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COINCIDENCE-ANTICIPATION TASKS UTILIZING SELECTED SPEEDS, DIRECTIONS, AND FIELDING SIDES IN FIELD HOCKEY

by

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

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This study investigated the effects of selected stimulus speeds, angles-of-approach, and fielding sides on the accuracy of field hockey coincidence-anticipation performance for collegiate women field hockey team members and physical education major students.

The women's collegiate varsity and junior varsity field hockey teams (goalies excluded) and twenty sophomore and junior women physical education majors from the University of Wisconsin - La Crosse served as subjects in the experiment. The coincidence-anticipation task utilized in the study required the subject to respond to a series of lights moving down a track. As the series of red lights reached the final light, the subject contacted the hockey ball at the end of the track with her field hockey stick. Stimulus light speeds of 10, 25, and 40 miles per hour were presented on the display as the subjects responded from both the right and left sides of the body and from positions simulating reception angles for flat, diagonal, and through passes. Each of the 18 trial conditions was randomly ordered and the score for each trial was the time difference between the arrival of the light at the designated point and the subject's response with the hockey stick against the timing mechanism. The accuracy score was recorded in milliseconds and indicated whether the response was early or late.

The analysis of variance procedure for the Statistical Analysis System (SAS) computer program was utilized to determine between-group differences for speed, angle-of-approach, and body side. The data reflecting the accuracy of

responses under each of the conditions were analyzed without regard to sign by the analysis of variance repeated measures design with fixed effects on all factors and subjects nested within groups. The Newman-Keuls test for post hoc comparisons of group means was applied when the analysis of variance procedure indicated a significant F value at .05 level or below.

The speed of the approaching object and the side from which the subject was required to respond were factors which differentially affected the performance accuracy of the two groups. The team members were more accurate than the major students when the speed of the stimulus was medium or fast, and when responses from the right fielding side were required. The performance of all subjects tended to be more accurate from the flat pass position and at the slower stimulus speed.

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TABLE OF CONTENTS

	Page
APPROVAL PAGE	ii
ACKNOWLEDGMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
CHAPTER	
I. INTRODUCTION	1
Statement of the Problem	2
Definition of Terms	3
Assumptions Underlying the Research	4
Scope of the Study	4
Significance of the Study	5
II. REVIEW OF LITERATURE	7
Delineation of Coincidence-Anticipation	7
Reaction Time and Coincidence-Anticipation	8
Stimulus Characteristics	10
Apparent Motion	10
Foreperiod	11
Stimulus Velocity, Duration, and Distance	11
Response Characteristics	18
Task Analysis	20
Taxonomies for Analyzing Sport Skills	20
Field Hockey Reception Task Demands	22
III. PROCEDURES	24
Selection of Subjects	24
Description of Equipment	25
Determination of Stimulus Speeds	26
Testing Environment	26
Experimental Condition	27
Instructions to Subjects	29

CHAPTER | Page

Determination of Accuracy Scores 30
Treatment of Data 30

IV. DATA ANALYSIS AND DISCUSSION 32

Data Analysis 32

Groups 33
Group-by-Side 33
Group-by-Angle 36
Angle 37
Group-by-Speed 37
Speed 40
Group-by-Side-by-Angle 42
Group-by-Angle-by-Speed 42
Group-by-Side-by-Speed 42
Side-by-Speed 46
Group-by-Side-by-Angle-by-Speed 46

Discussion 51

Summary 56

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 57

Summary 57
Conclusions 58
Recommendations 61

BIBLIOGRAPHY 62

APPENDIX A Data Forms 73

APPENDIX B Instrumentation 76

APPENDIX C Randomization of Traits 79

APPENDIX D Experimental Data 83

LIST OF TABLES

Table		Page
1.	Analysis of Performance by Groups	33
2.	Analysis of Performance: Group-by-Side	35
3.	Analysis of Performance: Group-by-Angle	36
4.	Analysis of Performance: Angle	38
5.	Analysis of Peformance: Group-by-Speed	39
6.	Analysis of Performance: Speed	41
7.	Analysis of Performance: Group-by-Side-by-Angle	43
8.	Analysis of Performance: Group-by-Angle-by-Speed	44
9.	Analysis of Performance: Group-by-Side-by-Speed	45
10.	Analysis of Performance: Side-by-Speed	47
11.	Analysis of Variance Results: Group-by-Side-by-Angle-by-Speed	48
12.	Analysis of Performance: Group-by-Side-by-Angle-by-Speed	49
13.	Randomized Trial Order: Physical Education Majors	81
14.	Randomized Trial Order: Field Hockey Team	82
15.	Computer Ordering of Conditions	85
16.	Raw Data: Physical Education Majors	86
17.	Raw Data: Field Hockey Team	87

LIST OF FIGURES

Figure		Page
1.	Factorial Design	31
2.	Group-by-Side	34
3.	Group-by-Speed	40
4.	Side-by-Speed	48
5.	Testing Environment	77
6.	Control System	77
7.	Testing Situation	78
8.	Response Control Unit	78

CHAPTER I

INTRODUCTION

Sport skill success is most often measured by the response accuracy of the performer. Participation in an open skill environment involving objects requires the performer to anticipate the future location of the object for interception. In order to be coincident, temporally and spatially, with a moving object, the performer must anticipate the intercept point one reaction time plus one movement time before the arrival of the object (Schmidt, 1975). The accuracy with which the player can make these time-space decisions is intrinsically related to her level of success in skill performance.

Past experience in an open skill environment helps the performer to discriminate among changes in object velocity, distance, and direction. The participant's ability to evaluate object movement variables is a function of the degree of information the performer can meaningfully assimilate during the relatively short duration of object movement and the recall from previous task interaction (Spaeth, 1972). The highly skilled performer is able to anticipate the intercept point from information gained during the early stages of object movement. Whiting (1970) stated that the skilled performer appears to move with relative ease in gaining control of the object. Performers lacking the ability to predict future location of an object must visually monitor the object movement over a longer period of time before moving to intercept it. The movement appears to be hurried and is often inaccurate.

Within the game of field hockey, the participant receives passes travelling at various rates of speed and approaching from several directions. The game also requires reception of the ball on either side of the body, although the ball can be contacted only with the flat side of the stick. This study attempted to analyze selected coincidence-anticipation tasks encountered in field hockey.

Statement of the Problem

The purpose of this study was to determine the effects of selected stimulus speeds, the angles-of-approach, and fielding side on the accuracy of field hockey coincidence-anticipation task performance of collegiate women field hockey team members and physical education major students.

This study attempted to answer the following questions:

1. Do the team members differ from the physical education major students in the accuracy with which they respond to slow, medium, and fast field hockey passing speeds?
2. Do the team members differ from the physical education major students in the accuracy with which they respond to fielding angles simulating flat, diagonal and through passes?
3. Do the team members differ from the physical education major students in the accuracy with which they respond when fielding a ball on the right and left sides of the body?
4. Do these factors interact in any systematic way?

This study tested the null hypothesis that there is no significant difference between the coincidence-anticipation task performance of women physical education major students and women intercollegiate field hockey team members on the accuracy of responses to selected speeds, angles-of-approach, and fielding sides in a field hockey specific task.

Definition of Terms

Coincidence-Anticipation - "making a motor response at the same time (coincidence) that a moving object arrives at a designated intercept point; and initiating the response before (anticipation) the arrival of the object at the intercept point, to avoid being late due to reaction time" (Stadulis, 1972, p. 70).

Fielding side - side of the player's body from which the ball is approaching.

Open sport skills - skilled movement required to conform or be molded to the spatial/temporal characteristics of the environment (Luria, 1966).

Perceptual learning - "an increase in the ability to extract information from the environment, as a result of experience and practice with stimulation coming from it" (Gibson, 1969, p. 3).

Reaction time - amount of time between the onset of a stimulus and initiation of response.

Response time - duration of time from presentation of stimulus to completion of response. The response time is equal to one reaction time plus one movement time (Drowatzky, 1975).

Selective attention - the ability to focus on relevant task stimuli.

Assumptions Underlying the Research

The following assumptions governed the study:

1. The subjects responded to the stimuli, under all conditions, and on every trial, as accurately as possible.
2. The Bassin Timer is a valid and accurate measure of coincidence-anticipation performance.
3. The stimulus speeds and angles-of-approach selected for the study represent those encountered in a field hockey game situation.
4. No attempt was made to control for the handedness of the subjects. All had received prior instruction in field hockey and were familiar with the striking implement.
5. Field hockey team members have had more experience receiving passes on either side of the body at the speeds and angles-of-approach examined in the study than the physical education majors at the University of Wisconsin - La Crosse.
6. No subject in the study had an uncorrected visual impairment which affected performance on the coincidence-anticipation tasks used in the study.

Scope of the Study

Data were collected between the dates of October 11 and October 15, 1976 at the University of Wisconsin - La Crosse. The study utilized the starting team members (goalies excluded) for the women's collegiate varsity and junior varsity field hockey teams and twenty women, sophomores and juniors, physical education major students. Subjects in this experiment were limited to those females who had field hockey instruction in the major preparation program or team experience.

The skill level of each of the two groups, selected stimulus speeds, angles-of-approach, and fielding side of the body comprised the independent variables in this study. The dependent variable was the accuracy of performance of the subjects on the coincidence-anticipation tasks.

Significance of the Study

Coincidence-anticipation accuracy is vital to the performance of sport skills in an open environment. To date, this attribute has received little experimental attention relative to total response accuracy with adult performers. Adams and Craemer (1962) and Schmidt (1969) agree that anticipation is one of the most important, but least studied, aspects in skilled performance.

Based on the assertion that coincidence-anticipation accuracy is intrinsically related to the performance of sport skills, two groups were selected which had different backgrounds in open skill environments. The nature of professional preparation in physical education requires that students become proficient in a wide variety of open skill environments. Participation on a varsity team, by comparison, emphasizes excellence in the performance of a specific sport activity. The examination of the coincidence-anticipation accuracy of these two groups may provide important information which is currently unavailable in physical education literature. Field hockey was selected as the sport to be investigated because it involved an open skill environment and is included in most professional preparation and varsity athletic programs in the United States.

Salmela (1975) stressed the importance of analyzing specific sports according to their task demands. He emphasized that research efforts should be directed toward analysis of the task demands of specific sports to remediate the present lack of understanding evident in the teaching of most practitioners and to provide a common frame of reference for researchers in the areas of motor learning and sports psychology. The present study examined coincidence-anticipation accuracy within a task analysis framework. The factors selected for the investigation were those which appeared to be important features of fielding skill in the game of field hockey. In a game situation, the performer encounters various ball speeds and intercepts the ball coming from several directions. The accuracy with which judgments of object speed and direction are made is crucial to skillful performance. In addition, the game of field hockey employs the use of an asymmetrical stick, but allows some freedom of fielding side except as limited by the obstruction rule and playing position on the field. To investigate coincidence-anticipation more realistically, the total response for the interception movement was required rather than measuring a response requiring a limited movement. The findings of the study may provide the practitioner and researcher with information that can be more readily applied to skill performance situations, and specifically to field hockey.

CHAPTER II

REVIEW OF LITERATURE

The purpose of the study was to determine the effect of selected stimulus speeds, angles-of-approach, and fielding side on a field hockey coincidence-anticipation task. Consequently, a review of the especially pertinent literature was organized into the following major sections: (a) delineation of coincidence-anticipation, (b) reaction time and anticipation, (c) stimulus characteristics, (d) response characteristics, and (e) task analysis.

Delineation of Coincidence-Anticipation

Excellence of performance in sports activities involving a moving object depends upon the participant's ability to gain control of the object through catching, fielding or striking. Several terms were utilized in the literature to describe the interception process that is critical to sport skills involving reception of an object. The term "coincidence-anticipation," although appearing relatively recently in the literature, clearly describes interception behavior. Stadulis (1972) defined coincidence-anticipation in the following way:

> (a) making a motor response at the same time (coincidence) that a moving object arrives at a designated intercept point; and (b) initiating the response before (anticipation) the arrival of the object at the intercept point, to avoid being late due to reaction time (p. 70).

Adam and Craemer, (1962); Buffan and Christina, (1975); Schmidt, (1968); and Williams, (1973) were some of the researchers using the word "timing" to explain object interception. "Prediction" was utilized by Gerhard, (1959); Gottsdanker, (1952); Poulton, (1957); and Weiner, (1962) to describe the task. To label interception behavior, the word "transit reaction" was employed by Slater-Hammel (1960) and Waechter (1969). The term coincidence-anticipation was selected for use in this study.

Reaction Time and Coincidence-Anticipation

The performance of sport skills requiring object coincidence depends primarily on the ability of the player to anticipate the arrival of the moving object. Due to the processing time needed within the central nervous system, the time required for the reaction to the stimuli and the time needed to execute the movement response become critical in response time accuracy (Belisle, 1963). Reaction time, which is approximately .24 sec., has been defined as the time between the onset of stimulus presentation and the initiation of a reaction by the performer (Williams & Macfarlane, 1975). The reaction time factor, plus the time taken to perform the movement required for coincidence with the object, necessitates anticipation in order to compensate for time lags in the information-processing capabilities of the individual. Belisle and Williams (1973) explained that in order to intercept an object at a certain point in space, the performer must initiate the response at least one reaction time and one movement time before coincidence. Failure to anticipate results in late arrival at the coincidence point. Through anticipation, the player attempts to reduce any lag caused by the processing times required for reaction time and movement time (Williams and Macfarlane, 1975. Schmidt (1969) noted that the performer must estimate the time required to execute the movement before initiating a movement response.

To predict object flight and to time the response accurately, the individual utilizes cues from the environment. Poulton (1952) demonstrated that individuals can learn to anticipate the arrival of moving objects by decreasing the uncertainty of the available display information. The reduction of uncertainty is crucial to a decrease in reaction time. According to Poulton (1965), anticipation provides a mental set and a possible course of action; as a result the reaction time may be somewhat faster. By anticipating, the time for reaction time and movement time components may be reduced and, therefore, a greater amount of time may be available for viewing the moving object and for selecting a movement response (Williams, 1973). The selection and execution of the movement response depend upon the environment and the demands of the task. Conrad (1953) succinctly described the importance of timing in the performance of skills:

> . . . frequently the problem will be not the hastening of response, but the delaying of it until the best moment. Timing permits the skilled operator to manipulate the time within the inherent limits, Good timing in fact provides the optimum temporal conditions for response (p. 173).

Poulton (1957), in an analysis of motor skill performance, presented the following three types of anticipation: (a) receptor anticipation, (b) perceptual anticipation, and (c) effector anticipation. In situations involving receptor anticipation, the subject is able to preview the stimulus and respond without reaction time lag. Perceptual anticipation allows no preview, but the stimulus presentation has some order and can be learned by the performer. The prediction of the time required to execute the movement response is defined as effector anticipation.

Schmidt (1968), in evaluating response proficiency, suggested that the two components of perceptual anticipation were (a) spatial anticipation, and (b) temporal anticipation. Schmidt stated that "spatial anticipation involves the prediction of where the stimulus will occur . . . temporal anticipation involves the prediction of the time of arrival of the stimulus" (p. 632).

Adams and Xhignesse (1960), Conrad (1953), Grose (1967), and Whiting and Hutt (1972) found no relationship between classical reaction time and anticipation timing. This tends to refute the statement by Knapp (1963) that success in sport is dependent upon the performer's reaction time. Drowatsky (1975) suggested that simple or choice reaction time has little effect on sports performance and that decisions are made on the basis of prediction and anticipation.

Stimulus Characteristics

Apparent Motion. Morin, Grant and Nystrom (1956), described apparent motion as the occurrence of the perception of movement when there is no physical movement of the stimulus. Graham (1965) and Kolers (1972) agreed that optimal apparent motion cannot be distinguished from real movement and that responses to apparent movement were equivalent to those produced by real movement. Gibson (1969) stressed that there are fundamental similarities between real and apparent motion so long as the stimulus for the perception of physical movement is correlated with the physical situation. Kaufman (1974) investigated the relationship of real and apparent motion and concluded that apparent movement and real movement may be complementary rather than parallel processes.

Although additional research is needed to establish the relationship between real and apparent movement phenomena, the research thus far tends to support the statement that real and apparent movement are similar in the response elicited. The use of a device which utilized apparent motion would seem to be appropriate for the present study.

Foreperiod. Rothstein (1975) suggested the establishment of a temporal expectancy to aid in prediction of the arrival of a moving object. It was found that as the degree of readiness increased, the reaction time decreased (Rothstein, 1973). Klemmer (1956) stressed that the predictability factor is greater at the end of a constant foreperiod, thus enabling the performer to anticipate and respond early. Further research by Klemmer indicated greater response accuracy for a constant foreperiod over a variable foreperiod. Based upon the available literature, the utilization of a constant foreperiod would be most desirable in coincidence-anticipation research.

Stimulus Velocity, Duration, and Distance. Relatively few studies have been conducted utilizing sport skills when investigating stimulus velocity, duration, and distance. Due to the constantly changing environment, very little time is available for prediction in sport skills. Motion prediction accuracy is highly dependent upon the spatial, temporal, and velocity cues available from the environment (Bonnet & Kolehmainen, 1969). Gerhard (1959) stated that in order to anticipate the future position of a moving object, information regarding direction and speed was crucial and that velocity discrimination further assisted in prediction accuracy. Gerhard also found that velocity estimates were based upon the time used to travel a specific distance rather than estimating the distance traveled in per unit of time.

The literature reviewed on stimulus velocity offered conflicting evidence regarding the effect on accuracy of performance. Brown, (1961); Ellingstad, (1967); Garvey, Knowles and Newlin, (1956); Goldstein, (1957); and Gottsdanker (1955), found that increased stimulus speeds resulted in a decrement in performance accuracy. Goldstein (1957), conducting a study in which subjects had to move a stylus along a horizontal bar, used stimulus velocity speeds of 2.4, 4.8, and 14.3 cms/sec. Ellingstad (1967), using a linear velocity prediction apparatus, employed stimulus velocities of .46 in/sec., 1.84 in/sec., and 9.15 in/sec. The subjects were positioned 15 inches from the target and viewed display durations of 5, 15, and 25 inches. Utilizing a radar scanning task, Garvey et al. (1956) measured differences between estimated and actual plots on four different radar displays under various stimulus speed conditions. Gottsdanker (1955) used a velocity of 8 mm/sec. in a paper-pencil prediction experiment. The authors of all the studies previously cited reported that performance accuracy decreased with an increase in stimulus speeds.

Increased stimulus speeds were found by Alderson, (1972a); Ellingstad and Heimstra, (1969); and Weiner (1962) to increase performance accuracy. In Weiner's study, the subjects had to predict the position of a target after it disappeared from view by tracing a stimulus path marked on paper. A constant linear velocity of .5, 1, 2, and 4 mm/sec. was employed with stimulus durations of 2, 4, 8, and 16 seconds. Ellingstad and Heimstra (1969) required the subjects to estimate final goal position of the target following a short period of concealment by depressing a microswitch. The stimulus velocity varied between 1.25 - 10.056 in/sec. The subject was seated 6 ft. from the display and monitored variations in target duration of 6, 12, and 18 in. Alderson (1972a), in an effort to simulate sport skills, utilized ball velocity speeds of 10, 20, and 30 ft/sec. with stimulus durations of 4', 8', and 12 ft. The subject was seated 15 ft. from the display and responded by depressing a button to indicate target coincidence. Alderson stated that the more general finding was that increased stimulus speeds resulted in decreased performance accuracy.

As noted by Bard (1973), the range of actual ball velocities in several sport activities was found to be between 30 ft/sec. and 156 ft/sec. Bard emphasized that past research failed to use stimulus velocities similar to speeds encountered in sport skills. The applicability of the previous research to sport skills is questionable due to the slow stimulus speeds and short display distances utilized.

Stimulus duration--the distance over which the stimulus is presented--was another factor said to affect performance on coincidence-anticipation tasks. In addition to the literature previously cited, Slater-Hammel (1960) and Goldstein (1957) found that stimulus duration affected response scores. The range of the viewing time utilized in both studies was between 2 and 60 seconds. Stimulus duration was found not to influence accuracy scores according to Alderson (1972a), Ellingstad and Heimstra (1969), and Weiner (1962). Alderson (1972a) summarized the limitations of the previous research on stimulus velocity and duration with the statement that "velocity never rises above 1 foot per second . . . and total track does not exceed 4 feet in length" (p. 38).

Display distance, the location of the subject in relation to the target, is also a factor affecting the accuracy of coincidence-anticipation performance. Alderson (1972a) and Weiner (1962) stated that the display distance had no effect on accuracy estimates. However, Ellingstad and Heimstra (1969) and Slater-Hammel (1960) found that response accuracy decreased as target distance decreased. The studies cited utilized target distances ranging from 1 ft. to approximately 6 ft., with the exception of the Alderson study, in which subjects were positioned 15 ft. away from the apparatus. Alderson (1972b) offered an explanation for the disagreement in the research findings:

> . . . the perception and prediction of motion is affected by the ranges of levels of independent variables used within the testing paradigm rather than by absolute values of velocity, prediction distance or prediction time (p. 40).

In studies investigating ball skills, Eastwood (1972) estimated that the critical viewing time for a ball in flight was approximately 200 milliseconds. Whiting, Gill & Stephenson (1970) reported that increased viewing time resulted in increased catching success. The study by Whiting et al. (1970) employed varying time periods of ball illumination after the object began the trajectory toward the subject. A distance of 9 ft. was maintained between the subject and the apparatus.

A study by Nessler (1973) measured catching accuracy by requiring the subjects to catch a tennis ball rebounding from a wall after being projected by a machine. Five periods of differing room illumination were utilized to investigate the effect of stimulus duration on catching accuracy. The subject was positioned 21 ft. from the wall and the ball speed was estimated to be 39 ft/sec. The findings of Nessler agreed with those of Whiting et al. (1970) that increased stimulus duration increased the accuracy of catching performance.

Miller and Shay (1964) reported that batters in softball have sufficient time to bring the bat over the plate with stimulus velocity speeds of 59.95 mph, a stimulus duration of .47 sec. and a display distance of 41 ft. Lack of success in batting according to Miller and Shay could be attributed to the reaction time of the batter. As noted previously, anticipation functions to reduce the reaction time required in a particular task.

Stadulis (1971) investigated the effect of age on coincidence-anticipation accuracy. The children, ages 7-11, observed four stimulus speeds and attempted to achieve coincidence at a target point on a 6 ft. track. Stadulis found that 9- and 11-year-old children responded more accurately to the slow and medium speed, and that 7-year-old children responded more accurately to the fast speed. Stadulis hypothesized the response of the 7-year-old children may have been a function of reaction time that coincided with the length of presentat- tion of the fast stimulus speed utilized in the study.

Bard (1973) investigated display time, angle of projection, occlusion and the influence of location on the subject's response in a ball trajectory prediction task. A more rapid judgment was made in response to the lower angle of aprojection (32° 30') than to the higher (40° 30') projection angle. Bard also found that volleyball players responded significantly faster than swimmers when the ball was projected directly toward them. The subjects responded faster when the ball was projected from the left than when projected from the right (Bard).

Williams (1968) had children predict where the ball would land when it was projected toward the subject and at an angle of 5° to the right and left. The subjects were more accurate in their performance when the ball was moving directly toward them or to the right. When the object was projected to the left, the accuracy of the response depended upon the speed of the object. Predictive judgments were more accurate when the object moved at the slower speed. Utilizing velocities of 39.7 ft/sec. and 48.0 ft/sec., Williams found more accurate responses to the higher vertical trajectory at the slower speed, while responses were more accurate at the faster speed for the lower trajectory.

Limited literature is available which reports on coincidence-anticipation in sports situations. Based on the literature reviewed, it appeared that speeds utilized in testing coincidence-anticipation should be consistent with task demands of the game environment. Since there is considerable variation in ball velocity among open sport skills, an analysis of coincidence-anticipation performance utilizing the ball speeds encountered in a single sport activity seemed to be the most appropriate research strategy. In addition, based on previous research (Bard, 1973; and Williams, 1968) indicating that object velocity interacted with the position of the subject, an important facet in the design of the coincidence-anticipation task was the requirement that subjects judge the velocity of the stimulus in a position which was consistent with the specific sport activity. The length of the track should also be comparable to the distance available for viewing the object under the conditions of the specific sport.

For the present investigation, the skill of object reception in field hockey was selected based on the ability to examine specific object velocities and fielding positions while eliminating the research problem encountered in the judgment of trajectories. Bard found that swimmers (closed skill performers) and volleyball players (open skill) differed in the accuracy of coincidence-anticipation prediction. This suggested the need to investigate coincidence-anticipation accuracy with groups differing in experience in open skill environments. College physical education majors and field hockey team members were selected as two groups with extensive, but different, experience in open sport skills.

Response Characteristics

> Skilled performance involves anticipating the nature of future environmental events, predicting the set of responses most likely to be used, and rapidly selecting and executing the most appropriate response with the shortest delay (Spaeth, 1972, p. 351).

Skilled performance has been defined by Spaeth (1972) as "maximizing goal attainment." To be successful in an open skill environment, the performer must clearly understand the goal of the task to be performed in order to predict where the object will be at the completion of the movement response (Gentile, 1972). According to Luria (1966), the execution of the movement response must conform to the temporal and spatial demands of the environment in order to be coincident with a moving object.

The ability of the performer to monitor the environment for cues that provide information crucial to movement response selection is basic to goal attainment. The time available for gleaning information from the environment is extremely limited in most open sport skills (Spaeth, 1972). This time constraint requires the performer to anticipate future events in order to initiate a response for object interception. Whiting (1970) has stated that to be spatially and temporally coincident with a moving object, criticial information is gained by visually monitoring the velocity, position, trajectory, and direction of the ball.

Bernstein (1967) stressed that previous experience in the sport activity enables the performer to extrapolate meaningful information learned from the past for use in planning future responses. Kay (1957) emphasized that through experience and practice, the individual recognizes which cues are important for successful goal attainment and is soon able to predict future behavior of the object by monitoring initial events of object movement. By anticipating responses that would meet environmental demands based on early monitoring information, the increased response speed allows a longer time for evaluation of the selected response prior to execution (Keele, 1968). The degree of goal attainment often is determined by the speed of response selection (Spaeth). Whiting (1970) has noted that the beginning performer usually has to monitor the environment for a longer period of time in order to select a movement response which meets the spatial and temporal demands of the task. Until the novice has learned to selectively attend to pertinent cues, the excess monitoring time severely limits necessary time for evaluation of the selected response.

As summarized by Poulton (1957), the following judgments are important factors in the selection of the movement response: (a) the perception of movement, (b) the planning of a motor response, and (c) the execution of the interception response. To date, most of the literature has been theoretical in nature and few studies were found that investigated coincidence-anticipation in sport-related skills.

Based on the literature reviewed, a crucial factor in coincidence-anticipation accuracy was the estimation by the performer of the time required to execute the movement (Poulton, 1957). Therefore, an important feature in the design of a coincidence-anticipation task related to sport skills was the inclusion of the movement necessary to contact the ball. In addition, the selection of a field hockey reception task dictated that the implement used in the game be employed in making all coincidence-anticipation responses.

Task Analysis

Critical analysis of a task depends upon the understanding of the task demands relative to a specific sport and/or sport skill (Salmela, 1975).

Taxonomies for Analyzing Sport Skills. Kay (1957) briefly sketched the historical development leading to the present conception of task analysis. Prior to 1940, psychologists were concerned almost exclusively with the movement response. During World War II, there was a shift in emphasis and researchers were concerned primarily with perceptual factors demanded in a specific task (Kay). As Kay noted, it soon became apparent that perceptual factors and the movement response were interrelated and research approaches were needed to encompass both aspects.

Annett & Kay (1956) proposed that information-processing theory be used to analyze specific skills. An important concept deriving from the approach was the assertion that the skilled performer was required to process less information than the beginner when performing an identical task (Annett & Kay). The skilled performer learned to attend to a few selected environmental cues which were critical, while the novice was unaware of which of the many cues in the environment were important to performance. Kay (1957) hypothesized that the result of fewer information-processing demands allowed the experienced performer more time to execute the movement response.

Fitts (1962) noted that early research in skill performance was carried out primarily in military and industrial settings. Following a comparison of teachers' comments for problems encountered in pilot training and physical education activities, Fitts noted striking similarities between the two activities. Based on these observations, Fitts proposed a taxonomy for skill learning intended to encompass sport skills as well as tasks involving limited body movement.

In literature directed primarily toward the task analysis of physical skill performance, Poulton (1957) advocated that sport skills could be described as being open or closed. Poulton described open skills as those which are performed in an environment that is unpredictable. Closed skills, by comparison, were said to be those not influenced by environmental factors (Poulton). Whiting (1972) elaborated upon Poulton's classification of open and closed skills by adding the category of closed skills performed in an open environment.

Gentile (1972) extended the open and closed skill taxonomy by suggesting implications for teaching the different types of skills. Gentile, Higgens, Miller & Rosen (1975) attempted to elaborate on the open and closed skill classification system. However, research attempts to verify their proposed taxonomy resulted in a return to their original open and closed skill classification. Of especial interest was the finding that on a dart-throwing task, characteristics of the target (environment) appeared to dictate the movement used regardless of differences in body structure. In addition, Gentile et al. (1975) noted that when adaptations were necessary in the movement, only the preparatory phase of the dart-throwing task appeared to be modified.

Salmela (1975) reviewed selected taxonomies available in the psychomotor and sports psychology literature. Noting the disparity in existing taxonomies, Salmela proposed that the following four categories may be used to analyze sports and sport skills based on their uncertainty: (a) response uncertainty--the complexity of the movement; (b) spatial uncertainty--the complexity of the environmental stimuli to which the performer must attend; (c) temporal uncertainty--the timing judgments that must be made in relation to spatial uncertainty; and (d) event uncertainty--the probability of the occurrence of a given event.

The studies cited represent important contributions to the understanding of physical skills. However, the task demands of specific sports skills remain to be identified.

Field Hockey Reception Task Demands. Task demands specific to the game of field hockey require that passes be made in all directions to avoid interception by opposing players. The passes used to accomplish this goal are called through passes, square (flat) passes, diagonal passes, and backward passes (Wein, 1974).

According to Wein, all field hockey players must be able to stop (field) the ball by absorbing the speed of the object in order to maintain control and redirect it immediately. The author noted that failure to field the ball properly was the result of improper footwork, poor technique, and/or insufficient concentration.

> A good hockey player must be able to stop a ball hit from any direction at speeds which vary enormously. Thus he has to estimate not only the speed of the approaching ball but also have sufficient speed, mobility and skill at his disposal to enable him to get his body and stick quickly into the desired position (Wein, 1974, p. 37).

Field hockey textbooks have generally dealt with the mechnical and technical aspects of the required movements, rather than addressing the skills in relation to the environmental changes encountered in the game. Therefore, little information appears in the field hockey literature that is consistent with the concept of task analysis. No studies were found which analyzed the skills in the game of field hockey based on task demands related to coincidence-anticipation.

CHAPTER III

PROCEDURES

The purpose of this study was to compare the effects of selected stimulus speeds, angles-of-approach, and fielding side on the accuracy of coincidence-anticipation task performance of collegiate women field hockey team members and physical education major students. The collection of data included the following procedures: (1) selection of subjects, (2) description of equipment, (3) test administration, (4) treatment of data.

Selection of Subjects

The subjects were 20 female physical education majors and 20 collegiate varsity and junior varsity field hockey team members enrolled at the University of Wisconsin - La Crosse during the fall of 1976. Subjects identified by the coach as starters for the varsity and junior varsity field hockey teams (excluding the goalies) comprised the field hockey team members for the investigation. All designated starters indicated their willingness to participate in the study by signing the Subject Data Form (Appendix A).

The following criteria were met in the selection of subjects included in the physical education major group:

1. All subjects had received previous field hockey instruction at the University of Wisconsin - La Crosse.

2. The subjects were either sophomore or junior physical education major students enrolled in a multiple activities class.
3. Current members of the collegiate field hockey team and past team participants were excluded from the major student group.

One section of sophomore and one section of junior physical activity classes were randomly selected for the study. The students had been randomly assigned to their class section. All students in the selected sections were requested to complete the Subject Data Form (Appendix A). The 60 major students consenting to participate in the study and meeting all the stated criteria were included on the respective subject lists and randomly assigned a number within each section. Ten sophomore and 10 junior physical education majors enrolled in the field hockey activity classes were randomly selected. The Hewlett-Packard Program (RNDORD) on the Time-Shared Basic Computer System was used to select the 10 subjects from each class.

Description of Equipment

The experimental equipment consisted of the Bassin Anticipation Timer System (Lafayette Instrument Company; Model 50-575) with three additional intermediate modular runways. The photographs of the experimental equipment are located in Appendix B. The track was 12 1/2 feet in length and contained a total of 80 high speed red L. E. D. lamps (Figure 5 in Appendix B). The control system registered early and late anticipation times in milliseconds. A constant foreperiod of 2.0 seconds proceeded each trial (Figure 6 in Appendix B).

Determination of Stimulus Speeds

A preliminary study was used to ascertain the speed settings at which the Bassin Anticipation Timer was operated. The stimulus speeds were determined by having three hockey team members dribble a ball toward a designated area and drive the ball to a teammate. A mobile police radar unit, which was positioned behind the driving area to allow for precise tracking, was employed to measure the speed of the hockey ball. To prevent extraneous interference on the radar recording unit, an isolated area of a putting green was used. The speed of 40 fast passes and 40 slow passes was recorded by the radar unit. The speed of the hockey ball was measured within the first fifteen feet after the ball was driven.

The fast speed setting for the Bassin Timer was determined by averaging the ten fastest speeds and the slow speed setting was determined by averaging the ten slowest speeds. The medium pass speed was the midpoint between the fast and slow speeds. Consequently, the variable light speeds, simulating the movement of the ball, were 10, 25, and 40 miles per hour.

Testing Environment

The actual testing positions were numbered one through six and the lines were three feet from the center of the contact surface of the ball. Testing stations one and six simulated receiving positions for flat passes, stations two and five, diagonal passes and stations three and four, through passes. The practice trial line was three feet in front of the ball so that the subject faced the oncoming lights (Appendix B).

The physical testing environment consisted of a series of lines placed on artificial turf around the perimeter of a hockey ball located at the end of the light track (Figure 7 in Appendix B). The push button response control, embedded in the hockey ball, was positioned so that contact was made in line with the runway.

A special apparatus was constructed which enabled the subject to respond to the series of lights by contacting the hockey ball with her field hockey stick (Figure 8 in Appendix B). A push-button response control was partially embedded in a field hockey ball and mounted in ten pounds of lead to prevent movement. The response mechanism was positioned to support the ball one-half inch above the artificial surface and allow unrestricted movement of the ball over the push-button cylinder. All subjects were instructed to contact the ball at the same time the last light was activated and the six-inch distance between the end light and the edge of the ball remained constant for the testing of all subjects.

Experimental Condition

In order to control the subject's activity level prior to measuring coincidence-anticipation task performance, a meeting was held with the instructor and coach to organize the class sessions and testing schedule. The physical activity was predetermined and consisted of the following activities: (1) dribbling and footwork drills, and (2) triangle passes, flat and through passes and dodges and tackles with a partner. The activity control employed for both groups attempted to establish an appropriate activity set compatible with the motor task demands of field hockey. Following a minimum of 20 minutes of activity, each subject reported to the testing area. All other subjects continued to participate in game play until requested to report to the testing station.

The coincidence-anticipation task utilized in the study required the subject to respond to a series of lights moving down a track. As the series of lights reached the final red light, the subject contacted a hockey ball at the end of the track with her hockey stick. The floor positions were designed to simulate fielding situations for flat, through, and diagonal passes. The testing situation was designed so that the subject approached the testing apparatus from both the right and left sides with a legal hockey stroke. Thus, each subject received passes from six different starting positions relative to the lighted track. In each of the six positions the subject responded to light speeds of 10, 25, and 40 miles per hour simulating the actual speed of hockey passes. The order of the 18 conditions for each subject was randomly determined by utilizing the random order program (RNDORD) on the Hewlett-Packard Time-Shared Basic Computer System (Appendix C).

Immediately prior to testing, nine practice trials--three trials at each of the stimulus speeds--were given to acquaint the subject with the testing instrument and to gain experience viewing the three different ball speeds. All practice trials were administered from a line three feet directly in front of the ball so that the subject faced the oncoming lights. Throughout all practice and experimental trials, no restriction was placed on the number of strides the subject used in moving to contact the hockey ball.

Each subject was tested individually with the experimenter and an assistant present during the testing. The test administration required ten minutes, and upon completion, the subject returned to activity. The subject was requested not to discuss the study with anyone until the testing of all subjects in the study had been completed. During the week following the testing, a debriefing session was held for the subjects to answer questions related to the study.

Instructions to Subjects

Prior to the practice trials, the following instructions were given to each subject:

> The object of this task is to touch the hockey ball with your stick at the same instant that the series of lights reaches the final red light. The far end of the track contains a yellow warning light that will come on prior to the series of red lights. You will have nine practice trials from behind the pre-trial line. Please keep your feet and stick behind the line until you see the yellow warning light. You may move toward the ball when you see the yellow light.

The subject then performed the practice trials.

Each subject was given the following instructions for the 18 trial conditions:

> The actual test consists of six stations and you will be tested at each station three times. Attempt to touch the ball with your stick when the series of lights arrive at the final red light.
>
> Do you have any questions?
>
> Please begin at station ____.

Determination of Accuracy Score

The score for each trial was the time difference between the arrival of the light at the designated point and the subject's response with the hockey stick against the timing mechanism. The control system of the Bassin Anticipation Timer registered the accuracy score in milliseconds and indicated whether the response was early or late; a plus sign was used to indicate an early response and a minus sign was used to indicate a late response (Table 16 and 17). The response score for each of the 18 trials was recorded.

Treatment of Data

The accuracy scores which comprised the data for the study were analyzed without regard to sign by the analysis of variance repeated measures design (2x2x3x3) with fixed effects on all factors and subjects nested within groups. The Statistical Analysis System (SAS) computed program was utilized to determine between group differences for speed, angle-of-approach, and body side. Figure 1 illustrates the factorial breakdown employed in the study.

When the analysis of variance procedure indicated that the F test was significant at .05 level or below, the Newman-Keuls test for post hoc comparison of group means was applied to determine where the difference occurred for those main and interaction effects. Graphs were utilized to plot the means of selected treatment conditions.

Side	B_1 Left									B_2 Right								
Speed	C_1 f			C_2 m			C_3 s			C_1 f			C_2 m			C_3 s		
Angle of Approach	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
S_1 A_1 Hockey Team S_{20}																		
S_{21} A_2 Physical Educa- tion Majors S_{40}																		

A = groups = 2
B = side = 2
C = speed = 3 (C_1 = fast, C_2 = medium, C_3 = slow)
D = angle = 3 (D_1 = flat, D_2 = diagonal, D_3 = through)

Figure 1. Factorial design

CHAPTER IV

DATA ANALYSIS AND DISCUSSION

This study examined the effects of speed, angle-of-approach and body side on task performance of field hockey team members and physical education majors. Eighteen trial conditions encompassing all task variables were administered to investigate these effects. Twenty female physical education majors and 20 members of the varsity and junior varsity field hockey teams, from the University of Wisconsin - La Crosse, served as subjects for the study.

The null hypothesis that the accuracy of performance on the coincidence-anticipation tasks would not be significantly affected by either the group, speed, angle-of-approach and side factors or the interaction of factors being investigated in the study was tested.

DATA ANALYSIS

The data reflecting the accuracy of responses under each of the conditions were analyzed without regard to sign by the analysis of variance repeated measures design with fixed effects on all factors and subjects nested within groups (Winer, 1971).

Accuracy scores were recorded in milliseconds, with a score of .000 milliseconds reflecting perfect coincident timing. Means were calculated to reflect group performance and graphs were employed to illustrate significant interactions.

Groups

An F value of 2.0192 indicated that no significant difference existed between the physical education major group and the field hockey team group when performance under all factors of the study was considered. The means reflecting the accuracy of performance for the two groups and the analysis of variance results are shown in Table 1.

Table 1

Analysis of Performance by Groups

Mean Scores

Group	N (observations)	Mean Score (milliseconds)
Majors	360	.2183
Team	360	.1938

Analysis of Variance Results (Group)

DF	SS	MS	F	Prob F
1	.1074	.1074	2.0192	0.1601
38	2.0214	.0532		

Group-by-Side

An F value of 6.6948, significant at the .05 level, was obtained for the Group-by-Side condition when the performance on all speeds and angles was included.

Post hoc comparisons to determine significant differences between conditions revealed that performance by the major group on the right side position was significantly less accurate than all other conditions. The response of the major group was significantly less accurate on the right side position than on the left side position (Figure 2). No significant difference was indicated between the performance of the two groups on the left side position. There was no significant difference in the accuracy with which the team responded from the left and right positions. The mean scores, analysis of variance results and the Newman-Keuls (Winer, 1971) for post hoc comparisons are presented in Table 2.

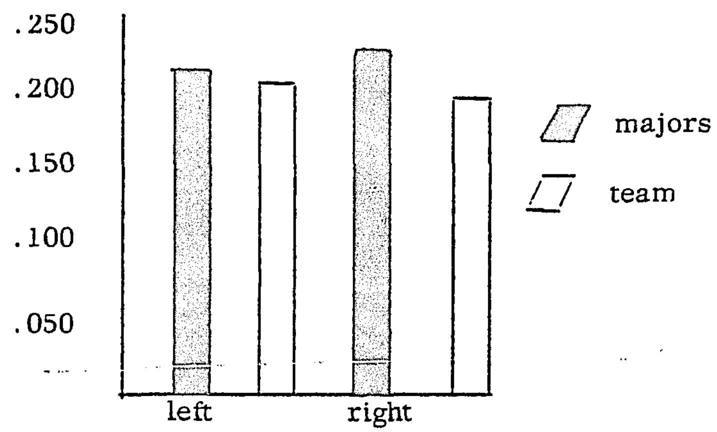

Figure 2. Group-by-Side

Table 2

Analysis of Performance
Group-by-Side

Mean Scores

Group	Side	N (observations)	Mean Score (milliseconds)
Major	1 right	180	.2278
	2 left	180	.2087
Team	1 right	180	.1899
	2 left	180	.1977

Analysis of Variance Results (Group-by-Side)

DF	SS	MS	F	Prob F
1	.0327	.0327	6.6948	0.0131
38	.1857	.0049		

Newman-Keuls Test

	a2b1	a2b2	a1b2	a1b1	Critical Value
a2b1	-	.0078	.0188*	.0379*	.0198
a2b2		-	.0110	.0301*	.0179
a1b2			-	.0191*	.0149
a1b1				-	

* significant .05 level
a=group: 1-major, 2-team
b=side: 1-right, 2-left
i.e. a2b1 = performance of team on all right side conditions
N = number of observations considered

Group-by-Angle

A nonsignificant F value of .5342 was found between the physical education major group and the field hockey team when considering flat, diagonal and through angle conditions. The results of the analysis of variance and the group means for each condition are found in Table 3.

Table 3

Analysis of Performance
Group-by-Angle

Mean Scores

Group	Angle	N (observations)	Mean Score (milliseconds)
Major	1 flat	120	.2017
	1 diagonal	120	.2264
	3 through	120	.2267
Team	1 flat	120	.1859
	2 diagonal	120	.1970
	3 through	120	.1986

Analysis of Variance Results (Group-by-Angle)

DF	SS	MS	F	Prob F
1	.0067	.0033	.5342	0.5938
76	.4764	.0063		

Angle: 1-flat, 2-diagonal, 3-through

Angle

When the data were considered without regard to group, there was a significant difference in the accuracy with which all subjects responded to the three angles utilized in the study. In general, the subjects responded more accurately in the flat pass condition than in either the diagonal or through pass condition. There was no significant difference between the performance of subjects in the diagonal and through pass conditions. Table 4 illustrates the mean scores for all subjects on each of the three angles.

Thus, although the accuracy with which all subjects responded differed as a function of the angle-of-approach, the two groups in the study tended to respond in a similar manner to the flat, diagonal and through pass conditions.

Group-by-Speed

An F value of 4.8792, significant at the .05 level, was obtained for the Group-by-Speed conditions. Post hoc comparisons of the means by the Newman-Keuls Test were used to determine which of the conditions within the two factors were significantly different. The results are presented in Table 5.

The performance of both groups at the fastest speed was significantly less accurate than the response made under the medium and slow conditions. The team was significantly more accurate than the majors in judging the fast speed. The response of the major group was significantly less accurate at the medium speed than at the slow speed. In addition, the major group showed significantly less accurate responses to the medium speed than that of the team

Table 4

Analysis of Performance
Angle

Mean Scores

Angle	N (observations)	Mean Score (milliseconds)
1	240	.1938
2	240	.2117
3	240	.2127

Analysis of Variance Results (Angle)

DF			F	Prob F
2	.0549	.0269	4.2989	0.0167
76	.4764	.0063		

Newman-Keuls Test

	d1	d2	d3	Critical Value
d1	-	.0179*	.0189*	.0173
d2		-	.0010	.0144
d3			-	

* significant .05 level
d= angle: 1-flat, 2-diagonal, 3-through

Table 5

Analysis of Performance
Group-by-Speed

Mean Scores

Group	Speed	N (observations)	Mean Scores (milliseconds)
Major	1 slow	120	.1589
	2 medium	120	.2091
	3 fast	120	.2868
Team	1 slow	120	.1648
	2 medium	120	.1799
	3 fast	120	.2368

Analysis of Variance Results (Group-by-Speed)

DF	SS	MS	F	Prob F
2	.0959	.0480	4.8792	0.0102
76	.7470	.0098		

Newman-Keuls Test

	a1c1	a2c1	a2c2	a1c2	a2c3	a1c3	Critical Values .05	Critical Values .01
a1c1	-	.0059	.0210	.0502**	.0779**	.1279**	.0373	.0446
a2c1		-	.0151	.0433**	.0720**	.1220**	.0356	.0431
a2c2			-	.0292*	.0569**	.1069**	.0336	.0411
a1c2				-	.0277*	.0777**	.0305	.0383
a2c3					-	.0500**	.0255	.0337
a1c3						-		

** significant .01 level
* significant .05 level
a = group: 1-majors, 2-team
c = speed: 1-slow, 2-medium, 3-fast

for both the medium and slow speed conditions (Figure 3).

No significant differences were found between the team's performance at the medium speed and that of the team and major group at the slow speed. There was no difference in the response accuracy of the two groups at the slow speed.

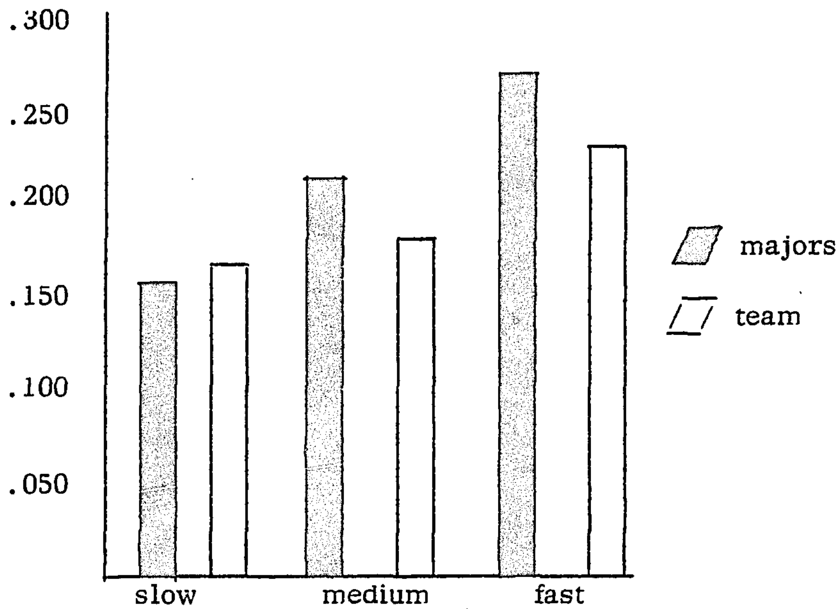

Figure 3. Group-by-Speed

Speed

When data for the speed condition were considered without regard to group, there was a significant difference in the accuracy with which all subjects responded to the three speeds employed in the study. The subjects responded more accurately to the slow speed than either the medium or fast speed. There was also a significant difference between the response accuracy for the fast speed and the medium speed favoring the medium speed. All subjects tended to respond differentially to the three speeds with the performance of the team being significantly more accurate at the fast and medium speeds than that of the major group (Table 5). The means for all subjects can be found in Table 6.

Table 6

Analysis of Performance
Speed

Mean Scores Speed	N (observations)	Mean Score (milliseconds)
1	240	.1619
2	240	.1945
3	240	.2618

Analysis of Variance Results (Speed)

DF	SS	MS	F	Prob F
2	1.2453	.6226	63.3428	0.0001
76	.7470	.0098		

Newman-Keuls Test

	c1	c2	c3	Critical Values .05	Critical Values .01
c1	-	.0326**	.0999**	.0214	.0273
c2		-	.0673**	.0181	.0240
c3			-		

** significant .01 level
c=speed: 1-slow, 2-medium, 3-fast

Group-by-Side-by-Angle

The analysis of variance for differences in the accuracy with which the two groups responded when approaching from different sides and the three passing angles included in the experiment resulted in an F of .0694, which was not significant and, therefore, no post hoc test was applied. The means reflecting the response accuracy of the two groups and the analysis of variance results are shown in Table 7.

Group-by-Angle-by-Speed

When considering the accuracy of performance for the major and team groups on the flat, diagonal, and through angles, at the slow, medium, and fast speeds, a non significant F value of 1.7672 was found and no post hoc test was performed. The analysis of variance results and the means reflecting the accuracy scores for the two groups are found in Table 8.

Group-by-Side-by-Speed

The F test for the analysis of variance of major and team group interaction with right and left fielding sides and slow, medium and fast speeds was not significant. Based on the nonsignificant F value, no post hoc comparison was conducted. Table 9 illustrates the means and analysis of variance table for the Group-by-Side-by-Speed conditions.

Table 7

Analysis of Performance
Group-by-Side-by-Angle

Mean Scores

Group	Side	Angle	N (observations)	Mean Score (milliseconds)
Majors	1	1	60	.2091
	1	2	60	.2422
	1	3	60	.2323
	2	1	60	.1944
	2	2	60	.2105
	2	3	60	.2211
Team	1	1	60	.1806
	1	2	60	.1965
	1	3	60	.1927
	2	1	60	.1912
	2	2	60	.1975
	2	3	60	.2046

Analysis of Variance Results (Group-by-Side-by-Angle)

DF	SS	MS	F	Prob F
2	.0008	.0004	.0694	0.9326
76	.4169	.0055		

Side: 1-right, 2-left
Angle: 1-flat, 2-diagonal, 3-through

Table 8

Analysis of Performance
Group-by-Angle-
by-Speed

Mean Scores

Group	Angle	Speed	N (observations)	Mean Score (milliseconds)
Majors	1	1	40	.1469
	1	2	40	.1886
	1	3	40	.2698
	2	1	40	.1806
	2	2	40	.2024
	2	3	40	.2961
	3	1	40	.1493
	3	2	40	.2364
	3	3	40	.2944
Team	1	1	40	.1739
	1	2	40	.1596
	1	3	40	.2243
	2	1	40	.1602
	2	2	40	.1972
	2	3	40	.2337
	3	1	40	.1605
	3	2	40	.1830
	3	3	40	.2523

Analysis of Variance Results (Group-by-Angle-by-Speed)

DF	SS	MS	F	Prob F
4	.0446	.0111	1.7672	0.1372
152	.9589	.0063		

Angle: 1-flat, 2-diagonal, 3-through
Speed: 1-slow, 2-medium, 3-fast

Table 9

Analysis of Performance
Group-by-Side-
by-Speed

Mean Scores

Group	Side	Speed	N (observations)	Mean Scores (milliseconds)
Majors	1	1	60	.1600
	1	2	60	.2109
	1	3	60	.3126
	2	1	60	.1578
	2	2	60	.2074
	2	3	60	.2609
Team	1	1	60	.1477
	1	2	60	.1838
	1	3	60	.2383
	2	1	60	.1820
	2	2	60	.1760
	2	3	60	.2352

Analysis of Variance Results (Group-by-Side-by-Speed)

DF	SS	MS	F	Prob F
2	.0231	.0115	1.5241	0.2229
76	.5749	.0076		

Side: 1-right, 2-left
Speed: 1-slow, 2-medium, 3-fast

Side-by-Speed

Analysis without regard to group revealed significant differences in the accuracy of subject responses to the Side-by-Speed conditions.

The responses of all subjects indicated that the fast speed resulted in significantly less accurate responses than were made to the slow and medium speeds. For the fast condition, the responses were significantly more accurate on the left position than on the right fielding position. The medium speed, right fielding position, was significantly less accurate than the slow speed on both the right and left positions. The accuracy of response for the medium speed, left fielding position, was significantly different from the slow speed, right fielding position, but was not significantly different from the slow speed, left fielding position. There was no significant difference between responses on the right and left positions for either the slow or medium speed. The means reflecting the response accuracy of the two groups can be found in Table 10.

Although the accuracy with which all subjects responded differed as a function of the side and speed, the two groups in the study tended to respond in a similar manner to the Side-by-Speed conditions (Figure 4).

Group-by-Side-by-Angle-by-Speed

An F test for the analysis of variance of all four factors in the experiment (2 groups X 2 sides X 3 speeds X 3 angles) resulted in a nonsignificant F value of 1.1075. As in previous conditions, which resulted in a nonsignificant F value, no post hoc comparison was applied. The analysis of variance table

Table 10

Analysis of Performance
Side-by-Speed

Mean Scores

Side	Speed	N (observations)	Mean Score (milliseconds
1	1	120	.1538
1	2	120	.1974
1	3	120	.2755
2	1	120	.1699
2	2	120	.1917
2	3	120	.2481

Analysis of Variance Results (Side-by-Speed)

DF	SS	MS	F	Prob F
2	.0568	.0284	3.7519	0.0271
76	.5749	.0076		

Newman-Keuls Test

	b1c1	b2c1	b2c2	b1c2	b2c3	b1c3	Critical Value
b1c1	-	.0161	.0379*	.0436*	.0943*	.1217*	.0329
b2c1		-	.0218*	.0275*	.0782*	.1056*	.0315
b2c2			-	.0057	.0564*	.0838*	.0297
b1c2				-	.0507*	.0781*	.0269
b2c3					-	.0274*	.0220
						-	

* significant .05 level
b=side: 1-right, 2-left
c=speed: 1-slow, 2-medium, 2-fast

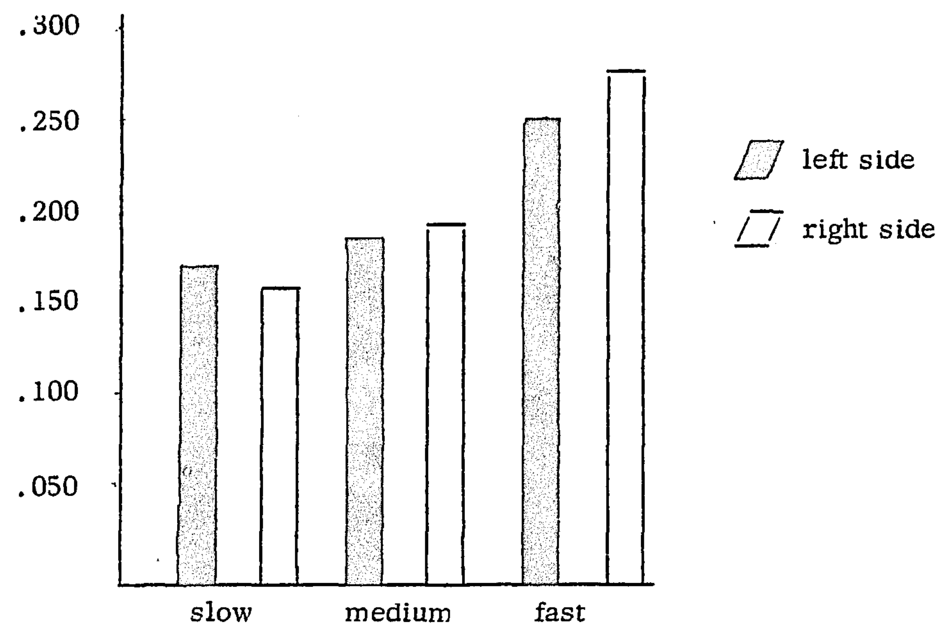

Figure 4. Side-by-Speed

for the Group-by-Side-by-Angle-by-Speed conditions are shown in Table 11. Table 12 illustrates the means reflecting the accuracy scores.

Table 11

Analysis of Variance Results
Group-by-Side-by
Angle-by-Speed

DF	SS	MS	F	Prob F
4	.0338	.0085	1.1075	0.3552
152	1.1605	.0076		

Table 12

Analysis of Performance
Group-by-Side-by-
Angle-by-Speed

Mean Scores Group	Side	Angle	Speed	N (observations)	Mean Scores (milliseconds)
Majors	1	1	1	20	.1327
	1	1	2	20	.2037
	1	1	3	20	.2910
	1	2	1	20	.2017
	1	2	2	20	.2054
	1	2	3	20	.3195
	1	3	1	20	.1457
	1	3	2	20	.2237
	1	3	3	20	.3275
	2	1	1	20	.1611
	2	1	2	20	.1736
	2	1	3	20	.2486
	2	2	1	20	.1596
	2	2	2	20	.1994
	2	2	3	20	.2727
	2	3	1	20	.1529
	2	3	2	20	.2492
	2	3	3	20	.2614
Team	1	1	1	20	.1461
	1	1	2	20	.1591
	1	1	3	20	.2367
	1	2	1	20	.1417
	1	2	2	20	.2154
	1	2	3	20	.2325
	1	3	1	20	.1553
	1	3	2	20	.1770
	1	3	3	20	.2458

Table 12 (continued)

Mean Scores Group	Side	Angle	Speed	N (observations)	Mean Scores (milliseconds)
	2	1	1	20	.2017
	2	1	2	20	.1600
	2	1	3	20	.2120
	2	2	1	20	.1787
	2	2	2	20	.1789
	2	2	3	20	.2349
	2	3	1	20	.1657
	2	3	2	20	.1891
	2	3	3	20	.2589

Side: 1-right, 2-left
Angle: 1-flat, 2-diagonal, 3-through
Speed: 1-slow, 2-medium, 3-fast

DISCUSSION

The present investigation examined the performance of two groups on a coincidence-anticipation task which was designed to simulate fielding responses used in field hockey game situations. The following elements of the fielding situation were included in the design of the experiment: (1) the subject responded by contacting the field hockey ball with her stick; (2) a legal field hockey stroke was required in contacting the ball; and (3) a requisite part of the task was that the subject move to get into a position to view the display and make the response. Specifically, the subjects moved from three pass reception positions (flat, through, and diagonal) to perform the task of fielding the ball. The groups were tested on their reception accuracy from both the right and left sides of the body. Three ball speeds representative of the speed of passes utilized in the game were presented at each pass reception position and on both sides of the body.

One distinctive feature of the game of field hockey is the nature of the implement utilized in propelling and controlling the ball. The asymmetrical design of the club head permits contact only on the flat surface area of the left side of the lever. Fielding a field hockey ball which is approaching from the right side of the body requires the performer to move to a position around the ball or use a "reverse stick" technique which utilizes the toe of the stick and greatly reduces the contact surface for reception. In general, reception from the right side of the body is more difficult due to the nature of the stick and the rules of the game.

When the performance of the two groups on all trials and under all conditions was evaluated, no significant difference was found to exist between the physical education major group and the field hockey team. However, significant differences were found between groups for specific conditions and the examination of the factors which were investigated in the study may aid in the understanding of coincidence-anticipation performance specifically related to the game of field hockey.

When performance on all speeds and angles was included, a significant F value was obtained for the Group-by-Side factor. Specifically, the response of the majors was significantly less accurate when approaching the ball from a right fielding position than from the left. Comparable differences in performance from the two fielding sides did not exist for members of the team. Consequently, team members were more accurate than the major students when approaching from the three positions on the right fielding side but were not significantly different in their performance when the task was performed from the left side position.

Differences which were found to exist may be attributed, at least in part, to the unique demands imposed by the legal use of the stick. It is suggested that these restrictions apparently hindered the performance of the majors, but did not affect the performance of team members.

Although no significant between-group difference was found to exist for the three angles-of-approach, significant differences were revealed when the angle factor was examined without regard to group. The performance of the subjects was found to be significantly more accurate on the flat pass condition than when required to move from either a diagonal or through fielding position. The coincidence-anticipation judgment was made more accurately from some positions than others and these differences in response were evident in the performance of both the major students and team members.

Although not explained by the literature, examination of the different angles involved would suggest that the response of the subjects was less accurate when a greater degree of body movement was required to get in line with the oncoming stimuli. The right angle approach, simulating a flat pass reception position, may have offered greater opportunity for viewing the display. Being able to approach the ball more directly may have affected the accuracy with which all subjects responded.

There was a significant difference in the accuracy with which all subjects, regardless of group, responded to each of the three speeds. Performance on the slow speed, with a mean score of .1619 milliseconds, was significantly more accurate than the responses to the other two speeds, with the fast speed being the least accurate.

Comparison of the accuracy of performance of the two groups showed that performance responses of the team at the medium and fast speeds were significantly more accurate than those for the major group. There was no significant difference in the performance on the two groups at the slow speed.

Research supports the findings that accuracy of performance decreased with an increase in stimulus speed (Garvey, Knowles & Newlin, 1956;

Brown, 1961). Conflicting evidence that accuracy improves with increased stimulus speeds was also to be found by Weiner (1962), Alderson (1972b), and Ellingstad and Heimstra (1969). Alderson (1972b) suggested that the more general finding is that greater error is found with increased stimulus speeds.

Of special interest in this investigation is the finding that the team members were able to make predictions more accurately than the major group. As previously stated in an assumption, team members hypothetically had more experience in receiving passes travelling through a greater range of speeds than did the major group. These findings may be consistent with the explanations formulated by Schmidt (1968), Spaeth (1972), Whiting (1970), and Hutt (1972) which state that the advanced performer is better able to anticipate future events and formulate responses that match the temporal and spatial demands of the task.

For the hockey stick to be coincident with the last illuminated red light, the subjects had to initiate their response at least one reaction time plus one movement time before actually contacting the ball. Anticipation of the arrival of the ball, by predicting the future action of the object, helps to reduce reaction time and movement time response (Stadulis, 1971; Williams, 1973).

Inspection of raw data revealed an overwhelming majority of the responses were late. The major students and team members responded similarly with 23 and 27 early responses, respectively, out of a possible 720 trials. Totally, 39 of these 50 early responses occurred at the slow speed. It was noted that, in almost every instance of an early response, the subjects commented or gestured, but made no such response when it was equally late. Research findings by Gentile et al. (1975) report subjects in their study selected the medium speed as a reference point and adjusted the temporal aspect of the response to meet task demands. Perhaps the subjects in this study may have geared their response to the medium speed and tried to amend their response from that reference point. This explanation is speculative and would need to be verified by future research.

Previous experience in reception of hockey balls travelling at a variety of speeds may have aided the team members in acquiring relevant cues to determine display regularities and the formulation of an anticipated response. Further research would be needed to test these tentative explanations.

Examination of the raw data revealed that the accuracy scores for the junior varsity members appeared to differ from those of the varsity team members. The junior varsity players seemed to respond less accurately than did the varsity players and tended to perform more like the major group. Additional analysis of the data would be necessary before a definite statement is justified.

No significant F value resulted from the analysis of variance for the Group-by-Side-by-Speed condition. However, analysis of data without regard to group revealed that significant differences did exist in the accuracy with which all subjects responded to various Side-by-Speed conditions. Generally, accuracy of response decreased with an increase in the speed of the stimulus especially when performed from the right fielding position. This is consistent with previous findings of the study.

No significant F test resulted from the following comparisons: Group-by-Side-by-Angle, Group-by-Angle-by-Speed, and Group-by-Side-by-Angle-by-Speed. Apparently, there was no significant interaction of factors which had not been explained by previous factorial analysis.

Summary

The factors which differentially affected the performance accuracy for the two groups appear to be the following: (1) the speed of the approaching object, and (2) the side from which the subject was required to respond. In general, team members in the study were found to be significantly more accurate in their performance than major students when the speed of the stimulus was medium or fast, and when responses from the right fielding side were required. The response of all subjects tended to be more accurate from the flat pass condition and at slower stimulus speeds.

Consistent with previous research findings, the speed of the stimulus affected the accuracy of response. However, the increased speed resulted in significantly less decrement in the performance of team members than was evident in the response of the physical education majors. These results suggest that, in an experimental situation designed to simulate specific elements of a field hockey receiving task, team members tended to show more accurate performance in some, but not all, of the factors selected for inclusion in the study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

This study investigated the effects of selected stimulus speeds, angles-of-approach, and fielding sides on the accuracy of field hockey coincidence-anticipation performance for collegiate women field hockey team members and physical education major students.

The women's collegiate varsity and junior varsity field hockey teams (goalies excluded) and twenty sophomore and junior women physical education majors from the University of Wisconsin - La Crosse served as subjects in the experiment. The coincidence-anticipation task utilized in the study required the subject to respond to a series of lights moving down a track. As the series of lights reached the final red light, the subject contacted the hockey ball at the end of the track with her field hockey stick. Stimulus light speeds of 10, 25, and 40 miles per hour were presented on the display as the subjects responded from both the right and left sides of the body and from positions simulating reception angles for flat, diagonal, and through passes. Each of the 18 trial conditions was randomly ordered and the score for each trial was the time difference between the arrival of the light at the designated point and the subject's response with the hockey stick against the timing mechanism. The accuracy score was recorded in milliseconds and indicated whether the response was early or late.

The analysis of variance procedure for the Statistical Analysis System (SAS) computer program was utilized to determine between-group differences for speed, angle-of-approach, and body side. The data reflecting the accuracy of responses under each of the conditions were analyzed without regard to sign by the analysis of variance repeated measures design with fixed effects on all factors and subjects nested within groups. The Newman-Keuls test for post hoc comparisons of group means was applied when the analysis of variance procedure indicated a significant F value at .05 level or below.

The speed of the approaching object and the side from which the subject was required to respond were factors which differentially affected the performance accuracy of the two groups. The performance of all subjects tended to be more accurate from the flat pass position and at the slower stimulus speed. The team members were more accurate than the major students when the speed of the stimulus was medium or fast, and when responses from the right fielding side were required.

CONCLUSIONS

Based on the null hypotheses which were tested and within the limitations of this study, the following conclusions seem justified:

1. There is no significant difference in the accuracy with which the two groups respond to slow, medium, and fast field hockey passing speeds.

This hypothesis was rejected based on the findings of the study. The team group was significantly more accurate at the fast and medium speeds. There was no significant difference in the response accuracy of the two groups at the slow speed.

2. There is no significant difference in the accuracy with which the two groups respond to fielding angles simulating the flat, diagonal, and through passes found in the game of field hockey.

No significant differences were found to exist and therefore, this hypothesis was accepted based on the findings of the study.

3. There is no significant difference in the accuracy with which the two groups respond when fielding a hockey ball from the right and left sides of the body.

Based on the findings of this study, this hypothesis was rejected. The major group was found to be significantly less accurate than the team when performing from fielding positions on the right side. No significant difference was indicated between the performance of the two groups from the left-side position. There was no significant difference in the accuracy with which the team responded from the left and right positions. However, the major group was significantly less accurate on the right side position than on the left side position.

4. There are no significant interaction effects for the factors of speed, angle-of-approach, and fielding side for the two groups.

This hypothesis was accepted based on the findings of this study.

The results of the study indicate that the amount and/or level of field hockey experience appears to affect the accuracy with which the fielding responses in field hockey are made. Specifically, the results suggest that field hockey team members make more accurate responses to faster stimulus speeds than less experienced players and are able to respond with comparable accuracy from either side of the body. Thus, additional experience in making the coincidence-anticipation judgments required in fielding situations appeared to increase the accuracy with which some responses were made.

Analysis of the data also revealed that different conditions were not responded to with equal accuracy. All three factors selected for investigation in the study exhibited significant differences in the accuracy of response within each factor. The task specificity of coincidence-anticipation responses required in the game of field hockey emphasized the response differences for each factor. In addition, it appears that these factors warrant inclusion in any task analysis of field hockey fielding skill. For teachers and coaches of activities involving coincidence-anticipation, these results support the necessity for analyzing the tasks that are crucial to the game and structuring practice situations that are consistent with these task demands.

RECOMMENDATIONS

The present investigation led to the following recommendations for future study:

1. Investigate the effect of knowledge of results on the accuracy of performance on the field hockey coincidence-anticipation factors included in the present study.
2. Increase the movement distance between the starting position and the ball at the end of the track to investigate the effects of making a coincident prediction while moving on the accuracy of performance in a field hockey task.
3. Limit the team group to varsity team members in order to maintain a more consistent standard of skilled performance.
4. Utilizing the same stimulus speeds, investigate the effects of viewing time and selected track lengths on a field hockey coincident-anticipation task.

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APPENDIX A

DATA FORMS

SUBJECT PERSONAL DATA FORM

Name ______________________________ Subject # ____________

School Address ______________________ Phone # ____________

Year in School: Fr. So. Jr. Sr. (Circle one)

Field Hockey Experience: PE 251 ____ PE 351 ____ Team ______

INFORMED CONSENT

I understand that the purpose of this study is to learn more about the game demands of field hockey.

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

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

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

I understand that all of my responses, written or oral, will remain completely anonymous.

I wish to give my cooperation as a subject. *

Signed: ______________________________

*From Locke, L. F. and Spirduso, W. W. Proposals that work. New York: Teachers College Press, 1976, p. 237.

SUBJECT # ___________

GROUP ___________

SUBJECT DATA FORM

Random Order		Trial #	Angle	Speed	Group	ID	Side	Angle	Speed	SCORE
		1	1	F			1	1	3	
		2	1	M			1	1	2	
		3	1	S			1	1	1	
		4	6	F			2	1	3	
		5	6	M			2	1	2	
		6	6	S			2	1	1	
		7	2	F			1	2	3	
		8	2	M			1	2	2	
		9	2	S			1	2	1	
		10	5	F			2	2	3	
		11	5	M			2	2	2	
		12	5	S			2	2	1	
		13	3	F			1	3	3	
		14	3	M			1	3	2	
		15	3	S			1	3	1	
		16	4	F			2	3	3	
		17	4	M			2	3	2	
		18	4	S			2	3	1	

APPENDIX B

INSTRUMENTATION

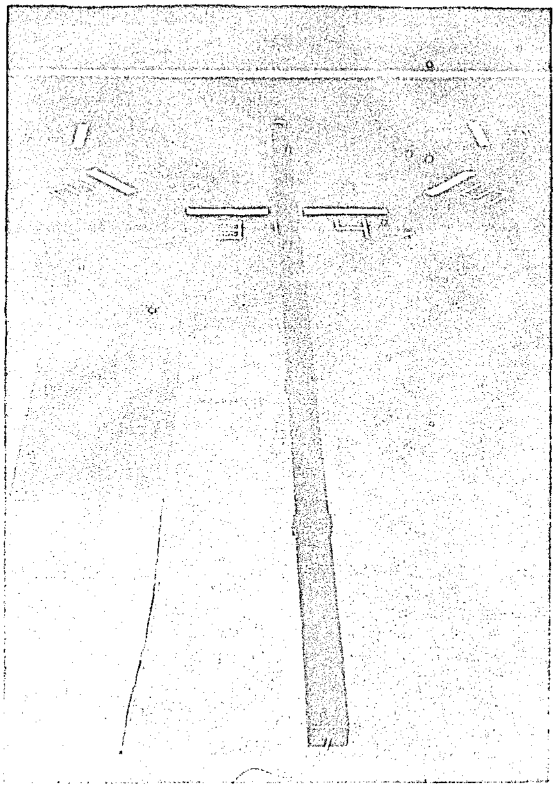

Figure 5. Testing Environment

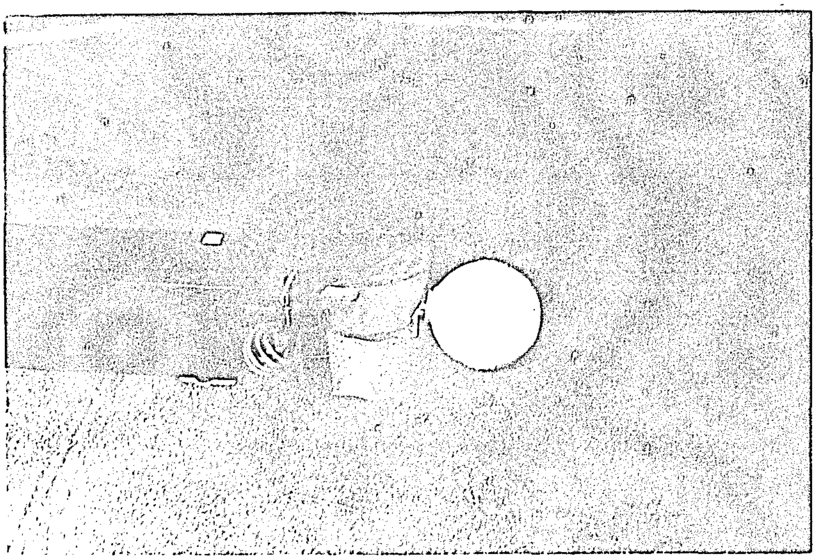

Figure 6. Control System

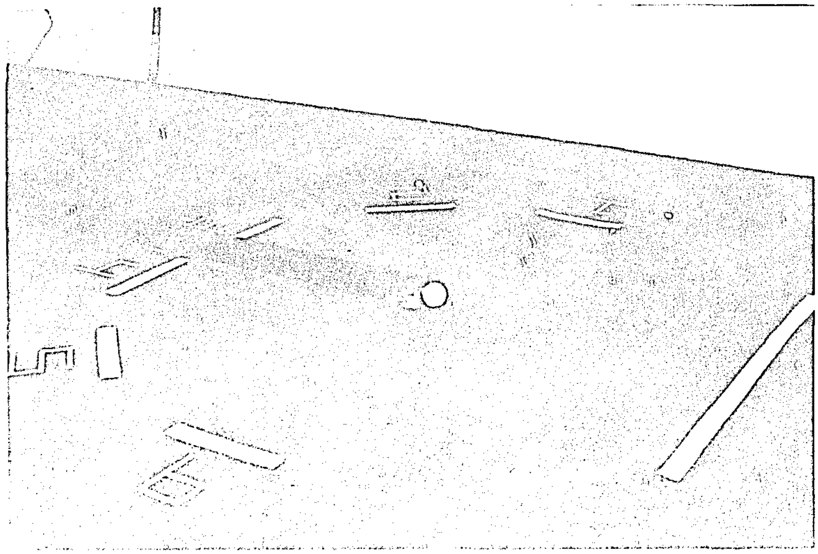

Figure 7. Testing Situation

#1 & #6--flat pass, #2 & #5--diagonal pass, #3 & # 4--through pass

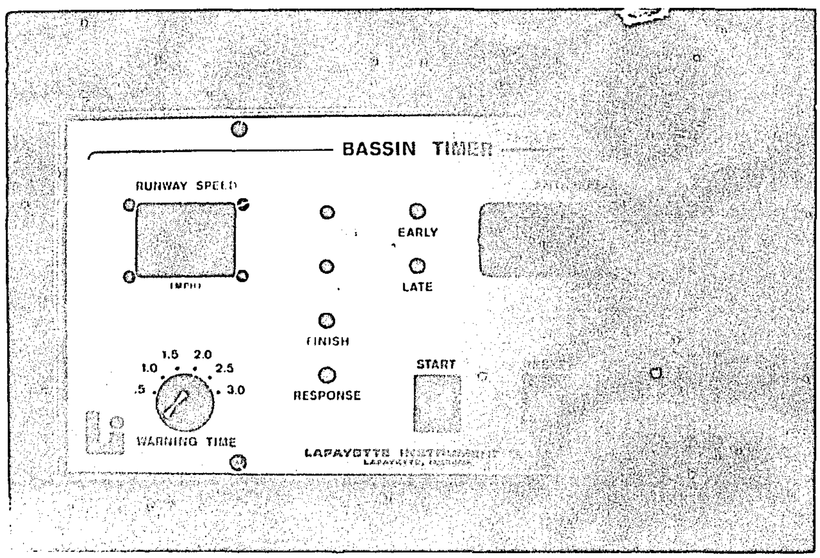

Figure 8. Response Control Unit

APPENDIX C

RANDOMIZATION OF TRIALS

$RNDORD*

LIST

```
1     REM   RNDORD:  PLACING INTEGERS IN RANDOM ORDER
10    PRINT "   THIS PROGRAM WILL LIST THE NUMBERS FORM 1 TO M IN"
15    PRINT "   RANDOM ORDER."
20    PRINT "HOW MANY DIFFERENT LISTS DO YOU DESIRE"
30    INPUT U
40    PRINT "WHAT DO YOU WANT YOUR M TO BE"
50    INPUT M
60    PRINT "HERE ARE "U" LISTS OF THE NUMBERS FROM 1 TO "M" IN"
65    PRINT "   RANDOM ORDER"
70    FOR Q=1 TO U
80    DIM [200], B[200]
90    N=1
100   Z=0
110   FOR A=1 TO M
120   LET A[A]=A
130   NEXT A
140   B=INT((M-N+1)*RND(1))+1
150   B[N]=A[B]
160   IF N=M THEN 200
180   A[B]=A[M-N+1]
185   N=N+1
190   GOTO 140
200   FOR V=1 TO M
210   PRINT B[V]
220   NEXT V
230   PRINT ""
240   PRINT ""
250   NEXT Q
260   END
```

*Contributed Program from the Hewlett-Packard Time-shared Basic Computer System #8405-36264A

Table 13

Randomized Trial Order Physical Education Majors

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

Table 14

Randomized Trial Order
Field Hockey Team

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

APPENDIX D

EXPERIMENTAL DATA

ACCESS TO REPEATED MEASURES ANOVA

Statistical Analysis System (1972)

```
DATA HOCKEY;
INPUT ID 1-2  GROUP 3  SIDE 4  ANGLE 5  SPEED 6  SCORE 7-11 3;
CARDS
   720 OBSERVATIONS IN DATA SET HOCKEY   6 VARIABLES
PROC SORT;
BY ID GROUP SIDE ANGLE SPEED;
PROC PRINT;
BY GROUP;
PROC ANOVA SORT = 5;
CLASSES ID GROUP SIDE ANGLE SPEED;
MEANS GROUP SIDE GROUP*SIDE ANGLE GROUP*ANGLE SPEED GROUP*SPEED
        SIDE*ANGLE GROUP*SIDE*ANGLE SIDE*SPEED GROUP*SIDE*SPEED
        ANGLE*SPEED GROUP*ANGLE*SPEED SIDE*ANGLE*SPEED
        GROUP*SIDE*ANGLE*SPEED;
MODEL SCORE = GROUP  GROUP*ID(GROUP) SIDE GROUP*SIDE SIDE*ID(GROUP)
        ANGLE GROUP*ANGLE  ANGLE*ID(GROUP) SPEED GROUP*SPEED
        SPEED*ID(GROUP) SIDE*ANGLE GROUP*SIDE*ANGLE
        SIDE*ANGLE*ID(GROUP) SIDE*SPEED GROUP*SIDE*SPEED
        SIDE*SPEED*ID(GROUP) ANGLE*SPEED GROUP*ANGLE*SPEED
        ANGLE*SPEED*ID(GROUP) SIDE*ANGLE*SPEED
        GROUP*SIDE*ANGLE*SPEED SIDE*ANGLE*SPEED*ID(GROUP;
TEST GROUP BY ID(GROUP);
TEST SIDE GROUP*SIDE BY SIDE*ID(GROUP);
TEST ANGLE GROUP*ANGLE BY ANGLE*ID(GROUP);
TEST SPEED GROUP*SPEED BY SPEED*ID(GROUP);
TEST SIDE*ANGLE GROUP*SIDE*ANGLE BY SIDE*ANGLE*ID(GROUP);
TEST SIDE*SPEED GROUP*SIDE*SPEED BY SIDE*SPEED*ID(GROUP);
TEST ANGLE*SPEED GROUP*ANGLE*SPEED BY ANGLE*SPEED*ID(GROUP);
TEST SIDE*ANGLE*SPEED GROUP*SIDE*ANGLE*SPEED BY SIDE*ANGLE*
        SPEED*ID(GROUP;
```

Table 15

Computer Ordering of Conditions

OBS	SIDE	ANGLE	SPEED
1	1	1	1
2	1	1	2
3	1	1	3
4	1	2	1
5	1	2	2
6	1	2	3
7	1	3	1
8	1	3	2
9	1	3	3
10	2	1	1
11	2	1	2
12	2	1	3
13	2	2	1
14	2	2	2
15	2	2	3
16	2	3	1
17	2	3	2
18	2	3	3

Table 16

Raw Data: Physical Education Majors

Subject Number

1	2	3	4	5	6	7	8	9	10
-.137	-.001	-.208	-.122	-.225	-.112	-.102	-.224	-.200	-.196
-.273	-.093	-.219	-.021	-.284	-.139	-.132	-.273	-.241	-.129
-.394	-.588	-.362	-.185	-.396	-.160	-.225	-.310	-.298	-.224
+.064	+.377	-.234	+.034	-.208	-.142	+.292	-.253	-.212	-.155
-.169	-.168	-.212	-.036	-.460	-.102	-.090	-.213	-.446	-.215
-.311	-.333	-.247	-.257	-.556	-.282	-.384	-.485	-.346	-.261
-.201	+.044	-.138	-.091	-.187	-.113	-.241	-.170	-.233	-.278
-.240	-.157	-.255	-.143	-.464	-.187	-.286	-.113	-.245	-.220
-.306	-.428	-.261	-.208	-.454	-.242	-.226	-.287	-.321	-.242
-.120	+.162	-.196	+.047	-.202	-.080	-.127	-.172	-.188	-.246
-.209	-.243	-.242	+.400	-.231	-.015	-.106	-.167	-.198	-.140
-.265	-.198	-.266	-.212	-.285	-.206	-.190	-.304	-.219	-.238
-.244	+.323	-.152	-.021	-.172	-.151	-.163	+.108	-.219	-.248
-.241	-.282	-.235	-.075	-.227	-.123	-.096	-.294	-.283	-.153
-.309	-.313	-.246	-.168	-.439	-.218	-.298	-.275	-.264	-.205
-.183	+.155	-.108	-.052	-.225	-.096	-.051	-.260	-.239	-.232
-.206	-.252	-.276	-.153	-.471	-.142	-.206	-.201	-.304	-.142
-.171	-.319	-.279	-.168	-.194	-.330	-.173	-.321	-.278	-.201

11	12	13	14	15	16	17	18	19	20
-.214	-.256	-.156	-.038	+.034	-.096	-.070	-.006	-.114	-.142
-.204	-.020	-.281	-.178	-.238	-.214	+.410	-.309	-.102	-.313
-.265	-.312	-.230	-.314	-.394	-.234	-.088	-.315	-.207	-.318
-.128	+.326	-.108	-.187	-.059	-.082	+.534	-.271	-.149	-.218
-.133	-.194	-.202	-.134	-.262	-.189	-.175	-.144	-.182	-.382
-.325	-.310	-.405	-.274	-.319	-.235	-.289	-.205	-.193	-.373
-.055	-.195	-.015	-.198	-.343	-.059	+.125	-.084	-.098	-.045
-.168	-.075	-.321	-.192	-.224	-.213	-.240	-.224	-.153	-.353
-.278	-.231	-.307	-.216	-.392	-.261	-.257	-.544	-.302	-.786
-.169	+.034	+.056	-.308	-.193	-.040	-.102	-.546	-.146	-.087
-.082	-.023	-.185	-.239	-.270	-.191	-.125	-.089	-.129	-.187
-.180	-.274	-.283	-.241	-.353	-.285	-.185	-.266	-.126	-.396
-.179	+.077	+.065	-.163	-.234	-.206	+.018	+.040	-.204	-.204
-.232	-.165	-.163	-.168	-.296	-.193	-.193	-.161	-.063	-.344
-.220	-.283	-.225	-.294	-.353	-.227	-.207	-.271	-.206	-.432
-.073	-.024	+.021	-.175	-.259	-.207	-.101	-.177	-.136	-.283
-.374	-.246	-.274	-.154	-.405	-.225	-.140	-.225	-.085	-.502
-.236	-.284	-.316	-.195	-.376	-.253	-.265	-.219	-.206	-.444

Table 17

Raw Data: Field Hockey Team

Subject Number

1	2	3	4	5	6	7	8	9	10
-.125	+.001	-.083	-.226	+.079	+.022	-.159	-.293	-.114	+.033
-.166	-.099	-.108	-.255	-.179	-.281	+.009	-.114	-.161	-.024
-.232	-.134	-.354	-.373	-.229	-.189	-.202	-.240	-.092	-.135
-.078	+.161	-.126	-.177	-.052	-.132	-.009	-.187	-.280	-.103
+.189	-.090	-.333	-.293	-.042	-.392	-.078	-.339	-.134	-.066
-.328	-.114	-.172	-.233	-.146	-.311	-.280	-.211	-.222	-.162
-.127	-.091	-.148	-.175	-.129	-.086	-.106	+.084	-.182	-.065
-.202	-.118	-.193	-.205	-.086	-.124	-.129	-.234	-.062	-.079
-.420	-.195	-.221	-.307	-.212	-.252	-.105	-.266	-.181	-.184
-.134	-.062	+.514	-.224	+.440	-.189	-.096	-.198	-.074	-.197
-.304	+.025	-.192	-.164	-.125	-.102	+.017	-.259	-.069	+.008
-.151	-.138	-.261	-.187	-.142	-.214	-.109	-.290	-.241	-.111
+.096	-.052	-.115	-.212	+.268	-.210	+.437	-.122	-.219	-.159
-.110	-.132	-.168	-.305	-.277	-.135	-.135	-.144	-.065	-.117
-.481	-.199	-.232	-.274	-.121	-.159	-.167	-.167	-.339	-.130
-.120	-.111	+.038	-.342	-.038	-.085	-.068	-.117	-.159	+.104
-.167	-.088	-.093	-.367	-.241	-.149	-.027	-.208	+.020	-.159
-.306	-.144	-.315	-.211	-.231	-.189	-.141	-.325	-.168	-.21[illegible]

11	12	13	14	15	16	17	18	19	20
-.133	-.087	-.079	-.192	-.272	-.063	+.076	-.291	+.442	-.151
-.104	-.059	-.079	-.169	-.283	-.204	-.307	-.230	-.268	-.083
-.212	+.351	-.268	-.287	-.275	-.248	-.227	-.295	-.286	-.105
-.193	-.066	-.163	-.080	-.268	-.052	-.128	-.233	-.257	-.088
-.095	-.244	-.153	-.641	-.243	-.232	-.246	-.231	-.237	-.030
-.138	-.210	-.262	-.370	-.180	-.217	-.380	-.234	-.310	-.169
-.170	-.171	-.165	-.256	-.259	-.128	-.312	-.233	-.193	+.026
-.084	+.007	-.299	-.238	-.191	-.360	-.303	-.166	-.391	-.068
-.194	-.212	-.234	-.257	-.373	-.223	-.313	-.242	-.369	-.155
-.137	-.112	-.179	-.233	-.250	-.197	-.197	-.229	-.182	-.189
-.103	-.153	-.157	-.211	-.345	-.210	-.206	-.302	-.226	+.022
-.146	-.203	-.250	-.260	-.269	-.242	-.288	-.212	-.335	-.190
-.164	-.008	+.178	-.232	-.294	-.168	-.117	-.165	-.204	-.153
-.088	-.144	-.228	-.228	-.169	-.214	-.276	-.139	-.322	-.182
-.159	-.120	-.250	-.358	-.266	-.255	-.295	-.235	-.310	-.180
-.134	-.269	-.181	-.260	-.264	-.164	-.162	-.311	-.267	-.120
-.150	-.168	-.287	-.150	-.313	-.259	-.297	-.221	-.411	+.007
-.214	-.200	-.223	-.902	-.267	-.230	-.289	-.172	-.322	-.113