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The purpose of this study was to investigate the relative effects on learning and on performance of a motor skill when visual information feedback was limited to: (1) action information feedback, (2) terminal information feedback, and (3) a combination of action and terminal information feedback. The motor skill used for this experiment was dart throwing.

The subjects for this experiment were forty-eight female students who were randomly selected from the freshman class at the University of North Carolina at Greensboro. The subjects were divided into three groups with sixteen subjects in each group. Each group was distinguished by the progressive order of the feedback conditions under which it practiced. The three feedback conditions were (1) action information; (2) terminal information; and (3) a combination of action and terminal information; and the three progressive orders were: 1-2-3; 2-3-1; and 3-1-2. On the first day of practice, each subject was given a pretest to determine her initial level of skill. On the second day, each subject began practice under the experimental conditions according to the progressive order assigned to her group. One day of practice was spent under each of the three experimental conditions. On the fifth and last day of practice, each subject was given a post-test to determine her final level of skill.

An analysis of variance and Fisher's "t" test of significance of difference between correlated mean differences were the statistical calculations used to determine if:

1. there was a difference between scores on the pretest and post-test.
2. the order of practice of the three experimental conditions (1-2-3; 2-3-1; and 3-1-2) affected learning and performance.
3. there was a difference in performance among the various practice conditions (pretest, action information feedback, terminal information feedback, a combination of both action and terminal information feedback, and post-test.

The calculations indicated that there was no significant difference between the pretest and post-test scores, therefore, no learning occurred during the experiment. Consequently, this writer concluded that one day of practice for each experimental condition (action information, terminal information, and a combination of action and terminal) was not a sufficient length of time for significant learning to occur.

Further results indicated that the order of practice of the experimental conditions (1-2-3; 2-3-1; and 3-1-2) had no significant effect upon post-test performance, however, specific performances were significantly affected by the type of practice condition. In all instances, performance was better during practices in which complete visual information feedback (pretest, a combination of action and terminal information, and post-test) was received, than during practice in which incomplete visual information feedback (action information or terminal information) was received.

THE RELATIVE EFFECTS ON LEARNING AND ON PERFORMANCE OF A MOTOR SKILL WHEN VISUAL INFORMATION IS LIMITED TO THREE KINDS OF FEEDBACK: ACTION INFORMATION, TERMINAL INFORMATION, AND THE COMBINATION OF BOTH

by

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TABLE OF CONTENTS

		Page
LIST OF TABLES		vi
LIST OF FIGURES		vii
Chapter		
I.	INTRODUCTION	1
II.	STATEMENT OF PROBLEM	3
	LIMITATIONS OF THE STUDY	4
	DEFINITION OF TERMS	4
III.	REVIEW OF LITERATURE	6
	The Necessity of Feedback in Learning	6
	Definition and Function of Feedback	9
	Variations of Feedback	12
	Delay of feedback	12
	Amount and specificity of feedback	16
	Frequency of feedback	17
	Types of Feedback	18
IV.	PROCEDURE	27
	APPARATUS CONSTRUCTION	27
	The Target	27
	The Light	29
	Photoelectric Cell and Stands	33
	The Screen	35
	Additional Equipment	37
	PILOT STUDY	37
	Procedure	37
	Results	38
	Limitations of the Pilot Study	41

Chapter Page

TESTING PROCEDURE. 42

Selection of Subjects. 42
Procedure. 43
Organization of groups and practice sessions. 43
Organizations of sessions. 44

INDIVIDUAL SESSIONS. 46

Pretest. 46
Action Information Feedback (AIF). 47
Terminal Information Feedback (TIF). 48
A Combination of Both Types of Information Feedback (Both). 49
Post-Test. 50

TREATMENT OF DATA. 50

V. ANALYSIS AND INTERPRETATION OF DATA. 52

Groups 53
Pretest and Post-Test Scores 55
Order of Practice. 55
Experimental Conditions. 58
Interpretation of Data 59

VI. SUMMARY AND CONCLUSIONS. 66

REFERENCES 70

APPENDIXES 73

APPENDIX A Correspondence. 74

APPENDIX B Practice Session Instructions 81

APPENDIX C Raw Scores. 90

APPENDIX D Photograph of Apparatus 95

LIST OF TABLES

Table		Page
I.	Analysis of Variance Between Pretest Scores of All Groups.	54
II.	Mean Difference and Significance of Difference Between Pretest and Post-Test Scores.	56
III[a].	Analysis of Variance Between Practice and Group Scores.	57
III[b].	Difference Between Practice Group Means and Calculated Scheffe Values	57
IV.	Mean Differences and Significance of Difference Between Practices for Group I	60
V.	Mean Differences and Significance of Difference Between Practices for Group II.	61
VI.	Mean Differences and Significance of Difference Between Practices for Group III	62
VII.	Mean Differences and Significance of Difference Between Practices for Combined Groups	63
VIII.	Significance of Differences for All Groups.	64

LIST OF FIGURES

Figure		Page
1.	The Target.	28
2.	The Target Face	30
3.	Placement of the Target	31
4.	Photoelectric Cell and Light.	32
5.	Side View Illustrating Screen	34
6.	Entire Testing Area as Seen from Subjects' Viewpoint	36
7.	Order of Sessions	44
8.	Testing Schedule.	45

CHAPTER I

INTRODUCTION

In analyzing the complexity of human learning, the role of feedback stands out as one of the most influential factors. Bilodeau and Bilodeau report that "'feedback' or knowledge of results, is the most important variable controlling skilled performance." (1966:213) Without any knowledge concerning one's performance, improvement is almost impossible. In the field of physical education, for example, it would be difficult to imagine a beginning archery student improving in accuracy without any knowledge of where the arrows were hitting the target. The same is true in almost any task in which learning or improvement is desired. For example, keeping a car on the road would be very difficult for a driver if he had no knowledge of where the car was in relation to the road.

Most prominent in current literature is the investigation into two basic types of feedback: (1) terminal and (2) action (or concurrent). These forms are distinguished by the type of information and the time of its arrival to the individual. Terminal feedback is information concerning performance that is received after the task or performance has been completed. Action (or concurrent) feedback is information concerning performance that is received during the performance of the task. Robb has defined "concurrent" feedback as "information that is 'on going' or is

provided for moment to moment regulation of behavior" (1966:42). The example of the archery student, cited above, illustrates terminal feedback in that the position of the arrow in the target after it has been released provides error information after the task has been completed. The driver of the car, cited above, illustrates action (or concurrent) feedback in that the driver is continuously receiving error information as he drives.

Terminal information feedback (knowledge of results) has been found to be a very necessary part of learning. This type of feedback is very common in the field of physical education. The bowler sees the strike and tries to repeat that performance, or the football player sees his pass intercepted and tries not to repeat that particular pattern.

In its effectiveness when learning a motor skill, action feedback has not yet been found to be equal to terminal feedback. If action information proves to be effective in learning, then new emphases in teaching may apply. Robb feels that "concurrent" feedback is very valuable for the beginner.

> One conclusion appears to be valid concerning terminal and concurrent feedback; a measure of performance obtained during the execution of the skill may be more valuable to the learner than the measure of terminal performance (1966:42).

If both types of feedback are found to be effective factors, then it would logically seem that effective methods must emphasize both types, a procedure which to date has not been evidenced in current literature.

CHAPTER II

STATEMENT OF PROBLEM

This study was an attempt to investigate the relative effects on learning and on performance of three different conditions of visual feedback: (1) action information feedback including vision during the act but not vision of the result, (2) visual terminal information feedback with vision absent during the action, and (3) a combination of both types of feedback with no limitation of visual information. Forty-eight women were randomly selected from the freshman class at the University of North Carolina at Greensboro. The subjects were then placed into one of three groups, each consisting of sixteen women. Each group was pretested and was then given one practice session under each of the three feedback conditions: (1) action information, (2) terminal information, and (3) a combination of both. There were three progressive orders of practice (1-2-3; 2-3-1; and 3-1-2) and each group practiced under a different order of progression. At the conclusion of the practice sessions, each group was then post-tested. Statistical comparisons were then made to determine the relative effectiveness of each of the feedback conditions.

LIMITATIONS OF THE STUDY

1. Due to the class schedules of the subjects, it was not possible for each individual to practice at the same time each day. Every attempt was made to avoid a large variance in each subject's schedule from day to day (more than three hours); however, in some cases it was not possible to avoid a large time variance.

2. During two of the five testing days, it was necessary to have an assistant as scorekeeper. Several different persons had to be employed since the time demand frequently conflicted with an individual's class schedule, making it impossible to have just one scorekeeper. However, the scoring necessary for this experiment was very objective in nature and each scorekeeper was carefully instructed.

DEFINITION OF TERMS

1. Action information feedback - visual information received by the subject while the act or movement was being performed. This condition did not include any knowledge of results (terminal information), but did include any proprioceptive and kinesthetic feedback during the act.

2. Terminal information feedback - visual information received by the subject after the act or movement had been completed. Visual information during the act (action information) was not included, although any proprioceptive and kinesthetic feedback during the act was not excluded.

3. Performance - "the skill level as it functions at any one time" (Lawther, 1968:123). In this experiment, performance without learning was indicated if no significant difference existed between pretest and post-test scores at the .05 level of confidence.

4. Learning - "is an interpretation of improvements in performance as estimated from successive performance measures over a span of time" (Lawther, 1968:123). In this experiment, learning was indicated if a significant difference existed between pretest and post-test scores at the .05 level of confidence.

CHAPTER III

REVIEW OF LITERATURE

The Necessity of Feedback in Learning

The earliest studies involving feedback deal primarily with its presence or absence in the learning situation. These investigations began as early as 1905 with Judd's experiment involving line drawing, in which his subjects were given no information concerning the accuracy of their responses. He concluded that no learning occurred and, therefore, mere repetition did not produce learning (Rosch, 1964:5). Although a control group receiving a knowledge of the accuracy of their responses might have strengthened this study, it still remains as one of the first investigations into the absence of feedback.

Spencer (1923) and Smith (1933) also were early investigators into the absence of feedback and its effects upon learning. However, both of these experimenters disagreed with the conclusions stated by Judd. Spencer questioned the mathematical calculations used in Judd's study. He found an improvement in Judd's subjects, and also for subjects within his own experiment, by utilizing a different statistical method. Smith concluded from his experiment that repetition did enhance learning, thus directly contradicting Judd's earlier findings.

Other investigators found evidence in their studies supporting the need for feedback in learning. Ross (1927), even

though he was studying motivation, found that subjects given complete knowledge of their performance improved more than those given incomplete knowledge or none at all. Trowbridge and Cason (1932) conducted a line drawing experiment in an attempt to validate a similar experiment performed in 1931 by Thorndike, which supported the conclusion that performance decreased when a knowledge of results was eliminated (Rosch, 1964:6). The experimenters used four variations of knowledge of results. One group of subjects was given no information at all; a second group was given "nonsense" information (information not pertaining to the task); a third group was simply informed as to whether they were "right" or "wrong"; and the final group was told the specific length of the line that they had drawn. Trowbridge and Cason found that the fourth group (with knowledge of specific length of the line they had drawn) became superior to all others. Among the remaining groups, the subjects that received the "right" or "wrong" response were superior. The group that received no information at all performed better than the group that was given "nonsense" results. In addition to concluding that feedback was necessary for learning, the experimenters also concluded that the type of information given was also a factor that influenced the amount of learning.

Additional support to the theory of feedback was found by Elwell and Grindley (1938). Their subjects were tested on a motor skill involving a coordinated movement of the hands in lining up a light beam with the bull's eye of a target. The

apparatus was constructed so that the light could remain on during the task, thus giving a knowledge of the result, or the light could be turned off allowing no knowledge of results. The experimenters concluded that no improvement occurred when no visual knowledge of results was available. Grindley then teamed with MacPherson and Dees and continued investigation into the effects of feedback on learning. They concluded from their experiments in line drawing and lever pressing that the visual knowledge given produced more improvement than no visual knowledge at all (MacPherson, Dees, and Grindley, 1948).

In spite of the confusion that has resulted from the countless investigations into the various aspects of feedback and their relative effects upon learning, the necessity of feedback for learning has remained as accepted theory. It is felt that Bilodeau and Bilodeau were correct in that

> . . . studies of feedback or knowledge of results (KR) show it to be the strongest, most important variable controlling performance and learning. It has been shown. . . that there is no improvement without KR, progressive improvement with it, and deterioration after its withdrawal (1966:214).

Annett made a very emphatic statement supporting this opinion. He stated,

> From the subject's point of view there is nothing to be learnt until correct and incorrect responses are specified: this would be true whatever the physiological mechanism of learning might be and whether the learner were a man, a rat, or a computer (1969:163).

Within Annett's conclusion of his book (of which the above statement is a part) he cautioned against broad generalizations on the

basis that the value of feedback is actually determined by the definition of learning (1969).

Definition and Function of Feedback

Even though it is recognized that feedback is a very important factor in learning, definitions of this term have made it very difficult to identify the specific role it plays in the learning situation. "Brown suggests that giving knowledge of results is the process of providing the learner with information concerning how accurate or appropriate his response was" (Rosch, 1964:2). Note the use of the past tense indicating knowledge received after the performance had been completed. Lawther did not confine his definition to the end result of performance. He stated that feedback is the "knowledge of how effective one's performance is becoming, as it occurs, of precisely what variations are less successful, and of just what the result of the performance was" (Lawther, 1968:98). According to this definition, feedback is received long before the task or movement is completed. Although the end result of a performance is very important in learning, it can be hypothesized that there is more to feedback than just the end result. Comparing the definitions of Brown and Lawther stated above, the wide scope of differences in attempting to define feedback can be evidenced. Feedback may be continuous during the act as well as terminal feedback or knowledge of the end-result of the act. Ammons defines feedback as "knowledge of various kinds which the performer received about his performance" (Ammons, 1956:279). Again the wide variation can be evidenced.

Annett and Kay, in 1956, attributed much confusion in the area of feedback research to the various definitions of feedback. They stated:

> Here again there is a diversity of findings which arise in the first place from giving one name to different kinds of indicators. This difficulty has arisen mainly because no clear distinction has been made between discussions about the skill itself and those about the end product of the skill. At one extreme may be distinguished knowledge of results, informing the operator how successful or unsuccessful was his score, and at the other knowledge of performance, telling him how he is performing the task (1956:115).

Not only has difficulty arisen in defining feedback, but equal confusion has evolved from the synonymous use of terms such as feedback, knowledge of results, and knowledge of performance. This can be evidenced not only within the information provided in this thesis, but throughout literature available concerning this subject. Within Annett's statement above he used knowledge of performance and knowledge of results. However, he was referring to two different aspects of feedback, and he was indeed implying that this must be recognized. Knowledge of performance implies information of the act itself and knowledge of results implies information of the end result of this act or performance. These are two entirely different types, both of which contribute to the total feedback received by the individual. However, in spite of the differences in scope, researchers have continued to draw generalizations concerning feedback from studies that deal with only one type or area of feedback. Before assumptions can be made we must name and define exactly what we are attempting to study. This opinion can be supported by a statement made by Bilodeau and Bilodeau published in 1966:

> Though most E's would agree that R (response) is some function of feedback, there is no agreement on the definition, never mind the function. Indeed, there is not even widespread agreement as to name; knowledge and feedback represent the core words, modified by other words such as results, performance, psychological, ... Feedback appears to be the more descriptive and harmless appellation (Bilodeau and Bilodeau, 1966:214)

Additional confusion arises when trying to determine the function of feedback in learning. Brown (Rosch, 1964:1) felt that knowledge of results had three basic functions: (1) that of reward to reinforce habits; (2) that of motivation to give incentive for learning; and (3) that of information to allow the correction of poor responses. Other researchers (MacPherson, Dees, and Grindley, 1948) were in agreement with Brown, although they did not use the same terminology. From their experiment they concluded that knowledge of results had both a "directive" and an "incentive" effect. In other words, knowledge of results had a directive effect in early learning primarily giving information enabling the correction of poor responses and the retainment of correct responses. After performance had reached a somewhat constant level, knowledge of results became an incentive factor in maintaining consistent performance. More recently, Annett (1969) has summarized the roles of feedback and recognized Brown's division of reward, incentive, and information. However, he stated that feedback serves primarily as information for learning or improving performance. He did not accept the theory encompassing reward and incentive as functions of feedback. Ross (1927) used the very simple task of tallying in an attempt to determine if knowledge of results served as any type of motivation.

He discovered that performance (in terms of speed) was superior when complete information as to position of performance level within the groups was given to the individual. This would indicate that feedback, in this case, did serve as a motivating factor. However, caution should be used in making a broad generalization for the task used in this experiment was very simple, thus eliminating the information function of feedback as a variable. It is very unlikely that this situation would ever occur in most normal learning situations. Smode (1958) also studied the relationship of feedback and motivation. He found that interest level was increased by an increase in the information feedback. Elwell and Grindley (1938), in a study already cited, noted that when information was withheld the subjects became bored very quickly. The evidence supporting motivation and information in relation to feedback is quite conflicting. One hypothesis to explain this might possibly be the difficulty in separating one from the other in an experimental situation. It would seem very difficult to attempt to determine where the information function ceased and where the motivation function began.

Variations of Feedback

Delay of feedback. As early as 1935, it was hypothesized that the length of delay in giving feedback might affect the rate of learning. Lorge and Thorndike (1935) were the pioneers in this area of research with a ball tossing experiment. The subjects

tossed balls to the rear over their shoulders, attempting to hit a target lying on a table. They were unable to see the end result. The results of each throw were given to various groups verbally with either a 0, 1, 2, 4, or a 6 second delay. The experimenters also introduced a one-trial delay variable, giving knowledge of results (terminal information) of each throw only after the next throw had been completed. They found that some improvement was lost with delays of 4 and 6 seconds, and that no learning was evidenced in the group under a one-trial delay situation.

Identical results were found in a study by Greenspoon and Foreman (1956). Forty subjects were divided into five groups and each group practiced a line drawing task under a different condition of feedback. One group had a delay of ten seconds, a second group had a delay of twenty seconds, a third group had a delay of thirty seconds, a fourth group received feedback immediately after each trial and a fifth group received no information at all. The experimenters found that an increase in the length of delay caused a decrease in the rate of learning (1956:228). Bourne (1957), using a concept identification task, also found an increase in the delay of knowledge of results decreased the effectiveness of performance.

Several researchers (Chase, et al., 1959) investigated the effects of delayed auditory feedback and its affects on speech and key tapping. Individuals were tested first by simply pronouncing a sound a specified number of times with immediate

auditory feedback of their voices. The subjects then practiced repeating the sounds with a 244 msec. delay of their voices through earphones. The experimenters reported marked differences when the delay was introduced. The subjects spoke louder when under delayed feedback. They also repeated sounds too many times and the time between pronunciations increased. Very similar results were evidenced with the key tapping portion of the experiment. Subjects tended to tap the key harder when the delay in auditory feedback was introduced. They also tapped the key too many times, held the key down longer and increased the time between taps (1959:903).

A very similar experiment was performed by Smith and McCrary in 1960. Their experiment involved the delay of visual feedback in the performance of a simple motor task. The delay was achieved through the use of a video-tape recorder. Subjects performed the simple motor task of tracing figures. One group of subjects had a delay of 520 msec. by way of the video tape (the actual task they were performing was covered); a second group had no delay of visual feedback but did receive the feedback by way of the video tape (again the task was covered); and a third group had no delay of visual feedback and was allowed to view the actual task. The experimenters found that the delayed visual feedback greatly affected performance. The writing of the subjects became illegible and distorted when practicing under the delayed conditions. Also, very frequently the error in writing was the addition of extra letters in the words, and the time factor was greatly increased (Smith and McCrary, 1960:1014).

In 1958, Bilodeau and Bilodeau introduced results that contradicted many of the previously done studies. They found in a series of five experiments that the amount of delay (from a few seconds up to several days) had no effect on the rate of learning. Bilodeau and Bilodeau, however, introduced a new variable--the intertrial interval. This new terminology referred to the period of time between each response or performance. They further categorized the intertrial interval into the (1) pre-KR interval and the (2) post-KR interval. The pre-KR interval referred to the time elapsing from the initial response to the reception of the knowledge of results. The post-KR interval refers to the time elapsing from the reception of the knowledge of results to the next response. Bilodeau and Bilodeau hypothesized that the increase of the pre-KR interval (delay of knowledge of results) was not the most important variable. They found that an increase in the post-KR interval had a greater detrimental effect upon the rate of learning. In other words, they felt that it was more important to receive knowledge of results just prior to the next response rather than immediately after the initial response (1958b).

Bilodeau continued his work in the area and teamed with Ryan to repeat Greenspoon and Forman's line drawing experiment, for they both questioned the original findings. The results obtained were contradictory to those of the original study. Bilodeau and Ryan found no significant difference in the rate of

learning between groups receiving immediate feedback and those groups receiving varying delays of feedback (Bilodeau and Ryan 1960).

Denny and his associates (1960) also researched this area of knowledge of results and supported Bilodeau's findings, stating that the most important variable was not the length of the pre-KR interval but rather the length of the post-KR interval. Thus, his hypothesis was in agreement with Bilodeau in that knowledge of results received just prior to the next response was more important than knowledge received immediately after the initial response.

Amount and specificity of feedback. Much research has been done in this area to support the hypothesis that greater specificity of knowledge and a greater amount of feedback results in a faster rate of learning.

Trowbridge and Cason (1932) used a line drawing experiment to test their hypothesis concerning specificity. To one group they merely gave a "right" or "wrong" verbal response after every attempt. To a second group they gave also the length of the line that the individual had drawn in addition to the right or wrong response. The group given the exact length of each line learned to draw a line of three inches much faster than the group that was only told whether or not they were right or wrong each time.

Bourne and Pendleton (1958) performed two experiments studying the effects of the amount and specificity of feedback on learning. In the first experiment, the subjects of one group

were given "complete" information concerning each response and the subjects of a second group were given "incomplete" knowledge of each response. It was found that the more complete the information, the greater the rate of learning. In the second experiment, the variable was the amount of feedback given. This study involved four groups, each receiving a different amount or percentage of information for every 128 trials. One group was given knowledge of results after every trial (100 percent information); a second group was given information after only 90 percent of the trials; a third group received 80 percent information; and a fourth received only 70 percent information. It was found that the higher the percentage of feedback given the greater the rate of learning. In other words, the group receiving the most reports of results learned the task faster than the groups receiving fewer reports of results.

Abbey and Cowan (1960) also studied the effects of specificity. Their experiment involved a tracking task in which one group was given complete visual feedback and a second group incomplete visual feedback. The researchers were in agreement with previous studies, finding that the group with complete visual information performed the task much better than the group receiving incomplete visual feedback.

Frequency of feedback. The frequency of feedback is concerned with how often feedback is received by the individual, not with how much or how specific. A good example to illustrate this is the study by Bilodeau and Bilodeau (1958a) in which they

studied the effects of "absolute and relative" frequency. Each of three groups received an identical number of reports of results, but each group was given a different number of trials. The first group was given ten trials with results given after each trial; the second group had twenty trials with results given after every two trials; and the third group was given thirty trials with results given after every three trials. Each group received ten reports of knowledge of results. It was hypothesized from the results that no learning occurred on the trials without knowledge of results. Their rationale for this conclusion was that all the groups achieved the same amount and that the number of trials was not the factor controlling learning. Therefore, in this particular experiment, Bilodeau concluded that the rate of learning was greater when a greater frequency of reports of results was given in proportion to the number of trials.

Lending support to this theory was another study by Bilodeau, Bilodeau, and Schumsky (1959) in which they studied the effects of introducing knowledge of results late in practice and withdrawing it early. The results of this study showed that no improvement occurred without feedback; there was improvement with feedback; and deterioration of performance was evidenced when feedback was removed.

Types of Feedback

Another very important aspect of feedback is concerned with the various kinds of feedback. As in the previous areas

discussed, much confusion has resulted from the inconsistency in terminology.

Most researchers agree that there are two basic or major categories of feedback. Most recently Annett (1969:26) termed these as (1) intrinsic KR implying information which is normally present or inherent in the situation and is not modified or controlled by an experimenter; and (2) extrinsic KR implying information which is given or modified by the experimenter. Annett also used the term augmented KR synonymously with extrinsic KR (1969:27). Extrinsic or augmented feedback as used by Annett and Kay (1957) signified additional information given by the experimenter - information normally absent from the actual learning situation. Gordon (1968) used a circular light tracking skill in an attempt to determine the effect of augmented feedback on the acquisition of a motor skill. He concluded that it aided in the learning of skills as long as it did not become the primary source of information, allowing the subject to ignore the information or cues inherent in the task. In other words, augmented feedback enhanced learning as long as it did not eliminate intrinsic feedback completely. Bell (1966) conducted a study using the long serve in badminton. Augmented feedback was given by the use of a rope similar to that used in many skill test situations which was placed parallel to the net 14 feet back and 15 feet high. The experimental groups practiced serving the shuttlecock over the rope and into the proper area on the court. The control group did not have the aid of the rope during their practices. No significant

differences were found between groups, thus Bell concluded that augmented feedback was not an advantage as long as sufficient knowledge of results was inherent in the task itself. In this particular experiment, Bell was concerned with the beginning levels of performance.

A secondary category used to classify the types of feedback is concerned with the time of the arrival of the feedback to the individual. Robb classifies these as "terminal" and "concurrent" feedback:

> Types of feedback can be distinguished further by the arrival time of the information about a performance. If, for example, a summary score is given to a subject or student after a defined performance, it is labeled terminal feedback. If the information is 'on going' or is provided for moment-to-moment regulation of behavior, it is referred to as concurrent feedback (Robb, 1966:39).

Here again, synonymous terminology can be evidenced for Annett and Kay (1957) used the term learning feedback to connote Robb's terminal feedback and the word action to connote concurrent feedback. More recently Fox and Levy have used a combination of both for in their experiments they refer to "action" and "terminal" feedback (1969:169).

Several researchers (Annett, 1959; Fox and Levy, 1969; and Robb, 1968) have studied the amount of learning under conditions of action information feedback as compared to learning under "standard" conditions of terminal feedback. Robb (1968) used a tracking task for the purpose of studying the effects of variations in the type of frequency of feedback. She had five groups and each group received a different combination of feedback.

Not only did she vary the use of concurrent and terminal information, but she also varied the modes of feedback reception (visual or proprioceptive). She hypothesized that both the time of the arrival of feedback and the mode of feedback would affect the rate of learning for each group. The experiment involved a great number of variables and some difficulty arose in attempting to isolate specific variables and their effects upon learning. However, from her results, Robb concluded that learning was more effective if practice and feedback were available rather than practice alone. She also concluded that "concurrent visual feedback was the most important variable for learning the movement pattern" (1968:183). Therefore, Robb concluded that concurrent visual feedback was more valuable than terminal visual feedback.

Robb's study of concurrent feedback appeared to contradict the earlier findings of Annett (1959) who concluded that augmented and concurrent feedback was not a sufficient condition for learning. However, it should be noted that Annett was most interested in the effects of an augmented or supplementary cue which would be presented in the form of concurrent or terminal feedback. While Robb's concurrent feedback was a supplementary cue (not normally present in the task), her emphasis was not placed on the fact that it was supplementary, rather on the fact that it was concurrent feedback. In other words, while Annett's and Robb's experiments had similar structure, their emphases were quite different.

Annett was most concerned with the fact that supplementary cues ("experimenter-supplied") would interact with the "natural" feedback already inherent within the task (intrinsic). Also, Annett felt that any augmented feedback provided would be useless unless the subject could maintain his attained level of performance once the supplementary cue had been removed (1959:3). Annett used a series of experiments in which he manipulated augmented feedback presented both concurrently and terminally. He was interested in the ability of the subjects to retain a response once the augmented feedback had been withdrawn. His task involved lever pressing in which a specific pressure was to be learned. In the experiments, the subjects underwent a specific number of training trials under varying conditions of augmented feedback. Upon completion of the training period, the supplementary cue was removed and the subjects were tested without the aid of this augmented feedback. From his results, Annett concluded that subjects performed accurately while the supplementary cue was present, but their accuracy declined immediately upon withdrawal of this augmented feedback (1959:12). In one particular experiment, the subjects received augmented feedback for only 50 percent of the training trials. For one group of subjects, the supplementary cue was presented on alternate trials. In the second group, the supplementary cue was presented in alternate blocks of five trials. From his results, Annett found that when the augmented feedback was present only 50 percent of the time, the error during the test trials was reduced (1959:12). Among

several hypotheses Annett felt that the simplest explanation was simply that the subjects were not able to attend to two sets of cues simultaneously. However, he found that some evidence in his experiment demonstrated that simultaneous attention did occur, resulting in an interaction of the two sets of cues; hence the deterioration in performance when one cue was suddenly removed. Annett seemed to support the interaction hypothesis more strongly than the hypothesis of the inability to attend simultaneously to two different cues. In this particular experiment, he was referring to the "feel" of the bar or kinesthesis as the intrinsic cue and the visual information given was the augmented and concurrent feedback.

> If subjects perform poorly on withdrawal of the visual cue simply because they have been attending solely to it and had, therefore, no experience of the 'feel' of the bar one could not predict the direction and extent of subsequent errors. If a subject is asked to estimate something which he has never experienced his estimation might not be random, he might make a guess and repeat this estimate, but one could hardly expect that all subjects would make errors of approximately the same extent and in the same direction. The fact that they do so suggests that subjects are estimating something which they have experienced, but that this experience has been systematically distorted. The subject's remarks and introspections add some support to the latter interpretation. All subjects could apparently feel the bar in the presence of the visual cue and in fact often reported that when the visual cue was removed, the 'feel' of the bar changed (Annett, 1959:13).

Fox and Levy (1969) have published one of the most recent studies involving action and terminal feedback. They conducted two separate line drawing experiments utilizing different forms of action and terminal information. In the first experiment, 144 subjects practiced with either 0, 4, or 12 trials under

action information and were then transferred to terminal information only. From the results the researchers concluded the "the amount of transfer was a negatively accelerated growth function of the number of trials devoted to action feedback training" (Fox and Levy, 1969:169). In other words, as the number of trials increased the mean absolute error decreased. In the second experiment 122 subjects were under one of four types of action or terminal information and were then tested with no information feedback at all. The results showed that none of the group produced any significant decrease in accuracy during the testing period in which no information was received. The conclusions drawn from this study appeared to strongly contradict the findings of Annett in 1959, who found that performance declined when subjects were transferred from action to terminal feedback and concluded that repetition was not a sufficient method under which learning could occur. Just recently, in response to the Fox and Levy study, Annett (1970) published an article in which he attempted to reiterate his position on this matter. He maintained that the results from his study and those from the Fox and Levy study did not differ to a great extent. He explained that "the apparent conflict between the 1959 results and those of Fox and Levy is. . . resolvable in terms of the gross differences in AIF gain between the two experimental tasks" (1970:220). Annett again introduced the hypothesis of interaction.

> There is an intersensory effect such that at some stage in the perceptual process visual and kinesthetic data are combined into a single impression of movement and modification of either visual or kinesthetic data could thus affect the impression (Annett, 1970:218).

Although Annett (1970) attempted to correlate his findings with those of Fox and Levy (1969), his co-researchers were not so considerate in their subsequent article in reply to Annett's effort. Fox and Levy (1970) rejected Annett's theory of data in terms of "AIF gain differences" and maintained that learning did occur when practice occurred under conditions of action information feedback and there was positive transfer when switched to terminal feedback.

Much research has been done in the area of terminal feedback and its wide use has continued to reinforce its value in learning. However, relatively little research has been conducted using action feedback and its value in learning is still controversial. Fox and Levy expressed this viewpoint:

> In any event, the great majority of research supporting the importance of IF for human learning (Bilodeau, 1969) is based upon studies manipulating TIF. The present results should emphasize that under certain conditions AIF, mainly ignored to date, has useful learning properties that warrant further exploration (Fox and Levy, 1969:179).

The limited amount of research that has been conducted concerning action feedback has also introduced the use of supplementary cues (augmented feedback) which are not normally present within the task. The question is whether or not action feedback enhances learning at all when eventually these supplementary cues are removed. However, it is hypothesized that there is action information that is intrinsic or inherent in the task itself. It is not supplementary and is continually present during the performance of the task. This information can be received through various sensory channels (kinesthetic, proprioceptive, visual,

auditory, etc.). The exact value of this type of action information feedback is less valued than that of the supplementary type. Fox and Levy expressed this opinion in their previously cited study:

> While movement produced cues are inherently involved in the arc drawing task, they are of themselves insufficient to produce successive improvements in response accuracy (Fox, 1962). For improvement to occur, S must also be given feedback through an external source, either E or the display (1969:179).

Before the additional factor of supplementary cues is added to action information, it might first be beneficial to determine if the action information inherent in the task itself enhances learning in any way.

CHAPTER IV

PROCEDURE

The purpose of this study was to investigate the relative effects of visual information feedback on learning and on performance of a motor skill when visual information was varied so as to include: (1) action information only, (2) terminal information only, and (3) the combination of both.

APPARATUS CONSTRUCTION

The apparatus used was designed to control the visual feedback conditions of a dart throwing task. It was constructed so that only action information, only terminal information, or a combination of both could be received by the subject. The apparatus consisted of a target, an overhead light, and a photoelectric cell designed to control the overhead light.

The Target

The target surface was constructed of three pieces of ceiling tile. Two of these pieces measured 1' by 6' and the third piece measured 4' by 6'. When placed parallel and held together by a wooden frame, the target surface measured 6' by 6' (Figure 1, page 28).

The actual target face was sixteen inches in diameter. The center circle of the target had a radius of one inch with

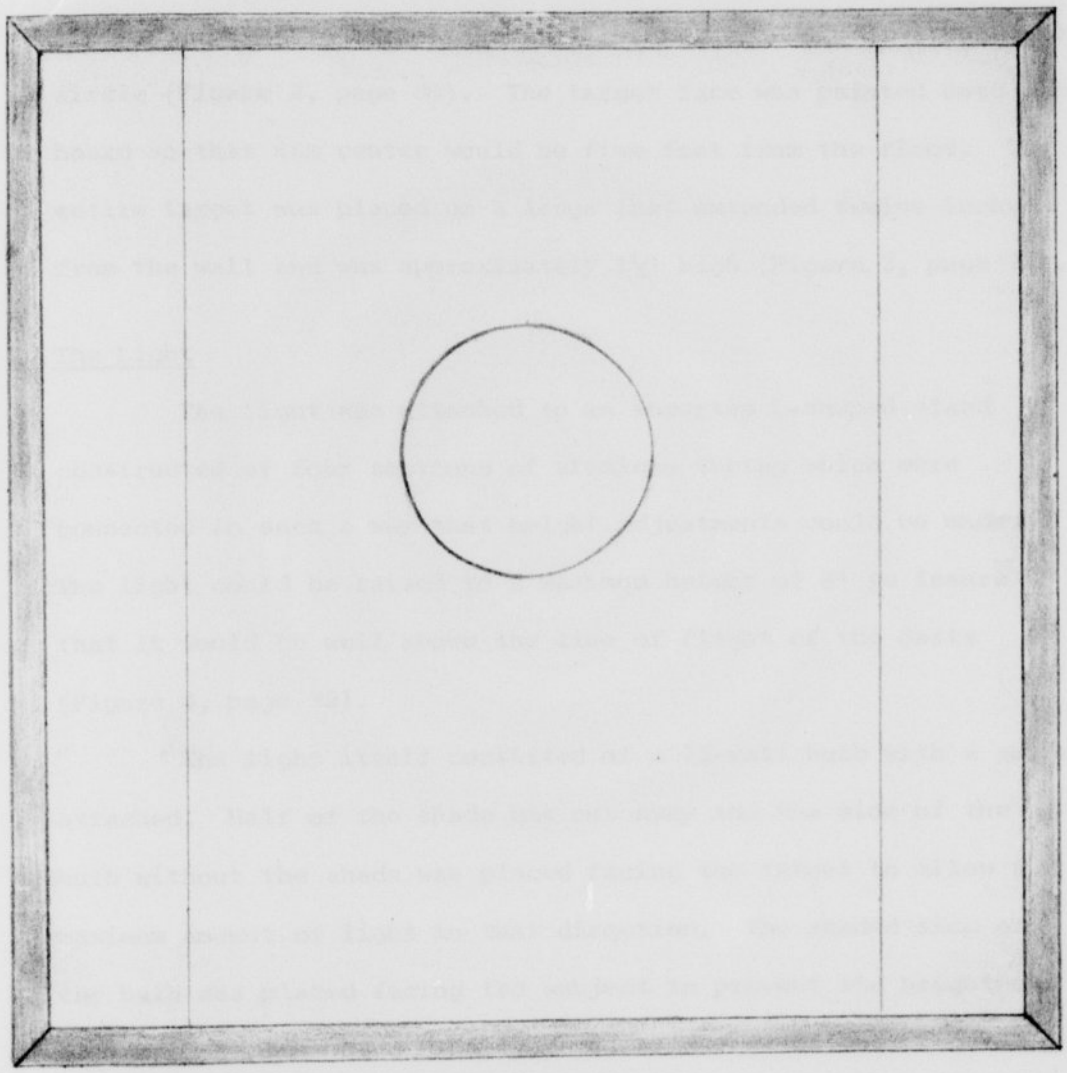

FIGURE 1

THE TARGET

each succeeding circle increased in radius by one inch. The point values corresponding to the circle were 8, 7, 6, 5, 4, 3, 2, and 1 points, with the highest point value corresponding to the center circle (Figure 2, page 30). The target face was painted onto the board so that its center would be five feet from the floor. The entire target was placed on a ledge that extended twelve inches from the wall and was approximately 1½' high (Figure 3, page 31).

The Light

The light was attached to an inverted L-shaped stand constructed of four sections of aluminum tubing which were connected in such a way that height adjustments could be made. The light could be raised to a maximum height of 8' to insure that it would be well above the line of flight of the darts (Figure 4, page 32).

The light itself consisted of a 75-watt bulb with a shade attached. Half of the shade was cut away and the side of the bulb without the shade was placed facing the target to allow a maximum amount of light in that direction. The shaded side of the bulb was placed facing the subject to prevent the brightness of the light from hindering the subject's view of the target.

The stand was placed to the left of the table allowing the arm of the stand (on which the light was attached) to extend over the middle of the throwing area (Figure 4, page 32).

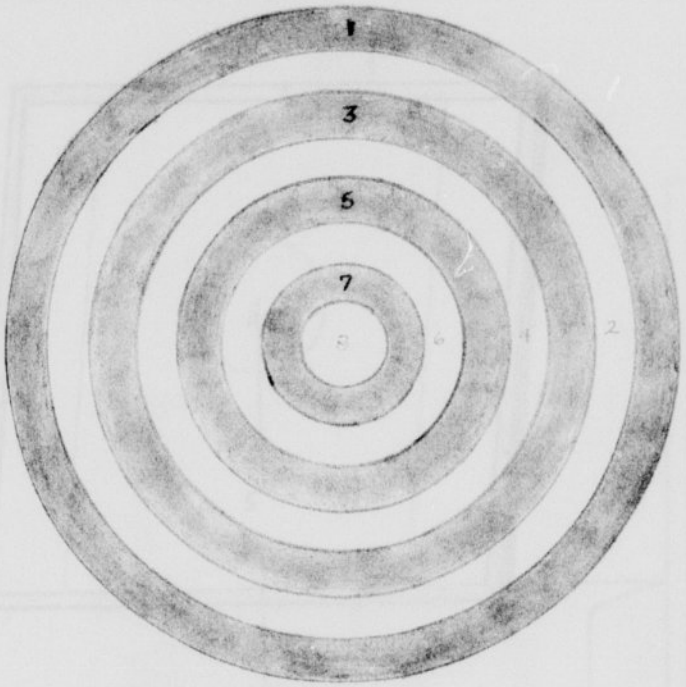

FIGURE 2

THE TARGET FACE

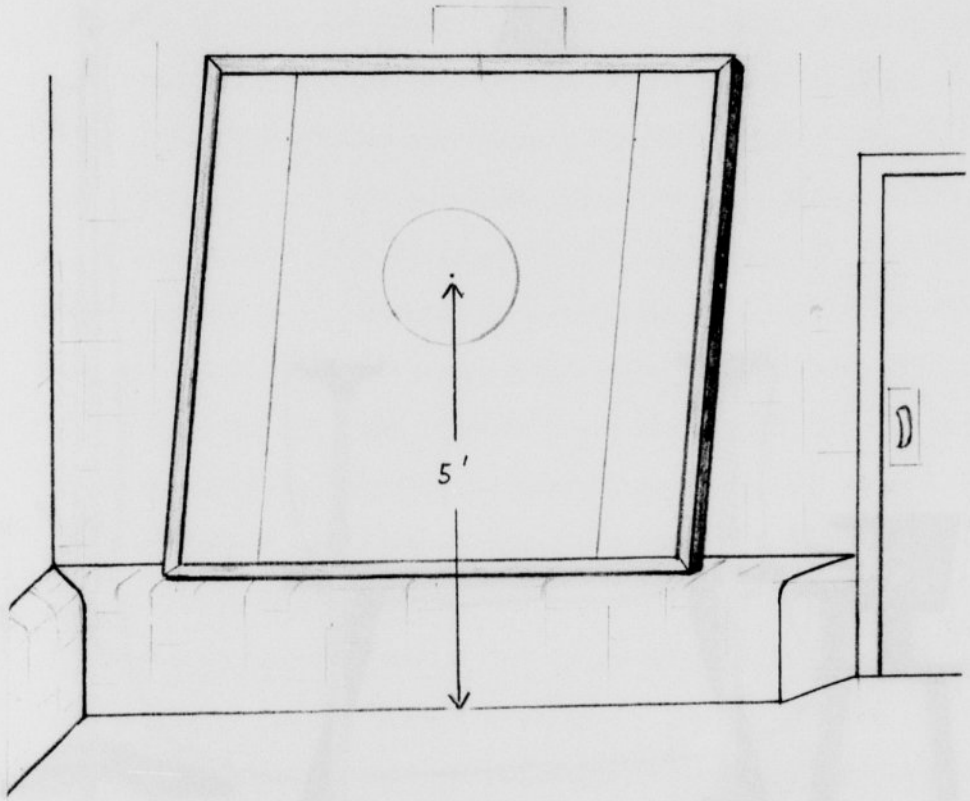

FIGURE 3

PLACEMENT OF THE TARGET

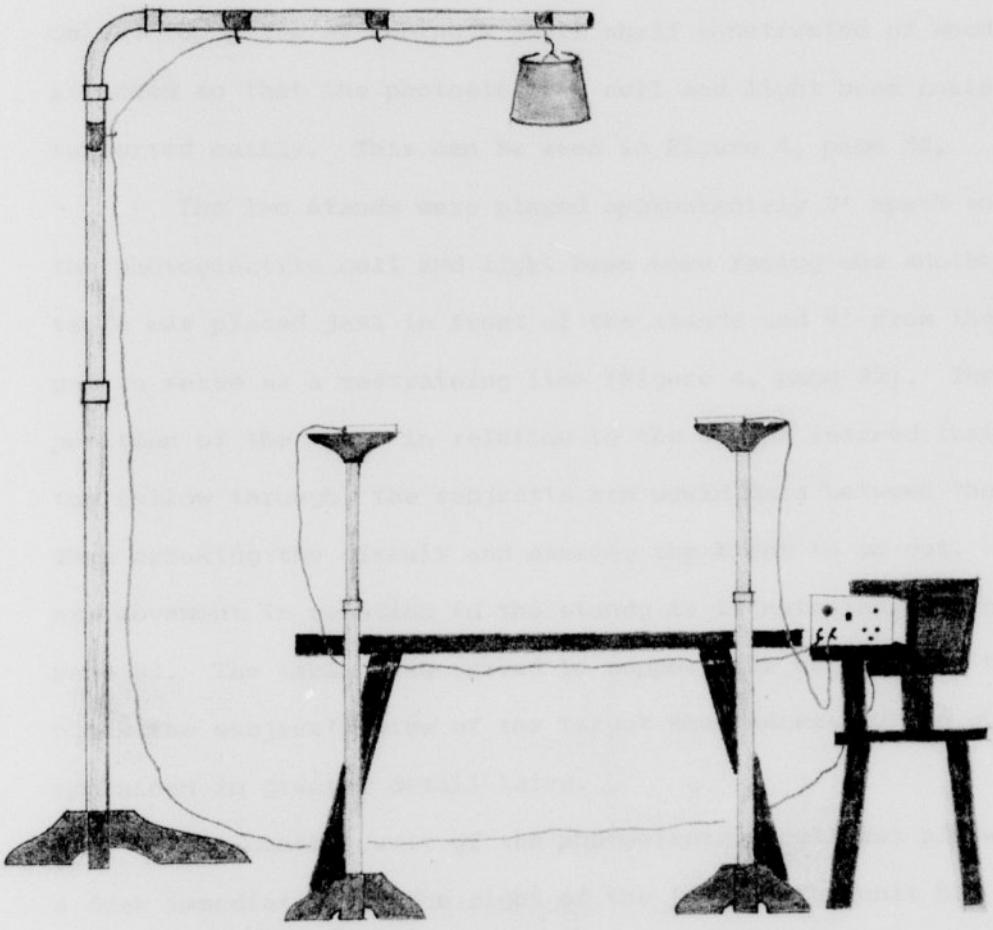

FIGURE 4

PHOTOELECTRIC CELL AND LIGHT

Photoelectric Cell and Stands

The photoelectric cell and light beam were placed on separate stands each of which was constructed of two pieces of aluminum tubing which allowed for necessary height adjustments. On the top piece of tubing a small shelf constructed of wood was attached so that the photoelectric cell and light beam could be supported easily. This can be seen in Figure 4, page 32.

The two stands were placed approximately 3' apart so that the photoelectric cell and light beam were facing one another. A table was placed just in front of the stands and 9' from the target to serve as a restraining line (Figure 4, page 32). The position of the table in relation to the stands insured that on the follow through, the subject's arm would pass between the stands, thus breaking the circuit and causing the light to go out. The arm movement in relation to the stands is illustrated in Figure 5, page 34. The table also served to support the screen used to block the subject's view of the target when necessary and will be explained in greater detail later.

The control unit of the photoelectric cell was placed on a desk immediately to the right of the table. The unit had to be placed next to the table because the wires connecting the cell and light beam to the controls were not of sufficient length to permit farther separation. However, the unit was completely out of the line of flight of the darts and was also well out of the way of the subject.

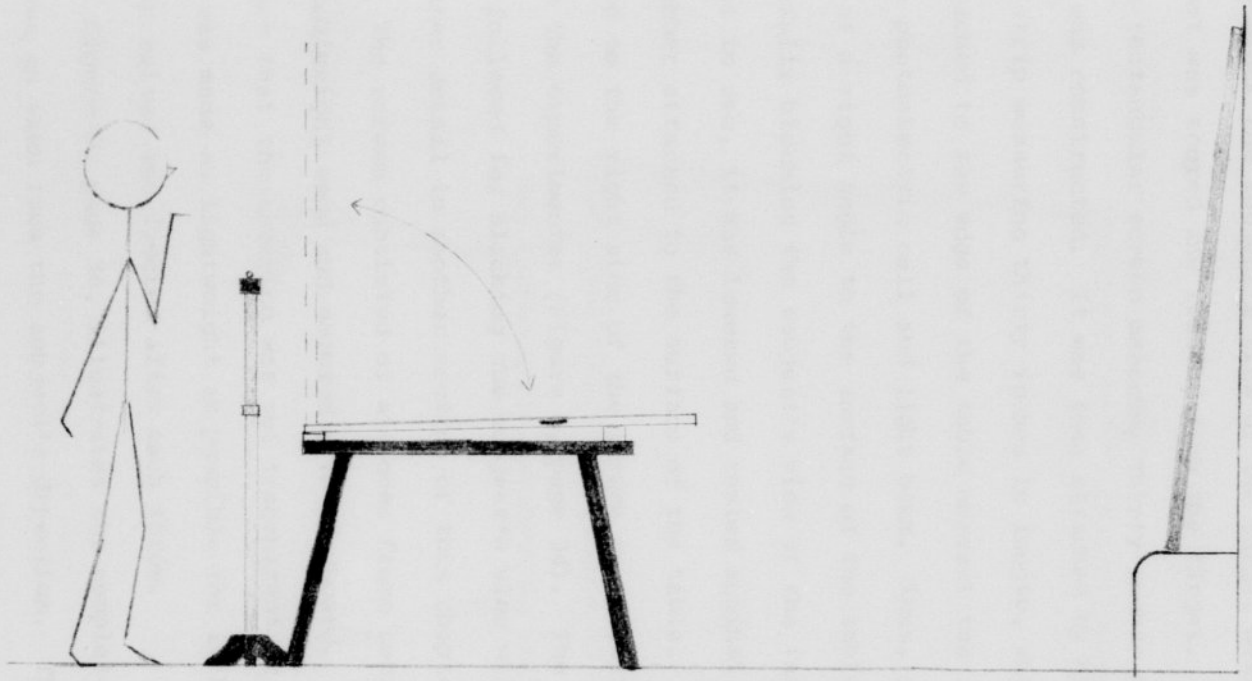

FIGURE 5

SIDE VIEW ILLUSTRATING SCREEN

The Screen

During one of the three practice sessions, it was necessary to block the subject's view of the target while the dart placement was scored and removed from the target. For this purpose, a rectangular screen measuring thirty inches by forty-two inches was constructed. It was then attached by hinges to a wooden strip measuring thirty inches in length, which in turn was attached to the edge of the table nearest the stands supporting the photoelectric cell and light beam. Thus, it could be raised at a right angle to the surface of the table, thereby successfully blocking the subject's view of the target area. When not in use, it was lowered and rested against a layer of foam rubber attached to the surface of the table. A handle was attached to the right side of the screen to facilitate manipulation by the experimenter (Figure 5, page 34). The actual procedure followed for blocking the subject's view will be discussed in greater detail in another section of this chapter.

The screen consisted of a wooden frame constructed of a very lightweight wood and covered with cardboard. Care was taken to insure that the covering was not transparent in any way. The screen was made as lightweight as possible for it had to be manually raised and lowered after each throw.

Figure 6, page 36, illustrates the complete view of the apparatus as seen from the subject's direction. The additional equipment to be discussed in the next section is not pictured.

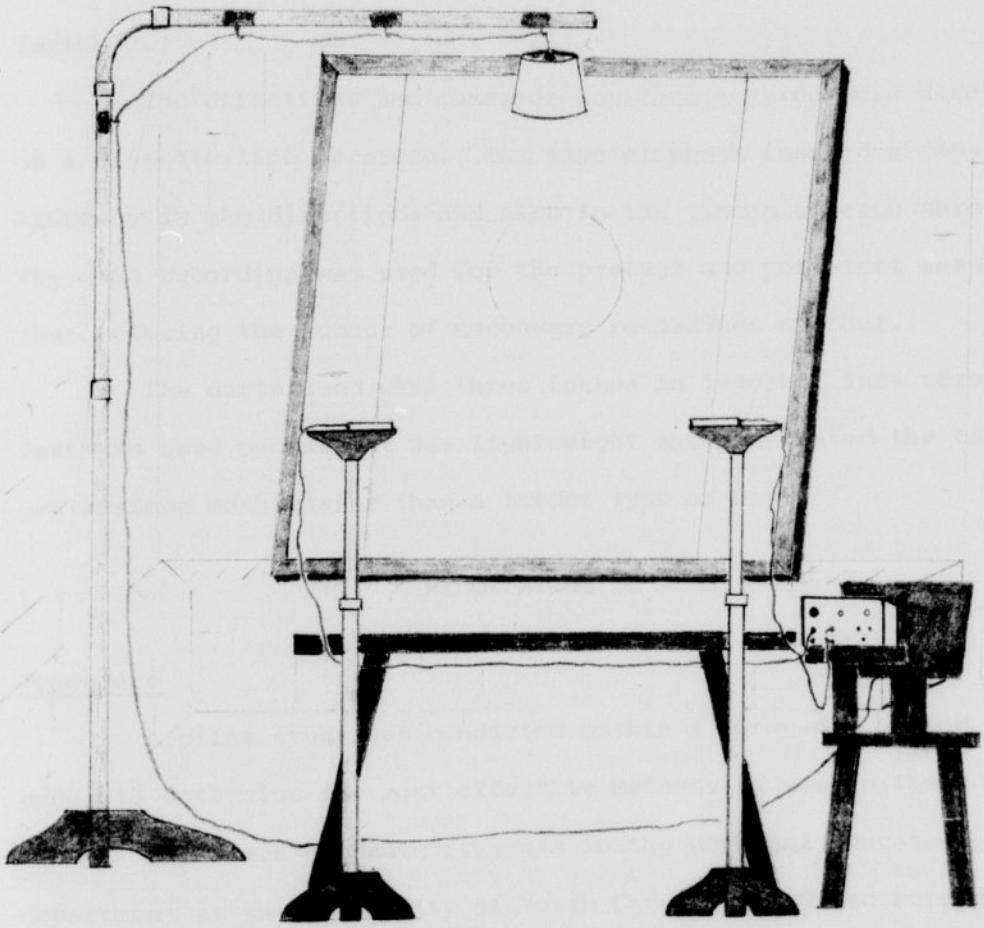

FIGURE 6

ENTIRE TESTING AREA AS SEEN
FROM SUBJECTS' VIEWPOINT

Additional Equipment

Earphones were necessary in order to eliminate any auditory feedback that the subject would normally receive. The earphones used were adjustable and could be fitted to each subject comfortably.

The directions and commands for each session were recorded on a cassette tape recorder. The tape playback insured a consistency in the directions and also in the timing of each throw. The same recording was used for the pretest and post-test sessions, thus reducing the number of necessary recordings to four.

The darts used were three inches in length. This size dart was used because it was lightweight and penetrated the target surface much easier than a larger type of dart.

PILOT STUDY

Procedure

A pilot study was conducted within a three-day period in order to determine the most effective methods to use in the actual study. Six women graduate students in the physical education department at the University of North Carolina at Greensboro were used. Two different subjects were used for each progressive order of the experimental conditions. There were three feedback conditions: (1) action information; (2) terminal information; and (3) a combination of both. There were three progressive orders (1-2-3; 2-3-1; 3-1-2). On the first day of the pilot study, each subject was given a pretest consisting of fifty throws under

"normal" conditions (continuous visual feedback). During the second day each subject practiced on three separate occasions - once under each specific condition but in the progressive order to which she was assigned. Care was taken to make sure that each practice period was separated by three or four hours so as to resemble the conditions planned for the actual study (a separate condition each day). On the third day each subject was given a post-test identical to the pretest given on the first day.

Results

Many adjustments were made in the procedure of the actual study due to influencing factors revealed during the pilot study.

The first problem which arose was an inconsistency of the photoelectric cell in breaking the circuit, and thereby varying the visual conditions. Adjustments were made in the length of the light beam to be interrupted, its height in relation to the subject's arm, and the sensitivity of the cell.

The light beam to be interrupted was originally about 3' long. It was discovered that this distance necessitated an extremely high sensitivity setting which caused an inconsistency in the breaking of the circuit. With the high sensitivity almost any movement near the light beam would break the circuit. It was found that if the light beam were shortened a lower sensitivity could be used, thereby eliminating circuit breaking by means other than the subject's planned movement. The most effective distance was found to be approximately 2'. This was the closest distance

that could be achieved and still allow the subject to be comfortable as she threw each dart. In conjunction with the appropriate apparatus length for each individual, the sensitivity setting also had to be adjusted. A setting which operated accurately for one individual did not necessarily operate accurately for another individual. If the control was set too low, the movement of the arm, when passing through the light beam, had to be very slow. This would naturally inhibit the normal swing of a subject. If the setting was too high, the margin of error in lining up the cell with the light was decreased, making it very difficult to control the breaking of the circuit consistently. It was decided that some type of practice trial or throws would have to be allowed in order to determine the best setting for each individual.

An additional factor influencing the effectiveness of the photoelectric cell was the portion of the arm that passed through the beam on the forward swing. The stands had to be adjusted in height so that the midpoint of the arm between the wrist and elbow would pass through the beam. If the point was close to the hand or the elbow, the variations in performance from throw to throw occasionally caused the arm to fail to pass through the beam.

In order to better control visual feedback under action information, it was found that an old target should be used. The subjects in the pilot study that were given a new target each time said that they frequently received terminal feedback by simply viewing where the hole from the preceding trial appeared on the target after the light was turned back on. Since the purpose of

having the light cut off was to deprive the subject of all terminal feedback, it was decided the same target, with a great number of punctures, would be used each time to minimize terminal feedback under this practice condition.

An attempt was made to eliminate auditory feedback through the use of earphones, but it was found to be an ineffective method. Several subjects could tell approximately where the dart landed just by the sound of impact. Some subjects could tell whether the dart landed on or off the actual target face through auditory feedback only. This finding revealed two aspects--first, it reinforced the hypothesis that auditory feedback was definitely a factor and would have to be eliminated, and second, it revealed that the earphones used during the pilot study were ineffective and would have to be replaced. A possible solution to this problem was simply to paint the target onto the surface of the target area. This would also eliminate the visual problem occurring when new targets were used.

The use of a tape recorder in giving instructions and commands during the study was found to be both effective and consistent. The use of the recorder also eliminated the need for an additional person during the pretest, the practice condition of both terminal and action, and the post-test. Therefore, an additional person was needed only during two practice sessions (action information and terminal information).

Ten seconds was found to be the minimum amount of time between throws that would permit scoring and apparatus adjustments.

Several subjects appeared restless because of the ten-second delay; and commented on this time lapse during the pretest and post-test. However, under action and terminal information practice conditions, it was not possible to shorten the time factor below ten seconds - ten seconds were needed for scoring and resetting the control switch. This time interval, hence subject restlessness, may be considered as a slight limitation; however, it could not be avoided if consistent conditions were to be maintained under each practice condition.

A one-minute rest period was given after every twelve throws and was determined during the pilot study to be a sufficient amount of time. Some type of rest was needed to allow the subject to relax. However, a period longer than one minute seemed to result in increased restlessness of the subjects and to defeat the purpose of the rest period.

The eight-point system on the target used was also found to be adequate and could be effectively scored within the ten seconds between throws. Eight circles provided good discrimination in ability, yet could be scored fairly easily.

Limitations of the Pilot Study

1. The subjects used were all graduate students in physical education. However, the specific purpose of the pilot study was to determine the most effective methods of experimental procedure, not to solve the problem.
2. The experiment was carried out within a three-day period

rather than the five-day period established for the actual study. However, this could not be avoided in the pilot study due to the time schedule of the subjects. As was mentioned earlier, care was taken to have the subjects practice with as much of a time lapse between each session as was possible within their daily schedule.

TESTING PROCEDURE

Selection of Subjects

A random sampling of sixty women was taken from the on-campus freshman women at the University of North Carolina at Greensboro. An introductory letter was sent to each of these sixty women explaining that they had been selected to participate in an experiment and would be contacted by phone. Approximately six days prior to each week of testing, calls were made to those selected until eight women were obtained (eight being the maximum number of subjects that could be tested per week). The remainder of the list not contacted by phone was held over until the following week of testing. Once the original list of sixty was exhausted a new list was compiled and letters sent. This procedure was followed until the experiment was complete. During the six weeks of testing, a total of forty-eight women participated.

As each subject was contacted by phone, a convenient schedule for the week was arranged according to the individual's class hours. On the Friday preceding the week of testing, an additional

letter was sent to the subjects reminding them of the time and place of testing. Included with this letter was a map of the gymnasium and a copy of their schedule for the entire week. On the Sunday preceding each week, an additional phone call was made to the eight subjects to make sure that they had received the information and were still planning to participate.

Procedure

Organization of groups and practice sessions. Three groups, each consisting of sixteen subjects, were used for this experiment. Since only eight persons could be tested per week, two weeks were necessary for the completion of each group. The groups were distinguished by the progressive order in which they practiced under the three feedback conditions (1 - action information; 2 - terminal information; and 3 - a combination of both). The three progressive orders were: 1-2-3; 2-3-1; and 3-1-2.

The first day of the week each subject was given a pretest in which she received continuous visual information feedback. The purpose of the pretest was to determine the initial level of skill. On the second day of the testing (Tuesday), each subject began practicing under one of the three feedback conditions. One day of practice was spent under each of the three conditions with the progressive order of these practice conditions determined by the group number to which the subject was assigned. On the fifth and final day of testing (Friday), each subject was given a post-test identical to the pretest.

Figure 8, page 45, is a diagrammatical schedule of the six weeks necessary for the completion of the experiment.

Organization of sessions. Each subject was scheduled for a one-half hour session per day. Although the length of time necessary for giving instructions varied slightly each day, one-half hour was sufficient for completion of each session. The cassette tape recorder was used for the instructions and for the commands to throw which were given every ten seconds. Each subject threw fifty darts per day, with a rest period of one minute duration after every twelve throws. Figure 7 illustrates the order of practice used for each session and the amount of time necessary for each section involved.

Time	Order of Sessions
2 min.	First group of twelve throws
1 min.	Rest period
2 min.	Second group of twelve throws
1 min.	Rest period
2 min.	Third group of twelve throws
1 min.	Rest period
2 min. 20 sec.	Fourth group of fourteen throws

FIGURE 7

ORDER OF SESSIONS

	Monday	Tuesday	Wednesday	Thursday	Friday	
1st week	eight subjects PRETEST	1 AIF	2 TIF	3 AIF-TIF	POST-TEST	GROUP # 1
2nd week	eight subjects PRETEST	1 AIF	2 TIF	3 AIF-TIF	POST-TEST	
3rd week	eight subjects PRETEST	2 TIF	3 AIF-TIF	1 AIF	POST-TEST	GROUP # 2
4th week	eight subjects PRETEST	2 TIF	3 AIF-TIF	1 AIF	POST-TEST	
5th week	eight subjects PRETEST	3 AIF-TIF	1 AIF	2 TIF	POST-TEST	GROUP # 3
6th week	eight subjects PRETEST	3 AIF-TIF	1 AIF	2 TIF	POST-TEST	

FIGURE 8

TESTING SCHEDULE

INDIVIDUAL SESSIONS

Pretest

During the first practice session, a pretest was administered to each subject to determine her initial level of ability in dart throwing. Instructions were given through the use of the cassette tape recorder. The recorder was stopped after the instructions were completed so that any questions could be answered. Once all questions had been answered, the recorder was again turned on and the testing began. Every ten seconds the command "ready, go" was given on the recorder, at which time the subject threw a dart. After each throw the experimenter removed the dart from the target and scored the trial-result on the sheet provided. After each twelve throws for the first three series had been completed, a one-minute rest period was provided. In the final series of throws of each session, fourteen darts were thrown so that the total of thrown darts per session would be fifty (12 x 3 + 14).

The photoelectric cell and stands, the screen, and the earphones used for the experimental conditions were not used for the pretest and post-test so that normal throwing conditions could be as closely approximated as possible. The only equipment set up for the pretest was the target, the light and the control box, and the table and desks. The table served as a barrier to the subject to augment the restraining line taped on the floor. One desk was used to support the control box for the overhead light and the other was used to support the tape recorder and the container for the darts.

Action Information Feedback (AIF)

During this practice session, the subject was to receive visual information of the throwing act itself, without terminal information feedback (knowledge of results). The photoelectric cell was necessary to control this feedback condition. As shown in previous diagrams (Figure 4, page 32, and Figure 6, page 36), the photoelectric cell and light beam were each placed on a stand and positioned opposite one another, one on each side of the table. The stands were placed so that the subject's arm would pass between the photoelectric cell and light beam as the dart was released on the forward swing. As the subject's arm passed between the photoelectric cell and light beam, the circuit controlling the overhead light was broken, causing the light to go off. The subject did not see anything beyond the point of release of the dart, therefore, she did not receive any terminal visual information concerning the results of her trials.

The instructions and commands were given on the cassette tape recorder. The basic procedure for the session was the same as the pretest, although some additions were made to facilitate control of the feedback and the scoring. Each subject threw a dart every ten seconds as the command "ready, go" was given. After each twelve throws for the first three series were completed, a one-minute rest period was provided. The last series of throws included two extra darts or fourteen so that each subject threw a total of fifty darts. Immediately after the release of the dart on each throw, the light went out. As the dart hit the target,

the experimenter seated at the desk which supported the control box raised the screen (Figure 5, page 34) to conceal the target from the thrower when the light came back on. After the screen was in place, the light was switched on and the scorekeeper removed the dart and scored the trial on the sheet provided. When the command "down" was given on the recorder, the experimenter lowered the screen and reset the circuit switch on the control box. This procedure was followed for each throw.

During this session, all the equipment shown in Figure 6, page 36, was used. In addition, the subject wore the earphones provided to exclude as much auditory feedback as possible. Once the subject had the earphones comfortably in place, the volume of the tape recorder was increased so that the subject could adequately hear the commands.

Terminal Information Feedback (TIF)

During this practice session, the subject was allowed visual information of the terminal result of her throw without visual action information feedback. In other words, the room was dark during the act of throwing and the light was turned on immediately as the dart hit the target.

The basic procedure for this session was identical to that followed in all other sessions; however, some additions were made to the commands to facilitate the control of the light and the scoring of each dart. The instructions and commands were given through the use of the cassette tape recorder. As in all other sessions, the subject threw a dart every ten seconds as the command

"ready, go" was given. After the first three series of twelve throws, a one-minute rest period was given. The last series consisted of fourteen throws of darts, so that the subject would complete a total of fifty darts per session. The command "off" was provided on the recorder approximately five seconds before each throw. This command served as a signal to indicate when the light should be turned off prior to each throw. The light was manually controlled by the experimenter who was seated at the desk which supported the control box. As the command "ready, go" was given, the subject threw a dart. As the dart hit the target, the experimenter immediately switched the light on and thus provided the subject with the visual end-result of her throw. As the light was turned on, the scorekeeper removed the dart from the target and scored it on the sheet provided. This procedure was followed for each throw.

The photoelectric cell and light beam were the only pieces of apparatus that were not necessary for the control of this condition. All other equipment was in place including the screen and the stands which normally contained the photoelectric cell and light beam. The earphones were necessary in order to eliminate as much auditory feedback as possible. Once the subject had the earphones on, the volume of the tape recorder was increased so that the subject could understand the commands.

A Combination of Both Types of Information Feedback (Both)

During this practice session, the subject was given both action information feedback and terminal information feedback. In

other words, each subject was allowed complete visual feedback. This practice session followed the same procedure as all other sessions. The instructions and commands were given through the use of the cassette tape recorder. Each subject was instructed to throw a dart every ten seconds as the command "ready, go" was given. The last series of throws of each session included fourteen dart throws, or two additional, so that a total of fifty darts were thrown per session. As each dart was thrown, the experimenter removed the dart from the target and scored it on the sheet provided.

All the equipment shown in Figure 6, page 36, except the photoelectric cell and light beam, remained in place. The photoelectric cell and light beam were not necessary for the control of the feedback conditions.

Post-Test

The post-test was administered during the last practice session. Statistical comparison between the pretest and post-test was made to determine if any degree of change in scores had occurred.

The procedure for the post-test was identical to the pretest and will not be repeated here.

TREATMENT OF DATA

To determine whether or not a significant amount of learning occurred during the experiment, pretest and post-test scores

were compared using Fisher's "t" test of significance of difference between means for correlated groups.

A one-way analysis of variance was used to equate the groups on the basis of the pretest scores.

Fisher's "t" test was also used between groups and treatments to determine if any significant differences were present.

A two-way analysis of variance using a three by five factorial design was used on all the scores to determine if the order of practice influenced the amount of learning.

CHAPTER V

ANALYSIS AND INTERPRETATION OF DATA

The purpose of this study was to investigate the relative effects on learning and on performance of a motor skill when visual feedback was limited to: (1) action information feedback, (2) terminal information feedback (knowledge of results), and (3) a combination of both types of information feedback.

Forty-eight female subjects from the freshman class at the University of North Carolina at Greensboro were randomly selected for this experiment. The subjects were divided into three groups with sixteen subjects in each group. Each group was distinguished by the progressive order of the feedback conditions under which they practiced. The three feedback conditions were: (1) action information, (2) terminal information, and (3) a combination of both, and the three progressive orders were as follows: 1-2-3; 2-3-1; and 3-1-2 (see Figure 7, page 45). Each subject was given a pretest on the first day of practice. On the second day of practice, each subject began practice under the experimental feedback conditions according to the progressive order assigned to her group. One day of practice was spent under each feedback condition. On the fifth day of practice, each subject was given a post-test.

Four null hypotheses were developed and a significance of difference at the .05 level of confidence was determined as an adequate criterion for determining whether the null hypotheses were tenable. The four hypotheses were:

1. There was no significant difference between the three groups of subjects on the basis of pretest scores.
2. There was no significant difference between the scores on the pretest and post-test.
3. There was no significant difference with respect to the order of practice of the three experimental conditions (1-2-3; 2-3-1; and 3-1-2).
4. There was no significant difference in performance among the practice conditions (pretest, action information, terminal information, a combination of action and terminal, and post-test).

Groups

A one-way analysis of variance was performed using the pretest scores to determine if there was a significance of difference between any of the three groups of subjects. The results were not significant at the .05 level of confidence, therefore, the null hypothesis that there was no difference between the three groups on the basis of pretest scores was found tenable. The results can be seen in Table I, page 54.

TABLE I

ANALYSIS OF VARIANCE BETWEEN
PRETEST SCORES OF ALL GROUPS

Source of Variance	Sum of Squares	df	Mean Square	F
Between	7324.1647	2	3662.0823	2.0668
Within	69099.9544	39	1771.7937	
Total	76424.1191	41		

Pretest and Post-test Scores

Fisher's "t" test of significance of difference between correlated mean differences was used to determine if there was significant difference between the pretest and post-test scores within each group. The results on each of the three calculations were not statistically significant at the .05 level of confidence. Therefore, the null hypothesis that there was no difference between pretest and post-test scores within each group was found tenable.

Fisher's "t" test of significance of difference between correlated mean differences was also used on the total scores. Mean differences were not significant at the .05 level of confidence, therefore, the null hypotheses of no difference between pretest and post-test scores was again found tenable. Results can be seen in Table II, page 56.

Order of Practice

A two-way analysis of variance using a three by five factorial design was used to test the null hypothesis that there was no significant difference with respect to the order of practice of the three experimental conditions (1-2-3; 2-3-1; and 3-1-2). The results were significant at the .05 level of confidence, therefore, the null hypothesis of no difference was rejected. The statistical results are shown in Table III[a], page 57.

The Scheffé method was used to determine where the significant differences were in regard to the order of practice conditions. Calculations indicated that group one which had the order of practice 1-2-3 and group three which had the order of practice 3-1-2 performed

TABLE II

MEAN DIFFERENCE AND SIGNIFICANCE OF DIFFERENCE BETWEEN PRETEST AND POST-TEST SCORES

Group	N	M_D	t
Group 1	15	-4.2000	-.4533
Group 2	13	+17.2308	+1.3650
Group 3	14	-10.0000	-1.2180
Combined groups	42	+.5000	+.0842

TABLE III[a]

ANALYSIS OF VARIANCE BETWEEN
PRACTICE AND GROUP SCORES

Source of Variance	Sum of Squares	df	Mean Square	F
Between groups	15631.896	2	7815.948	4.4456*
Between practices	483024.943	4	120756.235	68.6853*
Interaction	6752.254	8	844.031	0.4800
Error	342831.190	195	1758.108	
Total	848240.283	209		

*Significant at the .05 level of confidence.

TABLE III[b]

DIFFERENCE BETWEEN PRACTICE GROUP MEANS
AND CALCULATED SCHEFFÉ VALUES

Groups	Means	Difference	Scheffé
III	155.428		
vs.		18.582	17.7570*
II	136.846		
III	155.428		
vs.		.508	17.1445
I	154.920		
I	154.920		
vs.		18.074	17.5452*
II	136.846		

*Significant at the .05 level of confidence.

significantly better than group two which had the order of practice 2-3-1. The statistical results are shown in Table III[b], page 57.

Experimental Conditions

The two-way analysis of variance using a three by five factorial design was also used to test the null hypothesis that there was no significant difference in performance among the practice conditions (pretest, action information, terminal information, a combination of action and terminal information, and post-test). A statistical difference between scores of the practice conditions was found to be significant at the .05 level of confidence, therefore, the null hypothesis was rejected. The results can be seen in Table III[a], page 57.

Fisher "t" test of significance of difference between correlated mean differences was used to determine where the significant differences were in regard to the practice conditions. Statistical calculations were performed on the three individual group scores, as well as on a combination of group scores. Significant differences at the .05 level of confidence were found between the following conditions: (1) pretest and action information, (2) pretest and terminal information, (3) action information and a combination of action and terminal information, (4) action information and post-test, (5) terminal information and a combination of action and terminal information, and (6) terminal information and post-test. In addition to the above differences, group one also had a statistical difference between a combination of action and terminal

information and the post-test significant at the .05 level of confidence. This difference was not found in groups two and three. All other comparisons using Fisher's "t" test were not significant. Results of groups one, two and three are shown in Tables IV, V, and VI on pages 60, 61, and 62, respectively. Table VII, page 63, contains the results for the combined group totals and Table VIII, page 64, provides the "t" ratios for all three groups and the combination of groups.

Interpretation of Data

The analysis of variance technique utilized on the pretest scores indicated that there was no significant difference between groups at the beginning of the experiment.

Fisher's "t" test of significance of difference between correlated mean differences indicated that no significant learning occurred during the five days of the experiment. Therefore, this writer must conclude that one practice session per experimental condition was not a sufficient length of time for significant learning to occur. Any further conclusions that are stated must, therefore, be concerned with performance rather than with learning.

The order of practice (1-2-3; 2-3-1; and 3-1-2) was an additional variable that was considered. The analysis of variance indicated that the order of practice did have an effect upon the performance of the groups. Groups I and III performed significantly better than group II. In groups I and III, the order of practice was such that complete visual feedback (pretest, a combination of

TABLE IV

MEAN DIFFERENCES AND SIGNIFICANCE OF DIFFERENCE BETWEEN PRACTICES FOR GROUP I

Practices	N	M_D	t
Pretest - AIF	15	-97.5333	-5.6400*
Pretest - TIF	15	-114.7333	-7.2122*
Pretest - both	15	-17.2666	-1.7973
Pretest - post-test	15	-4.2000	-.4533
AIF - TIF	15	-17.2000	-1.6252
AIF - both	15	+80.2666	+4.9371*
AIF - post-test	15	+93.3333	+5.4009*
TIF - both	15	+97.4666	+6.9956*
TIF - post-test	15	+110.5333	+7.3021*
Both - post-test	15	+13.0666	+2.3334*

*Significant at the .05 level of confidence.

TABLE V

MEAN DIFFERENCES AND SIGNIFICANCE OF DIFFERENCE BETWEEN PRACTICES FOR GROUP II

Practices	N	M_D	t
Pretest - AIF	13	-83.6923	-4.5176*
Pretest - TIF	13	-104.8461	-7.5305*
Pretest - both	13	+1.3076	+.1065
Pretest - post-test	13	+17.2307	+1.3650
AIF - TIF	13	-21.1538	-1.0945
AIF - both	13	+89.4615	+6.0380*
AIF - post-test	13	+100.9230	+6.2219*
TIF - both	13	+106.1538	+11.4804*
TIF - post-test	13	+122.0769	+12.8202*
Both - post-test	13	+15.9230	+2.1570

*Significant at the .05 level of confidence.

TABLE VI

MEAN DIFFERENCES AND SIGNIFICANCE OF DIFFERENCE BETWEEN PRACTICES FOR GROUP III

Practices	N	M_D	t
Pretest - AIF	14	-95.7857	-8.6498*
Pretest - TIF	14	-97.5000	-11.6447*
Pretest - both	14	-7.3571	-1.6332
Pretest - post-test	14	-10.0000	-1.2180
AIF - TIF	14	-1.7142	-.1616
AIF - both	14	+95.8571	+9.2258*
AIF - post-test	14	+85.7857	+6.5120*
TIF - both	14	+97.5714	+11.2242*
TIF - post-test	14	+87.5000	+13.6731*
Both - post-test	14	+10.0714	+1.1221

*Significant at the .05 level of confidence.

TABLE VII

MEAN DIFFERENCES AND SIGNIFICANCE OF DIFFERENCE BETWEEN PRACTICES FOR COMBINED GROUPS

Practices	N	M_D	t
Pretest - AIF	42	-92.6666	-10.2701*
Pretest - TIF	42	-105.9285	-14.0191*
Pretest - both	42	-8.2142	-1.5400
Pretest - post-test	42	+.5000	+.0842
AIF - TIF	42	-13.2619	-1.6969
AIF - both	42	+88.3095	+10.9901*
AIF - post-test	42	+93.1666	+10.4494*
TIF - both	42	+100.1904	+15.8825*
TIF - post-test	42	+106.4285	+15.7966*
Both - post-test	42	+6.2380	+1.3760

*Significant at the .05 level of confidence.

TABLE VIII

SIGNIFICANCE OF DIFFERENCES
FOR ALL GROUPS

Conditions	Group 1 N = 15	Group 2 N = 13	Group 3 N = 14	Combined N = 42
Pretest - AIF	-5.6400*	-4.5176*	-8.6498*	-10.2701*
Pretest - TIF	-7.2122*	-7.5305*	-11.6447*	-14.0191*
Pretest - both	-1.7973	+.1065	-1.6332	-1.5400
Pretest - Post-test	-.4533	+1.3650	-1.2180	+.0842
AIF - TIF	-1.6252	-1.0945	-.1616	-1.6969
AIF - both	+4.9371*	+6.038 *	+9.2258*	+10.9901*
AIF - post-test	+5.4009*	+6.2219*	+6.5120*	+10.4494*
TIF - both	+6.9956*	+11.4804*	+11.2242*	+15.8825*
TIF - post-test	+7.3021*	+12.8202*	+13.6731*	+15.7966*
Both - post-test	+2.3334*	+2.1570	+1.1221	+1.3760

*Significant at the .05 level of confidence.

action and terminal and post-test) was received on two consecutive days. Subjects in group I practiced first under the condition of a combination of both action and terminal feedback. Subjects in group III practiced under the condition of a combination of action and terminal feedback on the fourth day followed by the post-test on the fifth day. Subjects in group II never practiced under complete visual feedback for two successive days. The analysis further indicated that there was a significant difference in performance among the experimental conditions (pretest, action information, terminal information, a combination of action and terminal information, and the post-test). Fisher's "t" test of difference between correlated mean differences indicated that performance was better during the practice under complete visual information feedback than performance during practice under incomplete visual information feedback (either action information or terminal information only). The Fisher's "t" test also indicated that there was no signficiant differences in performance under the two incomplete practice conditions of action information only and terminal information only. Group I did perform significantly better during the practice under a combination of action and terminal feedback than during the post-test. All other comparisons of performance, when there was complete visual information feedback, revealed no significant differences and, therefore, no apparent reason can be projected except chance fluctuation for the significant difference found between the Group I combination of action and terminal information and post-test scores.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the relative effects on learning and on performance of a motor skill when visual information feedback was limited to: (1) action information feedback, (2) terminal information feedback (knowledge of results), and (3) a combination of both types of information feedback.

The subjects for this experiment were forty-eight female students who were randomly selected from the freshman class at the University of North Carolina at Greensboro. The subjects were divided into three groups of sixteen subjects in each group. Each group was distinguished by the progressive order of the feedback conditions under which it practiced. The three feedback conditions were: (1) action information, (2) terminal information, and (3) a combination of both, and the three progressive orders were: 1-2-3; 2-3-1; and 3-1-2. On the first day of practice, each subject was given a pretest to determine her initial level of skill. On the second day, each subject began practice under the experimental feedback conditions according to the progressive order assigned to her group. One day of practice was spent under each of the three experimental conditions. On the fifth and last day of practice, each subject was given a post-test to determine her final level of skill.

The analysis of variance and Fisher's "t" test of significance of difference between correlated mean differences were the statistical calculations used to determine if:

1. There was a difference between scores on the pre-test and post-test.
2. The order of practice of the three experimental conditions (1-2-3; 2-3-1; and 3-1-2) affected learning and performance.
3. There was a difference in performance among the various practice conditions (pretest, action information feedback, terminal information feedback, a combination of both action and terminal information feedback, and post-test).

The Fisher's "t" test of significance of difference between correlated mean differences was used to determine if there was a significant difference between the pretest and post-test scores. No significant differences were found, therefore, it was concluded that no significant amount of learning occurred. From this conclusion, it was apparent that one day of practice for each experimental condition (action information, terminal information, and a combination of action and terminal information) was not a sufficient length of time for learning to occur. Thus, any further conclusions must be concerned with performance only.

A two-way analysis of variance with a three by five factorial design was used to determine if the order of practice

(1-2-3; 2-3-1; and 3-1-2) or the experimental conditions (pretest, action information, terminal information, a combination of action and terminal, and post-test) affected performance. The analysis indicated that the order of practice did have a significant effect upon performance. The groups (I and III) that received two successive days of complete visual feedback (pretest, a combination of action and terminal, and post-test) performed significantly better than the group (II) that did not receive two successive days of complete visual feedback. The analysis further indicated that performance was significantly affected by the type of practice. In all instances, performance was better during practices in which complete visual information feedback (pretest, a combination of action and terminal, and post-test) was received, than during practices in which incomplete visual information feedback (action information or terminal information) was received.

From the above information, it can be concluded that complete visual information feedback was more valuable to performance than incomplete information feedback.

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APPENDIXES

APPENDIX A

Correspondence

, 1971

Miss ,

You have been randomly selected to participate in a research experiment to be conducted in the physical education department at the University of North Carolina at Greensboro.

This experiment, involving dart throwing, will require approximately one-half hour of your time for five days (Monday through Friday). The week and time of day that you will participate will depend upon your class schedule. I will be contacting you by phone within the next several days to determine your willingness to participate and to make convenient arrangements concerning your schedule of participation. Also, at that time, I will be able to clear up any questions that you might have.

I think that you will find this an interesting experiment, and an enjoyable experience. I shall deeply appreciate your assistance in this project.

Sincerely yours,

Emma Jean Howard, Graduate Student
Physical Education Department

April 3, 1971

Dear Miss

Due to the Easter holidays, I was unable to contact you concerning your participation in my research project to be conducted in the physical education department. However, I will be contacting you by phone shortly after we return from the holidays to determine your willingness to assist me in this experiment.

Thank you for your patience. I am looking forward to talking with you upon your return to school.

Sincerely yours,

Emma Jean Howard

, 1971

Dear Miss

Enclosed is a map with the directions to the testing room which is located in the girls' locker room across from the dance studio. Also enclosed is a schedule listing the time of your participation. If you have any questions, please feel free to call me in Spencer Annex Dormitory. The number is 5197.

I enjoyed talking with you on the phone, and I am looking forward to working with you beginning Monday, _____.

Thank you again for your assistance.

Sincerely yours,

Emma Jean Howard, Graduate Student
Physical Education Department

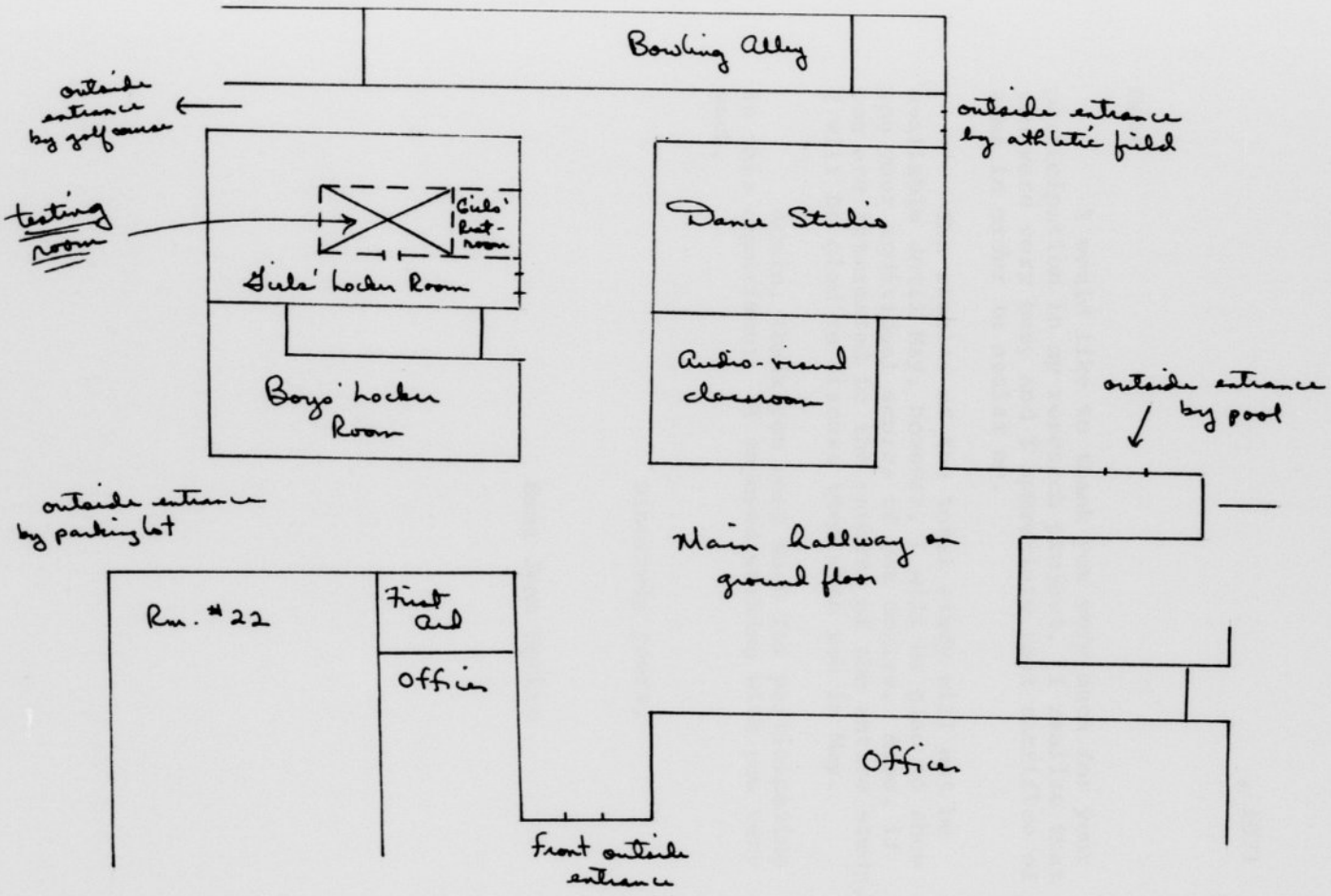
Enclosures: Map to Testing Room
Schedule of Participation

SCHEDULE INFORMATION

Name: _____ Address: _____
(Box) (Dorm)

Participation Schedule: Below is the time that you will participate each day. Please try and be on time so that all testing may proceed as scheduled.

TIME	MON.	TUES.	WED.	THURS.	FRI.
8:30 a.m.					
9:00 a.m.					
9:30 a.m.					
10:00 a.m.					
10:30 a.m.					
11:00 a.m.					
11:30 a.m.					
12:00 n.					
12:30 p.m.					
1:00 p.m.					
1:30 p.m.					
2:00 p.m.					
2:30 p.m.					
3:00 p.m.					
3:30 p.m.					
4:00 p.m.					
4:30 p.m.					
5:00 p.m.					
5:30 p.m.					



Ground Floor of Coleman Gymnasium

, 1971

Dear

I would like to thank you very much for your participation in my research project. I realize that you were very busy and I appreciate your sacrifice of time in order to assist me.

The results of the total study will not be available until May, however, I will be glad to show you your individual scores if you desire. Also, if you are interested in the results of the entire study, I will be glad to discuss them with you in May.

Again, thank you very much for participating in this experiment. I enjoyed working with you very much.

Sincerely yours,

Emma Jean Howard

APPENDIX B

Practice Session Instructions

RECORDED INSTRUCTIONS FOR PRETEST

"The first session of the experiment is called the pretest. The purpose of this pretest will be to determine your initial level of performance. In other words, how well you perform the task of dart throwing at the present time.

In the pretest, as in all other practice situations that you will undergo in this experiment, you will throw fifty darts. After you have thrown the first twelve, you will rest for one minute, after which you will begin again with the thirteenth dart and will throw another group of twelve. After those twelve, you will then rest again for another minute. After your minute's rest you will throw a third group of twelve throws followed by another minute of rest. Then your final group of throws will consist of fourteen darts.

You will throw each dart at ten second intervals. In other words, there will be ten seconds between each throw. You are asked to wait for the signal 'ready, go' before each throw. You are reminded that you must stay behind the line on the floor and the table as you throw each dart.

At this time are there any questions?"

During the period allowed for questions, each subject was reminded that the center of the target received the highest value and were asked to do their best during each session. They were also told that their scores would be combined with a group of fourteen other scores and statistically compared with two other groups.

"If there are no further questions, then we will prepare to begin. You will notice that the darts are on the table to your right. You may hold as many in your hand as you desire. You may hold just one at a time, two, three or more, whichever feels more comfortable for you.

You now have approximately ten seconds before you start, prepare to throw your first dart.

Ready, go. . . ready, go. . . (this continued until twelve throws had been completed). . . we will now rest for approximately sixty seconds. You will be notified approximately ten seconds before you begin the next group. . . (one minute). . . you now have ten seconds before you begin the next group. Prepare to throw your first dart. . . ready, go. . . ."

Upon completion of these twelve throws, the second rest period was provided, followed by the third group of throws, the third rest period, and the final group of fourteen throws.

RECORDED INSTRUCTIONS FOR ACTION
INFORMATION FEEDBACK

"The practice session that you will be working under today is called AIF, meaning action information feedback. In other words, the light will be on as you throw, but as you throw and your arm passes between the two stands in front of you, the light will go off so that you will not see where the dart lands. The same procedure as in the pretest will be followed. You will throw fifty darts in groups of twelve with the last group consisting of fourteen darts. Each group will be separated by one minute of rest. There will be ten seconds between each throw, and you are asked to wait for the command 'ready, go' each time before you throw the dart. In this experiment, you will notice the stands in front of you. Mounted on these stands is a photoelectric cell. Between these two cells is a light beam, and as your arm passes through this light beam, the light that is overhead will be cut off. Each time your arm comes forward to throw the dart, it will be necessary for it to pass through the line between the two cells. In just a moment the experimenter will help you regulate the height of the cells so that your arm will pass through the line comfortably. As you throw, and the light goes off, the experimenter will raise a screen in front of you to block your view of the target. As soon as this is done, the light will be turned on and the dart will be removed from the target. As soon as the dart is removed from the target, the screen will be lowered and you will wait for the next command

to throw. There will also be a command on the recorder so that the experimenter will know when to lower the screen. The command will simply be 'down'. You are asked to ignore this command and go on with your preparation for the next throw, since it is only a cue for the experimenter to lower the screen. In this condition, it is necessary for you to wear the earphones provided for you. At this time we will stop so that the experimenter can adjust the photoelectric cell, can assist you with the earphones, and can also answer any questions that you might have.

If there are no further questions, then we will prepare to begin. The earphones should be comfortably in place. You will notice to your right that the darts are on the table. You may hold as many in your hand as you desire. Please prepare to throw your first dart.

You have approximately ten seconds before you begin. . . ready, go. . . down. . . ready, go. . . down. . . (this continued until twelve throws had been completed) . . . we will now rest for approximately one minute. I will notify you approximately ten seconds before you begin the next group. . . (one minute). . . you have approximately ten seconds before you begin. Prepare to throw your first dart. . . ready, go. . . down. . . ready, go. . . down . . . ."

Upon completion of these twelve throws the second rest period was provided, followed by the third group of throws, the third rest period, and the final group of fourteen throws.

RECORDED INSTRUCTIONS FOR TERMINAL
INFORMATION FEEDBACK

"The practice session that you will be working under today is called TIF or terminal information feedback. It simply means that you will see the end result of your throw. In other words, the light will be off as you throw and will come on as the dart hits the target. You will see only where the dart lands. We will follow the same procedure as we have followed in past practices, including the pretest. You will throw fifty darts in groups of twelve with the last group consisting of fourteen throws and there will be one minute of rest between each group of twelve. There will be ten seconds between each throw, and you are asked to wait for the signal 'ready, go' each time before you throw the dart. There will be an additional command on the recorder. This command, 'off', is a cue for the experimenter to turn the light off prior to each throw. You are asked to ignore this command and go on with your preparations to throw. It will be necessary in this condition for you to wear the earphones that are provided. At this time we will stop so that the experimenter can assist you with the earphones and can also answer any questions that you might have.

If there are no further questions then we will prepare to begin. The earphones should be comfortably in place. You will notice that the darts are on the table to your right. Again, you are reminded that you may hold as many in your hands as you desire.

You have approximately ten seconds before we begin. Prepare to throw your first dart. . . (at this time the light was turned out). . . . Ready, go. . . off. . . ready, go. . . off. . . (this continued until twelve throws had been completed) . . . . We will now rest for approximately one minute. You will be notified approximately ten seconds before we begin the next group. . . . You have approximately ten seconds before we begin. Prepare to throw your first dart. . . ready go. . . off. . . ready, go. . . off. . . ."

Upon completion of these twelve throws the second rest period was provided, followed by the third group of throws, the third rest period, and the final group of fourteen throws.

RECORDED INSTRUCTIONS FOR THE COMBINATION OF BOTH TYPES OF FEEDBACK

"The practice session that you will be working under today is a combination of both AIF and TIF. In this situation, the light will always be on. This practice session is almost identical to the pretest, except that you must wear the earphones. The procedure is the same as all other sessions. You will throw fifty darts in groups of twelve throws, with the last group consisting of fourteen darts. There will be a one minute rest period after each group of twelve throws. It is necessary for you to wear the earphones during this session, so we will stop the recorder so that you may place these on comfortably. Also, you may ask any questions that you have."

At this point the pretest tape was used, since the commands used were identical. The pretest tape was started at the point which began: "Since there are no further questions, we will prepare to begin. . . ."

RECORDED INSTRUCTIONS FOR POST-TEST

There were no recorded instructions for the post-test since it was identical to the pretest. The pretest tape was used for the commands and was started ten seconds prior to the first throw.

"You now have approximately ten seconds before you start. Prepare to throw your first dart. . . ready, go. . . ready, go. . . ."

APPENCIX C

Raw Scores

RAW SCORES

Group 1

Subject Number	Pretest	AIF	TIF	Both	Post-Test
1	161	145	105	203	205
2	227	87	139	208	230
3	189	125	45	171	193
4	209	102	89	209	205
5	149	134	81	80	62
6	258	43	71	200	219
7	108	78	105	173	172
8	242	10	0	200	227
9	262	229	186	246	246
10	186	41	69	162	147
11	249	161	73	197	236
12	145	87	99	91	153
13	198	116	89	201	227
14	205	68	50	178	199
15	237	136	103	247	241
Total	3025	1562	1304	2766	2962

RAW SCORES

Group 2

Subject Number	Pretest	AIF	TIF	Both	Post-Test
1	165	150	14	173	167
2	240	81	123	231	258
3	231	90	26	187	217
4	199	184	70	155	187
5	151	43	75	125	181
6	132	2	39	149	166
7	181	83	109	205	163
8	168	77	90	160	195
9	170	55	59	194	190
10	35	112	33	151	188
11	174	106	53	177	165
12	188	34	127	204	207
13	187	116	40	127	161
Total	2221	1133	858	2238	2445

RAW SCORES

Group 3

Subject Number	Pretest	AIF	TIF	Both	Post-Test
1	219	97	116	210	191
2	175	157	47	184	134
3	194	125	105	192	199
4	205	159	134	210	169
5	203	13	34	184	128
6	151	50	67	177	187
7	180	102	99	190	163
8	198	139	125	190	185
9	253	123	146	246	251
10	153	46	16	136	132
11	216	105	103	212	220
12	184	72	134	149	228
13	200	101	113	218	195
14	214	115	141	248	223
Total	2745	1404	1380	2746	2605

APPENDIX D

Photography of Apparatus

JULY 1971

PHOTOGRAPH OF APPARATUS