris for clarifying the statistical concepts. The most important people to the study were the students at The Ohio State University who served as subjects.

Computation of the statistics would not have been possible without the assistance of the Instructional and Research Computer Center, in particular Mr. Madhudar B. Golhar and Mr. Theodore Smith.
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CHAPTER I

INTRODUCTION

One question that is basic to the teaching and learning of sport skills involves asking, "What is the essential knowledge that the learner must have for successful performance in that sport?" To what should the learner initially pay attention during the execution of a skilled movement?

The most effective teaching methods, as listed by Lawther are: "Show him the act, then let him try it out; demonstrate again if necessary; point out major aspects; guide him manually if necessary; and let him practice."¹ What information feedback (IF) is the beginner learning to use as a result of this experience? The major premise in this study is that feedback concepts are feasible means for understanding sport skills learning.

The essential information for successful performance in a sport is limited to the demands of that particular sport. As a consequence, the beginning player must learn what is relevant for successful performance and what aspects

of the environment can and should be ignored. He must learn to predict what will occur as a result of his movement patterns and, according to Bruner, "to check what goes with what."^2  

Successful performance is determined by the participant's ability to consistently reduce error. A response is made and from that act comes information to be used in correcting the next response; the information regarding error correction builds until a scheme or plan of action is developed.

The effective stimuli present during a skilled act form feedback loops. According to Miller, Galanter, and Pribram, feedback loops form the elements of behavior they refer to as TOTE patterns.\(^3\) (TOTE is an acronym for Test-Operate-Test-Exit.) On the following page is a diagram of a TOTE unit in which the arrows represent information flow.\(^4\)

For example, the Test phase might be the question, "Is the putter behind the ball?" If the answer is yes, then the next TOTE unit is referred to, but if the answer


\(^4\)Ibid., p. 26.
is no, then the "Operate" phase would involve moving the putter behind the ball.

The TOTE represents a plan, that is, an organizing, coordinating unit. It becomes automatic through over-learning. Skill development is seen as a progression of plans that govern subplans forming a hierarchy of behavioral units.

Practice in making specific corrective responses to specific errors enhances the ability to perform error corrections. Relating this to the previous example of the
TOTE unit, the learner is required to design his own Test questions in order to bring about changes in skill performance.

The term "feedback" is frequently used in noun and verb forms. It can represent the stimulus or designate on-going activity. Confusion also occurs because all tasks are treated with the same feedback vocabulary, as though task demands were the same. It is possible that a continuous task will not have terminal feedback in the same sense as the term is used relative to discrete tasks.

When the flow or pattern of information is discussed, closed and/or open feedback loops are involved. The exact patterning can only be a rough design in human behavior in contrast to the precise diagram found in mechanical devices. Feedback loops are discussed in terms of the relationship between the output of a system and the input.

Feedback can be discussed on a time continuum basis. The same or different stimuli can be used during the execution of a movement and at the end of the act for subsequent performances. The former is referred to as concurrent (or action feedback) and the latter is referred to as terminal information feedback (or knowledge of results).

There are two main types of feedback signals or cues: intrinsic and extrinsic. Intrinsic feedback cues are inherent in the task whether they be proprioceptive, visual,
internal, or external. Reflexive movement patterns are sources of intrinsic feedback stimuli and so are visual-kinesthetic feedback loops such as those found in the skill of driving a car.

The second type, extrinsic, are also called augmented or artificial feedback stimuli which implies additional feedback information supplied by the experimenter or teacher either during the performance or at the completion of the act. In sport activities this may take the form of using a rope to designate the minimum height for the badminton long serve. Virginia Bell found that this did not result in better performance than that of a control group tested without augmented feedback.

Sensory feedback cues may also be delayed or immediate, depending on the task. By manipulating the timing of the feedback stimuli, it is possible to determine the relevance of that feedback information to making error corrections. Another variation is to supply delayed dynamic


information feedback, i.e., intrinsic feedback at the termination of a response.

Feedback, according to Fitts and Posner, also functions to provide knowledge, motivation, and reinforcement. However, there is some disagreement in viewing feedback as a source of motivation. Annett states:

The mere existence of a feedback loop does not guarantee goal-directed activity until some value for target output has been specified and an "error signal" can be generated which can then be fed back to control the power supply.®

Later he adds, "Since plans involve hierarchies of feedback loops, feedback is essential to motivation but motivation is not an additional energizing factor; it is simply descriptive of feedback in action." More recently, Adams has taken the position that the purpose of information feedback is error correction rather than motivation.10

Bilodeau reports the necessity for the frequency of IF. In relating the results of the study, she concludes:

This appears very clearly in the need for IF in improving and sustaining performance, or in three repeatedly demonstrated empirical effects: performance fails to improve unless IF is intro-

---


8 Annett, *Feedback and Human Behaviour*, p. 120.


duced; performance improves with IF; and performance either deteriorates if IF is withdrawn, or shows no further improvement.\textsuperscript{11}

There is considerable research from psychology and physical education to substantiate Bilodeau's position, some of which will be discussed in the next chapter.

One other point can be made regarding IF necessary for error reduction in performance. Adams postulates that there are multiple feedback loops such as visual, auditory, and kinesthetic serving to control different aspects of the task. He concludes that "our most promising approach at present for studying these loops is to enter the loops and decrease or delay the feedback to S and determine the effects on performance."\textsuperscript{12}

One way of determining what IF is relevant to the execution of a sport skill is to control the available information. The learner is then forced to attend to only specific aspects of the stimulus field during the execution of the skill. It is possible to restrict what has been thought to be essential information feedback to determine whether that information is indeed essential.


Statement of the Problem

In the learning of a sport skill such as putting in golf, to what stimulus information feedback should the beginner initially attend in order to be successful? Should the teacher emphasize "the feel" of the putting movement pattern or should he emphasize features related to task execution such as observing the follow-through?

One way in which the learner is forced to attend to only one aspect of the stimulus field is to restrict visual inputs. The beginning golfer is then required to attend to only stimuli arising from tactual, equilibrium, position, and auditory sources. If these modalities are vital to the skilled performance required in putting, his performance should be better for having had that experience.

The purpose of this study was to discover the amount of visual information feedback necessary for learning to occur. Sub-problems included: (1) gaining a better understanding of the motor learning theories as applied to physical education activities, and (2) developing a technique to study IF sources during the execution of a skilled act.

Hypotheses

1. There were no real differences among the directional (and distance) error means due to the main effects
of treatment conditions during the experimental sessions (and test session).

2. There were no real differences among the directional (and distance) error means due to the main effects of two separate experimental sessions nor due to three targets used in the testing sessions.

3. There were no real differences among the directional (and distance) error means due to the main effects of practice during the experimental (and test) sessions.

4. There were no real differences among the directional (and distance) error means due to the interactions among the factors.

5. There were no significant relationships between the initial errors and the subsequent corrections.

**Basic Assumptions**

The basic assumptions of the study were:

1. That a distortion effect does not result from having the lights go out as one is stroking.

2. That the subjects' only commonality was limited golf experience and that all other abilities were randomly assigned.

3. That the subjects were sufficiently motivated so that their performance was not reflective of their motivational state but, instead, reflected their attention state and feedback sources.
Limitations

1. This study was limited to beginning golfers who were enrolled in physical education classes (not necessarily golf classes) at The Ohio State University during the Spring Quarter, 1971.

2. Putting was done indoors.

3. The subjects were all right-handed.

Definitions

Attention.--Adams defines attention in that it "is best used as a descriptive term for directive, discriminative response to a stimulus subset of a general stimulus field."¹³ Instead of implying a necessary pre-condition of arousal of the organism, this definition implies that attention is a definite response that has been brought about through discrimination among the environmental stimuli.

Or, in Hebbian phraseology, "Attention is selectivity in what is responded to, or sensory selectivity; set is a selectivity of response, motor rather than sensory."¹⁴ Hilgard and Bower also suggest the same meaning in their definition of attention: "the control of behavior by only


selected aspects of a complex stimulus." Attention then involves discrimination, i.e., the organism must learn to isolate what is relevant for him in order to learn an appropriate response. In other words, what he is attending to will determine, in part, what his response will be.

**Information.**—The characteristics of a stimulus—what its invariant properties consist of, or in what category the stimulus could be coded.\(^{16}\)

**Feedback.**—Information resulting from a response.\(^{17}\)

**Feedback loop.**—Closed feedback loops suggest circularity in which the response influences the outcome of subsequent responses. An example may be as innate as the feedback loop connecting the motor cortex to the cerebellum.

**Information feedback.**—Bilodeau defines IF "as an independent variable and as any function of the discrepancy between the R made and the R required."\(^{18}\)

**Knowledge of result.**—(KR) This form of psychological feedback takes two forms: (1) intrinsic KR which


\(^{17}\)Fitts and Posner, *Human Performance*, p. 27.

is the external and internal feedback normally present in a task and is not commonly manipulated by the experimenter, and (2) extrinsic KR or augmented feedback which is under the experimenter's control.\textsuperscript{19}

\textbf{Learning}.—A relatively permanent change in behavior brought about as a result of practice and inferred from changes in performance.\textsuperscript{20}

\footnotesize{\begin{itemize}
\item \textsuperscript{19}Annett, \textit{Feedback and Human Behaviour}, p. 26.
\item \textsuperscript{20}Hilgard and Bower, \textit{Theories of Learning}, pp. 2-6.
\end{itemize}}
CHAPTER II

REVIEW OF THE LITERATURE

Information Feedback

Feedback and learning theories

Learning theories applicable to physical education are a recent addition to the literature. For the most part, learning theorists have studied verbal learning, and references of the writer to the sports situation are used only for illustrative purposes.

Learning theorists have yet to contend with information feedback's dualistic role of providing both an energizing force and a set of signals. The research only confounds the issue since removal of information feedback (IF) results in poor performance because: (1) the stimuli were not present for learning to occur, (2) the motivating force is not there, or (3) reinforcement is absent.¹

Skinner states that feedback is "a term widely misused as

a synonym for operant reinforcement."^2 He recognizes two independent functions of feedback—guidance and reinforcement.

Reinforcement and motivation feedback.—Learning theorists are oriented toward reinforcement in that they believe a given response becomes associated with a stimulus through reinforcement. Learning theory is not based on error correction mechanisms but, rather, on the reinforced sequencing of stimulus-response patterns.

The use of information feedback in motivation theory is dependent on the goal the subject establishes for himself. It can represent a standard that the participant uses to judge his performance relative to that of his peers or in previous experiences with the task.^3 The golf score can be used as motivational IF in comparing past and present performances on the same course. If the golfer were to establish higher goals, IF in the form of scores will have a greater motivational effect than if no goals were established.

Another aspect of the motivational function of IF is discussed by Anokhin in which the outcome of a response


has an emotional quality of satisfaction or dissatisfaction.\textsuperscript{4} Performance is energized to obtain the satisfying stimulus resulting from feedback.\textsuperscript{5}

Bilodeau reviewed the studies on motivational IF and concluded that experimental designs have not as yet been able to separate the effects of learning and motivation.\textsuperscript{6} It could be that the difficulty arises because learning can only be inferred from performance and the latter is greatly influenced by such things as fatigue, drugs, interest, and time of day. Wickens stated that "neither magnitude of drive nor magnitude of incentive influences the amount you learn in a single trial."\textsuperscript{7} Performance is a reflection of incentive and not learning when incentives are manipulated and practice is constant. Learning is a function of practice.

\textbf{Directive feedback.}--IF functioning as knowledge or directive information falls into the closed loop and ideomotor learning theories. Learning, in these systems,


\textsuperscript{5}Fitts and Posner, \textit{Human Performance}, p. 28.

\textsuperscript{6}Bilodeau, "Supplementary Feedback and Instructions," p. 250.

\textsuperscript{7}Delos D. Wickens, Psychology 600, Psychology of Learning, The Ohio State University, October 27, 1969.
involves correcting errors, i.e., developing discriminative capabilities for error detection as well as selecting appropriate responses. 8

Feedback represents information regarding the outcome of an action against which a comparison is made. Any discrepancy between the desired output and actual output results in error information that can be used to reduce the discrepancy. The closed-loop or servomechanism is referred to by biologists in their discussion of homeostatic reflexes. 9

One such reflex basic to human movement is the myotatic reflex in which changes in tension in the neuromuscular spindle are fed back to the central nervous system, resulting in a muscular contraction that reduces the stretch in the spindle. 10 The gamma loop affords appropriate, coordinated responses by regulating the output of the system, through the process of matching the output


(muscular response) with the intended contraction or "the desired pattern which conditioning has prescribed and established, and if the signal indicates any divergence from this pattern, the activity of the proper muscles is appropriately increased or decreased to correct the difference." It is interesting to notice that Gardner indicates a previously learned pattern of movement that serves as reference to which the output can be compared and the resulting difference used to modify the output. Adams uses the term "Perceptual Trace" instead of "Reference" to indicate the memory of past movement experiences and also stresses that it is learned through stimulus contiguity.

Closed-loop motor theory.—The initiation of a response brings about an anticipatory arousal of the reference or perceptual trace and the forthcoming response-produced stimuli are compared with the memorized trace. Just as in Thorndike's "connectionism," greater experience with the feedback stimuli strengthens the perceptual trace. The reference is developed through experience with a number of different situations so that the error-correction ability is learned. In relating this to the sports


situation, one should practice under all the conditions that occur in the game: basketball lay-ups should be executed from any position on the court and with any conceivable type of shot; or tennis drives should be practiced when the beginner is forced to return shots from any given angle or speed.

William James, in 1890, more eloquently phrased the concept of the reference development in the following passage:

Well, we are no more endowed with prophetic vision of what movements lie in our power, than we are endowed with prophetic vision of what sensations we are capable of receiving. As we must wait for the sensations to be given us, so we must wait for the movements to be performed involuntarily, before we can frame ideas of what either of these things are. We learn all our possibilities by the way of experience. When a particular movement, having once occurred in a random, reflex, or involuntary way, has left an image of itself in the memory, then the movement can be desired again, proposed as an end, and deliberately willed. But it is impossible to see how it could be willed before.\textsuperscript{13}

The "Memory Trace" as explained by Adams, functions "to select and initiate the response, preceding the use of the perceptual trace."\textsuperscript{14} From the command to respond in a given way comes the feedback from the response which is


compared with the perceptual trace, the latter indicating the need for error correction.

The difference between memory and perceptual traces is that of recognition and recall: to recall a motor act is memory trace and it functions independently of response recognition. It is one thing to start an appropriate response and another process to discriminate a correct from an incorrect movement pattern. The memory trace is not dependent on feedback but develops as a function of practice.

The early stage in motor learning Adams calls the "verbal-motor stage" in which external stimuli are of paramount importance. As the subjects perform a task, they verbally correct their errors by suggesting what they must do on the next trial. In learning sport skills, the coach or teacher facilitates this verbal feedback, drawing from prior experience with error correction. In fact, the better coach is able to discern the error being made and to apply the appropriate verbal command to remove the error.

The "motor stage" represents the second stage in Adams' design. At this point the conscious verbal correction behavior is withdrawn and the task can be performed automatically without the presence of external information feedback.

An example of this differentiation can be seen in Basmajian's work on controlling the rate of a single motor neuron's firing. The task is made possible by displaying the rate on an oscilloscope and also supplying auditory feedback. After these were removed, the patient was still able to control the desired rate of firing. 16

When the function of IF is reinforcement, i.e., motivation, withdrawal results in extinction or poor performance. However, when IF functions as knowledge or a directive, and performance is at the automatic state, performance does not deteriorate. 17 The explanation for this is that during early learning, external cues are used and become conditioned to the "movement-produced" stimuli which formulate the trace. After conditioning has occurred,

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the movement-produced stimuli are still present and can serve as references (the perceptual trace).

It is not necessary that the internal reference be produced by proprioceptor loops exclusively, since visual, auditory, tactual, vestibular, etc., receptors could serve in conjunction with one another. In fact, the more feedback loops involved in a learning situation, the greater the probability of correct recall.  

One problem to be dealt with in the closed-loop theory is the amount of time needed in order to make corrections once the movement pattern is under way. If stimuli from one response are to be effective in controlling the next response, then the feedback must occur rapidly enough for it to be effective. Chernikoff and Taylor concluded in their study involving reaction time to limb displacement, "that kinesthetic reaction time is too long to permit continuous voluntary control of short-duration hand and arm

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movements by information furnished through feedback."\(^{19}\)

Their alternative hypothesis suggests a previously organized movement response such as the golf swing that is voluntarily triggered but which, once under way, cannot be altered voluntarily.\(^{20}\)

Gibbs adds to this by stating that the feedback from the proprioceptors is in terms of rate of movement over time and from this the extent of movement may be estimated and anticipation of final limb position determined.\(^{21}\)

In this way, response changes in direction and force can be predicted from incoming sensory feedback.

Kimble and Perlmutter state that the second stage of automatized behavior involves two major mechanisms: attentional and motivational. In the attentional mechanism, behavior will proceed in a highly stereotyped manner and will not come under attention unless blocked, at which point the individual is alerted and must make alternative plans. Another mechanism is motivational, in which a response is

\(^{19}\)Chernikoff and Taylor, "Reaction Time to Kinaesthetic Stimulation Resulting from Sudden Arm Displacement," p. 8.

\(^{20}\)Ibid., p. 7.

automatically made in a dangerous situation before the emotional after-effect occurs.\textsuperscript{22}

\textbf{Ideo-motor mechanisms.--} The ideo-motor theory assumes that the function of IF is to contribute to the formation of the image of the correct response. "Wherever movement follows unhesitatingly and immediately the notion of it in the mind, we have ideo-motor action. We are then aware of nothing between the conception and the execution."\textsuperscript{23}

Comparing the closed-loop feedback hypothesis and the ideo-motor mechanism, Greenwald wrote the following:

In the closed-loop formulation, the image may serve as a template for comparison with correct feedback and need not be activated prior to performance, while the ideo-motor formulation requires the image to be active prior to performance for the purpose of initiating movement.\textsuperscript{24}

A keyword in ideo-motor mechanism theory is anticipation. The response to be selected is dependent on the anticipation of sensory feedback to be obtained from that response.\textsuperscript{25} For example, in typing the letter "f" in

\begin{itemize}
\item \textsuperscript{22}Kimble and Perlmutter, "The Problem of Volition," pp. 376-377.
\item \textsuperscript{23}James, \textit{The Principles of Psychology}, p. 522.
\item \textsuperscript{24}Greenwald, "Sensory Feedback Mechanisms in Performance Control: With Special Reference to the Ideo-Motor Mechanism," p. 89.
\item \textsuperscript{25}Ibid., p. 91.
\end{itemize}
contrast to other letters, the correct response is selected on the basis of anticipated tactile, proprioceptive and kinesthetic sensory feedback from the index finger of the left hand. The anticipated sensory feedback forms an image that is used to initiate the chain of responses. In this way it also differs from the closed-loop hypothesis in that the latter does not require sensory feedback from a response until the response is being executed, while the ideo-motor mechanism demands anticipation of the sensory feedback prior to the response in order to activate the movement. \(^{26}\)

Bartlett also postulated the importance of anticipation for controlled serial movements. The relation of stimulus events and patterns is used to "project action towards a phase yet to come." \(^{27}\) The way in which movements are anticipated involves two processes: (1) a retention of the stimulus events that can be used to facilitate the direction of subsequent action; (2) the development of a principle that can be used to direct future action. The first process occurs during the execution of a skill, while the latter is developed as various strategies are explored.

The development of principles is the same concept as Miller, Galanter, and Pribram's development of strategies as Miller, Galanter, and Pribram's development of strategies

\(^{26}\) Ibid., p. 89.

to form a "Plan." It is the "Plan" or principle that permits the learner to anticipate feedback. He determines the future feedback and establishes movement patterns appropriate for producing such feedback.

**Information feedback variables**

In addition to the theoretical approach, a great deal of research has concerned manipulating IF when feedback is considered a stimulus or signal.

Miller, although not concerned with the closed-open feedback loops dichotomy, differentiated feedback into that used to make the next response and/or to know what to do when repeating the task. Action feedback provides "cues or signals which tell the operator or student what to do next in response to the changing demands of the task." They tell him what he is doing at the moment. Learning feedback involves those signals which tell him what he should have done in order to respond correctly. This is important information to be used when repeating the task.

Both learning and action feedback include "artificial" and "operational" feedback cues (Miller's terminology).

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30 Ibid., p. 111.
Artificial feedback cues are those not necessarily a part of the operating machinery but, instead, depict performance in a graphic form or in terms of scores. Holding implies a similar but more general explanation of artificial feedback cues in that these cues will not be available when the training period is completed. Holding's concept of artificial feedback cues could be termed "augmented" or "extrinsic" feedback. \(^{31}\) Miller's concept of artificial feedback cues are those cues present in the final task and which are specific to the task.

Operational feedback cues, according to Miller, provide information about the output of the system when the device is used in the operational setting. Holding refers to this as "intrinsic" feedback cues or signals. These cues are a natural part of the task and would include the speedometer in an automobile and the lines on a tennis court.

Both artificial and operational feedback cues may function in action and learning feedback situations. According to Miller, the difference in the function of the cue is in the attitude of the operator. \(^{32}\) He may use the feedback signal just to get through the task instead of applying it to his next response.


Feedback cues or signals, whether artificial or operational, are limited to the task and, in sport situations, it may not be possible to use artificial cues since graphic records are not presented to the player during the performance. However, it is realistic to consider that some feedback cues may serve to tell the performer what he is to do next as well as what he should have done. The difference is only a time factor—the image of the putter prior to striking the ball tells the golfer when he is going to make contact and how fast the blade is moving (action feedback), while the end result of that act tells him that the motion of the putter was too fast or too slow for the playing conditions (learning feedback).

Additional feedback variations

Information feedback has been studied under the following conditions: internal and external; concurrent and terminal; intrinsic and extrinsic; and delayed and immediate.

Concurrent and terminal feedback have been very popular research topics and the results have been fairly consistent: performance deteriorates when concurrent information is withdrawn;\(^\text{33}\) concurrent information alone is

\(^{33}\)Robert Lincoln, "Learning a Rate of Movement," Journal of Experimental Psychology, 47 (1954), p. 469; John Annett, "Learning a Pressure under Conditions of Immediate and Delayed Knowledge of Results," Quarterly Journal of
superior to terminal information alone;\textsuperscript{34} the more concurrent information available, the more accurate the performance;\textsuperscript{35} improvement occurs with terminal IF; however, removal of terminal IF after skill has been acquired results in deterioration in performance.\textsuperscript{36}

Bilodeau and Bilodeau studied the effects of practice with varied amounts of terminal IF as a function of the number of trials for a simple motor task. Groups received terminal IF under four different situations: (1) on all trials, (2) every third trial, (3) every fourth trial, and (4) every tenth trial for one hundred trials. The results of the TIF + 1 trials (trials preceded by TIF) for all groups failed to demonstrate any differences in

\textsuperscript{34}Alfred F. Smode, "Learning and Performance in a Tracking Task under Two Levels of Achievement Information Feedback," Journal of Experimental Psychology, 56 (October, 1958), p. 303.


\textsuperscript{36}Elwell and Grindley, "The Effect of Knowledge of Results on Learning and Performance," p. 53.
terms of magnitude of absolute error among the groups. In other words, error reduction can occur as efficiently immediately after TIF is given, regardless of the total amount of previous TIF experiences. However, performance deteriorates in those trials following no TIF.\textsuperscript{37}

In reviewing the research on extrinsic or augmented feedback, Annett concluded that augmented feedback does not facilitate learning, while Bilodeau stressed the fact that augmented feedback facilitates performance but not learning.\textsuperscript{38}

Internal (proprioceptive) and external feedback cues have been studied under different conditions. Fleishman and Rich concluded that subjects who are adept in using proprioceptive feedback cues will be able to reach higher levels of performance than those limited to spatial cues.\textsuperscript{39} Smith and Coleman also found internal cues to be more important to learning.\textsuperscript{40}


\textsuperscript{39}Fleishman and Rich, "Role of Kinesthetic and Spatial-Visual Abilities in Perceptual-Motor Learning," p. 11.

Research concerned with the delay of IF can be subdivided into the delay of concurrent and delay of terminal IF. Delay of concurrent IF produces drastic results in performance as a function of the amount of delay, with the longer time lag resulting in greater performance decrement. However, the effect of the delay of terminal IF is not as great, the important variable being the interpolated activity.

Summary

The discussion on information feedback reviewed in this paper suggests the following:

1. Information feedback may be categorized as follows:
   a) as a flow of information or a signal;
   b) a signal for the next response or to be considered in later performances;
   c) reinforcement, knowledge, or motivation.

2. Although performance scores reflect learning, they also reflect motivational and physiological states of the individual.

3. Studies of concurrent and terminal IF demonstrate the importance of feedback for error control.

4. Response accuracy is a function of available IF; removal of IF results in less efficiency.

5. Multiple loops suggest the learning of different stimulus-response relationships.

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41 Holding, Principles of Training, p. 27.
Golf

The review of the literature regarding golf is limited to what highly skilled players say is involved in successful performance and to the conclusions derived from research.

Empirical observations by professional golfers provide a source of putting hints which may give some insight into the nature of the task. The professional golfer has devoted considerable effort to perfecting his putting skill, and also has a vital interest in the outcome of his performance. The results of his observations can only be verified by his success. The difficulty with the empirical approach applied to golf is that the skilled performer may not know what he is doing, or he may think that he is doing one thing and in fact be performing quite another.

There are as many putting techniques as there are golfers. Certainly no other aspect of the game permits such individualistic approaches. The vast differences among putting styles used by successful players would cause one to conclude that the position of the body parts is irrelevant to successful performance. Runyan, 43 for example, advocates a split-hand grip whereby the right hand slides down the shaft and the left hand supports the butt of the

shaft against the waist. Another extreme position of the hands is the very common reverse over-lapping grip, first introduced in the 1910's by P. A. Vaile.\textsuperscript{44}

The position of the feet relative to the cup does not appear to be a major factor in successful putting because of the variations found among successful golfers. Vaile\textsuperscript{45} advocates a half-open stance with the feet well apart, while Stanley\textsuperscript{46} approves of the stance but would prefer the feet not to be far apart. Rehling\textsuperscript{47} and Palmer\textsuperscript{48} use a square stance, although Bobby Locke\textsuperscript{49} used a closed one.

The putting stroke has been differentiated into the arm (pendulum or stroke) and wrist methods (hinge) with advocates of each as well as some successful players using both, depending on the putting conditions. Smith and Taylor explain this as follows:

\textit{If my ball lies within the closest circle, I}

\begin{itemize}
  \item \textsuperscript{44}P. A. Vaile, \textit{The Short Game} (London: Duckworth, 1936), p. 40.
  \item \textsuperscript{45}Ibid., p. 56.
  \item \textsuperscript{47}Conrad H. Rehling, "Putting Made Easy," \textit{Athletic Journal}, 36 (April, 1956), pp. 25-27, 70-72.
  \item \textsuperscript{48}Gary Player, "How to Improve Your Putting this Winter," \textit{Golf Digest}, December, 1966, p. 54.
  \item \textsuperscript{49}Ibid.
\end{itemize}
will use a putting stroke that involves hand action alone; if it lies within the 30-foot circle, I will use a stroke involving hand and forearm action; if it lies within the 45-foot circle, I will use a stroke involving hand, arm and shoulder action.  

The pendulum method of putting stabilizes the hands and wrists, so that the action is that of the arms and shoulders. The only difference in the hinge technique is that the wrists bend or "break." One author distinguishes the two methods by result: "... arm putting usually gives better line, but wrist putting gives a better feel for distance due to the use of finer muscles." Apparently, success can be achieved with either method. The difficulty to be overcome is to get "the hand to do what the eye wishes," a function of practice according to Willie Park.

A persistent theme expounded by successful golfers is the importance of maintaining a stable body position. "Keeping the eye on the ball" serves to stabilize the

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The stability of posture has been shown to be very clearly a function of the focus of the eyes on a fixed point.  

A second theme is concerned with the concept of concentrating on the anticipated feedback as demonstrated by such statements as: "Decide in advance how hard you need to hit the putt, and stick to your decision"; or, "When I begin to feel tense on a putt, I concentrate solely on taking the clubhead back on a straight line and making solid contact between the face of the putter and the back of the ball"; and, "Try to get a mental picture of the ball following the correct line and traveling at the right speed to take it into the middle of the cup."

Professional golfers also have remedies for correcting direction and distance errors. Stanley states that directional errors can be controlled by a rhythmic putting action as well as a long follow-through. Distance errors, in contrast, are thought to be influenced by the

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56 Wininger, "Seek Solid Contact on Long Putts."


58 Player, "How to Improve Your Putting This Winter," p. 56.

59 Stanley, This Is Putting, p. 120.
length of the backswing. Wininger stresses the speed of the ball, rather than putter, as the anticipated external feedback needed for distance control.

In summary, empirical statements by successful golfers suggest that the position of the body is not as important a variable as remaining still during the act and concentrating on the anticipated feedback. Follow-through and rhythm are thought to be important for direction control, while the length of the backswing and desired speed of the ball supposedly relate to distance control.

Research on putting

Some of the comments previously discussed have been researched in order to verify and correct the players' statements. Numerous studies have been concerned with the putting technique to discover the factors that make one golfer better than another.

Neale and Anderson were concerned with aiming errors as a function of stroking differences with croquet and regular style putters rather than as a function of initial aiming differences. They found aiming errors when the

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61 Wininger, "Seek Solid Contact on Long Putts."

subjects did not stroke but manipulated a putter to the position they felt was most accurate. The errors were of a greater magnitude (2.82°) with the conventional putter than with the croquet style of putter (1.27°).  

Regarding the putting style (wrist or arm), Randleman found that inexperienced golfers improved in putting regardless of style used: wrist, arm, or their own modification. Hodge combined the factors of putting style with two different grips (Vardon or overlap and the reverse overlap). She concluded that the grip was not a factor in putting success but putting style was a factor. After the seventh day of practice, the differences in putting style became apparent in favor of the arm-shoulder stroke method.

Many golfers stress the need for looking at the back of the ball, but in a study by Bowen, it was found that performance (at least for beginners) was not dependent on

63Ibid., p. 93.
66Ibid., p. 56.
whether one looked at the ball or the cup for 15' and 35' distances.

By administering ten kinesthetic tests before and after training sessions involving putting and driving, Phillips found kinesthetic test scores to be related more to putting than to driving.68

There have been a number of studies concerned with feedback and its relationship to golf. The studies can be divided into those concerned with augmented versus reduced feedback and further categorized into concurrent and terminal information feedback.

Augmented feedback occurring during the performance of a skill has generally been found not to be any more conducive to learning than regular practice of a skill. Although Mathews and McDaniel found the "Golf-Lite" (a small light attached to the clubhead) improved beginners' ability to hit a target 150 yards away with a five iron, they did not control for the added effect of the weight of the Golf-Lite on the club.69 Six years later, when Gensemer controlled this effect, he did not find a significant


difference between the experimental and control groups. Also, the Golf-O-Tron has been found to be no more effective than practice on a driving range after a four-week exposure to both methods. (The Golf-O-Tron simulates the game of golf with the aid of a computer and color photography of a golf course.)

That performance scores are dependent on the amount of information available during performance has been previously discussed in the first section of the review of information feedback literature. In terms of sports, the results concur with the general premise that reduction in IF causes a deterioration in performance measures. Walker found a relationship between the amount of visual IF as controlled by a stroboscope light source and performance in catching a tennis ball: the more light available, the better the score.

In a golf study by Anderson, reduced concurrent IF resulted in a similar performance reduction as measured by


accuracy scores. Three groups practiced hitting a golf ball under the following conditions: minimum IF meant reduced proprioceptive feedback, and in this case the subjects did not hit the ball; high level proprioception meant that the subjects hit the golf ball and were given terminal, augmented feedback of the amount and direction of error. The group receiving maximum feedback contacted the ball and were also given corrective feedback by the instructor.

One major point of contention with this type of study is that subjects who do not get to hit the golf ball also do not get to see the ball or hear the contact. It is, therefore, not just proprioceptive feedback that is involved but also visual and auditory feedback. The investigator did find, however, that "practice which includes a high level of proprioceptive feedback and knowledge of results regarding error appears to be better than practice without such feedback."

Another method of reducing visual IF is blindfolding the subjects. Griffith gave initial instructions, including practice sessions and demonstrations, before the

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74 Ibid., p. 6.

75 Ibid., p. 73.
experimental group was blindfolded.\textsuperscript{76} During the four weeks of practice under the experimental conditions, the control group missed the ball 105 times, in contrast to 264 misses by the blindfolded group. However, in terms of clean and direct shots, the blindfolded group steadily improved so that by the fourth week they surpassed the control group. Griffith concludes as follows:

The results described above seem to say that, if one keeps his head immovable, and if he learns to pay attention to the feel of the thing, he may increase his rate of learning in driving a golf ball.\textsuperscript{77}

He does not stress the fact that the subjects had a visual representation of the act prior to treatment and it might have been this combination of events that led to success, rather than treatment alone.

A study preventing a portion of concurrent visual IF in a golf driving skill was concerned with the prediction of the direction of golf shots by proficient and beginning golfers as a function of practice. Practice and test sessions consisted of hitting 20 golf balls to a target and predicting the results. Terminal IF reduction was achieved by placing paper bags over the subjects' heads. "This enabled them to see the ball at address and during

\textsuperscript{76}Coleman R. Griffith, "An Experiment on Learning to Drive a Golf Ball," \textit{The Athletic Journal}, 11 (June, 1931), pp. 11-12.

\textsuperscript{77}\textit{Ibid.}, p. 13.
the swing, but once the ball was struck, the bag prevented any sight of the ball in flight."  

The performance results would indicate that seeing the ball in flight provided relevant information for the next performance. When this was prevented, subjects were unable to "learn" how to alter subsequent golf drives. The experimental-proficient group correctly predicted, on the average, 13.0 out of a possible 20 shots on the pre-test and 13.6 shots on the post-test, while the control-proficient group improved from 12.2 to 12.4. The beginners showed a similar pattern: the experimental group went from 7.0 to 9.4, while the control group went from 8.6 to 6.6.  

None of the results were statistically significant.

The ability to predict the result of each drive improved slightly for all groups except the beginning control group, which decreased in prediction accuracy. Although the differences were not large, the point to be made is that the proficient golfers more accurately predicted the results of their acts than did the beginners. Pash explained that this was partly due to the fact that the experimental group hit the target with greater frequency. It could also be that the proficient group had a

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79 Ibid., p. 25.  
80 Ibid., p. 34.
more accurate representation of the correct act from which
discriminations could be made.

One study concerned with terminal IF involved
augmented (external) feedback in the form of a graph-check-
sequence camera (delayed dynamic feedback). The experi­
mental group reviewed the photos of their performance and,
following those sessions, took a battery of three golf
skills tests. The results of the study were that the use
of the graph-check-sequence camera facilitates the learning
of the golf drive. 81

There have been very few putting tests devised; the
one usually used was designed in 1931 by Clevett. 82 It
involves a 27" x 20' carpet marked off into 48 areas (each
area is a 9" square). The target, painted on the carpet,
was 15 feet away. Scoring values were pre-assigned to the
target areas with higher values near the target. Areas
beyond the target had a higher point value than those in
front of the target. "The reason for this was that on a
regular green a ball that seems to be rolling too far fre-

81Donnis Hazel Thompson, "Immediate External Feed­
back in the Learning of Golf Skills," Research Quarterly, 40

82Melvin A. Clevett, "An Experiment in Teaching
Methods of Golf," Research Quarterly, 2 (December, 1931),
p. 107.
quently rolls into the hole, whereas a ball that is too short never goes into the hole."

A similar but more precise means for determining putting accuracy was devised by Hodge, in which she measured distance and direction deviations for each putt. Another type of putting test reviewed by Hodge involved counting the number of putts to complete each hole when 16 balls were putted for cups 5, 10, 20, and 30 feet away.

Summary

The following conclusions are drawn from the discussed golf literature:

1. Successful putting performance is not dependent on a particular stance or grip.

2. Remaining still and concentrating on the intended path of the ball are primary considerations for successful performance, rather than where one looks or the style one uses.

3. The croquet-style putter permits greater accuracy in aiming than the regular putter.

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83 Ibid., p. 107.

84 Hodge, "A Comparison of Golf Putting Techniques for Beginning Women Golfers," p. 34.

85 Ibid., p. 11.
CHAPTER III

METHOD

The question asked in this study involved determining the information feedback (IF) essential to the initial learning of a motor skill for success in the performance of that skill. It is assumed that information feedback is necessary if learning is to occur and, therefore, any IF that is removed will be reflected in performance. In this study, performance was measured during the experimental and criterion test sessions in which errors in direction and distance were recorded for each trial.

The subjects were seventy-five men and women undergraduate students at The Ohio State University, seventy-four of whom ranged in age from 18 to 22 years; one subject was 30. Nineteen of the subjects had never played miniature golf prior to the study, and none of the subjects had played on a regulation or par 3 golf course. One-third of the subjects had played sports at the varsity level, and almost half the subjects had played on intramural teams both in college and high school.

During the experimental sessions, the task involved putting for a target seven and a half feet away with an arc
of $84^\circ$ and attempting to make the ball stop on the target circle. For the test, three targets were used: the same seven and a half foot target, a second target ten and a half feet away with an arc of $93^\circ$, and a third target thirteen and a sixth feet away with an arc of $80^\circ$. Three targets were used instead of one in order to simulate the game situation.

Two sessions consisting of 30 trials were given under the experimental conditions, and the third and last session involved putting 62 times under the test conditions. The control group took only the test.

**Design of the Study**

The experimental-condition sessions constituted one part of the study, while the test session was another aspect—although sixty subjects were involved in both sessions. One other factor to be taken into consideration was that each trial yielded two independent scores: a direction error score and a distance error score.

The experimental session incorporated two factors with repeated measures: the repeated measure on each subject was the two separate sessions of thirty trials each. (See example of design construction on the following page.) "A" is the experimental condition involving four levels, "B" is the practice sessions on different days, and "G" represents groups of fifteen subjects each. This design
was used for both the direction and distance error scores.

\[
\begin{array}{ccc}
 & b_1 & b_2 \\
a_1 & G_1 & G_1 \\
a_2 & G_2 & G_2 \\
a_3 & G_3 & G_3 \\
a_4 & G_4 & G_4 \\
\end{array}
\]

The experimental design for the test is of similar construction with the three repeated measures being the targets (b). The first four levels represent the experimental conditions, the fifth level represents a control group—they merely took the test without prior practice. Subjects were randomly assigned to groups and the ordering of targets (b₁, b₂, and b₃) was randomly arranged to reduce the effect of one target distance on another. The design of the criterion test sessions is diagrammed below:

\[
\begin{array}{ccc}
 & b_1 & b_2 & b_3 \\
a_1 & G_1 & G_1 & G_1 \\
a_2 & G_2 & G_2 & G_2 \\
a_3 & G_3 & G_3 & G_3 \\
a_4 & G_4 & G_4 & G_4 \\
a_5 & G_5 & G_5 & G_5 \\
\end{array}
\]
Selection of Subjects

Subjects were obtained by asking for volunteers in forty-three physical education classes and the Varsity Soccer team, the only prerequisite being limited golf experience. A student volunteer form was used, describing what was expected, how to get to the testing area, and when sessions would start. Prospective subjects completed the lower portion of the form, giving name, address, phone number, and hours that they would be free to serve, and these were collected from each class.

Because the subjects had to come on three different occasions, it was necessary to schedule half-hour sessions within the time periods they had designated. Subjects were phoned regarding the scheduled times and were assigned an experimental session. Notices were sent to each prospective subject, indicating the appropriate date and hour.

Of the ninety-four subjects who agreed to participate in the study, eighty-two completed the three sessions and seventy-five subjects were randomly selected in order to have fifteen subjects in each group.

No effort was made to place subjects in groups by sex, age, or previous sport experience. Table 1 summarizes the composition of the sample with regard to subjects' age, sex, and prior experience in sports.
### TABLE 1
COMPOSITION OF THE SAMPLE

<table>
<thead>
<tr>
<th>Group</th>
<th>Avg. Age</th>
<th>Male</th>
<th>Female</th>
<th>Miniature Golf Experience</th>
<th>Varsity Team</th>
<th>Intramural Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18.93</td>
<td>3</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>19.50</td>
<td>3</td>
<td>12</td>
<td>9</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>19.53</td>
<td>3</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>18.73</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>19.17</td>
<td>4</td>
<td>11</td>
<td>9</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

The Equipment

A grid, with 4-inch squares, painted on a 9.5' x 25.5' carpet, extended 18 2/3' to within three feet of the subject. Targets, consisting of red cloth circles 4" in diameter were placed in the appropriate position for the test conditions; however, a 6" diameter circle target was used during the experimental condition sessions.

The electrical equipment included two overhead light bulbs, electrical timer and photo electric cell apparatus. The equipment was assembled in such a way that interruption of the light beam caused the lights to go out for a predetermined time period (established by setting the electrical timer) when the experimenter turned the single hand switch to the "on" position. When the single hand switch was in the "off" position, the lights would remain
on regardless of the interruption of the photo electric cell's light beam.

The golf equipment involved a putter long enough to be used by both men and women and two dozen Mac-Col golf balls.

The Experimental Sessions

The two experimental sessions involved a total of 70 trials and were conducted on different days so that performance scores would not reflect boredom or fatigue. Although the experimental groups differed according to the amount of time the lights remained on during the execution of the putting stroke, the procedure was not very different from one subject to the next.

To begin with, each subject was asked to complete a form indicating his sex, age, and previous sporting experience. He (or she) then listened to taped instructions identical for all subjects in the group that explained where he (or she) was to stand, and how each trial was to be performed.

To summarize, the equipment and the purpose of the apparatus were described; the subject then stood, gripped the putter and practiced moving the club. Subjects then were instructed to stand so that their feet were on either side of the box and to place the putter about four inches behind the ball and then, when ready, closer to the ball in
the "address" position. Because subjects in group one turned the lights out as soon as they placed the putter close to the ball, all subjects had to follow the same procedure so that direction errors would be a function of the experimental condition and not initial aiming differences. All of the subjects had five practice putts before the experimental sessions began. Success in the task demanded that the ball stop on the red circle located seven and a half feet away.

The subject began each trial by getting a ball from a box that was positioned far enough away for him to move from the putting stance. Each trial, therefore, was like the preceding one in that the subject had to move out of position, get a ball, and then re-establish himself.

During the five practice putts, it was possible for the experimenter to correct any misunderstandings regarding the appropriate procedure. A common error, for example, was that of putting directly from the point four inches behind the ball without a preliminary backswing.

After the subjects had putted five times, the experimental session began. All of the subjects received terminal information feedback during the experimental session in that they got to see where the ball had stopped rolling. Instead of augmenting the IF, action IF was reduced visually by having the lights go out at predetermined periods. This was controlled by placing the photo
electric cell in varying positions and arranging it so that
the subjects turned the lights out when the club or, in one
case, the ball interrupted the light beam. The following
diagram illustrates the experimental conditions.

<table>
<thead>
<tr>
<th>Group</th>
<th>Contact</th>
<th>Follow-</th>
<th>Ball</th>
<th>Ball</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Address</td>
<td>Backswing</td>
<td>Ball</td>
<td>Through</td>
</tr>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td>(dark 7 seconds)</td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
<td>(dark 4 seconds)</td>
<td></td>
</tr>
<tr>
<td>Group 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1.—Period of time during which the lights are out during the execution of the stroke.

Subjects in group one turned the lights out for seven seconds as soon as they placed the putter close to the ball; the lights came on again after the ball had stopped rolling. Group one subjects were prevented from seeing any aspect of their stroke as well as the visual IF provided by the rolling ball. The following discussion explains the placement of the photo electric cell equipment as a function of the experimental group. (See Figure 2.) In situation one the photo electric cell receiver remained in place but the light source was moved so that the ball was to the left of the light beam.
Subjects in group two followed the same procedure as those in group one regarding placing the club on the marker and then behind the ball. However, in this experimental condition the subject turned the lights out when he contacted the ball and the lights remained out until the ball had stopped rolling. The interval timer was set for 4 seconds. The subject was prevented from seeing his follow-through as well as IF regarding the roll of the ball.

![Diagram of apparatus for group two]
In situation two the receiver remained in place but the light source was moved to the left so that the ball was then to the right of the light beam.

Subjects in group three also placed the sole of the putter on the scotch-tape marker prior to addressing the ball. They turned the lights out as soon as they stroked the ball through the beam of light located about 1 1/2' in front of them. They were prevented from seeing the ball roll after they had completed the follow-through.

Fig. 4.--Position of the apparatus for group three.

In situation three the photo electric cell unit was moved 1 1/2' in front of the golf ball.

Subjects in group four were not deprived of light at any time during the experimental conditions. The control group (group five) did not undergo any of the experimental conditions but merely took the criterion test.
Function of the Experimental Condition

The experimental conditions were designed to remove visual IF during different parts of the putting stroke which were as follows: (1) from the address until the ball had stopped rolling; (2) from the follow-through until the ball had stopped rolling; (3) only the visual IF of the ball rolling was removed; and (4) no visual IF was removed.

Subjects in group one were prevented from making corrections in direction and distance errors through visual IF. To improve, i.e., to make corrections and reduce the resulting errors, they were forced to rely on other sense modalities. The researcher believed that their ability to formulate an appropriate reference would be inadequate and that this would be reflected in performance scores.

Group two subjects were permitted to see their address and backswing but not their follow-through nor the ball rolling. If the latter is necessary information for error correction ability, the results would be a reflection of the incomplete visual IF. The investigator thought that they should do better than group one subjects because they had more complete information with which to build discriminative capabilities.

Group three subjects were permitted to see their follow-through but not to see the ball roll. The writer thought it possible that being able to see the ball roll
supplied information regarding velocity and, therefore, constituted distance error correction information.

Group four subjects served as a control in that they performed under lighted conditions throughout the experimental sessions.

The Criterion Test Session

All subjects took the criterion test requiring them to putt for three different targets that were placed 7 1/2', 10 1/2', and 13 1/6' away. The middle target lay to the left of the first target and had an arc of 84°, while the third target lay slightly to the right of the first, with an arc of 80°.

The following instructions were given to all subjects (via a tape recorder), including the control group:

This session is determined to see how well you can putt for three different targets. You are to putt for each of the three red circles in a varying order. The circle closest to you is number one, the one further away is number three. I will call out each circle that you are to be putting to before each trial.

The session will consist of 60 trials. You are to get the ball to stop in the red circle. In other words, try to get the ball to come as close to the circle as you can.

You may begin by getting a ball from the chair and putting it in between the two dots on the carpet. You may begin when you are ready.

In order to counter the effect of putting for one target on another, it was necessary to develop a balanced sequencing of trials. There were six possible effects
(e.g., putting from 3 to 2; 1 to 2; 2 to 3; 1 to 3; 3 to 1; and 2 to 1) and these were randomly arranged in such a way that no two numbers directly followed each other. Four different arrangements were used and these were randomly assigned to the five groups.

**Scoring Direction and Distance Errors**

The score sheet was basically the same for all subjects, the difference being in the four different orderings of target numbers for the test session. The grid was arranged with letters representing the units on the abscissa and numbers representing units on the ordinate. The "score" for each subject was the coordinate of x and y. (See Appendix G for a resume of the scoring procedure used.)

The raw scores were converted into direction and distance error scores, i.e., horizontal and vertical deviations from the target. (See Appendix I for a more complete explanation.)

**Summary**

The seventy-five volunteer subjects were randomly assigned to one of five experimental conditions: group one executed the putting stroke totally in the dark by interrupting the beam of light as soon as they addressed the ball; group two was prevented from seeing their follow-through and the ball roll since they interrupted the light
beam when they contacted the ball; group three failed to see the ball roll since the photo electric cell equipment was positioned so that the ball turned the lights out; group four practiced with the lights on during the experimental sessions, while group five only participated in the test session.

All subjects in the experimental conditions received the same initial instructions and the same amount of treatment trials. They all putted a distance of 7 1/2 feet to a target that was 6 inches in diameter, with the intent of coming as close to the target as possible. The sessions were divided among three days:

First day: initial instructions + treatment trials
5 trials with lights on
30 trials--treatment
putting distance is 7 1/2 feet
total time is 20 minutes.

Second day: treatment
40 trials--treatment conditions
putting distance is 7 1/2 feet
total time is 15 to 20 minutes.

Third day: Criterion test
60 trials, 20 trials at each of 3 distances
putting distances were 7 1/2 feet,
10 1/2 feet, and 13 1/6 feet
total time is 20 to 30 minutes.

In order to measure the effects of treatment and not the effects of putting for one distance on another, the subjects within each group were randomly assigned to different sequences of the putting distances.
CHAPTER IV

ANALYSIS AND DISCUSSION OF THE DATA

The data were subjected to two different analyses in order to study different questions asked of the experiment. The questions were: (1) Do the groups differ in direction and distance accuracy scores (a) during the experimental sessions and (b) during the test period? (2) What are the subjects correcting after each trial during the experimental sessions, direction or distance errors or both? Is this a function of experimental conditions?

**Direction and Distance Accuracy**

In order to answer the first question, the experimental sessions were studied first. The direction and distance error scores were treated separately and the raw data were converted into absolute error scores. Although the sixty subjects involved in the experimental sessions experienced a total of 70 trials, only the 30 trials from the first session and the first 30 of 40 trials from the second session were used for analysis.

By using a factorial design with repeated measures, it was possible to study three aspects of the experimental
conditions: (1) the effect of treatment on direction (also distance) error scores; (2) the effect of two separate sessions on direction (also distance) error scores; and (3) the effect of practice on direction (also distance) error scores. An F ratio was obtained for the main effects of each of the three factors as well as for the interactions. The null hypothesis was tested for each factor through the analysis of variance and was stated as follows:

1. There were no real differences among the directional error means due to the main effects of treatment conditions during the experimental sessions. (A)

2. There were no real differences among the directional error means due to the main effects of two separate experimental sessions of thirty trials each. (B)

3. There were no real differences among the directional error means due to the main effects of practice. (C)

4. There were no real differences among the directional error means due to the interactions among the factors. (AxB, BxC, AxC, and AxBxC)

The five per cent level of significance was selected for the F ratio, as well as any additional tests of significance that were done. Because of the arrangement of the

factorial design, any difference among the group means was due to the experimental conditions or the variability of the group members (the first hypothesis). The second and third hypotheses were within group arrangements so that the differences, should they be significant, reflect the main effects of separate sessions and practice rather than the experimental effects.

The results of the mean direction errors by experimental group and as a function of the sessions are listed in Table 2.

### TABLE 2

DIRECTION ERROR MEANS DURING THE EXPERIMENTAL SESSIONS

<table>
<thead>
<tr>
<th>Experimental Group (A)</th>
<th>Experimental Session (b₁)</th>
<th>Experimental Session (b₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group One</td>
<td>2.240</td>
<td>2.067</td>
</tr>
<tr>
<td>Group Two</td>
<td>1.689</td>
<td>1.633</td>
</tr>
<tr>
<td>Group Three</td>
<td>1.531</td>
<td>1.596</td>
</tr>
<tr>
<td>Group Four</td>
<td>1.820</td>
<td>1.496</td>
</tr>
</tbody>
</table>

By observation alone it is apparent that there is not a great deal of difference among the means of session one (b₁) and session two (b₂). The group means reflect the amount of light available, although the differences among the means are not very great.
Table 3 summarizes the analysis of variance for directional errors during the experimental sessions.

**TABLE 3**

**ANALYSIS OF VARIANCE FOR THE DIRECTION ERROR DURING THE EXPERIMENTAL SESSIONS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>192.251</td>
<td>3</td>
<td>64.0837</td>
<td>3.5962^a</td>
</tr>
<tr>
<td>error</td>
<td>1005.449</td>
<td>56</td>
<td>17.9544</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>13.444</td>
<td>1</td>
<td>13.4444</td>
<td>3.8123</td>
</tr>
<tr>
<td>AxB</td>
<td>18.629</td>
<td>3</td>
<td>6.2096</td>
<td>1.5396</td>
</tr>
<tr>
<td>error</td>
<td>225.861</td>
<td>56</td>
<td>4.0332</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>125.098</td>
<td>29</td>
<td>4.3137</td>
<td>1.5361^b</td>
</tr>
<tr>
<td>AxC</td>
<td>243.959</td>
<td>87</td>
<td>2.8041</td>
<td>.9985</td>
</tr>
<tr>
<td>error</td>
<td>4560.504</td>
<td>1624</td>
<td>2.8082</td>
<td></td>
</tr>
<tr>
<td>BxC</td>
<td>102.271</td>
<td>29</td>
<td>3.5266</td>
<td>1.0949</td>
</tr>
<tr>
<td>AxBxC</td>
<td>226.234</td>
<td>87</td>
<td>2.6004</td>
<td>.8074</td>
</tr>
<tr>
<td>error</td>
<td>5230.738</td>
<td>1624</td>
<td>3.2209</td>
<td></td>
</tr>
</tbody>
</table>

^aAt the 5 per cent level, F > 2.78 is required for significance.

^bAt the 5 per cent level, F > 1.47 is required for significance.

The value of F required for significance at the 5 per cent level for between subjects effects was 2.78. The computed F ratio was 3.5962, slightly exceeding the required value for significance and, therefore, the first null hypothesis was rejected. The within subject "B"
factor required an F value of 4.18 for significance; the obtained F ratio was 3.8123, indicating that the direction error scores made during the first thirty trials were not significantly different from those made during the last thirty trials. This could indicate that the task was not very different from one day to the next.

The interaction of "A" and "B" was also found to be non-significant; i.e., groups performed the same way on one day as they did on the second day. The obtained F ratio was 1.5396, while the value of F required for significance is 1.98.

The main effect of practice was found to be significant at the 5 per cent level with a calculated F of 1.5361; the F value required for significance was 1.47. Because of the slight difference between the values, it is not practical to interpret the influence of practice on direction error scores. This was substantiated by the results of the Scheffe Test\(^2\) for comparison among all pairs of means, which did not show any differences to be significant.

In order to more specifically determine the source of the significance shown in terms of correcting for directional errors during the experimental sessions, the Scheffe test was applied since it permits comparisons among all

pairs of means and because it gives maximum protection against the Type I error. Table 4 gives the means of the four groups as well as the differences between each pair of means.

**TABLE 4**

THE DIFFERENCES BETWEEN DIRECTION ERROR MEANS DURING THE EXPERIMENTAL SESSIONS (FACTOR "A")

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group One</td>
<td>2.153</td>
<td>..</td>
<td>.492</td>
<td>.590&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.495</td>
</tr>
<tr>
<td>Group Two</td>
<td>1.661</td>
<td>..</td>
<td>.098</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>Group Three</td>
<td>1.563</td>
<td>..</td>
<td>.095</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Four</td>
<td>1.658</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at the 5 per cent level; difference > .53 required at the 5 per cent level.

The Scheffé test, "s," was computed to be .53, thereby restricting the significant differences to be between the direction means by Group One (2.153) and Group Three (1.563), which indicates that directional error correction was more difficult and less successful for those subjects required to putt in the dark than for those who were only deprived of not seeing the ball roll. All the other means were not found to be significantly different from one another according to the Scheffé test of significance.

That there are no great differences for directional
errors is not surprising since the range of error scores does not reach the same magnitude as for distance error scores. It would also seem reasonable that putting in the dark would be a more difficult task than putting under the condition of seeing everything but the ball roll. The direction error means do, in part, reflect the differences in the amount of light available to perform the task, with Group One (mean of 2.153) making the larger directional error, followed by Group Two (1.661), then Group Four, who did the task with the lights on (1.658), and then Group Three (1.563).

An identical analysis was made on the distance error scores made during the experimental sessions. The design and hypotheses are exactly the same and the results are given in Table 5.

TABLE 5
DISTANCE ERROR MEANS DURING THE EXPERIMENTAL SESSIONS

<table>
<thead>
<tr>
<th>Experimental Group (A)</th>
<th>Experimental Session (b₁)</th>
<th>Experimental Session (b₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group One</td>
<td>5.296</td>
<td>4.322</td>
</tr>
<tr>
<td>Group Two</td>
<td>5.787</td>
<td>3.936</td>
</tr>
<tr>
<td>Group Three</td>
<td>4.233</td>
<td>3.442</td>
</tr>
<tr>
<td>Group Four</td>
<td>3.576</td>
<td>3.269</td>
</tr>
</tbody>
</table>
Table 5 demonstrates a difference among the group means (A) as well as between the two sessions (B). This would seem to verify what many of the subjects said, and that was that it was easy to make the ball go over the target but very difficult to make it stop on the target.

When the data were subjected to an analysis of variance, it was found that the effects of all three factors (A, B, and C) were significant at the 5 per cent level. Table 6 summarizes the analysis of variance for distance errors during the experimental sessions.

The obtained F was 3.71964 for the main effect of experimental treatment, while the F value required for significance at the 5 per cent level was 2.78. When subjected to the Scheffé test in order to determine what pair of means significantly differed from one another, it was found that only the means of Group Two (could not see the follow-through and the ball roll) and Group Four (light on all the time) were significantly different at the 5 per cent level. The Scheffé statistic was found to be 1.40 for the values in Table 6, while the difference between means of Groups Two and Four was 1.44.

The obtained "b" values of 4.173 for the mean of the first thirty trials (regardless of treatment) and 3.742 for the mean of the second set of thirty trials were found to be significant at the 5 per cent level. The obtained F
ratio was 31.989; the value required for significance is 4.18.

**TABLE 6**

ANALYSIS OF VARIANCE FOR THE DISTANCE ERROR DURING THE EXPERIMENTAL SESSIONS

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1385.758</td>
<td>3</td>
<td>461.9192</td>
<td>3.7196</td>
</tr>
<tr>
<td>error</td>
<td>6954.293</td>
<td>56</td>
<td>124.1838</td>
<td></td>
</tr>
<tr>
<td>Within Subjects:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>865.340</td>
<td>1</td>
<td>865.3398</td>
<td>31.980</td>
</tr>
<tr>
<td>AxB</td>
<td>280.785</td>
<td>3</td>
<td>93.5949</td>
<td>1.4184</td>
</tr>
<tr>
<td>error</td>
<td>3695.239</td>
<td>56</td>
<td>65.9864</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2299.532</td>
<td>29</td>
<td>79.2942</td>
<td>4.8444</td>
</tr>
<tr>
<td>AxC</td>
<td>1840.187</td>
<td>87</td>
<td>21.1516</td>
<td>1.2922</td>
</tr>
<tr>
<td>error</td>
<td>26581.789</td>
<td>1624</td>
<td>16.3681</td>
<td></td>
</tr>
<tr>
<td>BxC</td>
<td>785.714</td>
<td>29</td>
<td>27.0936</td>
<td>1.8128</td>
</tr>
<tr>
<td>AxBxC</td>
<td>1509.892</td>
<td>87</td>
<td>17.3551</td>
<td>1.1612</td>
</tr>
<tr>
<td>error</td>
<td>24271.969</td>
<td>1624</td>
<td>14.9458</td>
<td></td>
</tr>
</tbody>
</table>

\[a\] At the 5 per cent level, F > 2.78 is required for significance.

\[b\] At the 5 per cent level, F > 4.18 is required for significance.

\[c\] At the 5 per cent level, F > 1.47 is required for significance.
TABLE 7
THE DIFFERENCES BETWEEN DISTANCE ERROR MEANS DURING
THE EXPERIMENTAL SESSIONS (FACTOR "A")

<table>
<thead>
<tr>
<th>A</th>
<th>Mean</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group One</td>
<td>4.81</td>
<td>.05</td>
<td>.97</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>Group Two</td>
<td>4.86</td>
<td>.05</td>
<td>1.02</td>
<td>1.44a</td>
<td></td>
</tr>
<tr>
<td>Group Three</td>
<td>3.84</td>
<td>.05</td>
<td>.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Four</td>
<td>3.42</td>
<td>.05</td>
<td>.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aSignificant at the 5 per cent level; a difference > 1.40 is required at the 5 per cent level.

For the main effect of practice, or the "C" source of variance, the computed F ratio of 4.844 was significant at the 5 per cent level (an F value of 1.47 is required for significance). The Scheffé test (s = 3.46) showed that the first trial with a mean of 7.20 differed significantly from each of the means in Table 8.

TABLE 8
MEANS AND TRIALS DIFFERENT SIGNIFICANTLY FROM
THE FIRST TRIAL: MEAN DISTANCE ERRORS
DURING THE EXPERIMENTAL SESSIONS

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mean</th>
<th>Trial</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.69</td>
<td>23</td>
<td>3.58</td>
</tr>
<tr>
<td>16</td>
<td>3.71</td>
<td>26</td>
<td>3.56</td>
</tr>
<tr>
<td>17</td>
<td>3.64</td>
<td>28</td>
<td>3.58</td>
</tr>
<tr>
<td>18</td>
<td>3.74</td>
<td>29</td>
<td>3.48</td>
</tr>
<tr>
<td>19</td>
<td>3.62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results of the experimental session in terms of distance and direction errors demonstrate that performance is a reflection of the amount of action-visual IF and that improvement can be made, at least in terms of distance errors, from one day to the next regardless of experimental condition.

The experimental design for the test sessions was also a factorial arrangement with repeated measures. The independent variables were the same four groups used during the experimental sessions plus a control group (Group Five) who took the test without any previous practice. There were fifteen subjects in each group. The variables \(b_1, b_2, \text{ and } b_3\) were the three test targets, with \(b_1\) representing the target closest to the subject. Twenty trials were taken at each target by each of the seventy-five subjects.

The same hypotheses as those listed for direction errors during the experimental sessions were tested for significance. They were as follows:

1. There were no real differences among the directional error means due to the main effect of treatment conditions during the test sessions. (A)

2. There were no real differences among the directional error means due to the main effect of the three different targets. (B)

3. There were no real differences among the directional error means due to the main effect of practice. (C)
4. There were no real differences among the directional error means due to interactions among the factors. (AXB, AXC, BXC, and AXBXC)

Table 9 represents the mean distance and direction error scores by group per target. They have been combined because the only significant F ratio was found to be among the three target means for both distance and direction.

TABLE 9
MEAN DIRECTION AND DISTANCE ERRORS DURING TEST SESSIONS

<table>
<thead>
<tr>
<th>Experimental Group (A)</th>
<th>Target 1 (b1)</th>
<th>Target 2 (b2)</th>
<th>Target 3 (b3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direction:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group One</td>
<td>1.7</td>
<td>2.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Group Two</td>
<td>1.7</td>
<td>2.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Group Three</td>
<td>1.4</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Group Four</td>
<td>1.6</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Group Five</td>
<td>1.9</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Distance:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group One</td>
<td>3.8</td>
<td>5.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Group Two</td>
<td>3.3</td>
<td>5.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Group Three</td>
<td>3.5</td>
<td>4.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Group Four</td>
<td>3.2</td>
<td>4.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Group Five</td>
<td>4.3</td>
<td>5.5</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Tables 10 and 11 list the F ratios for the direction and distance sources of variation. It can be seen that the only significant F ratio for both direction and distance errors occurs for different targets: F ratios
of 84.233 and 98.928 were obtained for direction and distance error means, respectively (the value of $F$ required for significance at the 5 per cent level is 3.00). This is a logical and obvious result, implying that accuracy is dependent on distance; the further away the target, the greater the distance and direction errors regardless of experimental treatment.

**TABLE 10**

**ANALYSIS OF VARIANCE FOR THE DIRECTION ERROR DURING THE TEST SESSION**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>202.455</td>
<td>4</td>
<td>50.6136</td>
<td>1.787</td>
</tr>
<tr>
<td>error</td>
<td>1983.120</td>
<td>70</td>
<td>28.3303</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>2072.431</td>
<td>2</td>
<td>1036.2156</td>
<td>84.233(^a)</td>
</tr>
<tr>
<td>error</td>
<td>205.512</td>
<td>8</td>
<td>25.6890</td>
<td>2.0882(^b)</td>
</tr>
<tr>
<td></td>
<td>1722.241</td>
<td>140</td>
<td>12.3017</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>154.633</td>
<td>19</td>
<td>8.1386</td>
<td>1.159</td>
</tr>
<tr>
<td>error</td>
<td>551.159</td>
<td>76</td>
<td>7.2521</td>
<td>1.033</td>
</tr>
<tr>
<td></td>
<td>9338.918</td>
<td>1330</td>
<td>7.0217</td>
<td></td>
</tr>
<tr>
<td>BxC</td>
<td>431.959</td>
<td>38</td>
<td>11.3673</td>
<td>1.7224(^c)</td>
</tr>
<tr>
<td>error</td>
<td>1054.880</td>
<td>152</td>
<td>6.9400</td>
<td>1.0515</td>
</tr>
<tr>
<td></td>
<td>17554.676</td>
<td>2660</td>
<td>6.5995</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)At the 5 per cent level, $F \geq 3.00$ is required for significance.

\(^b\)At the 5 per cent level, $F \geq 2.02$ is required for significance.

\(^c\)At the 5 per cent level, $F \geq 1.38$ is required for significance.
### TABLE 11
ANALYSIS OF VARIANCE FOR THE DISTANCE ERROR DURING THE TEST SESSION

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A error</td>
<td>500.241</td>
<td>4</td>
<td>125.0602</td>
<td>2.141</td>
</tr>
<tr>
<td></td>
<td>4089.458</td>
<td>70</td>
<td>58.4208</td>
<td></td>
</tr>
<tr>
<td>Within Subjects:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>4794.316</td>
<td>2</td>
<td>2397.1582</td>
<td>98.928a</td>
</tr>
<tr>
<td>AxB error</td>
<td>95.129</td>
<td>8</td>
<td>11.8911</td>
<td>.492</td>
</tr>
<tr>
<td>C</td>
<td>3410.365</td>
<td>19</td>
<td>179.4929</td>
<td>11.095b</td>
</tr>
<tr>
<td>AxC error</td>
<td>949.065</td>
<td>76</td>
<td>12.4877</td>
<td>.772</td>
</tr>
<tr>
<td>BxC</td>
<td>21516.238</td>
<td>1330</td>
<td>16.1776</td>
<td></td>
</tr>
<tr>
<td>AxBxC error</td>
<td>640.925</td>
<td>38</td>
<td>16.8664</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>2314.814</td>
<td>152</td>
<td>15.2290</td>
<td>.948</td>
</tr>
<tr>
<td></td>
<td>42726.758</td>
<td>2660</td>
<td>16.0627</td>
<td></td>
</tr>
</tbody>
</table>

aAt the 5 per cent level, F \( \geq 3.07 \) is required for significance.

bAt the 5 per cent level, F \( \geq 1.59 \) is required for significance.

Although the control group does make greater directional and distance errors (except for the distance error for the second target), the differences are not very large. The obtained F ratio for the "A" source of variance (or treatment differences) in direction errors was 1.787, less than the F value of 2.52 needed for significance at the 5 per cent level. The null hypothesis for the "A" or treat-
ment variance was accepted. For distance errors the obtained F ratio for between groups variance was 2.141, again less than the 2.52 at the 5 per cent level, thereby requiring acceptance of the null hypothesis.

The Scheffe test, when applied to distance and direction error means, demonstrated that all possible pairs of means were significant at the 5 per cent level as listed in Tables 12 and 13.

**TABLE 12**

THE DIFFERENCES BETWEEN DIRECTION ERROR MEANS DURING THE TEST SESSIONS (FACTOR "B")

<table>
<thead>
<tr>
<th>B</th>
<th>Mean 1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target 1</td>
<td>1.670</td>
<td>..</td>
<td>.96&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Target 2</td>
<td>2.629</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Target 3</td>
<td>3.325</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>

<sup>a</sup>Difference of >.27 is required for significance at the 5 per cent level.

**TABLE 13**

THE DIFFERENCES BETWEEN DISTANCE ERROR MEANS DURING THE TEST SESSIONS (FACTOR "B")

<table>
<thead>
<tr>
<th>B</th>
<th>Mean 1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target 1</td>
<td>3.622</td>
<td>..</td>
<td>1.55&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Target 2</td>
<td>5.165</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Target 3</td>
<td>6.128</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>

<sup>a</sup>Difference of >.39 is required for significance at the 5 per cent level.
The only other effect found significant was "C" (the trials per target) for distance errors, indicating that performance improved as a function of practice. Table 11 indicates an obtained F ratio of 11.095; this exceeds the value required for significance at the 5 per cent level, permitting rejection of the null hypothesis.

In summarizing the analysis of variance calculated for the two separate experimental and test sessions, it should be noted that even though the experimental groups differed in terms of treatment and practice trials for both direction and distance errors, they did not differ significantly on the test performance even from a control group who did not have the 70 practice trials and even when one of the targets had been used for the 70 practice trials. This could indicate that during the experimental sessions, the subjects had learned to make error corrections specific for that act. When the subjects were required to putt for three different targets with the ordering of targets being randomly assigned and no two directly following each other, it seemed they had not learned to adapt to a changing situation. It is possible that this is a demonstration of the effects of habituation or a rote form of learning.

Another explanation might be that the test did not adequately differentiate what had been learned as a function of the experimental treatment sessions. This could be because the task was either too easy or too hard.
The results do demonstrate that distance and direction errors are a function of the amount of visual IF—the more the information, the greater the error reduction.

**Influence of One Trial on Another**

The last question asked of the data involved the effect of one trial on another. Again, only the experimental sessions were studied since the subjects always putted for the same target. The effect of the previous trial would not be confounded with having putted too long, for example, to a distant target when currently putting for the closer target and also remembering what had previously occurred when putting for the closer target.

The effects of one trial on another are limited to corrections for distance, direction, or both distance and direction. Mistakes, in this case, would be considered as repeating the same response. In order to obtain this information from 4,200 scores, it was necessary to initially categorize the data according to areas relative to the target, as diagrammed in Figure 5.

The data were already recorded numerically as "24 53" for example, so it was necessary to convert each direction and distance combination into an assigned number corresponding to the appropriate area. For example, "24 53" is to the left and short. Numbers were assigned to the possible combinations as shown in Table 14.
TABLE 14

THE ASSIGNMENT OF AREA NUMBERS TO DISTANCE AND DIRECTION SCORES

<table>
<thead>
<tr>
<th>Assigned Number</th>
<th>Distance-Direction</th>
<th>Direction</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>long - left</td>
<td>0 - 27</td>
<td>0 - 42</td>
</tr>
<tr>
<td>2</td>
<td>long - center</td>
<td>28</td>
<td>0 - 42</td>
</tr>
<tr>
<td>3</td>
<td>long - right</td>
<td>29 - 50</td>
<td>0 - 42</td>
</tr>
<tr>
<td>4</td>
<td>center - right</td>
<td>29 - 50</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>short - right</td>
<td>29 - 50</td>
<td>44 - 60</td>
</tr>
<tr>
<td>6</td>
<td>short - center</td>
<td>28</td>
<td>44 - 60</td>
</tr>
<tr>
<td>7</td>
<td>short - left</td>
<td>0 - 27</td>
<td>44 - 60</td>
</tr>
<tr>
<td>8</td>
<td>center - left</td>
<td>0 - 27</td>
<td>43</td>
</tr>
<tr>
<td>9</td>
<td>center - center</td>
<td>28</td>
<td>43</td>
</tr>
</tbody>
</table>

The next step involved recording all the possible combinations of having putted to one area on another area and from this information, it was possible to categorize the data.

Cramer's statistic, $\phi'$, was employed to determine the degree of relationship between the type of error made
in a given trial and the performance in subsequent trials. The \( \psi' \) values for each group are reported in Table 15. The indices of relationship, though not large, were statistically significant at the 5 per cent level, as shown by the \( X^2 \) significance test. (Chi-square values are also shown in Table 15.)

**TABLE 15**

**CHI-SQUARE ANALYSES FOR THE RELATIONSHIP OF INITIAL ERROR AND SUBSEQUENT ERROR CORRECTION**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cramer's Phi</th>
<th>( X^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>.22</td>
<td>145.189(^{a})</td>
</tr>
<tr>
<td>Two</td>
<td>.18</td>
<td>95.774(^{a})</td>
</tr>
<tr>
<td>Three</td>
<td>.15</td>
<td>71.289(^{a})</td>
</tr>
<tr>
<td>Four</td>
<td>.33</td>
<td>111.78(^{a})</td>
</tr>
</tbody>
</table>

\(^{a}\)Significant at the 5 per cent level (\( X^2 .05, 21 \text{ df}\)) 11.59).

These findings indicate that subjects were able to extract information from preceding performances and apply it to the modification of subsequent performances.

What is of interest, regarding the results of the


analysis, are the sums for the columns from one group to the next. Although the sums could not be subjected to statistical tests, they did suggest a relationship between error correction and the amount of visual information feedback permitted. This is illustrated in Table 16, in which the column totals are listed as a function of group number.

**TABLE 16**

**GROUP TOTALS OF SUBSEQUENT RESPONSES BY CATEGORY**

<table>
<thead>
<tr>
<th>Group</th>
<th>Repeat</th>
<th>Correcting for Distance</th>
<th>Correcting for Direction</th>
<th>Correcting Both Direction and Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>262</td>
<td>239</td>
<td>253</td>
<td>266</td>
</tr>
<tr>
<td>2</td>
<td>205</td>
<td>238</td>
<td>263</td>
<td>304</td>
</tr>
<tr>
<td>3</td>
<td>224</td>
<td>227</td>
<td>235</td>
<td>319</td>
</tr>
<tr>
<td>4</td>
<td>190</td>
<td>233</td>
<td>225</td>
<td>356</td>
</tr>
</tbody>
</table>

Group One, who performed the task without action-visual IF, tended to make corrections in a rather random order. They tended to repeat the same response as often as they corrected for both direction and distance, or corrected for distance, or corrected for direction. It would be difficult to assess what aspect they were correcting for and this could be a reflection on their inability to determine what corrections in their stroke were needed during performance in order to bring about the appropriate change.

When comparing the changes made in terms of
correction responses from one group to another, the column results indicate an increasing tendency to correct for both distance and direction (261 to 356) and a decreasing tendency to repeat the same response (262 to 190) as a function of the amount of visual IF available during the execution of the skill.

It is apparent, therefore, that with increased visual IF during the execution of the putting stroke, subjects are better able to correct for both direction and distance errors and that the results of one trial affect the results of the next trial. Error correction is an important aspect of what is being learned as a function of practice.

One other point that can be made is that it appears the groups deprived of some visual IF are correcting more for direction than for distance errors, than the group permitted to perform the task under lighted conditions. The subjects, regardless of experimental condition, agreed that distance error was very difficult to correct, while it was easier to make directional changes. This would also indicate that the tasks differed in complexity, with performance in unlighted conditions being more difficult than in lighted situations.

The results may also be interpreted as indicative of a difference in the feedback loops being used. Subjects performing in Group One indicated that they could tell what
they had done by the sound of the club contacting the ball, as well as the feel of the contact. The auditory and tactual IF loops apparently are not as efficient for error correction as the visual IF loop.

Summary

The results of the study can be summarized as follows:

1. The amount of visual IF available during the execution of the putting stroke affects the magnitude of direction and distance scores obtained during the experimental session, as well as the number of hits. The more IF available, the more accurate the performance.

2. The further away the putting target, the greater the direction and distance errors.

3. Repeated practice at putting for one target at a given distance does not significantly improve the ability to putt for three targets at different distances.

4. The ability to make corrections in distance and direction errors appears to be somewhat dependent on the amount of visual IF permitted during the execution of the skill.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of the study was to discover the amount of information feedback necessary for learning to occur. Sub-problems included were:

1. To gain a better understanding of the motor learning theories as applied to physical education activities.

2. To develop a technique for studying IF sources during the execution of a skilled act. To achieve this, visual IF was removed at three different points during the execution of the stroke: Group One performed totally in the dark; Group Two did not see their follow-through or the ball roll; Group Three did not see the ball roll; and Group Four performed under lighted conditions. All subjects received terminal IF in that they got to see where the ball stopped.

The seventy-five volunteer subjects came from 42 physical education classes and the Varsity Soccer team at The Ohio State University during Spring Quarter, 1971. The subjects were considered new to the putting task since the
major qualification was that they have no golfing experience. They were randomly assigned to groups so that each group contained fifteen subjects.

The experimental task involved putting for a target seven and a half feet away for a total of 70 trials. To reduce the effects of boredom and fatigue, the experimental sessions were conducted on two different days. The test session involved putting for three targets that differed in their location on the grid. Twenty trials per target were taken in such a way that each of the possible six orders of testing was randomly dispersed. Subjects were instructed to cause the ball to stop on the target circle, i.e., to come as close to the target as possible. No teaching hints were given regarding the putting stroke.

Conclusions

The results of the study are limited to those individuals who have had little golf experience. The results of the statistical analysis support the following conclusions regarding putting:

1. The evidence indicates that the amount of visual information feedback determines to a great extent the ability: (a) to accurately perform, and (b) to make corrections from one trial to the next in terms of direction and distance.

2. The evidence indicates that repetition of the
putting stroke was not significantly conducive to putting under changing task demands.

3. The evidence indicates that the results of preceding trials are contingent on subsequent trials so that subjects are learning to correct for both distance and direction errors from one trial to the next. This appeared to be a function of the amount of visual IF available during performance of the stroke.

4. The evidence indicates that reduced visual information feedback results in an inadequate reference and this is reflected in performance scores.

In general, the evidence from this study demonstrates that successful performance is dependent on the opportunity to formulate a reference or perceptual trace of the execution of the movement from which to compare subsequent acts. The more complete the information feedback, the more accurate the performance. In relation to physical education activities, attention should be focused on those movement patterns which will result in error correction.

The findings also seem to indicate that where the final task involves adjustments to a changing environment, practice sessions should involve such experiences rather than repetitive performances in an unchanging environment. The more closely the information feedback from the practice sessions approximates that of the test session, the greater the transfer.
Recommendations

As a result of this study, the investigator recommends consideration of the following concerns for further research:

1. Since the subjects in this study were new to the task, another study should be done with trained subjects in order to answer the question regarding the development of a reference or perceptual trace. The hypothesis would be that there would be no significant differences among trained subjects as a function of experimental treatment since they would have already formulated a reference relative to the task.

2. It would be interesting to see the effect of removal of visual IF during the performance of a task in which the visual system is less important. This would be another way of studying the development of a reference.

3. The same study could be repeated in which the limitation of visual information feedback would be a function of selected time intervals rather than events occurring during the task.
APPENDIX A

INTRODUCTORY INSTRUCTIONS FOR SUBJECTS IN EXPERIMENTAL GROUPS 1, 2, AND 3
INTRODUCTORY INSTRUCTIONS FOR SUBJECTS IN
EXPERIMENTAL GROUPS 1, 2, AND 3

This is a learning experiment. The motor skill you will be learning is putting. The electrical equipment that you see will only be involved with turning the lights out and switching them on again. The interval timer is set to keep the lights out for a predetermined period of time. The photo electric cell is sensitive to interruption in the light beam so that it is possible to turn the lights out by drawing the putter in front of the light beam. The only sounds you may hear are the click of the relay switch and the hand switch.

Now we will review the putting stroke with you. Take the putter and practice moving the club. Grip the putter with both hands so that the right hand is lower to the floor than the left hand. You should be in a slightly bent-over position so that your head is directly over the ball. The main thing to remember is to be perfectly still throughout the stroke—only your arms should move.

Now place your feet on the "X's" that are on either side of the black box. Lower your putter so that it rests on the scotch tape. This is to help you line the putt up. When you are ready to stroke the ball, place the putter closer to the ball and then draw the club back and through the ball. Practice this sequence: putter on scotch tape, almost touching ball, back and through the ball. [Subjects stroked the ball at this point.]

To begin with, you will have 5 practice putts just to make sure that you understand the task, followed by 30 condition trials. To be successful, you must try to get the ball to stop on the red circle. In other words, try to get the ball to come as close to the circle as you can.

Do you have any questions? We are ready to begin. Go to the chair and get one of the balls. You will do this for every trial. Look at the path your ball must make in order to stop on the red circle.
Step on the appropriate marks again and place the ball between the two dots. Remember to remain still throughout the stroke—even to the point of holding the position on the follow-through until you are certain that the ball has stopped rolling. You may begin.
APPENDIX B

INTRODUCTORY INSTRUCTIONS FOR SUBJECTS IN
EXPERIMENTAL GROUP 4
INTRODUCTORY INSTRUCTIONS FOR SUBJECTS IN
EXPERIMENTAL GROUP 4

We will review the putting stroke with you. Take the putter and practice moving the club. Grip the putter with both hands so that the right hand is lower to the floor than the left hand. You should be in a slightly bent-over position so that your head is directly over the ball. The main thing to remember is to be perfectly still throughout the stroke--only your arms should move.

Now place your feet on the "X's" that are on either side of the black box. Lower your putter so that it rests on the scotch tape. This is to help you line the putt up. When you are ready to stroke the ball, place the putter closer to the ball and then draw the club back and through the ball. Practice this sequence: putter on scotch tape, almost touching ball, back and through the ball. [Subjects stroked the ball at this point.]

To begin with, you will have 5 practice putts just to make sure that you understand the task, followed by 30 condition trials. To be successful, you must try to get the ball to stop on the red circle. In other words, try to get the ball to come as close to the circle as you can.

Do you have any questions? We are ready to begin. Go to the chair and get one of the balls. You will do this for every trial. Look at the path your ball must make in order to stop on the red circle.

Step on the appropriate marks again and place the ball between the two dots. Remember to remain still throughout the stroke--even to the point of holding the position on the follow-through until you are certain that the ball has stopped rolling. You may begin.
APPENDIX C

INSTRUCTIONS FOR GROUP 1
INSTRUCTIONS FOR GROUP 1

Now we will introduce you to the condition sessions. The only difference you will find is that you will be able to turn the lights out for about 7 seconds as soon as you place the putter behind the ball. To see what this experience will be like, place your feet in the appropriate position on either side of the box and lower your putter to the scotch tape and then, when ready, closer to the imaginary ball. [Break for seven seconds.] Remember to hold your position on the follow-through.

We will start the condition session. You will do thirty trials. Go to the chair and get a ball and put your feet on the appropriate marks. With your left hand, place the ball between the two spots on the rug. You may begin to putt as soon as you are ready.
APPENDIX D

INSTRUCTIONS FOR GROUP 2
INSTRUCTIONS FOR GROUP 2

Now we will introduce you to the condition sessions. The only difference you will find is that you will be able to turn the lights out for 4 seconds as soon as you stroke the ball. To see what this experience will be like, place your feet in the appropriate position on either side of the box and place your putter on the scotch tape and then, when ready, closer to the imaginary ball. Now draw the putter back and through the ball. [Break for four seconds.] Remember to hold your position on the follow-through.

We will start the condition session. You will do thirty trials. Go to the chair and get a ball and put your feet on the appropriate marks. With your right hand, place the ball between the two spots on the rug. You may begin to putt as soon as you are ready.
APPENDIX E

INSTRUCTIONS FOR GROUP 3
INSTRUCTIONS FOR GROUP 3

Now we will introduce you to the condition sessions. The only difference you will find is that you will be able to turn the lights out for about 3 seconds as soon as you stroke the ball through the beam of light in front of you.

To see what this experience will be like, place your feet in the appropriate position on either side of the box and lower your putter to the scotch tape and then, when ready, closer to the ball. Bring the club back and through the ball. [Break for three seconds.] Remember to hold your position on the follow-through.

We will start the condition session. You will do thirty trials. Go to the chair and get a ball and put your feet on the appropriate marks. Place the ball between the two spots on the rug. You may begin to putt as soon as you are ready.
APPENDIX F

INSTRUCTIONS FOR GROUP 4
INSTRUCTIONS FOR GROUP 4

Now we will introduce you to the condition session. You are to putt in the same manner as you have done before; that is, try to get the ball to stop on the red circle. Remember to hold the position on the follow-through until you are certain that the ball has stopped rolling. You will have thirty trials.
APPENDIX G

RECORDING THE SCORE FOR EACH TRIAL
RECORDING THE SCORE FOR EACH TRIAL

When the ball stopped rolling, the experimenter noted the quadrant with the square that the ball had stopped as well as the appropriate letter and number. This was done for each trial taken by each subject and was recorded as follows:

<table>
<thead>
<tr>
<th>0</th>
<th>L 41</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>P 38</td>
</tr>
<tr>
<td>0</td>
<td>K 45</td>
</tr>
</tbody>
</table>
APPENDIX H

INDIVIDUAL SCORE SHEET
<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Age</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Have you played miniature golf?</th>
<th>Can you play 18 holes of golf?</th>
<th>Have you had golf lessons?</th>
<th>What Varsity sports have you played?</th>
<th>Intramural teams?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

1 2 3 4 5
APPENDIX I

DETERMINATION OF DIRECTION AND DISTANCE ERROR SCORES
DETERMINATION OF DIRECTION AND DISTANCE ERROR SCORES

To determine the direction and distance error for each trial, a graph was devised that approximated the actual grid on the carpet. In order to determine direction errors, the abscissa was scaled in such a way that each quadrant was divided in half and then values were assigned ranging from zero to fifty; for example:

```
42
43 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 ...
44 A B C D E F G H
```

By using a piece of string on the graph paper, it was possible to determine the line from the point where the ball started to where it stopped and where it would have crossed the abscissa. The left and right sides of each quadrant were assigned the appropriate value by projecting the line through the previously scaled abscissa (see page 103). The lines were calibrated with the carpet by repeating the same process with some of the quadrants on the carpet.
To determine distance error values for each quadrant, a similar process was used in that string was extended from the point where the ball started to the center of each quadrant in the ordinate scale and then the radius formed was used to determine an arc:

In the above diagrams, for example, a trial score of $^0_{45}$ would have the directional value of 24 and the distance value of 44.
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