THE CONSTRUCTION OF A TEST TO MEASURE PERCEPTUAL ABILITY IN TENNIS FOR COLLEGE WOMEN

THESIS

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CHAPTER I

INTRODUCTION

The trend today in the field of education is to educate the whole child. Students with learning difficulties have been encountered numerous times by the classroom teacher. Therefore, considerable research has been done to explain why students have these difficulties in learning.

According to Woodruff (10, pp. 3, 125, 158), most learning problems can be traced back to the area of perception. Perception may be defined as the way in which the stimuli are received and organized into a "picture" in the brain. It is therefore the organization of the stimuli with which educators are concerned (9, p. 3). Because of this broad definition perceptual problems are not limited to any one field, but are involved in the learning of many kinds of tasks.

Perception may be broken down into many factors. Some of these factors are visual perception, sensory perception, spatial perception, and temporal perception. Due to overlapping of the elements involved in each broad factor, precise information is limited on certain factors. An example of this overlapping would be visual and spatial perception. Visual perception involves such elements as convergency, binocular vision, depth perception, tracking, size constancy, and figure-ground control. Spatial perception involves such elements as reaction time, reach perception, kinesthetic awareness, depth perception, tracking, and figure-ground control. To make the picture even more confusing, these elements overlap within themselves, _i.e._, depth perception involves size constancy, binocular vision, figure-ground control, reach perception, kinesthetic awareness, tracking, and reaction time (3, pp. 87, 94, 134, 136, and 138).

Since many sports activities depend upon the participant striking, throwing, or catching a moving object, such as a ball, it would be of great importance for physical educators to understand all that is involved in the performance of a motor skill. Since the physical educator is concerned with teaching basic motor skills, he normally assumes that the ability to make perceptual judgments is learned in connection with the motor skill. However, students do not always give satisfactory performances in motor skills. Many theories have been advanced about the cause or causes of these performances. Some physical educators feel that a general lack of strength on the part of the student is the main cause. Others feel that a lack of spatial concept formation is the cause. There are others who feel that there are other causes than these. However, until recently not much research on perception was done in the field of physical education. The increase in research can be attributed to such physical educators as Schurr (7, p. 39) and Lawther (4, p. 43) who feel that the learning of motor skills is influenced by perceptual development.

When a physical educator undertakes to teach motor skills such as those involved in tennis, he is faced with a difficult and complex learning situation. He must not only teach the students the basic mechanics of each stroke but also how to use these strokes in a game situation. After the student is capable of dropping and hitting the ball with some proficiency, he is ready to rally the ball. This transition presents a problem to the student because he is required to make several decisions in a short period of time. According to Broer (2, p. 27) the student must consider (1) speed of movement, (2) distance, (3) height, and (4) force which may result from contact with the ball. The result of these considerations should be the maneuvering of the body into the best position for the performance of the stroke. But as Barnes (1, p. 389) points out, a common error in beginning tennis players is to get too close to the ball. Smith (8, p. 53) feels this error is due to faulty perceptual judgments. These perceptual judgments are the result of the brain's organization of the stimuli and the selection of the appropriate response. The stimuli for these judgments are received from two sources. Cratty (3, p. 76) states the first source is external cues. The external cues to which he refers are visual, auditory, and tactile. Smith (8, p. 53) also points out that the second source would be internal cues, i.e., from proprioreceptors in the muscles and tendons. After the brain receives all of these stimuli, it must organize them into a mental picture and select the correct response which is based on past experience (2, p. 28). The time it takes for the brain to complete this mental process and the body to react is important in the execution of motor skills. The reaction time can be shortened by faster recognition of stimuli. This process is accomplished through learning by substituting a part of the original stimulus for the total stimulus (4, p. 44). This makes it possible for the student to perceive a stimulus and to react to it faster. After observing tennis classes for an extended period of time, it appears the student does learn to make these perceptual judgments through practice in game situations.

To summarize, one could say that the ability to play tennis depends to an extent on the students' perceptual ability. This perceptual ability is composed of many factors, some of which are depth perception, reaction time, kinesthetic sense, and past experience.

Statement of the Problem

After careful consideration of opinions by experienced tennis instructors and review of literature, it has become evident that the perceptual ability involved in tennis is a complex problem. Because definite evidence is not available concerning specifically which factors are involved in successfully hitting a forehand or backhand drive, it would be most helpful to identify those factors and use them to diagnose difficulties of the student in an early stage of skill development.

Purpose of the Study

The purposes of this study are (1) to identify some of the factors involved in this perceptual ability, (2) to devise a test to measure these factors, and (3) to determine if this test has any predictive validity.

Definition of Terms

Depth Perception.--Oxendine (6, p. 284) defines depth as the ability to distinguish the distance of objects or to make judgments about relative distance.

Perceptual Ability.--A working definition for this study will be: the ability of the student to judge the force and distance of a tennis ball and to react to it.

Reaction Time.--Lotter (5) defines reaction time as the amount of time which elapses from presentation of the stimulus to the initiation of the motor response.

Spatial Orientation.--Schurr (7, p. 36) defines spatial orientation as a concept of the relationship of the body and body parts with objects in space.

Spatial Visualization.--Cratty (3, p. 134) defines spatial visualization as the mental manipulation of objects in space.

Limitations of the Study

This study was limited by three items: (1) the tennis classes were taught by four different instructors; (2) due to the length of the testing period, motivation of the subjects was difficult to control; and (3) the weather conditions throughout the testing period.

CHAPTER BIBLIOGRAPHY

1. Barnes, Mildred J., Margaret C. Fox, and M. Gladys Scott, Sports Activities for Girls and Women, New York, Appleton-Century-Crofts, 1966.

2. Broer, Marion R., Efficiency of Human Movement, Philadelphia, W. B. Saunders Company, 1966.

3. Cratty, Bryant J., Movement Behavior and Motor Learning, Philadelphia, Lea and Febiger, 1964.

4. Lawther, John D., The Learning of Physical Skills, Englewood Cliffs, New Jersey, Prentice Hall, Inc., 1968.

5. Lotter, Willard S., "Interrelationships among Reaction Times and Speeds of Movement in Different Limbs," Research Quarterly, XXXI (May, 1960), 147-155.

6. Oxendine, Joseph E., Psychology of Motor Learning, New York, The MacMillan Company, 1968.

7. Schurr, Evelyn, Movement Experiences for Children: Curriculum and Methods for Elementary School Physical Education, New York, Appleton-Century-Crofts, 1967.

8. Smith, Hope M., Introduction to Human Movement, Reading, Massachusetts, Addison-Wesley Publishing Company, 1968.

9. Smith, Karl U. and William M. Smith, Perception and Motion, London, W. B. Saunders Company, 1968.

10. Woodruff, Asaheld D., The Basic Concepts of Teaching, San Francisco, Chandler Publishing Company, 1962.

CHAPTER II

REVIEW OF LITERATURE

Since the devised test was dependent to some extent on two primary factors, the review of literature was divided into two sections, one on perception and the other on reaction time.

Perception

A review of available literature revealed that the problem of perceptual judgments has been under investigation for many years. There was a significant lack of studies of perception in gross motor skills. There were, however, numerous studies on some of the factors thought to be involved in the perceptual process. Treatment of these factors vary from study to study with the emphasis on such items as size cues, illumination, figure-ground, visual acuity, convergency, accomodation, and apparent movement. Because the broad area of perception was broken down into these factors the review of literature which follows was also broken down into some of these various factors.

Size

In studies of size as a cue to distance, the investigators were concerned with the relationship of relative and familiar size cues to relative and absolute distances. Ittelson (10), as well as others, defined relative distance as the ratio of distances of two objects from the observer and absolute distance as the distance of one object from the observer. He conducted a study to determine if (1) relative size was a cue to relative distance, (2) absolute size was a cue to absolute distance and, (3) a change in size would indicate a change in distance. He found that a single object would be perceived at a definite distance from the observer and this apparent distance was determined by the size cue presented to the observer. He also found that if the physical property of the size cue changed, then the perceived distance appeared to change.

Gruber and Dinnerstein (5) hypothesized that knowledge of the distance would influence the perceived judgment of relative and absolute distance. They concluded that knowledge acted selectively on these judgments in that it had a great effect on perception of aboslute distance but little on relative distance.

Broadening the scope on size as a cue to distance, Gogel (3) found that relative size and familiar size cues have the common factors of perceived size by the subject and the retinal size of the object. He concluded that it was the combination of these factors which produced depth.

In studies where the visual field was restricted, distance judgments became more difficult. Luria and Kinney (15) attempted to explain the overestimation of pilots and divers using the variables of emptiness of space and lack of contrast. They found that in the absence of cues, distances of objects were overestimated and that this overestimation was due to emptiness of space rather than lack of contrast.

The findings of Over (19), comparing size and distance judgments under restricted and nonrestricted conditions, appeared to support the conclusions of Luria and Kinney. Over found that judgments made under nonrestricted conditions corresponded to the object while those judgments made under restricted conditions did not correspond to the physical size and distance of the object.

Figure-Ground

Perception of a stimulus may depend on the observer's ability to distinguish between figure and ground. In a study conducted by Witkin (28), it was found that women were influenced more by structure and direction of the visual field, when perceiving the direction of an object within the field. He further stated that this ability varied from individual to individual.

In a study by Holzman (8) and a later study by Holzman and Klein (9) the terms leveling and sharpening were used to describe the ability of the observer to distinguish between figure and ground. In these studies the term leveling implied that the observer tended to disregard figure-ground distinctions and assimilate stimuli so that any slight change in the stimulus field was ignored. Sharpening on the other hand implied that the observer tended to pay close attention to the figure-ground distinctions and recognize the independence of the stimulus. Both of these studies supported the idea that the rate of differentation of figure-ground varied from individual to individual.

The problem of individual differences of figure-ground influence was investigated by Rudin and Stagner (21). They found that an individual who was figure oriented would be less affected by variations of the ground than the individual who was ground oriented and would modify the figure characteristics to the changes in the ground.

Rudin (20) in a later study pointed out that although an individual could shift his perception of what was figure and what was ground, the process was dependent upon the "set" of stimuli the individual was instructed to observe.

Apparent Movement

The perception of distance becomes more complex as the aspect of motion was added. In a study conducted by Goldstein (4), it was found that linear, saggital acceleration produced the effect of motion on a stationary object. The object appeared to approach with forward acceleration and to recede with backward acceleration.

In keeping with this, Ittelson (11) stated that the observer made some assumptions about, to use his terms, the "external configuration," and it was these assumptions upon which the observer based his judgments of distance when motion was involved.

Smith (26) hypothesized that sensitivity to movement would be greated to a stimulus which possessed the "property of movement," that is to say an object which would normally be perceived as moving, such as a ball. He found, however, that sensitivity to a stimulus which possessed this characteristic was not any greater than to a stimulus which did not possess this characteristic.

Reaction Time

It has been recognized for some years that certain activities in physical education require the participant to react quickly to a visual stimulus. There has been an abundance of research to determine the nature of this reaction process and what factors could effect it. This reaction process known as "reaction time" was defined by Lotter (14) as the amount of time which elapses from presentation of the stimulus to the initiation of the motor response.

For many years it has been assumed that fast reaction time was a prerequisite for a skilled performance in activities such as football, basketball, baseball, softball, and tennis. Keller (12), in a study of the relationship of total body reaction time to success in athletics, pointed out that even though there was a positive relationship between total body reaction time and success in athletics, the requirements for quickness in the various sports were not the same. He suggested that an individual who was slow in total body reaction time could become a highly skilled performer in an activity, where he was not required to react to several fast changing stimuli. An example of a fast changing stimulus would be the ball approaching a batter. Both Slater-Hammel (22) and Miller and Shay (16) proved that an individual with slow reaction time would be unable to successfully hit a fast pitched ball. Knapp (13), in her study of racket game players, also noted that the athletes had faster reaction times than did the research students used in her study.

There have been many investigations concerning the factors which could effect the reaction time of individuals. Due to the number of studies available, the following review contains but a few of the studies completed on these factors.

Few studies comparing the reaction time of men and women have been made. In her study, Hodgkins (7) reported that in general women have slower reaction times than men. She attributed the faster reaction of men to greater muscular strength but there was no evidence to prove this. She further concluded that between the ages of twelve and fifty-four men have faster reactions than women and that there was no relationship between reaction time and movement time.

Studies have been conducted comparing reaction times of women with women. Beise and Peaseley (1) compared skilled women engaged in archery, golf, and tennis with a group of nonskilled women. They found that the skilled group had faster reaction times than did the nonskilled group. They also found that within the skilled group the tennis players had the fastest reaction times and those in archery had the slowest.

In a similar study, Youngen (29) compared women athletes in tennis, fencing, swimming, and field hockey with nonathletes enrolled in beginning classes of tennis, fencing, and swimming. She found that the skilled group had faster reaction times than did the unskilled group but found no significant difference within the skilled group.

In addition to the factors of sex and age, studies (2, 6, 14, 17, 18, 23, 24, 25, 27) have shown that such factors as motivation, type of stimulus, presentation of stimulus, location of stimulus in visual field, fatigue of subject, practice on the task, and which limb was used in the response could have some effect on the reaction time of an individual.

CHAPTER BIBLIOGRAPHY

1. Beise, Dorthy and Virginia Peaseley, "The Relation of Reaction Time, Speed and Agility of Big Muscle Groups to Certain Sport Skills," Research Quarterly, VIII (March, 1937), 133-142.

2. Elbel, E. R., "A Study of Response Time Before and After Strenuous Exercise," Research Quarterly, XI (May, 1940), 86-95.

3. Gogel, Walter C., "Size Cue to Visually Perceived Distance," Psychological Bulletin, LXII (October, 1964), 217-235.

4. Goldstein, Alvin G., "Linear Acceleration and Apparent Distance," Perceptual Motor Skills, IX (September, 1959), 267-269.

5. Gruber, Howard E. and Albert J. Dinnerstein, "The Role of Knowledge in Distance-Perception," American Journal of Psychology, LXXVIII (December, 1965), 575-581.

6. Henry, Franklin M., "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," Research Quarterly, XXIII (March, 1952), 43-53.

7. Hodgkins, Jean, "Reaction Time and Speed of Movement in Males and Females of Various Ages," Research Quarterly, XXXIV (October, 1963), 335-343.

8. Holzman, Philip S., "The Relation of Assimilation Tendencies in Visual, Auditory, and Kinesthetic Time-Error to Cognitive Attitudes of Leveling and Sharpening," Journal of Personality, XXII (March, 1954), 375-394.

9. Holzman, Philip S. and George S. Klein, "Cognitive System-Principles of Leveling and Sharpening: Individual Differences in Assimilation Effects in Visual Time-Error," Journal of Psychology, XXXVII (January, 1954), 105-122.

10. Ittelson, W. H., "Size As A Cute to Distance: Static Localization, American Journal of Psychology, LXIV (January, 1951), 54-67.

11. Ittelson, W. H., "Size As A Cue to Distance: Radial Motion," American Journal of Psychology, LXIV (April, 1951), 188-202.

12. Keller, Louis F., "The Relation of Quickness of Bodily Movement to Success in Athletics," Research Quarterly, XIII (May, 1942), 146-155.

13. Knapp, Barbara, "Simple Reaction Times of Selected Top-Class Sportsmen and Research Students," Research Quarterly, XXXII (October, 1961), 409-411.

14. Lotter, Willard S., "Interrelationships among Reaction Times and Speeds of Movement in Different Limbs," Research Quarterly, XXXI (May, 1960), 147-155.

15. Luria, S. M. and Jo Ann S. Kinney, "Judgments of Distance Under Partially Reduced Cues," Perceptual and Motor Skills, XXVI (June, 1968), 1019-1028.

16. Miller, Robert C. and Clayton T. Shay, "Relationship of Reaction Time to the Speed of a Softball," Research Quarterly, XXXV (October, 1964), 433-437.

17. Patrick, John, "Quick Reaction Time Means Athletic Ability," The Athletic Journal, XXX (September, 1949), 68-70.

18. Pierson, William R., "Comparison of Fencers and Nonfencers by Psychomotor, Space Perception and Anthropometric Measures," Research Quarterly, XXVII (March, 1956), 90-96.

19. Over, Ray, "Size and Distance Estimates of a Single Stimulus Under Different Viewing Conditions," American Journal of Psychology, LXXVI (September, 1963), 452-457.

20. Rudin, S. A., "Figure-Ground Differentiation Under Different Perceptual Sets," Perceptual and Motor Skills, XXVII (August, 1968), 71-77.

21. Rudin, Stanley A. and Ross Stagner, "Figure-Ground Phenomena in the Perception of Physical and Social Stimuli," The Journal of Psychology, XLV (April, 1958), 213-225.

22. Slater-Hammel, A. T. and R. L. Stumpner, "Batting Reaction-Time," _Research Quarterly_, XXI (December, 1950), 353, 356.

23. Slater-Hammel, A. T., "Reaction Time to Light Stimuli in the Visual Field," _Research Quarterly_, XXVI (March, 1955), 82-87.

24. ____________________, "Comparisons of Reaction-Time Measures to a Visual Stimulus and Arm Movement," _Research Quarterly_, XXVI (December, 1955), 470-479.

25. Smith, Leon, "Individual Differences in Strength, Reaction Latency, Mass and Length of Limbs, and Their Relation to Maximal Speed of Movement," _Research Quarterly_, XXXII (May, 1961), 208-220.

26. Smith, William M., "Sensitivity to Apparent Movement in Depth as a Function of 'Property of Movement,'" _Journal of Experimental Psychology_, XL (August, 1951), 143-152.

27. Wilson, Don J., "Quickness of Reaction and Movement Related to Rhythmicity or nonrhythmicity of Signal Presentation," _Research Quarterly_, XXX (March, 1959), 101-109.

28. Witkin, H. A., "Individual Differences in Ease of Perception of Embedded Figures," _Journal of Personality_, XIX (September, 1951), 1-15.

29. Youngen, Lois, "A Comparison of Reaction and Movement Times of Women Athletes and Nonathletes," _Research_ Quarterly, XXX (October, 1959), 349-355.

CHAPTER III

PROCEDURES

Subjects

The subjects for this study were 150 women enrolled in beginning tennis classes in the spring semester of 1970 at North Texas State University.

Design of Study

The primary purpose of this study was the development of a test which would measure the perceptual ability involved in playing tennis. The devised test was based on two assumptions, first that some of the factors which are involved in the perceptual judgment required for successful performance in tennis were depth perception, reaction time, spatial orientation and spatial visualization, and second that a person who possesses ability in these areas would also score well on a test of tennis ability.

In order to determine if these assumptions were sound, a battery of six tests was given to all of the subjects. Four of the six tests were used to measure the factors of depth perception, reaction time, spatial orientation and spatial visualization. The two remaining tests were a forehand and backhand achievement test and the devised test of perceptual tennis ability.

Description of Tests

Hilliard Test of Perceptual Ability in Tennis

The purpose of this test was to measure the ability of an individual to make the necessary perceptual judgments prior to the execution of a stroke in tennis.

The subject assumed a position twelve inches behind the baseline at the center mark on one side of the net. On the opposite side of the net a hitter assumed a similar position.

The court on the subject's side of the net was divided into twenty equal areas, four areas across the court from sideline to sideline and five areas the length of the court from net to baseline. The areas were separated by a one inch white line. A five inch square box, with a numeral visible on five surfaces, was placed in the center of each area. The areas were numbered one to twenty with area one starting in the extreme top left corner next to the net and the numerical sequence of the areas continuing back toward the subject (Appendix A).

The hitter hit a total of twenty-two balls, the first two being practice balls and the next twenty were test trials. The hitter was instructed to hit balls to various areas of the court at random and to attempt to keep the flight of each ball at least three feet above the top of the net as it crossed the net.

As each ball was in flight, the subject was required to judge the area of the court in which the ball would bounce. She verbally reported her decision to the scorer who stood right beside her.

Five scorers were utilized in testing each subject. Four of the scorers were positioned so that there were two on each side of the court, with one of the two nearer the net and the other nearer the baseline. As each of the twenty test balls landed on the subject's side of the court, all four of these scorers recorded the actual area in which the ball bounced.

The fifth scorer was positioned right next to the subject and she recorded the subject's judgment of each of the twenty test balls in the following manner: (1) if the subject verbally identified the area she thought the ball would land in before the ball had started its downward path, the number of the area she identified was recorded; or (2) if the subject verbally identified the area after the ball had started its downward flight, the scorer placed a dash on the scoresheet. A subject's score was the number of correct responses as to which area the ball bounced in (Appendix B).

The final form of this test as administered in this study resulted from two preliminary pilot studies. The test as it was initially designed was first administered to two classes of intermediate tennis. Based on the comments of the subjects and observations by the investigator, revisions were made in terms of details such as the arrangement of the scoring areas. The test was then administered to a class of beginning tennis students and further changes were made. None of the students who participated in the pilot studies were involved in the present investigation.

Visual Choice Reaction Time Test

The subject was seated at a table with the dominant hand resting flat on the table behind a one inch restraining line. The subject was required to respond to a light stimulus by depressing the appropriate key which caused the light to go out. Between each trial the subject was required to return to the original starting position.

The visual choice reaction time set consisted of a box which was placed six inches from the restraining line in front of the subject. On one side of the box were three keys with a light above each key. On the opposite side of the box were two selector keys, which controlled the stimulus light and the key response. The light and key combinations which were used are as follows: light 1, key 3; light 2, key 2; and light 3, key 1. The order of light and key combinations for the twenty trials was done in a predetermined manner (Appendix C). Before each trial the verbal signal "Ready" was given to the subject, then the light stimulus was varied from one to three seconds in a random manner.

The amount of time which elapsed from stimulus to response was recorded in seconds and hundreds of a second. Each trial was recorded on a score card.

Variable Rod Test

The purpose of this test was to determine the ability of the subject to perceive depth. The test subject was seated seven meters from the test box. The test box consisted of a closed box with an opening in the front, through which the subject could observe two black rods against an opal glass background. The rods moved along a track in opposite directions with the farthest point of separation being 10.5 cm.

The subject was required to maneuver the rods by use of a string, so that they were laterally aligned. She was allowed twenty-five trials, with each score being the amount of error in judgment of alignment. The scores were recorded on the subject's score card. The reliability coefficient was .69 (5).

Guilford-Zimmerman Spatial Orientation Test

This was a standardized written test which required ten minutes to administer. The purpose of this test was to determine the ability of the subject to see changes in direction and position of an object (Appendix D). The validity coefficient was .63 and the reliability coefficient was .88 (1).

Guilford-Zimmerman Spatial Visualization Test

This was also a standardized written test requiring ten minutes to administer. The purpose of this test was to determine the ability of the subject to see changes in rotation of an object (Appendix E). The validity coefficient was .71 and the reliability coefficient was .93 (1).

Hewitt's Forehand and Backhand Drive Test

The court was marked between the service line and the baseline with three one inch lines four and a half feet apart. The point value of each area beginning at the baseline was as follows: 5, 4, 3, 2, and in front of the service line 1 (Appendix F). In addition to the markings, a rope was stretched seven feet above the top of the net.

The test was scored by giving the point value of the area in which the ball, hit by the subject, landed. Those balls which passed over the rope were scored half the value of the area in which it landed.

The hitter took a position at the service line and the center line on the same side of the court as the markings. She hit five practice balls and twenty test balls to each subject. All balls which the subject was expected to return had to bounce between the service line and the base line within the singles sideline. Any ball which did not bounce in the required area or hit the net was not counted and that ball was rehit.

The subject took a position on the opposite baseline at the center mark. She was required to return all balls hit to her which landed in the required space. She was also required to return to her original starting position between balls.

After evaluating all of the available skill tests which are designed to measure the ground game in tennis, the Hewitt test was selected because it appeared to involve the same general factors as the devised perceptual ability test. After further analysis of the Hewitt test, the investigator made three minor changes in the requirements of the test. These changes were (1) a time limit of three seconds for the subject to return to the starting position after contacting the ball; (2) the first practice ball was hit to the fore-hand side regardless of whether the subject was right or left handed, and the rest of the practice balls and test balls were alternated from forehand to backhand side; and, (3) the subject was not allowed to choose which balls he would hit forehand or backhand. It was felt that these revisions created a more game-like situation. As Scott (4, p. 12) points out, a player in a game is not allowed to choose which balls he will return nor any amount of time between balls and that a skill test should be as much like a game situation as possible if accurately performed skills are to be evaluated.

The validity and reliability coefficients for the forehand drive were .67 and .75 respectively. The validity and reliability coefficients for the backhand drive were .62 and .78 respectively.

Administration of Tests

The testing period did not begin until the mid-point of the spring semester. It was felt that this would give the subjects sufficient time to become familiar with the basic skills of the forehand and backhand drive. The testing period lasted seven weeks with the tests being given in the following order: (1) Hilliard Test of Perceptual Ability in Tennis, (2) Visual Choice Reaction Time Test, (3) Variable Rod Test, (4) Guilford-Zimmerman Spatial Orientation Test, (6) Hewitt's Forehand and Backhand Drive Test, and (7) retest of Hilliard Test of Perceptual Ability in Tennis. Each of these tests was administered on separate days to all of the subjects. Except for the Hilliard test, Hewitt's tennis test, and the two written tests, no subject was allowed to observe any other subject take any of the tests.

Statistical Analysis

Statistical analysis of the data collected involved the following procedures:

1. Computation of a zero-order correlation between the first and second administrations of the Hilliard Test of Perceptual Ability to determine reliability.

2. Establishing validity of the Hilliard Test of Perceptual Ability involved three different aspects:

    a. The first administration of the Hilliard Test was correlated with the Hewitt Test to determine predictive validity.

    b. A multiple regression analysis of the Hilliard Test, Reaction Time Test, Variable Rod Test, Spatial Orientation Test, and Spatial Visualization Test was run to establish content validity.

    c. A multiple regression analysis of the Hewitt Test, Reaction Time Test, Variable Rod Test, Spatial Orientation Test, and Spatial Visualization Test was also run.

CHAPTER BIBLIOGRAPHY

1. Guilford, J. P. and Wayne S. Zimmerman, "Guilford-Zimmerman Appitude Survey," Beverly Hills, California, Sheridan Supply Company, 1947.

2. Hewitt, Jack E., "Hewitt's Tennis Achievement Test," Research Quarterly, XXXVII (May, 1966), 231-240.

3. Scott, Gladys M. and Esther French, Measurement and Evaluation in Physical Education, William C. Brown, Dubuque, Iowa, 1959.

4. Weymouth, Frank W. and Monroe J. Hirsch, "The Reliability of Certain Tests for Determining Distance Discrimination," The American Journal of Psychology, LVIII (July, 1945), 379-390.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Data collected in the study included scores for each of the 150 subjects on perceptual tests, a reaction time test, a skill test and the devised test. In order to determine if there was any relationship between the factors assumed to be involved in the perceptual judgment in tennis, performance on the devised test and a skill test of tennis ability, the data were first analyzed by computing the correlation coefficients among these variables. The results are shown in Table I. It should be noted that some of the coefficients are negative, which was due to the scales being in reverse order. A low score was desirable on the reaction time and Variable Rod tests; whereas, a high score was desirable on all of the other tests.

It was of major interest in this study to determine which of the selected factors of perception were being measured by the devised Hilliard Test and also the Hewitt Test. Based on the correlation coefficients obtained, spatial orientation, spatial visualization and depth perception were not significantly related to the Hilliard Test when it was first administered.

TABLE I

INTERCORRELATIONS OF PERCEPTUAL FACTORS, HEWITT TEST AND HILLIARD TEST ONE AND TWO
N = 150

	HT	HRT	SO	SV	DP	RT	H
Hilliard Test One (HT)	1.000	.122	.050	.091	-.087	-.240**	.232**
Hilliard Test Two (HRT)		1.000	.115	.020	-.160*	-.354**	.277**
Spatial Orientation (SO)			1.000	.597**	-.191*	-.182*	.070
Spatial Visualization (SV)				1.000	-.269**	-.202*	.107
Depth Perception (DP)					1.000	.128	-.120
Reaction Time (RT)						1.000	-.292**
Hewitt Test (H)							1.000

*Significant at the .05 level.

**Significant at the .01 level.

The coefficient between reaction time and the Hilliard Test was significant at the .01 level and a significant correlation was also obtained between the Hewitt and Hilliard Tests.

In regard to the second administration of the Hilliard Test, the coefficient between spatial orientation and the Hilliard Test increased over the coefficient of the first administration. The coefficient between depth perception and the Hilliard Test increased and become significant at the .05 level. Likewise the coefficient between reaction time and the Hilliard Test and the coefficient between the Hewitt and Hilliard Tests increased over the respective coefficients of the first administration. The relationship between spatial visualization and the Hilliard Test, however, decreased with the second administration.

The intercorrelations of the four perceptual factors produced the following results: (1) the coefficient between spatial orientation and spatial visualization was significant at the .01 level; (2) the coefficient between spatial orientation and depth perception was significant at the .05 level; (3) the coefficient between spatial orientation and reaction time was significant at the .05 level; (4) the coefficient between spatial visualization and depth perception was significant at the .01 level; (5) the coefficient between spatial visualization and reaction time was significant at the .05 level; (6) the coefficient between reaction time and depth perception was not significant.

Reliability of the devised test was determined by the test-retest method and the coefficient between the two administrations was .122, which was not significant. However, the correlations between the Hilliard and Hewitt Tests were .232 for the first administration and .277 on the second administration, both of which are significant at the .01 level.

As a further means of analyzing the data, a multiple regression was done to determine to what extent each of the four perceptual factors contributed to the performances of the subjects on the first and second administration of the Hilliard Test and the Hewitt Test. The results are shown in Table II.

In the stepwise reduction of the factors, the decrease in R^2 indicates the contribution of the deleted factors in the performances of the subjects. The results show that of the four factors, reaction time contributed most to the variance in performance on all three tests.

TABLE II

MULTIPLE REGRESSION OF SELECTED PERCEPTUAL FACTORS IN PERFORMANCE ON THE HILLIARD AND HEWITT TESTS
N = 150

Factors	Hilliard Test	Hilliard Retest	Hewitt
	R^2	R^2	R^2
Spatial Orientation Spatial Visualization Depth Perception Reaction Time	6.25	15.42	9.35
Spatial Visualization Depth Perception Reaction Time	6.19	14.55	9.32
Depth Perception Reaction Time	6.09	13.84	9.24
Reaction Time	5.77	12.50	8.55

CHAPTER V

SUMMARY, DISCUSSION OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purposes of this study were (1) to identify the factors involved in the perceptual ability required in tennis, (2) to devise a test to measure this ability, and (3) to determine if this test has any predictive validity. Of primary concern was the selection of the factors assumed to be involved in this perceptual ability. The factors which were selected for consideration in this study were spatial orientation, spatial visualization, depth perception, and reaction time.

The subjects used in this study were 150 women enrolled in beginning tennis in the spring semester at North Texas State University.

The devised perceptual test was administered to all of the subjects at the beginning of the testing period and again at the end. In addition to the devised test, a battery of five other tests which included a skill test designed to measure the ground game in tennis and tests to measure the selected perceptual factors were administered. The testing period lasted seven weeks beginning at the midpoint in the semester.

The data collected in the study were analyzed by two methods. The first method entailed computing the correlation coefficients among all of the variables. The second method involved a multiple regression to determine the contribution of each factor to the subject's performance. The results indicate that several of the coefficients were statistically significant and that reaction time contributed the most to the subject's performance on the devised test.

Discussion of Findings

Since this was in the nature of an exploratory study to gain insight concerning the role of perceptual factors in a complex motor skill such as tennis, it seemed advisable to examine some of the relationships which were indicated by the analysis of the data.

There are several possible reasons why an individual might have difficulty in performing the task of returning a tennis ball successfully. First, they must identify, recognize, and orient the stimulus (approaching ball); secondly, they must process the information so that a decision can be made in terms of response; and thirdly, they must make the appropriate response.

The factors of spatial orientation, spatial visualization, and depth perception would be related to the first stage.

Based on the data from this study, these three factors are related to each other, but they were not significantly important to performance on the initial administration of the perceptual ability test nor to performance on the tennis skill test. When the perceptual ability test was administered the second time, after the subjects had more experience, the contribution of these factors increased somewhat. This could be an indication that their importance to performance comes at a later stage of learning a complex skill.

The relationship of reaction time to both the perceptual ability test and the skill test was consistent throughout the analysis of the data. The implication of this is that difficulties in successfully hitting an oncoming object may stem from the processing of input information rather than from identification of the stimulus. The perceptual ability test did not require an actual response in terms of movement, but the Hewitt Test did include this feature. The relationship of reaction time to both of these tests was similar, which would seem to indicate that regardless of whether a movement response was made, the delay occured during the processing of the stimulus information.

Based on the correlation coefficients obtained, the Hilliard Test of perceptual ability would have to be considered unreliable in its present form. Validity of the test would also be questionable based on the data obtained. Since the coefficients between the Hilliard and Hewitt tests were relatively high and since the same pattern of relationships between the other factors existed with both tests, it appears that the two tests do involve the same kind of ability.

A great deal of research will be necessary before the precise involvement of various factors to gross motor performance can be successfully pinpointed. Although the results of the investigation were statistically inconclusive, the investigator felt that they provide at least a basis from which to launch further studies.

The major difficulty of the study stemmed from motivation of the subjects. This problem arose because of the length of the testing period and the number of tests administered. Toward the end of the testing period it could be questioned whether the subjects performed to the best of their ability on specific tasks.

Conclusions

Based on the findings of this study, the following conclusions may be drawn:

1. Perceptual ability involved in making judgments about an oncoming ball and in successfully contacting the ball appears to depend more upon reaction time than other perceptual factors.

2. The devised test to measure this ability is not reliable enough in its present form to be of practical use.

3. The devised test to measure this ability appears to lack predictive validity more than it does content validity.

Recommendations

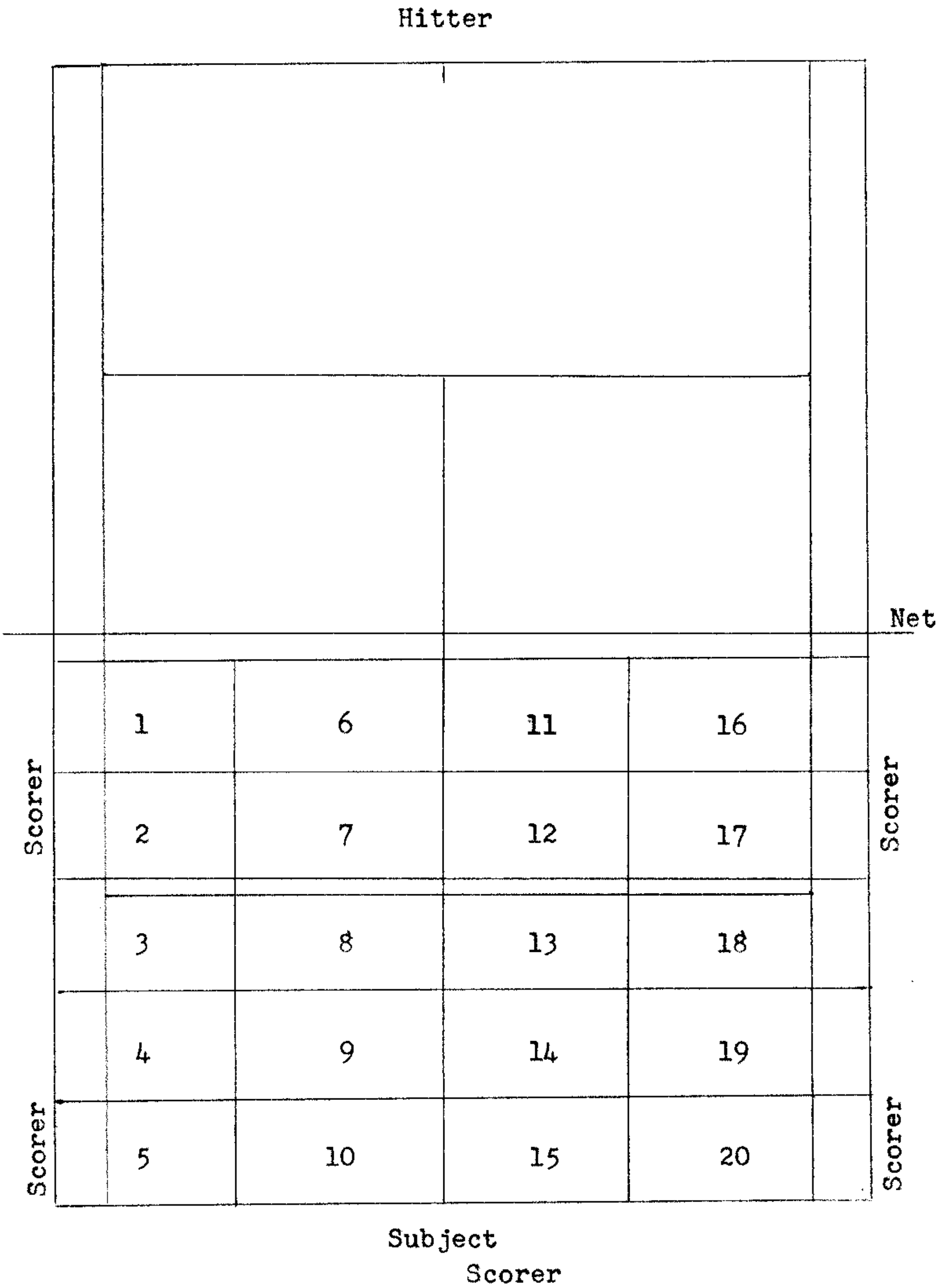
Based on the findings of this study, the following recommendations seem appropriate:

1. Additional studies be conducted further investigating the selected variables of this study.

2. Additional studies be conducted at the secondary school level.

APPENDIX A

HILLIARD TEST OF PERCEPTUAL ABILITY IN TENNIS



APPENDIX B

SCORESHEET

NAME ______________________________

Right __________ Wrong __________ Slow __________

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

APPENDIX C

The following are the light and key combinations used in the Visual Choice Reaction Time Test.

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

THE GUILFORD-ZIMMERMAN APTITUDE SURVEY

Part V Spatial Orientation

Form A

Name______________________________________Date____________________Score__________

Nearest age: 10 15 20 25 30 35 45 55 65 75 Sex: M F

Years of school completed: 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

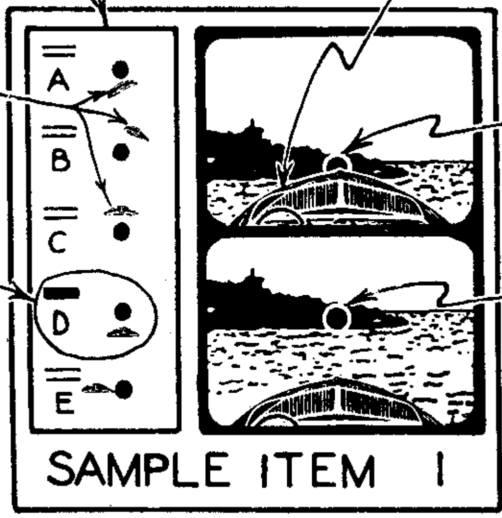
Instructions.—This is a test of your ability to see changes in direction and position. In each item you are to note how the position of the boat has changed in the second picture from its original position in the first picture.

Here is a sample item.

These are the five possible answers to the item.

These are tiny pictures of the boat's prow.

This is the correct answer. It shows that the prow of the boat has dropped below the aiming point.



This is the prow (front end) of a motor boat in which ***you*** are riding.

This is the aiming point. It is the exact spot you would see on land if you sighted right over the point of the prow.

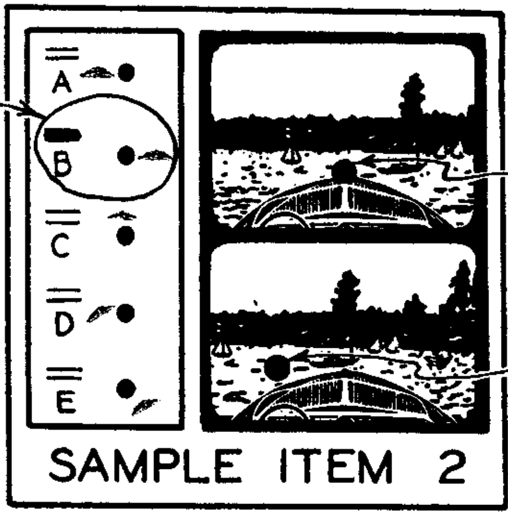
This is the same aiming point shown above. Note that the prow of the motor boat has dropped below it.

(If the prow had risen, instead of dropped, the correct answer would have been C, instead of D.)

Other items in the test are very similar to SAMPLE ITEM 1. To work each item: ***First,*** look at the top picture. See where the motor boat is headed. ***Second,*** look at the bottom picture and note the CHANGE in the boat's heading. ***Third,*** mark the answer that shows the same change.

Try Sample Item 2.

This also shows that the prow of the boat is to the right of the aiming point. So, it is the correct answer.



This is the aiming point.

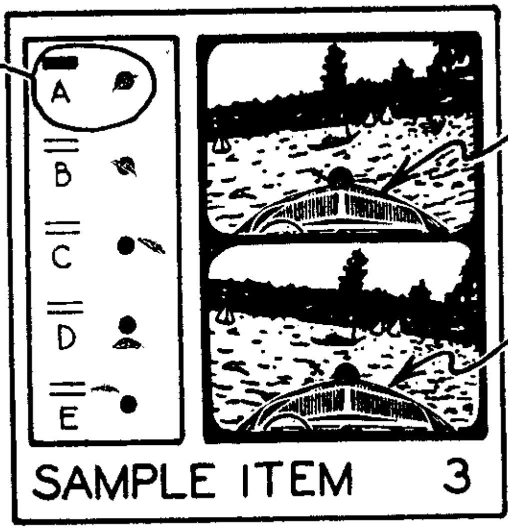
This is the same aiming point. The motor boat is now headed to the right of it.

(If the boat had turned to the left, instead of to the right, the correct answer would have been A.)

APPENDIX D

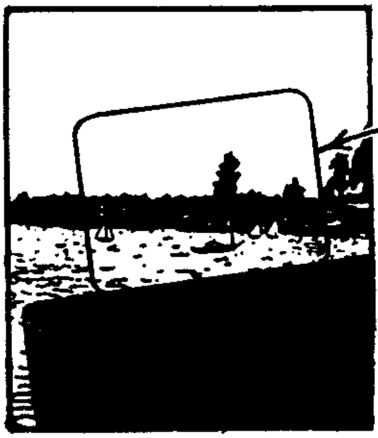
Now try Sample Item 3.

This is the correct answer. It shows that the motor boat changed its slant to the left, but that it is still heading toward the aiming point.



Here the motor boat is slanted slightly to the right. (Note that the horizon appears to slant in the opposite direction.)

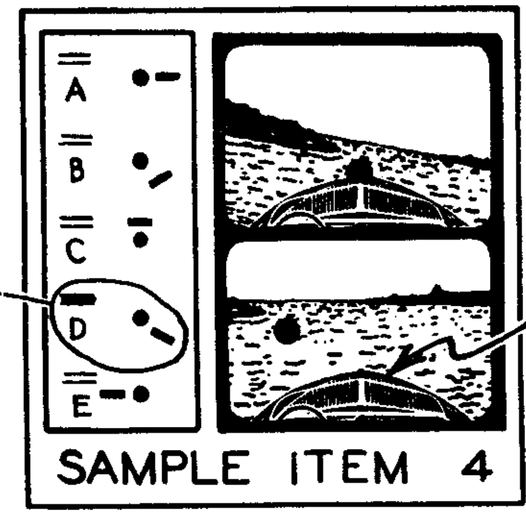
Here the boat has changed its slant toward the left. (See explanation below.)



Imagine that these pictures were taken with a motion picture camera. The camera is fastened rigidly to the boat so that it bobs up and down, turns and slants with the boat. Thus, when the boat tips or slants to the left (as in the lower picture in SAMPLE ITEM 3), the scene through the camera view finder looks slanted like this.

Look at Sample Item 4.

D is the correct answer. It shows that the boat (from now on only a bar will be shown in the answer in place of the tiny picture of the boat's prow) changed its heading both downward and to the right; also that it changed its slant toward the right. (In the top picture the boat was slanting left. To become level, the boat slanted back toward the right.



The prow of the boat has moved downward and toward the right. Also it has changed its slant toward the right. (It was slanted left in the top picture, and it became level. To become level, it had to slant back toward the right.)

Now Do Practice Items 5, 6, and 7. Record Your Answers.

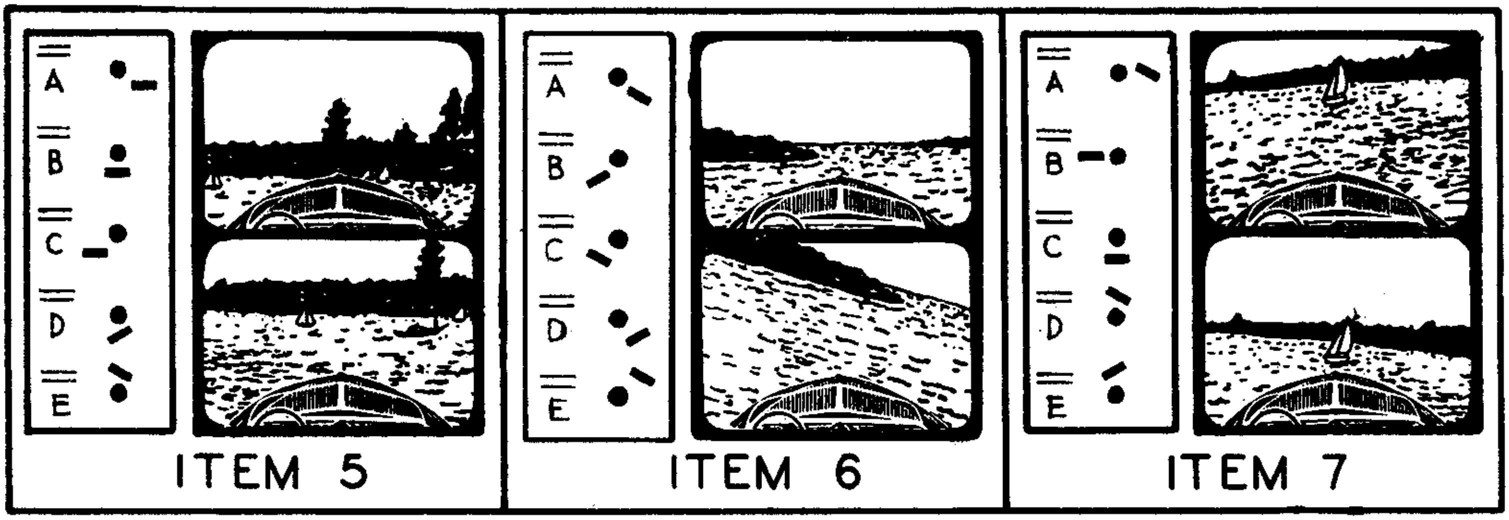
The aiming point is not marked in the test items. You must see the change in the boat's position without the aid of the dots.

To Review:

First — Look at the top picture. See where the motor boat is headed.

Second — Look at the bottom picture. Note the change in the boat's heading.

Third — Mark the answer that shows the same change (in reference to the aiming point before the change).



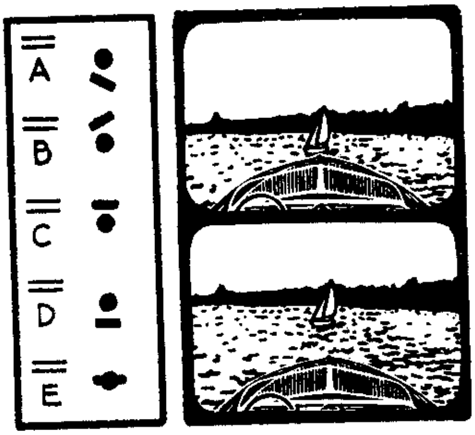
C is the correct answer. The prow appears to have moved to the left and downward. It has not changed its slant.

B is the correct answer. The prow appears to have moved to the left and downward. Also, it has changed its slant to the left.

E is the correct answer. The prow appears to have moved upward, and to have tipped left. It has not turned.

If you have any questions, ask them now.

At the signal from the examiner, not before, turn the page and begin working on the test. Work rapidly. If you are not sure about any item, you may guess, but avoid wild guessing. Your score will be the number of answers correct minus a small fraction of the number wrong. You will have ten minutes to work on the test. Wait for the signal to begin.



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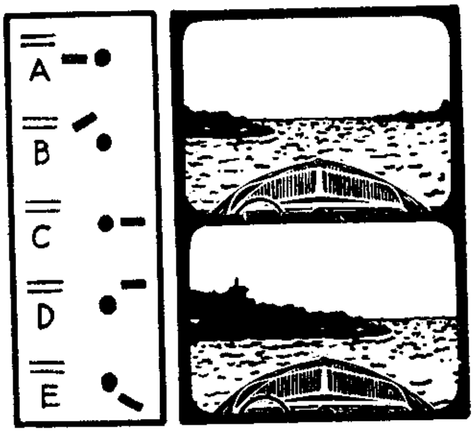

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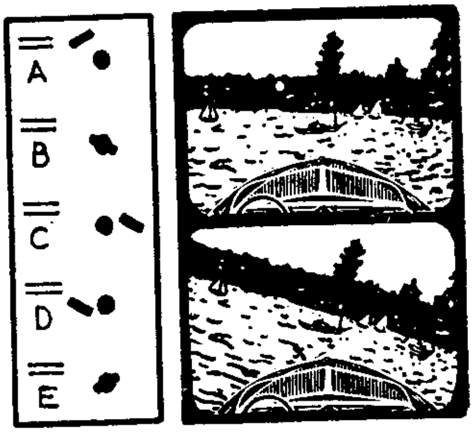

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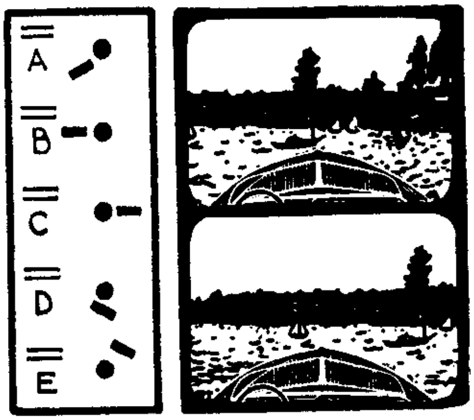

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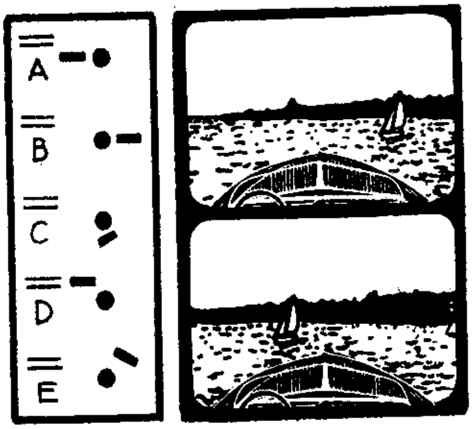

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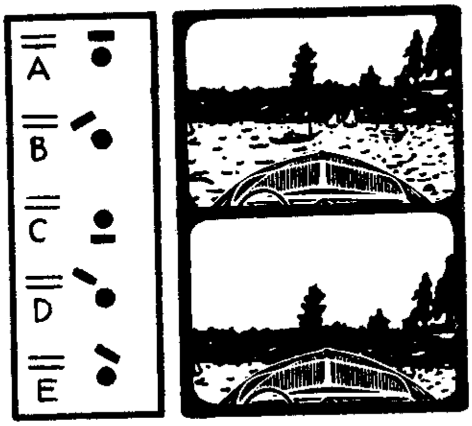

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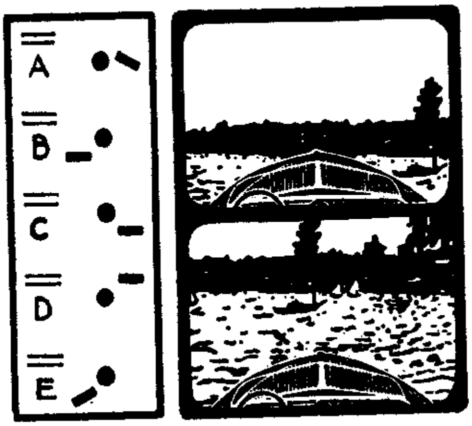

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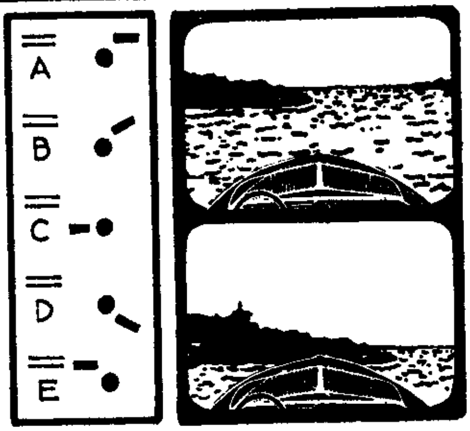

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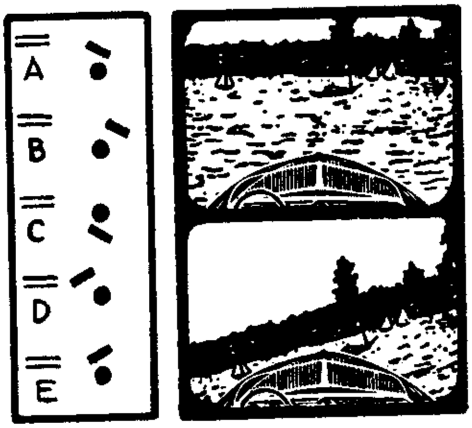

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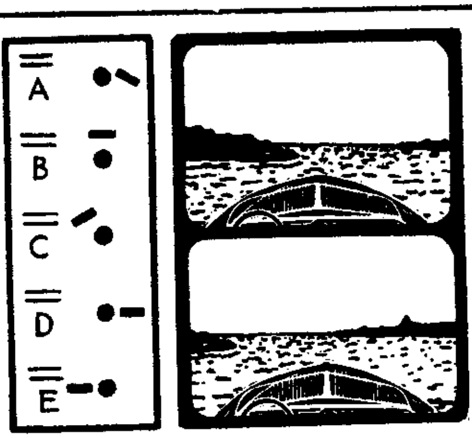

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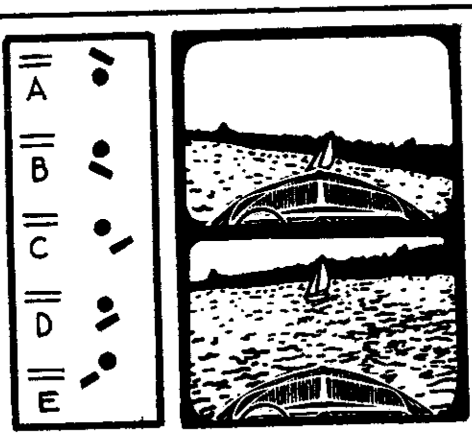

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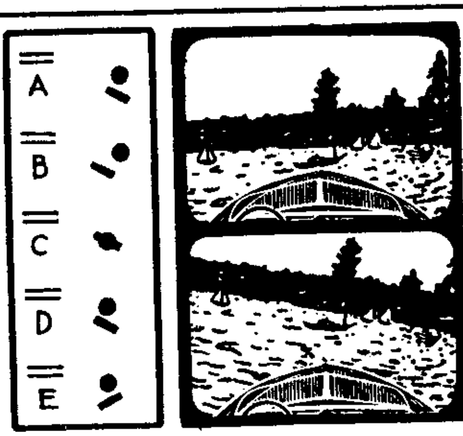

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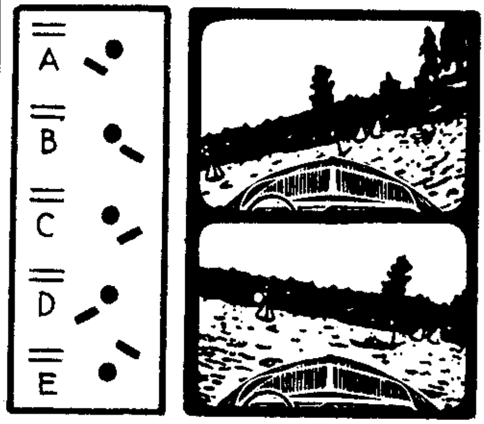

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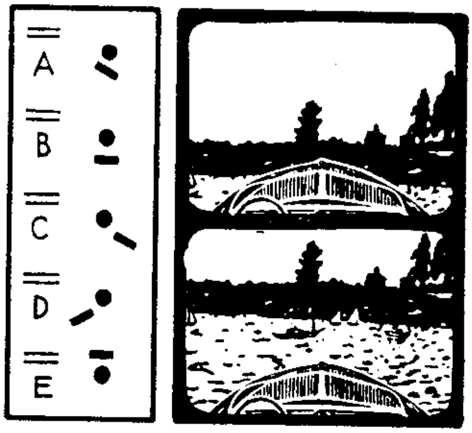

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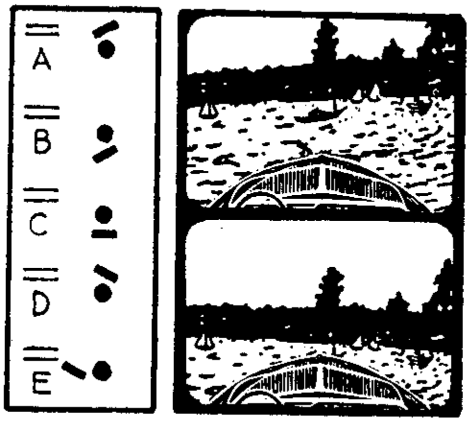

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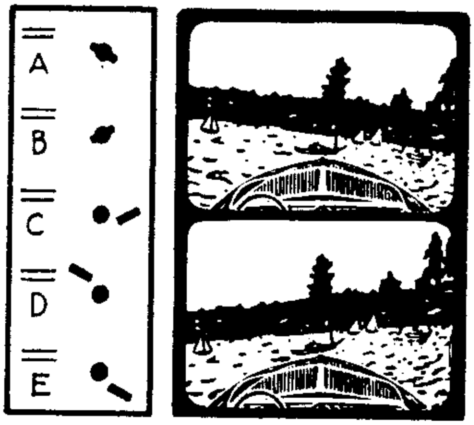

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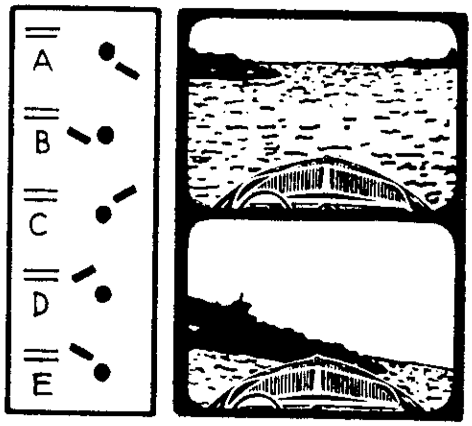

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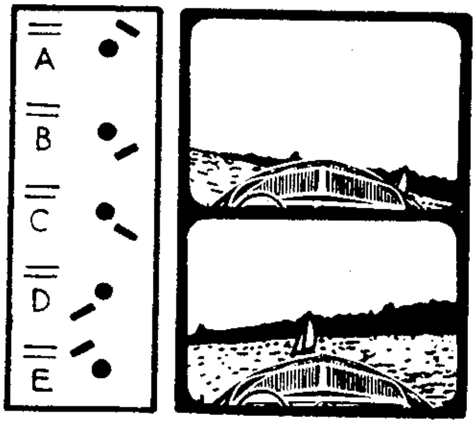

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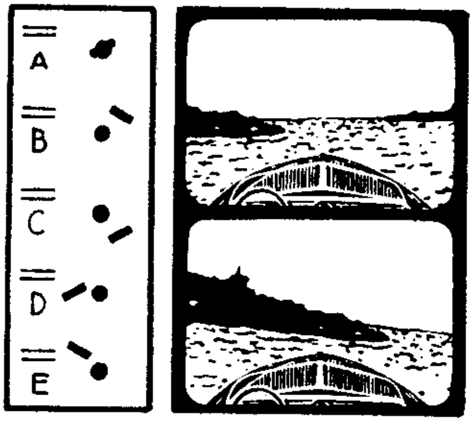

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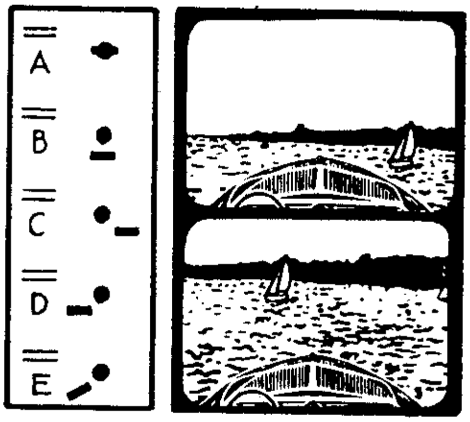

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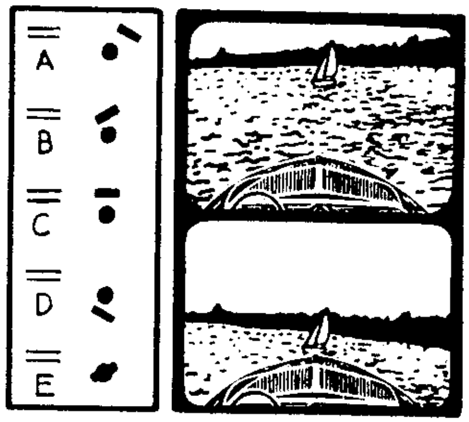

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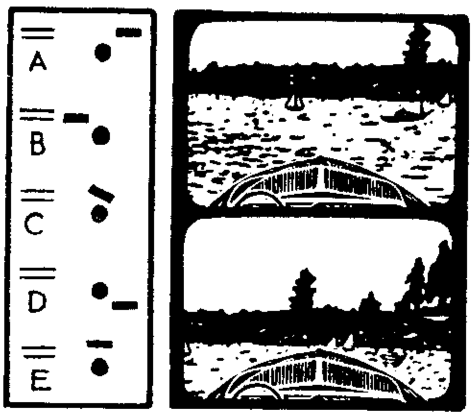

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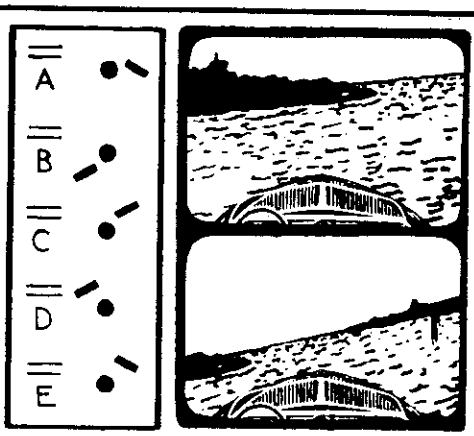

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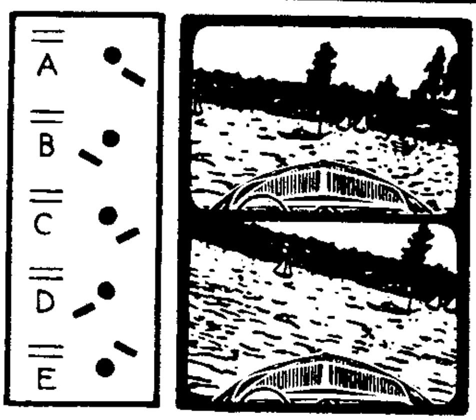

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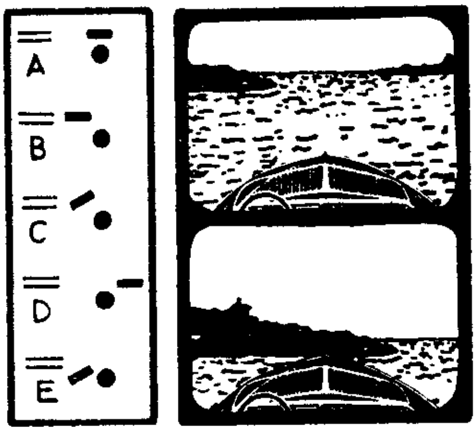

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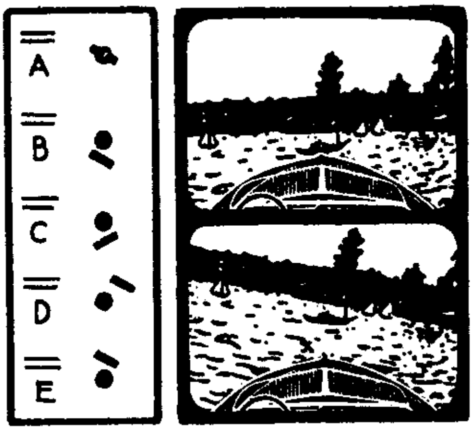

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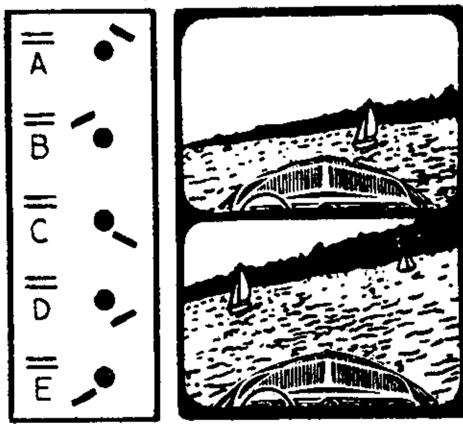

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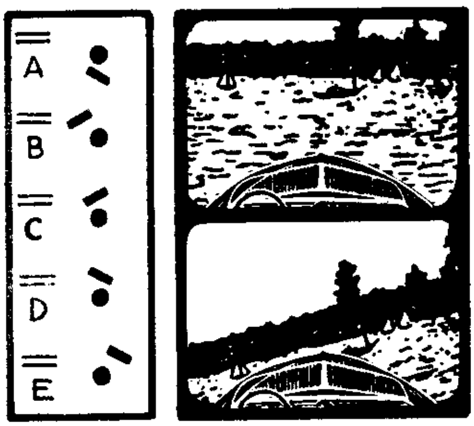

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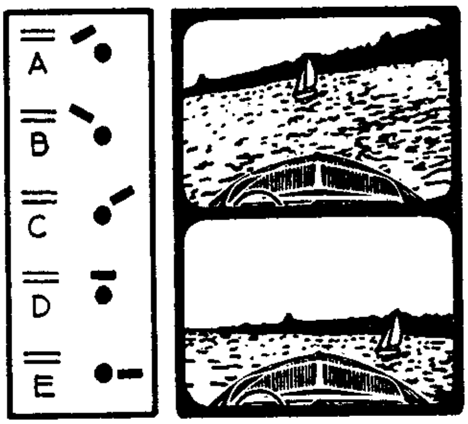

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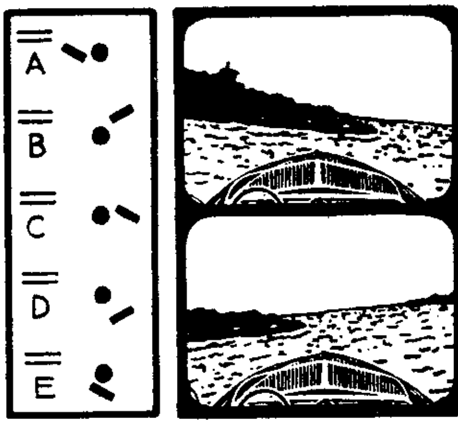

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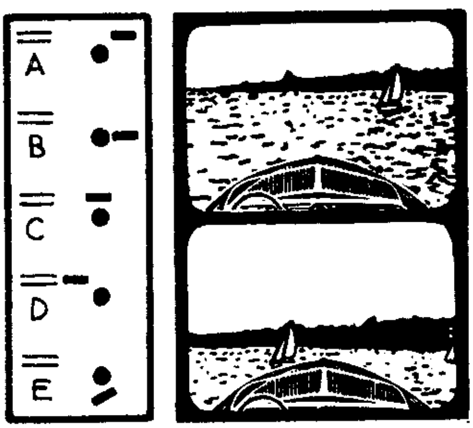

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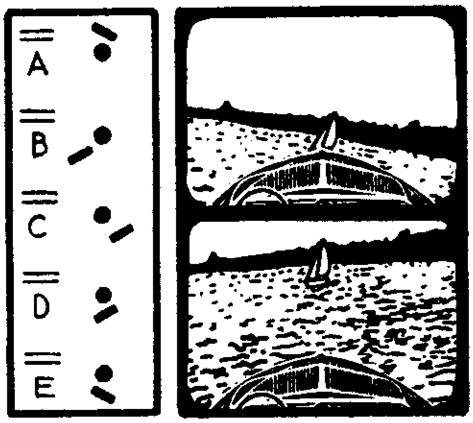

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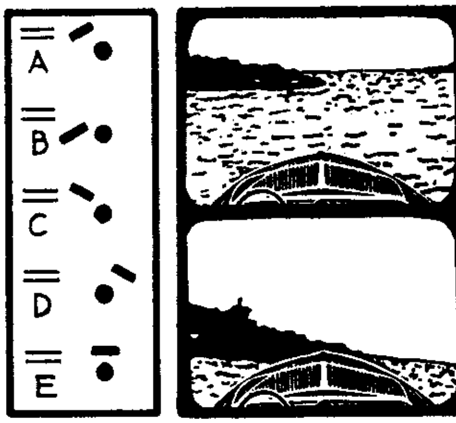

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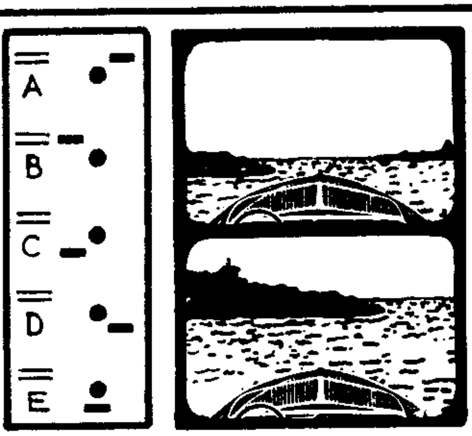

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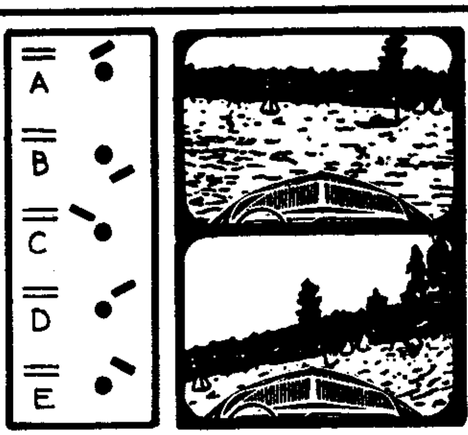

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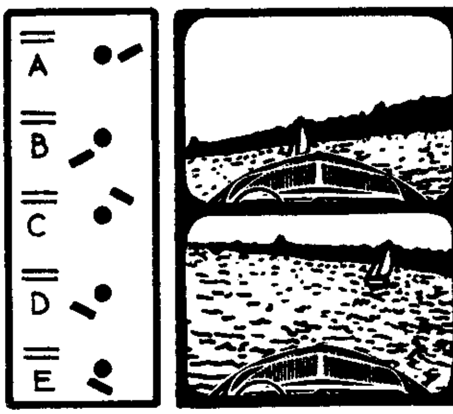

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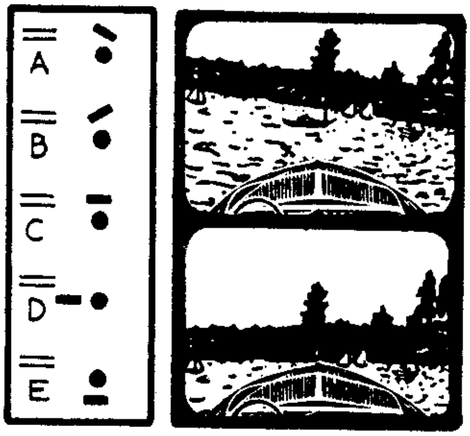

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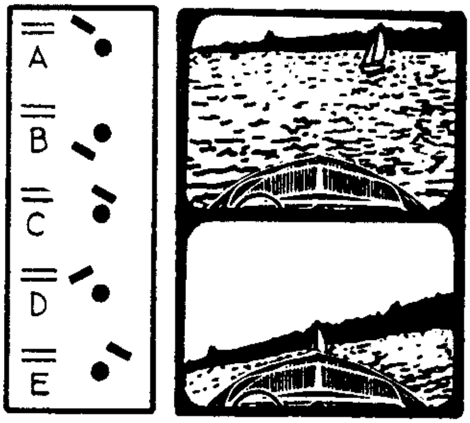

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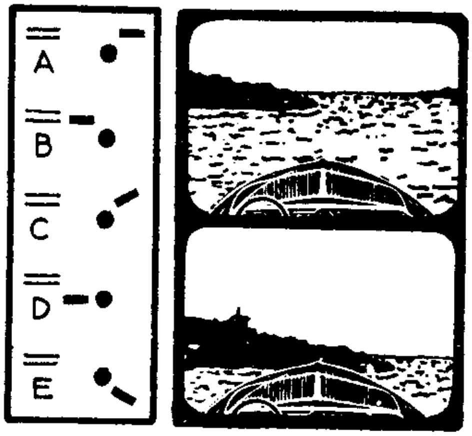

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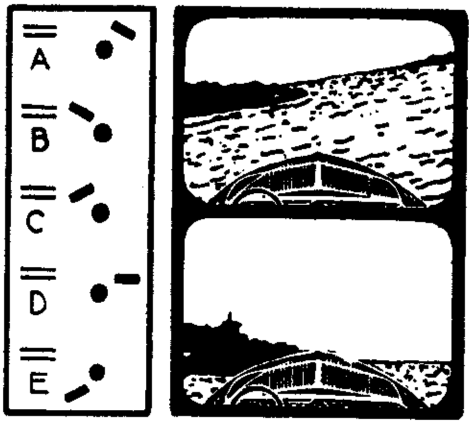

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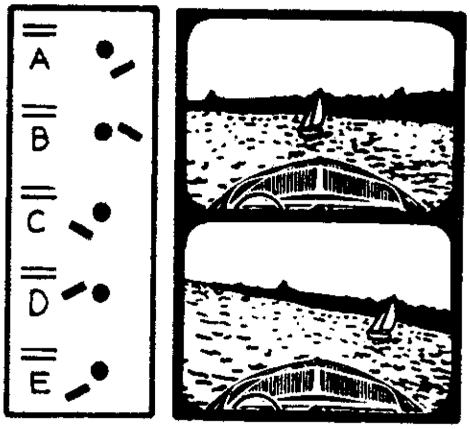

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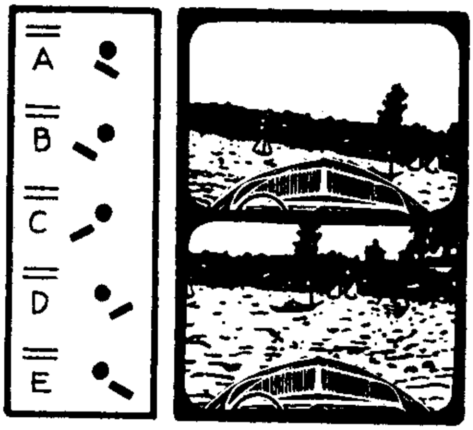

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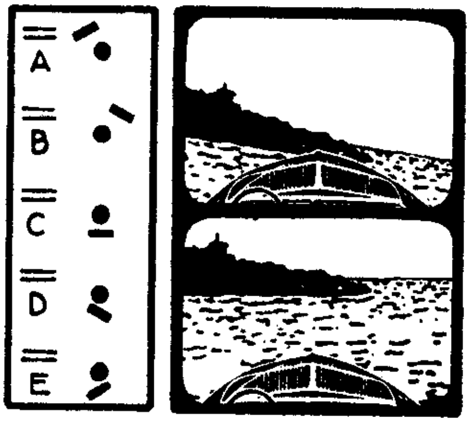

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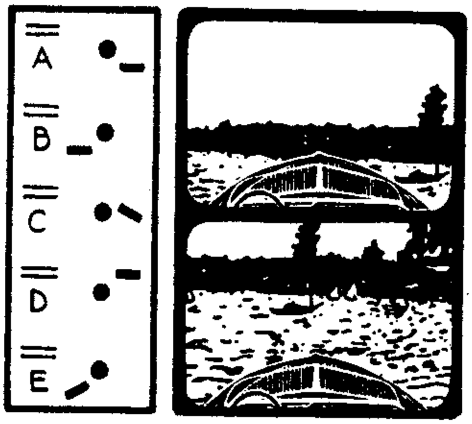

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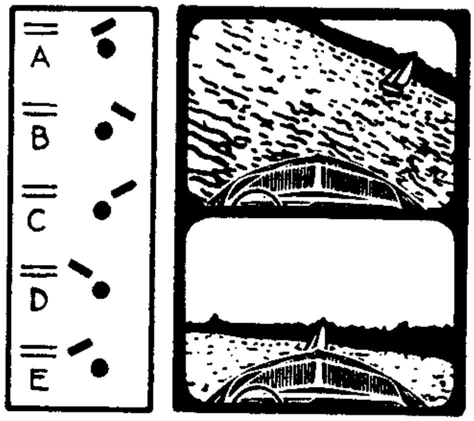

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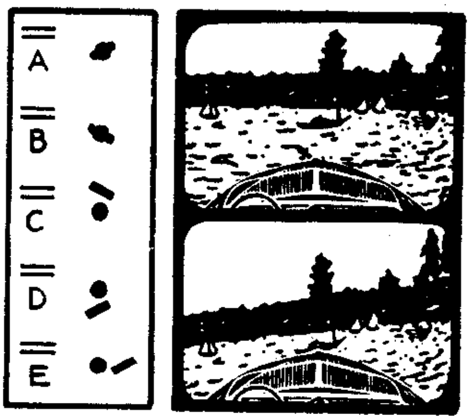

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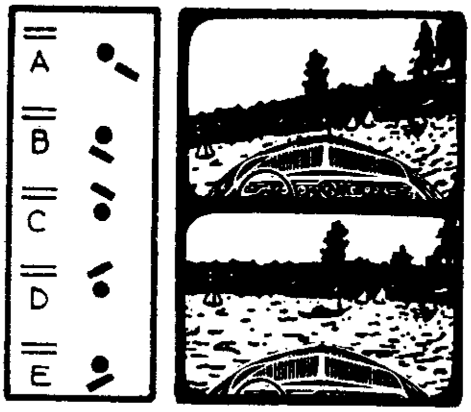

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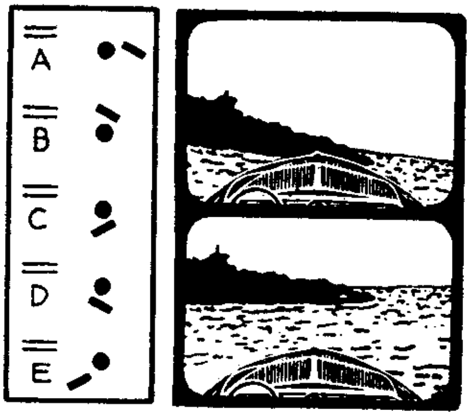

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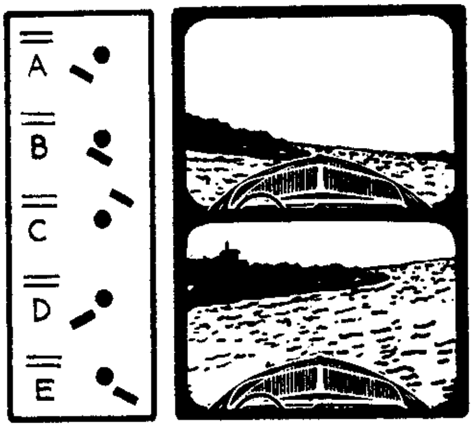

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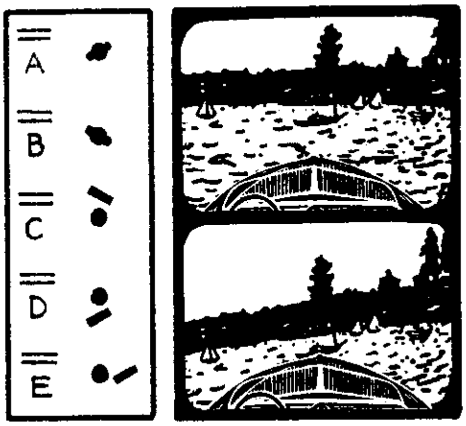

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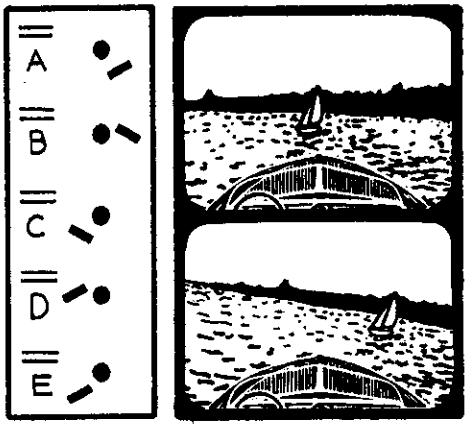

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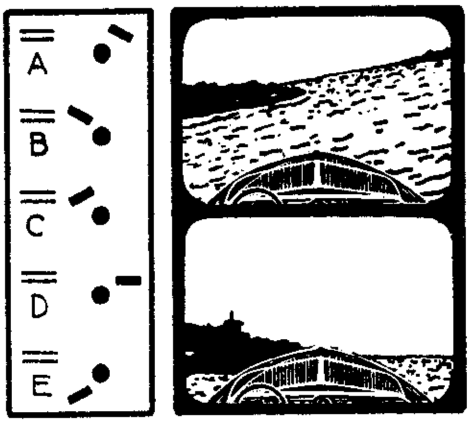

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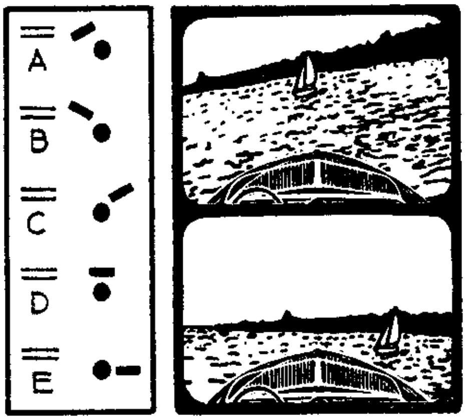

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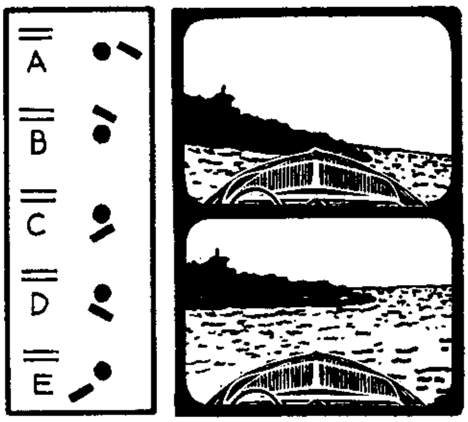

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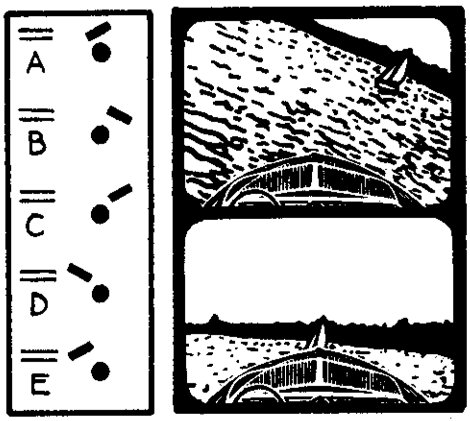

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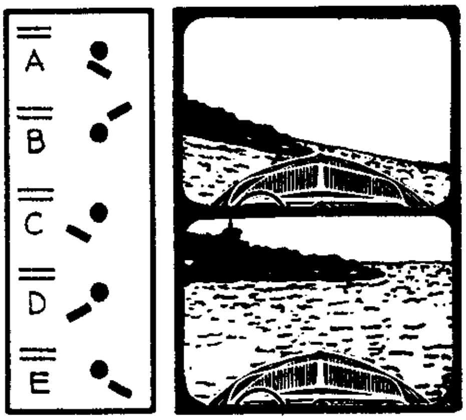

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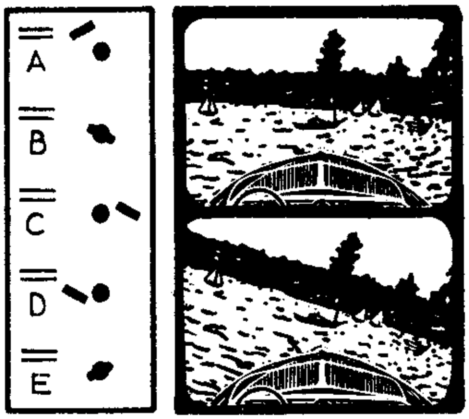

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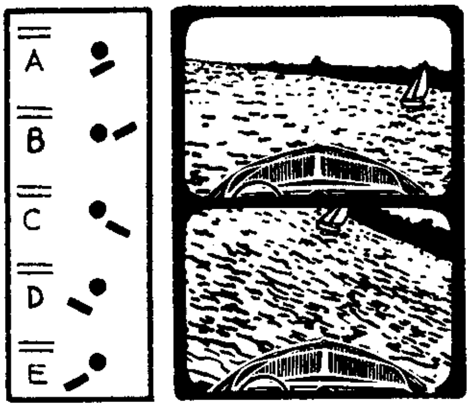

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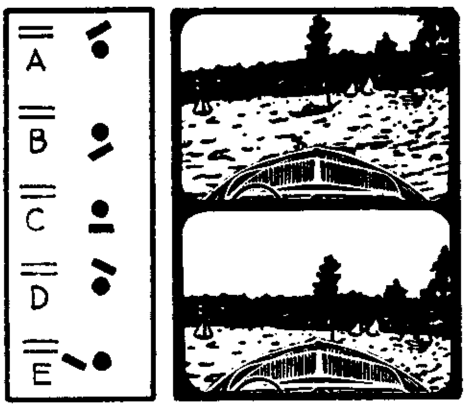

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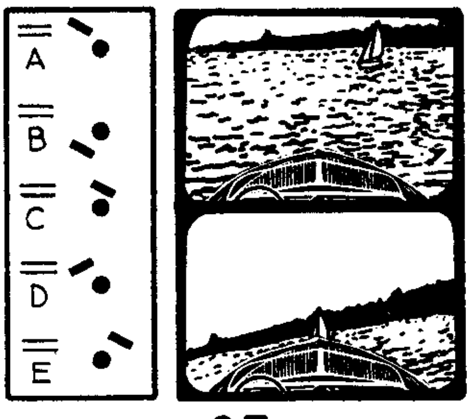

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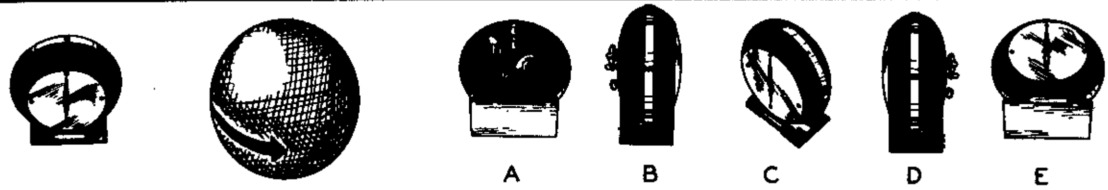
APPENDIX E

THE GUILFORD-ZIMMERMAN APTITUDE SURVEY

Part VI Spatial Visualization

Form B

I

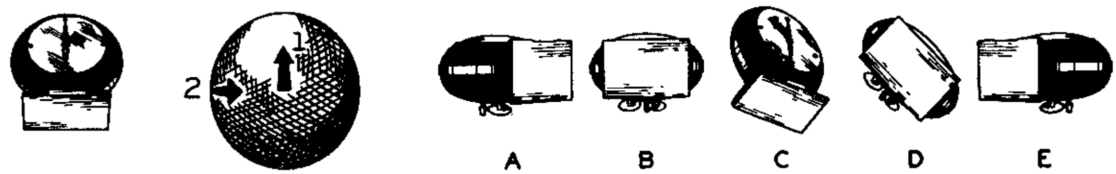


The first picture at the left shows a clock. Next to it is a sphere with an arrow marked on it. The arrow shows how the clock is to be moved. This move is illustrated (in two steps) in the picture below. When the clock is moved the one-quarter turn shown by the arrow, it is then in position B. B is therefore the correct answer. You would record this by blackening the answer space right below B on your answer sheet. (But do not record answers to sample items.)

Original position

Position after the move has been completed.

II



Two movements of the clock are called for by the two arrows on the sphere. Move number 1 must be visualized first. Move number 2 must then be started from the clock's position after the first move. In item II, each arrow shows one-eighth of a turn. The two moves, if visualized correctly, would place the clock in position A. The pictures below illustrate, in two steps, how the two moves should be visualized, one following the other.

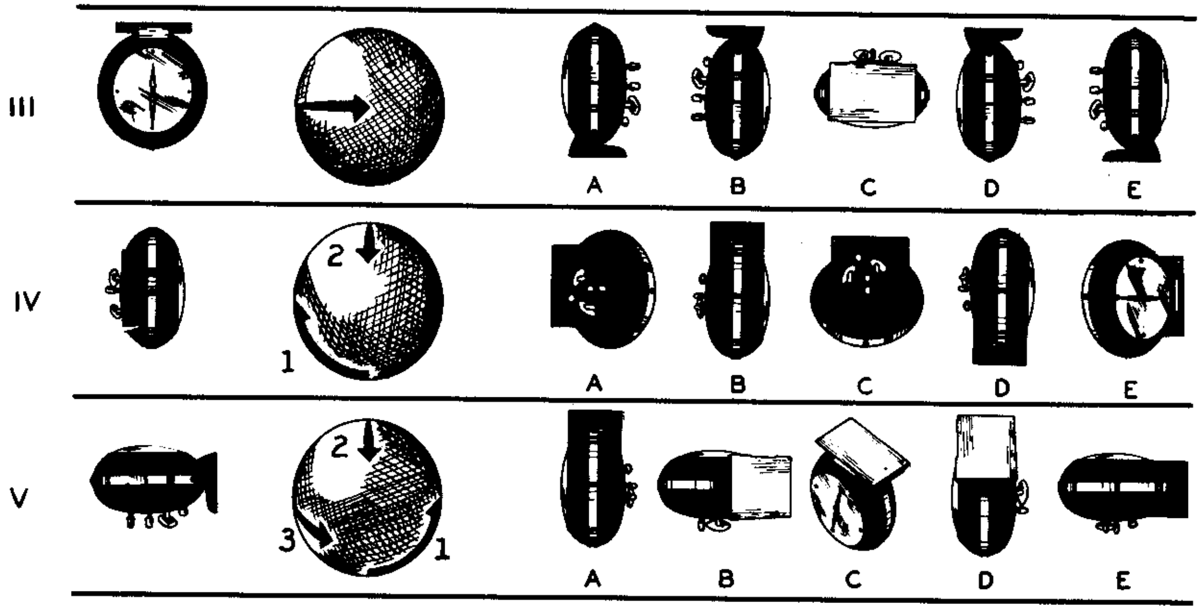
Original Position

Position after move number 1

Position after move number 2

In some of the items, three moves will be called for. Remember that each move, after the first, must be started from the clock's position after the move just before has been completed.

Now try sample items III, IV, and V:



The correct answers are: III, B; IV, C; V, C. If you did not get these answers, look over the items again to see where you made your mistakes.

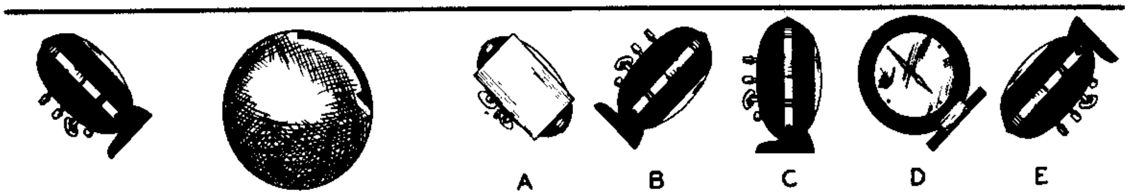
If you have any questions, ask them NOW.

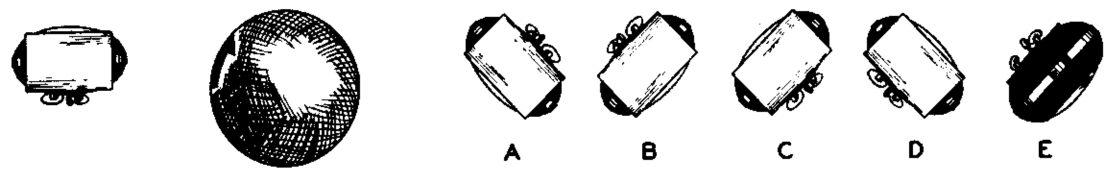
You will have 10 minutes to work on this test. Do not spend too much time on any one item. If you finish before time is called, you may go back and check your work.

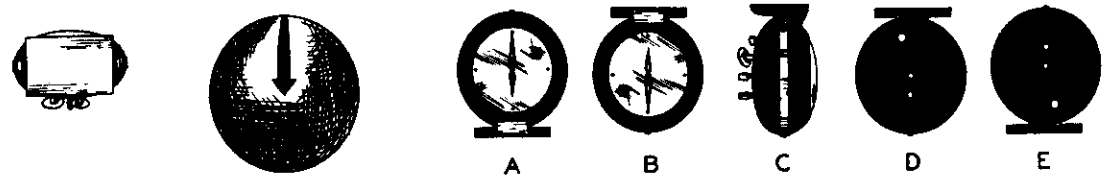
If you are not sure about the answer to any item, you may guess, but avoid wild guessing. Your score will be the number of correct answers minus a fraction of the number wrong.

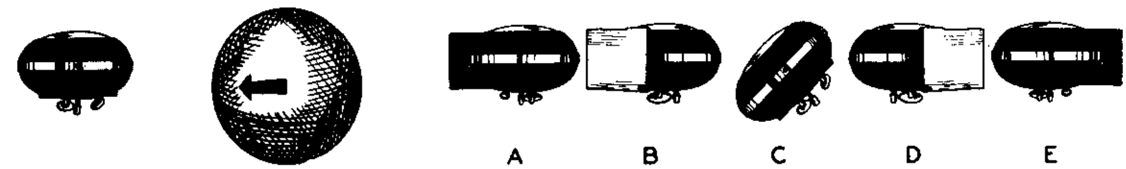
WAIT FOR THE SIGNAL TO BEGIN.

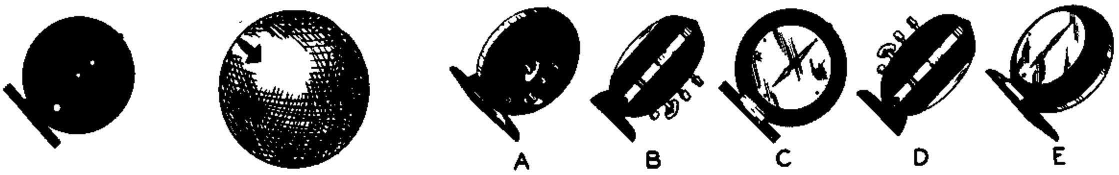
DO NOT WRITE IN THIS BOOKLET

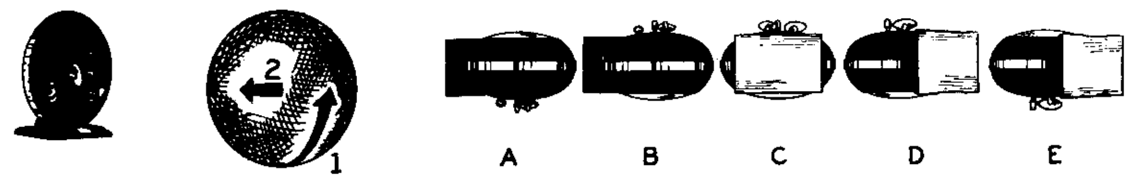
1 

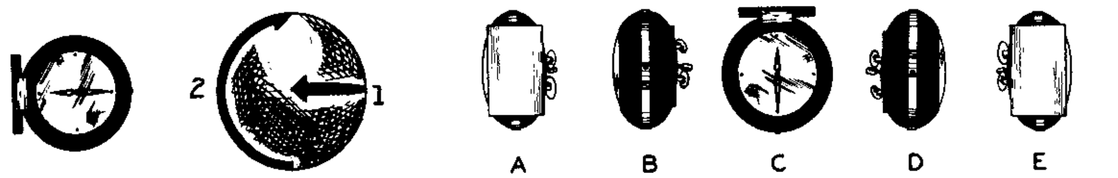
2 

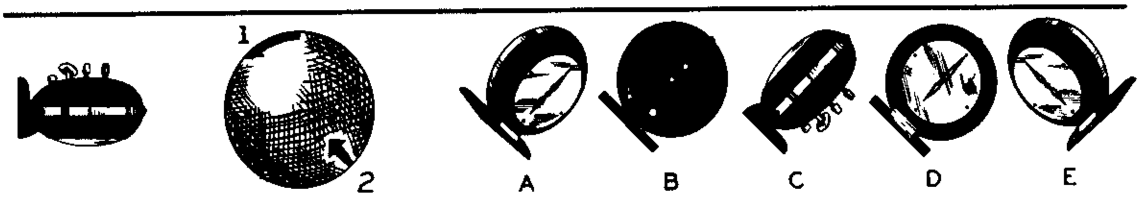
3 

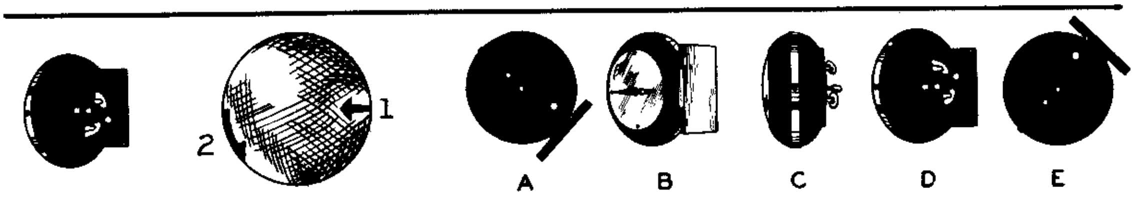
4 

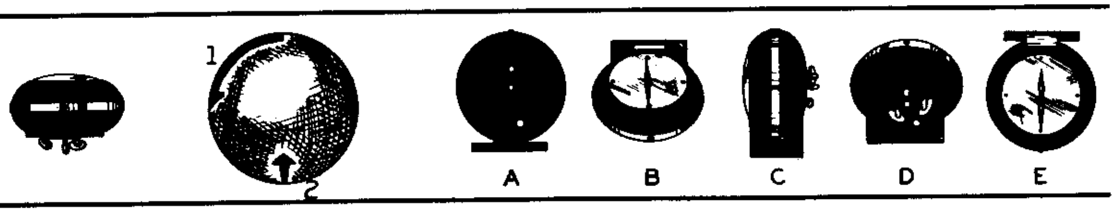
5 

6 

7 

8 

9 

10 

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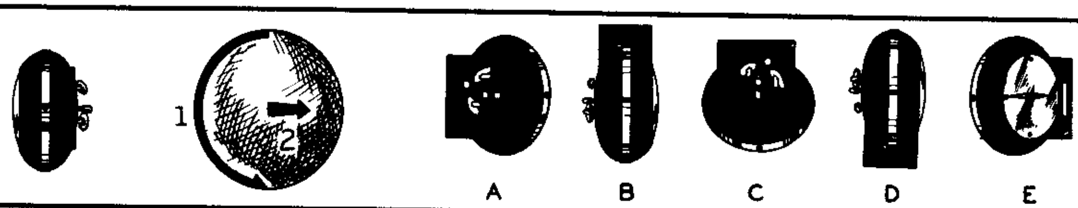

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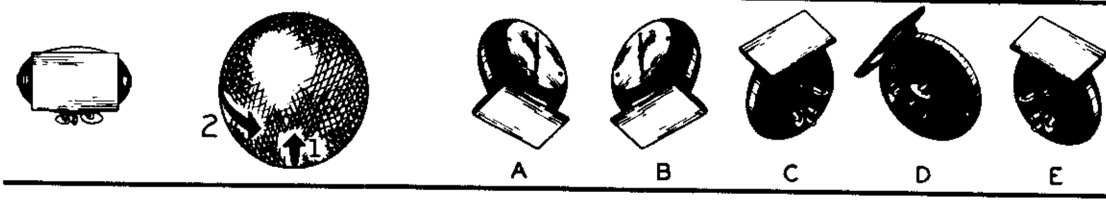

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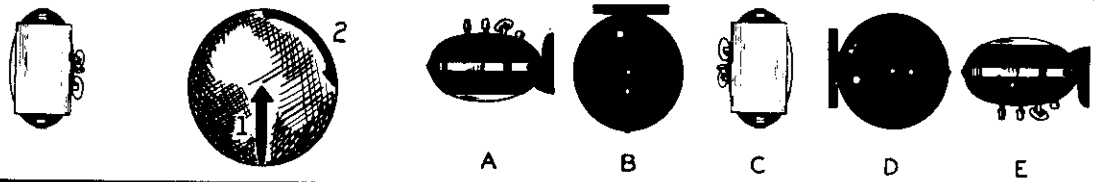

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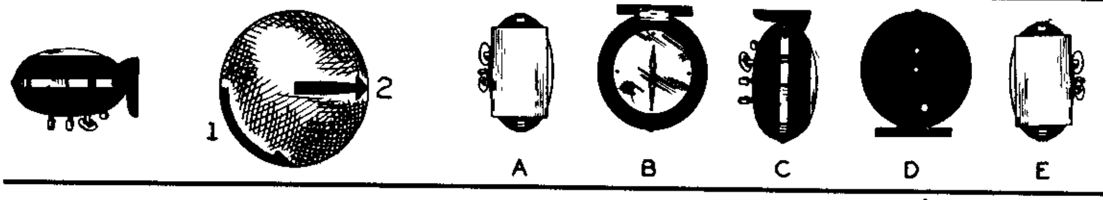

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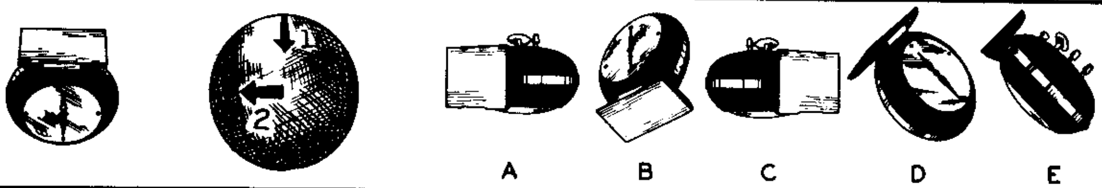

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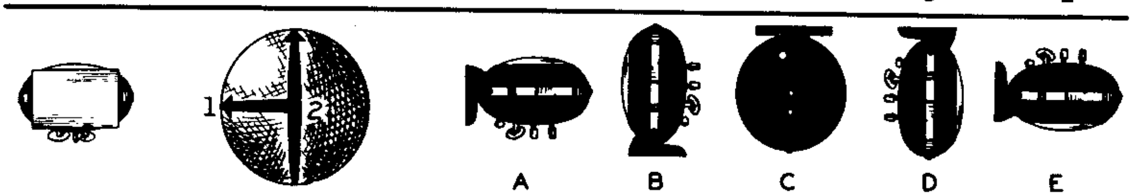

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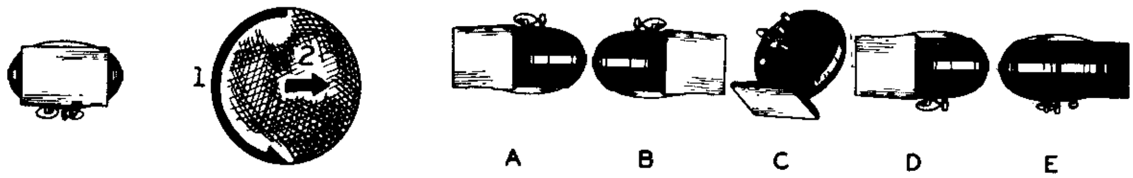

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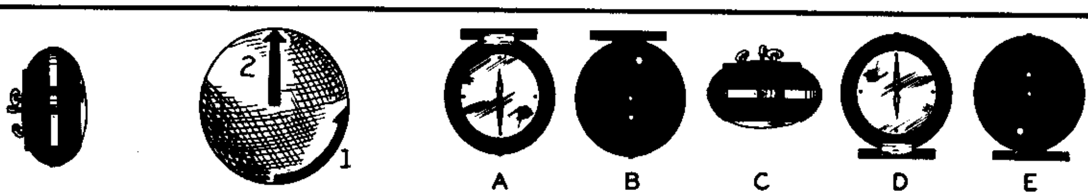

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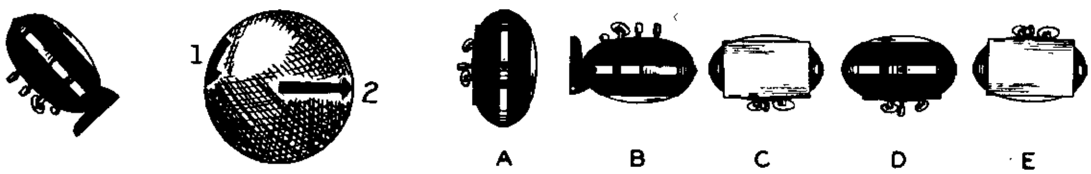

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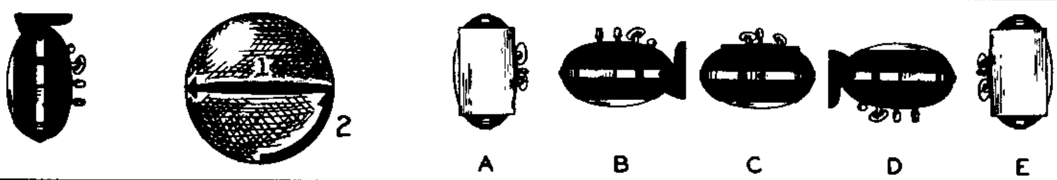
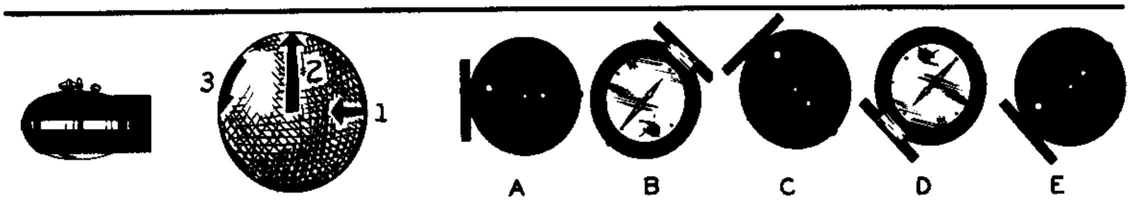
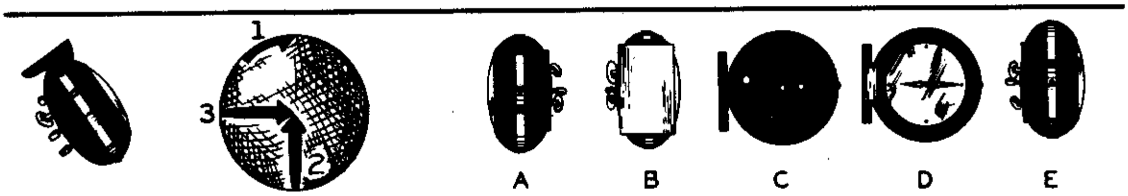
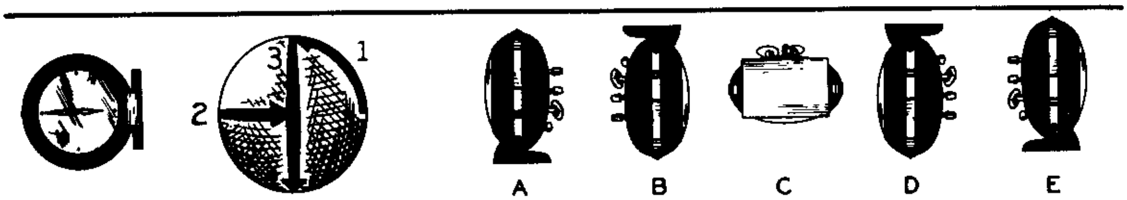
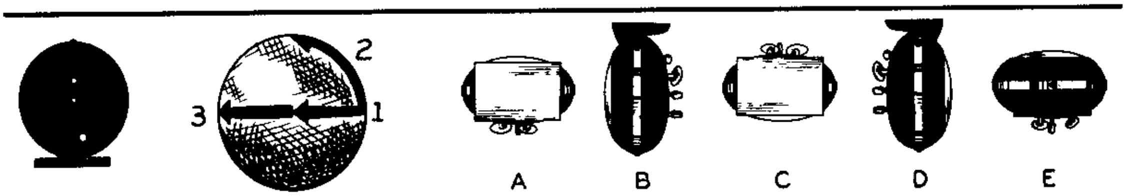
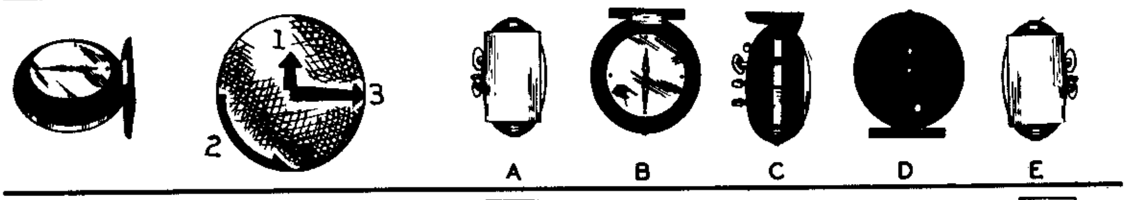


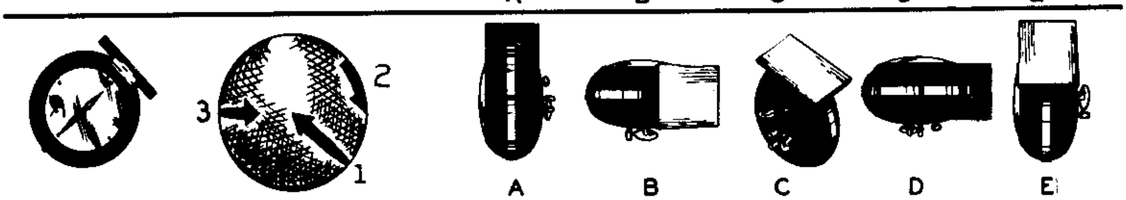
21 

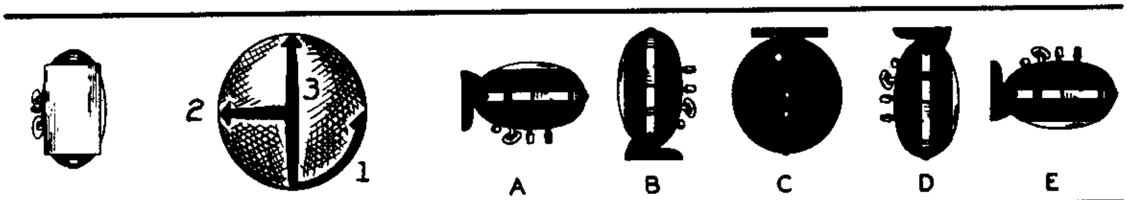
22 

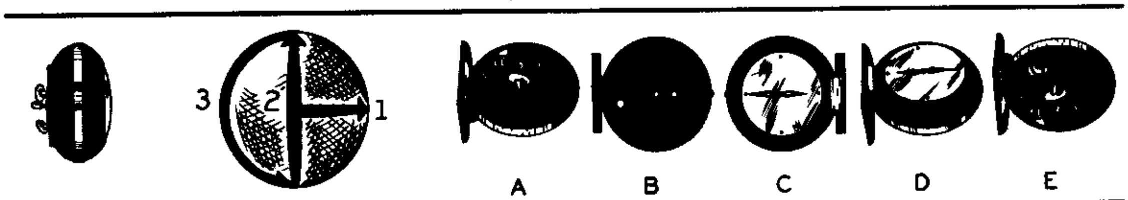
23 

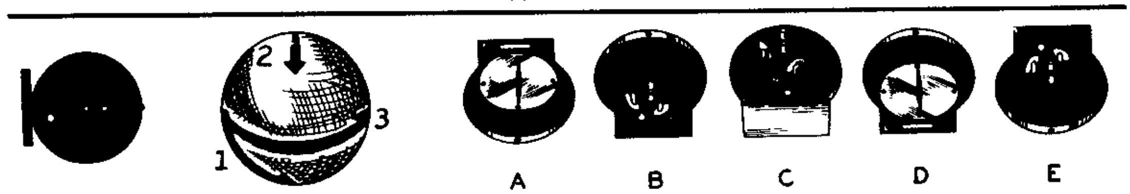
24 

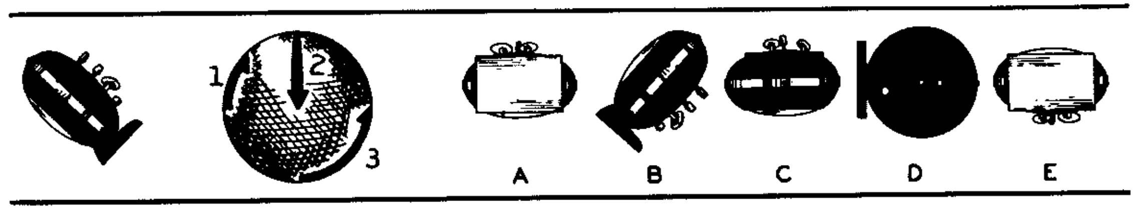
25 

26 

27 

28 

29 

30 

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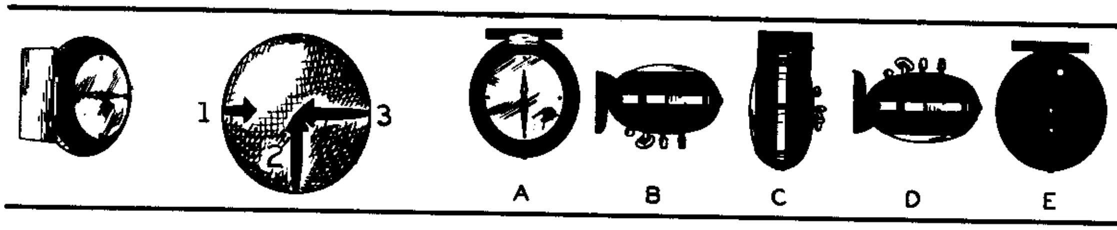

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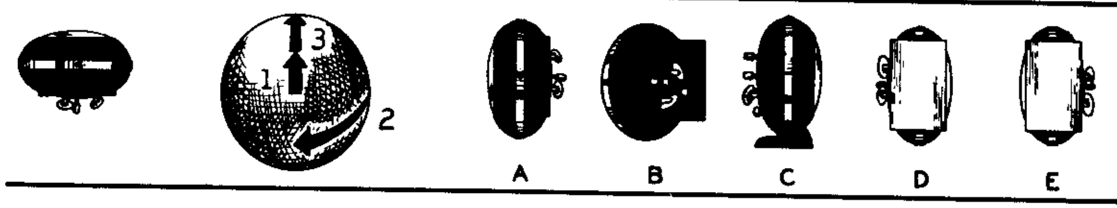

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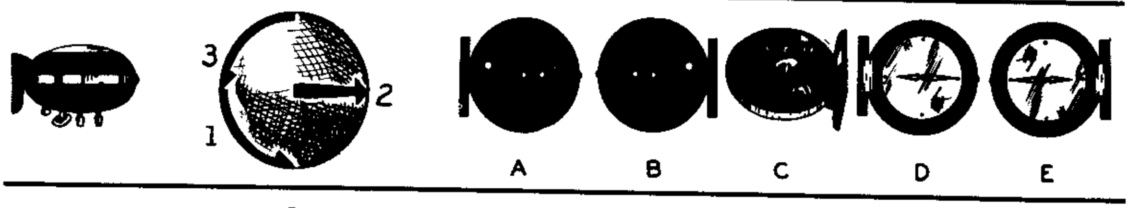

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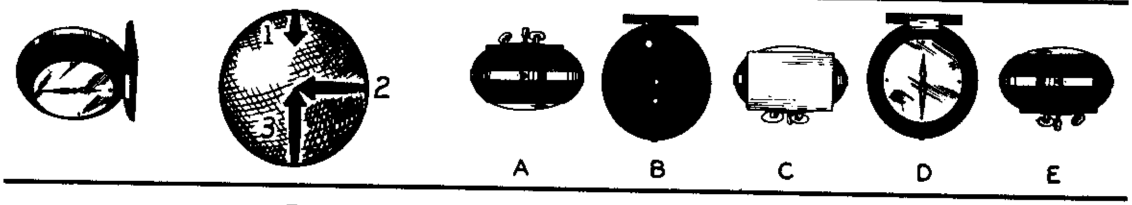

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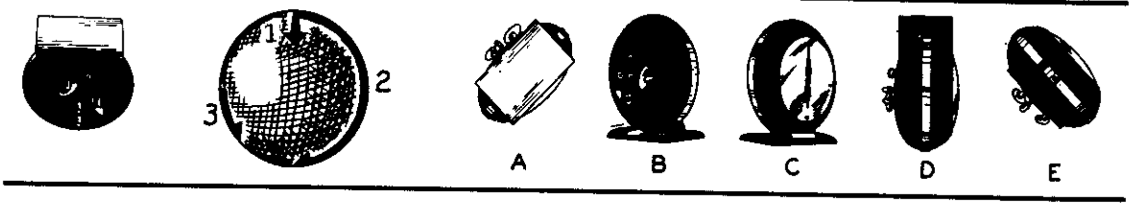

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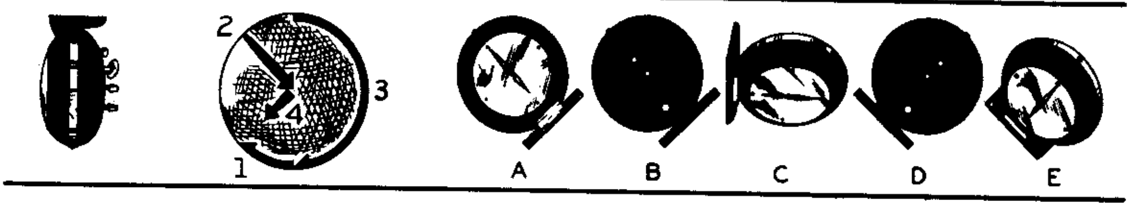

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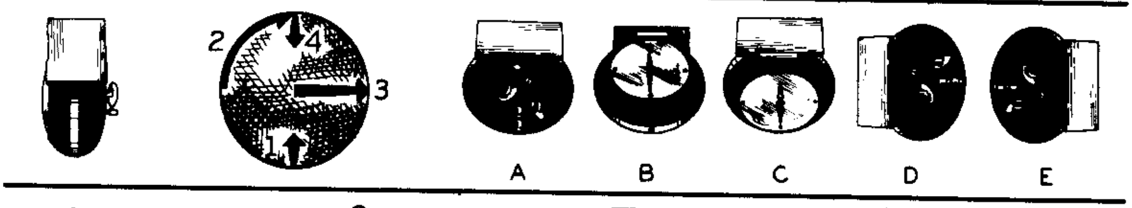

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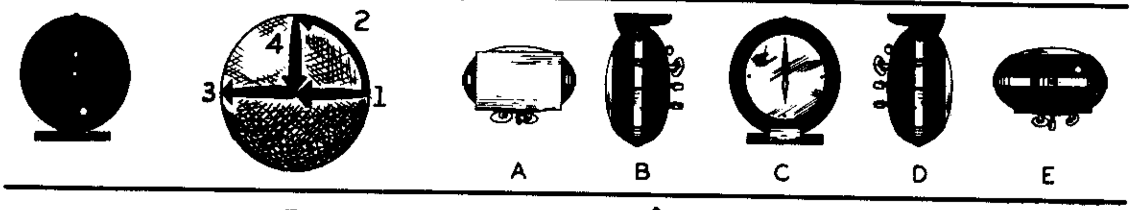

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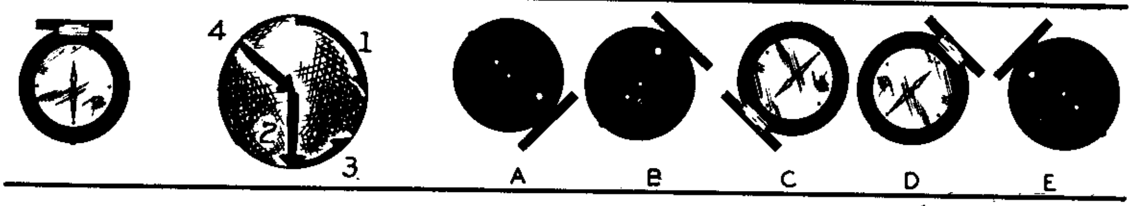

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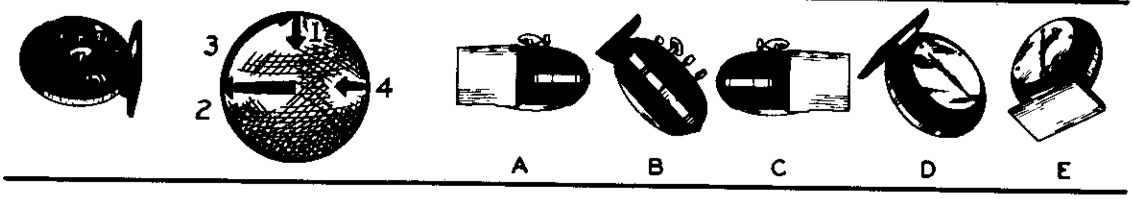
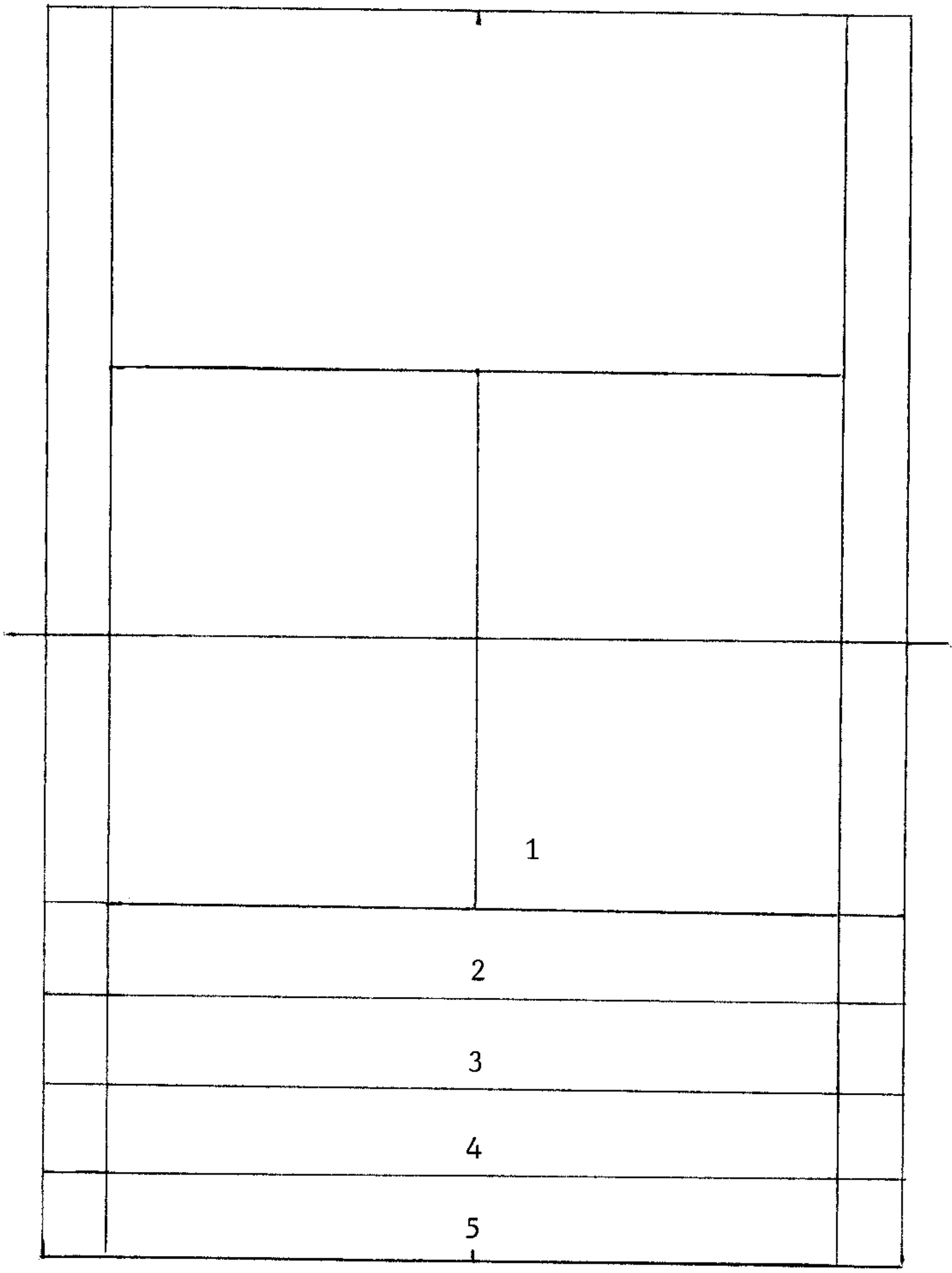


APPENDIX F

HEWITT'S FOREHAND AND BACKHAND DRIVE TEST



BIBLIOGRAPHY

Books

Barnes, Mildred J., Marget C. Fox, and Gladys Scott, Sports Activities for Girls and Women, New York, Appleton-Century-Crofts, 1966.

Broer, Marion R., Efficiency of Human Movement, Philadelphia, W. B. Saunders Company, 1966.

Cratty, Bryant J., Movement Behavior and Motor Learning, Philadelphia, Lea and Febiger, 1964.

Lawther, John D., The Learning of Physical Skills, Englewood Cliffs, New Jersey, Prentice Hall, Inc., 1968.

Oxendine, Joseph E., Psychology of Motor Learning, New York, The MacMillan Company, 1968.

Schurr, Evelyn, Movement Experiences for Children: Curriculum and Methods for Elementary School Physical Education, New York, Appleton-Century-Crofts, 1967.

Scott, Gladys M. and Esther French, Measurement and Evaluation in Physical Education, William C. Brown, Dubuque, Iowa, 1959.

Smith, Hope M., Introduction to Human Movement, Reading, Massachusetts, Addison-Wesley Publishing Company, 1968.

Smith, Karl U. and William M. Smith, Perception and Motion, London, W. B. Saunders Company, 1968.

Woodruff, Asaheld D., The Basic Concepts of Teaching, San Francisco, Chandler Publishing Company, 1962.

Articles

Beise, Dorthy and Virginia Peaseley, "The Relation of Reaction Time, Speed and Agility of Big Muscle Groups to Certain Sport Skills," Research Quarterly, VIII (March, 1937), 133-142.

Elbel, E. R., "A Study of Response Time Before and After Strenuous Exercise," Research Quarterly, XI (May, 1940), 86-95.

Gogel, Walter C., "Size Cue to Visually Perceived Distance," Psychological Bulletin, LXII (October, 1964), 217-235.

Goldstein, Alvin G., "Linear Acceleration and Apparent Distance," Perceptual Motor Skills, IX (September, 1959), 267-269.

Gruber, Howard E. and Albert J. Dinnerstein, "The Role of Knowledge in Distance-Perception," American Journal of Psychology, LXXVIII (December, 1965), 575-581.

Henry, Franklin M., "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," Research Quarterly, XXIII (March, 1952).

Hewitt, Jack E., "Hewitt's Tennis Achievement Test," Research Quarterly, XXXVII (May, 1966), 231-240.

Hodgkins, Jean, "Reaction Time and Speed of Movement in Males and Females of Various Ages," Research Quarterly, XXXIV (October, 1963), 335-343.

Holzman, Philip S., "The Reaction of Assimilation Tendencies in Visual, Auditory, and Kinesthetic Time-Error to Cognitive Attitudes of Leveling and Sharpening," Journal of Personality, XXII (March, 1954), 375-394.

Holzman, Philip. and George S. Klein, "Cognitive System-Principles of Leveling and Sharpening: Individual Differences in Assimilation Effects in Visual Time-Error," Journal of Psychology, XXXVII (January, 1954), 105-122.

Ittelson, W. H., "Size As A Cue to Distance: Static Localization," American Journal of Psychology, LXIV (January, 1951), 54-67.

________________, "Size As A Cue to Distance: Radial Motion," American Journal of Psychology, LXVI (April, 1951), 188-202.

Keller, Louis F., "The Relation of Quickness of Bodily Movement to Success in Athletics," Research Quarterly, XIII (May, 1942), 146-155.

Knapp, Barbara, "Simple Reaction Times of Selected Top-Class Sportsmen and Research Students," Research Quarterly, XXXII (October, 1961), 409-411.

Lotter, Willard S., "Interrelationships Among Reaction Times and Speeds of Movement in Different Limbs," Research Quarterly, XXXI (May, 1960), 147-155.

Luria, S. M. and Jo Ann S. Kinney, "Judgments of Distance Under Partially Reduced Cues," Perceptual and Motor Skills, XXVI (June, 1968), 1019-1028.

Miller, Robert C. and Clayton T. Shay, "Relationship of Reaction Time to the Speed of a Softball," Research Quarterly, XXXV (October, 1964), 433-437.

Patrick, John, "Quick Reaction Time Means Athletic Ability," The Athletic Journal, XXX (September, 1949), 68-70.

Pierson, William R., "Comparison of Fencers and Nonfencers by Psychomotor, Space Perception and Anthropometric Measures," Research Quarterly, XXVII (March, 1956), 90-96.

Over, Ray, "Size and Distance Estimates of a Single Stimulus Under Different Viewing Conditions," American Journal of Psychology, LXXVI (September, 1963), 452-457.

Rudin, S. A., "Figure-Ground Differentiation Under Different Perceptual Sets," Perceptual and Motor Skills, XXVII (August, 1968), 71-77.

Rudin, Stanley A. and Ross Stagner, "Figure-Ground Phenomena in the Perception of Physical and Social Stimuli," The Journal of Psychology, XLV (April, 1958), 213-225.

Slater-Hammel, A. T. and R. L. Stumpner, "Batting Reaction-Time," Research Quarterly, XXI (December, 1950), 353-356.

Slater-Hammel, A. T., "Reaction Time to Light Stimuli in the Visual Field," Research Quarterly, XXVI (March, 1955), 82-87.

________________, "Comparisons of Reaction-Time Measures to a Visual Stimulus and Arm Movement," Research Quarterly, XXVI (December, 1955), 470-479.

Smith, Leon, "Individual Differences in Strength, Reaction Latency, Mass and Length of Limbs, and Their Relation to Maximal Speed of Movement," Research Quarterly, XXXII (May, 1961), 208-220.

Smith, William M., "Sensitivity to Apparent Movement in Depth as a Function of 'Property of Movement,'" Journal of Experimental Psychology, XL (August, 1951), 143-152.

Weymouth, Frank W. and Monroe J. Hirsch, "The Reliability of Certain Tests for Determining Distance Discrimination," The American Journal of Psychology, LVIII (July, 1945), 379-390.

Wilson, Don J., "Quickness of Reaction and Movement Related to Rhythmicity or nonrhythmicity of Signal Presentation," Research Quarterly, XXX (March, 1959), 101-109.

Witkin, H. A., "Individual Differences in Ease of Perception of Embedded Figures," Journal of Personality, XIX (September, 1951), 1-15.

Youngen, Lois, "A Comparison of Reaction and Movement Times of Women Athletes and Nonathletes," Research Quarterly, XXX (October, 1959), 349-355.

Miscellaneous

Guilford, J. P. and Wayne S. Zimmerman, "Guilford-Zimmerman Appitude Survey," Beverly Hills, California, Sheridan Supply Company, 1947.