CHILDREY, ANITA M. The Relationship of Hand-Eye Coordination as Measured by the Pursuit Rotor and Selected Motor Tasks at Various Age Levels. (1967) Directed by: Dr. Gail M. Hennis. pp. 52.

Four groups of girls from grades three, six, nine, and college sophomores comprising fifteen subjects each, were given four tasks involving hand-eye coordination. Their raw scores on these tasks--Aiming, Throwing, Catching, and Pursuit Tracking--were used to determine if there was any significant relationship between the tasks for the total group, and between the tasks among groups. The means of each group were calculated in order to compare them for significance of difference using the Fisher's "t" for small, uncorrelated groups.

The following results were obtained:

1) There were no significant relationships between any of the tasks for the total group.

2) There were no significant relationships for any of the tasks within grade groups.

3) Performance differed significantly only on the Pursuit Rotor task between grades three and nine and three and college level. However, the scores indicated that performance did improve as age level increased, up to the ninth grade, although these increments were not statistically significant. In every task except the Throw, the scores for the ninth grade exceeded those of the college group. In no case except one, however, was the score of the college group

lower than the scores of the third or the sixth grades. On the Aiming task, the scores of the third graders exceeded both the sixth grade and the college level.

On the basis of the results obtained, the following conclusions can be drawn:

1) According to the correlation between scores on the Pursuit Rotor and tasks designed by the researcher, there were no statistically significant relationships either among the total group or among the four groups divided according to grade level.

2) Though there was little statistical significance, there was indication that performance within the limits of this study improved with increasing age up to the ninth grade level, with the exeption of the Throw which showed improvement through the college group. There was a statistically significant difference in the scores of the third and ninth graders and the third graders and college sophomores on the task of the Pursuit Rotor, which indicated that between the third grade and the ninth grade, performance ability on the Pursuit Rotor increased or hand-eye coordination, as measured by the Pursuit Rotor, improved.

This investigation suggests that further study might involve refinement of the tasks as well as the study of additional task relationships. Factors such as handedness, eye dominance, and other motor and visual variables provide possibility of further study.

THE RELATIONSHIP OF HAND-EYE COORDINATION
AS MEASURED BY THE PURSUIT ROTOR AND
SELECTED MOTOR TASKS AT
VARIOUS AGE LEVELS

by

Anita M. Childrey

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Approved by

Gail M. Hennis
Director

APPROVAL SHEET

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

Thesis Director: Gail M. Hennis

Oral Examination Committee Members:

Ethel Martus

Donaldson Russell

June 23, 1967

Date of Examination

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CHAPTER I

INTRODUCTION

It was Walter Cannon (4) who, after working with the human body and seeing the complex relationships that contribute to its unity, spoke of the "wisdom of the body." As Sherrington (12) had indicated earlier, at the basis of this "wisdom" is the nervous system and brain, which through its integrating behavior, coordinates and controls the body's many complex units into a functional whole.

Although for research purposes, the body's units must of necessity be broken down and observed in isolated parts, the researcher must, nevertheless, be constantly aware that the body can never truly be observed in parts. The body's units are inextricably bound through the nervous system, one part affecting others and thus creating many variables for the researcher.

The functional aspect of hand-eye coordination, upon which this study is based is an example of a unit with many variables. One could think of several ways in which the hand-eye relationship could be affected. We could see, for instance, that poor vision could affect the coordination of the hand and eyes; another example would be a high synaptic threshold which could slow reaction time and other respondent behavior. Perhaps age level could be an influencing factor because of increasing neural development during childhood. Also, since the state of the nervous system can change from day to day, depending on the internal environment, state of health, external stimuli, food or drugs, etc., hand-eye coordination is perhaps not a stable relationship. Good visual images going to the brain may not be eliciting efficient motor response, or because of poor visual images, good motor response may not be adequate for the situation. Despite the variables inherent to this study and any study on the performance of an organism, this researcher felt that because hand-eye coordination is so basic to the performance of the activities in physical education involving throwing, aiming, catching, and watching a moving target, it would be well to study hand-eye coordination and hopefully to observe patterns of performance of an entire group as well as to observe performance at various age levels, recognizing all the while that limitations were inherent to the study.

The researcher became interested in hand-eye coordination when she began teaching tennis. She observed that there were some differences in ability to hit the ball with the racket and that older pupils were generally more successful than younger pupils. This difference could be due to several factors: weight of the racket in relation to the size of the pupil, concentration span, or neuro-muscular development. The writer hypothesized that the development of hand-eye coordination could also be a factor.

When she began to set up the present study, the researcher decided to use school-age children from the youngest age that could probably have some success at a difficult game such as tennis, to the oldest enrolled in required physical education classes, college sophomores. The researcher decided to use girls and young women instead of a mixed group, since boys tend to develop coordination patterns at a different rate from girls.

The researcher wished to find a task of hand-eye coordination which included more than the fine, limited movements of many of the psychological apparatus tasks, yet which did not involve such gross movement that too many variables entered into the testing situation. A review of the literature did not specify such tasks. Because hand-eye coordination appears to be so important to many of the skills which are used as tools of physical education, this researcher decided to devise several tasks which would appear to involve hand-eye coordination and which would utilize movements that could be classified between fine and gross movement. No attempt was made to validate these tasks although experimentation was involved in their development (see Appendix). She also decided to use the pursuit rotor which is frequently referred to as "a nearly 'pure' measure of perceptual hand-eye coordination." (52) The pursuit rotor is considered to measure a combination of gross and fine movement.

CHAPTER II

STATEMENT OF PROBLEM

The purpose of this study was two-fold: 1) to investigate in girls the relationship between hand-eye co-ordination as measured by the Illuminated Target Pursuit Apparatus and skill level in three motor skills involving hand-eye coordination; and 2) to investigate the differences in the hand-eye coordination of girls at four different age levels.

The literature suggests that good hand-eye coordination is essential to successful motor performance, especially in skills involving aiming, striking, catching, and accuracy throwing. Tests in physical education for hand-eye coordination involve gross motor skills and do not successfully isolate hand-eye coordination from the gross motor pattern. This study attempted to measure hand-eye coordination by testing a more refined form of these motor skills attempting to eliminate as nearly as possible the variables involved in gross movement. The results of four tasks of hand-eye coordination were correlated for the total group as well as among the groups, and a test for significance of difference between the means of the four groups was computed.

CHAPTER III

REVIEW OF LITERATURE

In normal persons, the coordination between the hands and the eyes is perhaps one of the basic relationships in performing tasks essential to daily living. The ability to look at an object, make a judgment about it and then accurately to reach out and manipulate by hand the object or its parts with amazing facility and precision, has set man, the user of tools, high above his less skilled relatives.

Hand-eye coordination is of especial interest to physical education since proficiency in performance of activities involving accuracy throwing, aiming or catching is often based on this coordination ability. Thus, in order to understand better the relationship of the eyes to the hands in performance the writer reviewed the following literature.

I. STUDIES IN HAND-EYE COORDINATION

Hand-eye coordination, though long recognized by experts as being essential to skilled movement involving aiming (accuracy throwing, catching, striking, tracking), has been sadly neglected as an object of study per se. That hand-eye coordination exists at all is accepted mainly at face validity, especially in the field of physical education, where the so-called tests of hand-eye coordination are found in motor ability batteries. These tests have inherent problems for the researcher because of the number of variables involved in the performance of gross movement. As Ross (52) has pointed out, a possible reason for the scarcity of studies may be due to the difficulty in devising ways to demonstrate the association between the two variables, physical performance and visual perception.

McCloy, as early as 1939, stressed the importance of hand-eye coordination by suggesting that it should be an important factor in the testing program (10), and, with the other fifteen components of motor educability, should be tested in as pure form as possible and explored at each important age level (44). He added, however, that the tests for hand-eye coordination which had been devised had not been validated in the field of physical education, but he listed them, "for research purposes," as being the Miles Pursuit Pendulum, the Miles Pursuitmeter, and Koerth Pursuitmeter. (10) The latter instrument will be described later in this review. To the writer's knowledge none of these tasks has been validated to date in physical education.

Ross (52) in 1961 found in the physical education literature no standardized tests specifically for measuring hand-eye coordination so she devised four tests which involve the manipulation of an object. Her four tasks, a ring toss, a ball bounce (below the waist), a wall rebound-catch (above the waist), and a target throw (using bean bags), all received high reliability scores in a pilot study using the odd-even method with twenty-four subjects, grouped into eight subjects each from the second, fourth, and sixth grades. She found that boys were superior to girls in all but the target throw, and she projected that possibly this was because of the tendency for boys to have had more experience in ball handling and throwing. Ross also found that older children were better than younger ones, and that each grade made better scores than the grades below.

Wilberg (53) in 1960 divided hand-eye coordination into two distinct events: 1) the initial visual location of the stimulus, and 2) the motor reaction in response to the situation. In attempting to find the relation of the initial visual location of the original stimulus and the motor response when the number of alternatives in the visual field increased, he found that subjects made generally two types of errors: 1) in locating the stimulus-object correctly, and 2) incorrect motor response which was generally due either to loss of perceptual information or incorrect use of the information. The motor response was more often incorrect than the initial visual location of the object.

Barrow and McGee (1) likewise acknowledge the importance of hand-eye coordination for many sports skills. They characterized skillful coordination as involving control, accuracy, and steadiness, and, like Wilberg, also recognize the two responses involved in coordination of hand and eye. "All such movements involve a primary objective, and the performer must keep his eyes trained on this primary objective while he carries out the initial part of the movement." (1:121)

Smith and Harrison (49) speak of the dual aspect of hand-eye coordination in terms of visual-motor learning, or as an improvement of scores on a hand-eye coordination task from beginning to end. They state that the change "is dependent both on the improvement of perceptual recognition of the stimulus objects and on the increase in proficiency of the motor response resulting from such stimulus." (49:299)

II. MEASUREMENT OF HAND-EYE COORDINATION

The few measures of hand-eye coordination that have been devised have been done in the field of psychology. One of the very first to experiment with test instruments was W.R. Miles with his Pursuit Pendulum (45) in 1920 and the Pursuitmeter (46) in 1921. The pendulum released water at the height of every arc which the subject attempted to catch in a small cup marked to measure the amount caught. The Pursuitmeter was an electrical instrument with a moving target which changed direction, and thus required great accuracy on the part of the subject. This instrument has since been modified and improved.

The Pursuit Pendulum was the inspiration for the machine designed and built by Wilhelmine Koerth (42) in cooperation with Seashore. Now designated the "Koerth Pursuitmeter," it was built "to measure capacity for the acquisition of skill in coordination of eye and hand." (42: 288) It followed Miles' principle of using a moving stimulus following a fixed path at constant speed. This Koerth Pursuitmeter is the basis for many of the pursuit rotors in use today. From the Koerth original which consisted of a small metal disc resting in the wooden turntable of a 60-rpm phonograph, came machines now generally made of a bakelite material with the metal target still inserted flush with the surface. A hinge-jointed metal stylus is used to make contact with the target, and a counter or timer scores either number of contacts or time on target. Speed variations as well as other modifications are sometimes built into the newer machines. Apparently modifications became so numerous that in 1955 Ammons (24) made a plea for standardization of equipment. Listing eighteen variables which were prevalent in the machines and research at that time, he noted that unless the machines were standardized to some degree, theoretically, all research would have to be repeated before it could be applied.

III. RESEARCH USING THE PURSUIT ROTOR

Jahnke and Hammer (39) in 1963 modified a Koerth-type pursuit rotor which they based on the principle established through the findings of Ammons, Ammons, and Morgan (26) (1958) that "pursuit movements of greater duration and frequency occur close to the target." (39:318) They monitored an area both around and in the target in order to time the duration of time on target as well as the duration and location of pursuit response (leading, following, inside, outside, and off target). When five minutes of practice (twenty trials of 15 seconds, with 45 seconds rest between trials) had elapsed, it was found that "somewhat more than 80% of the pursuit time is spent within the monitored area." (39:320)

The Air Force has used the pursuit rotor extensively, though Fleishman (33) reports that Air Force analyses were not certain whether it was a test of "Psychomotor Coordination" which "involved more coordination between muscle groups, are not entirely restricted to arm movement, and do not seem as concerned with speed," or as a task of "Psychomotor Precision" which "seems similar to Finger Dexterity, although more eye-hand coordination seems involved. . . .It is distinguished from Psychomotor Coordination in that grosser arm motion is not included." (33:249) One would infer that the status of the rotory pursuit apparatus needs further analysis.

A number of studies have used the pursuit rotor as a measure of learning a hand-eye coordination task. Among the factors studied have been age, practice, work decrement, reminiscence and retention, and motivation.

Age and sex were found to have a significant effect on pursuit rotor ability. Ammons, Alprin, and Ammons (27) found from their subjects in grades three, six, nine, eleven and twelve that overall proficiency increased with age, with the boys being increasingly superior to the girls. They also found that the proficiency of the girls decreased from grades nine to twelve. Temporary work decrement and warm-up decrement generally increased in amount with age, affecting boys more than girls, and relating proportionally with level of proficiency.

Davol, Hastings, and Klein (31) in 1965, using even younger children, from kindergarten through the third grade, found results similar to those of Ammons, Alprin, and Ammons in that overall proficiency increased steadily with age. They found greatest increase occurred between kindergarten and the first grade. Though they used speeds lower than Ammons, et al (33 and 45 rpm), they nevertheless found the increase in proficiency to relate to age of the subjects. Also, upon corresponding with Ammons, it was found that kindergarten children had been tested successfully at 60 rpm after practice at lower speeds. The significant sex difference that Ammons had found was not shown significantly in the Davol study, though there was a larger difference at the third grade level than at any other. Davol found an interest, fatigue, and motivation problem in using very young children since the pursuit rotor is "repetitive, fatiguing, and less interesting than a more complex task might be." (31:356) However, as he pointed out, pursuit rotor scores on children are very valuable toward producing more precise data on motor skill development in young children.

Studies on handedness relating to rotory pursuit performance could not be found, but the study by Grant and Kaestner (34) using a constant velocity tracking task, may or may not have implications for the present study. Grant found that neither handedness nor target direction was significant to his experiment, but the combined effect was statistically significant. The right hand, it was reported, tracked best right to left, while the left hand tracked best left to right. Also as a motor factor, they found that pushing or thrusting was superior to pulling.

The bulk of the literature on rotory pursuit skill has been done in the area of practice effects, rest and work decrement. Although not all of the studies are in agreement, it was generally felt that continuous practice led to poorer performance at all stages of practice. (25,8,28) Often, however, it was difficult to determine from one study to the next just what the criterion for defining massed practice from distributed practice was. How much time had to elapse before one became the other? Though a specific answer in relation to pursuit rotor performance is unknown at present, generalizations regarding work decrement have been made. The term "work decrement" was developed by Ammons (25), who noticed in his subjects that in a block of massed trials, performance would tend to taper off toward the end, only to pick right up again after a rest period. The conclusion was that inhibitory effects built up over a practice period causing a temporary performance decrement due perhaps to fatigue, boredom, or other factors not known. A period of rest served to dissipate these depressant effects. Thus Ammons concluded that an intermediate level of distribution of practice was most efficient for performance (21,30) This tends to support the theory of Hull (8) that distribution of practice would dissipate effects of reactive inhibition (temporary work decrement).

It is interesting to note the effects of rest on the performance curve. Ammons (25,21) found that the literature generally agreed that after rest, the performance curve shoots to a much higher level than if there had been no rest. After this phenomenon, called reminiscence, the curve begins to flatten out and leads to a relatively decremental segment, after which the pre-rest curve is resumed, tending toward gradual improvement. Ammons also reports that though the reminiscence, decremental segment, and recovery is typical, that not all learning curves follow this pattern. It occurs mainly in a block of massed trials separated by rests of several minutes, and where the task is a new one. (25)

Retention of pursuit rotor skills is quite high (some research has reported as much as a year) (29), but the literature does not seem to agree as to whether massed or distributed practice had the best retention. Adams and Reynolds (19) found little difference regarding permanent learning effects, only the individual performance variations, but Jahnke and Duncan (38) found that distributed practice had better retention value. Bourne and Archer (30) indicate that skill in staying on target for longer durations was not learned as well by massed practice.

At one time there was some debate as to whether the source for work decrement was in the visual system. Ammons had indicated it was not (22) (1951), but Humphries and McIntyre (36), Adams (18), and Rosenquist (49) reported that visual pursuit activity interpolated between tracking periods of massed practice could block the dissipation of temporary work decrement. Their studies had the person watching the tracking press a button whenever he thought his partner was on target. Rosenquist reported dissipation of work decrement at two rates: "readily during rest and slowly during continued active watching." (47:560) Adams indicated that active watching led to significantly lower time on target scores in the final session. Perhaps the disparity between Ammons' results and the others' lay in the type of interpolated watching. Ammons' subjects watched passively, i.e., without responding to the partner's hits, while in the later studies, the person watching had an active involvement in pressing a button when the partner was on target. The general consensus was that a source of temporary work decrement lies in the visual system.

Kephart and Chandler (40) found in a pursuit tracking test a significant decrement in visual span, which they ascribe to the concentrated attention on the task and a diminishing of attention to the periphery. Attention to the periphery as well as the target has been shown to have significant bearing on accuracy and efficiency. As Oberteuffer and Ulrich (11:262) point out,

> If the point that is to be fixed is located in reference to other points near or around it and seen in its relative depth and direction, the judgment with regard to it is more accurate. . . . The sense of direction and distance is improved if a number of cues in the field are used instead of just one.

They further state that if in seeing a moving target the viewer could broaden his visual field to encompass as many cues as possible by "looking through the one point and at many points. . . .", the task would be easier and more effective.

Graham (7:345) indicated that "visual acuity is relatively poor for a moving test object even when the eyes appear to be successfully pursuing it (Ludvigh, 1948)." Thus the task of the tracker to "watch the target" or the athlete to "keep his eyes on the ball," may really be beyond their means. Their success will depend rather on seeing the target in relation to the cues in its background.

The relationship of kinesthesis to pursuit rotor activity was really beyond the scope of this study. However, as Cratty (3:110) has stated:

> Kinesthetic feedback from the eye muscles aids in the formation of perceptions of depth and movement within the visual field. . . .It is probably, however, that learning a complex movement is not entirely dependent upon kinesthesis but is a product of total perceptual organization.

In summary, a review of the literature shows little study in the aspect of hand-eye coordination per se, though the researchers agree as to the importance of hand-eye coordination to many motor skills. Several tasks have been devised, but the pursuit rotor seems to have been the most popular task of hand-eye coordination used in motor learning research and has shown many significant results in tests at various ages regarding practice, work decrement, reminiscence, retention and motivation. Because of its extensive use over a long period of time, it is regarded as one of the best measures available for the study of motor development and learning.

CHAPTER IV

PROCEDURE

Purpose of Study

The purposes of this study were: 1) to investigate in girls the relationship between hand-eye coordination as measured by the Illuminated Target Pursuit Apparatus and skill level in three motor skills involving hand-eye coordination; and 2) to investigate the differences in the hand-eye coordination of girls at four different age levels.

Selection of Subjects

The sixty subjects were divided by grade level into groups of fifteen subjects each. The elementary, junior high, and high school subjects were selected from the third, sixth and ninth grade girls' physical education classes at the Curry School, Greensboro, North Carolina. The fifteen sophomore college subjects were drawn from a women's tennis class in the general college program of the University of North Carolina at Greensboro.

Selection of Tasks

The Illuminated Target Pursuit Apparatus, a type of pursuit rotor, was chosen as an instrument for indicating ability in performance on tasks of hand-eye coordination.

The other three tasks were designed by the researcher in attempting to measure motor skills involving accuracy throwing, aiming, and catching.

The first task was a task of aiming where the subject had to thrust a twenty-seven inch probe through three rings decreasing in size from four inches to three inches to two inches in diameter. The subject had three trials at each ring. The second task, a throw for accuracy, required the subject to be seated before a target bearing five four and one-half inch diameter holes numbered one through five in a pattern similar to a "five spot" in a deck of cards. The subject was asked to throw a small cork ball, approximately three fourths of an inch in diameter, through the holes in numerical order. The subject had three trials to accomplish this. Hole Number One was in the upper left corner, Number Two in the lower right, Number Three in the upper right, Number Four in the lower left, and Number Five in the center of the board. One point was allowed for each successful throw, and the highest possible score was fifteen. The third task required the subject to catch in a net a plastic ball two inches in diameter as it rebounded from a throw by the researcher at a space on a wall above the head of the subject. The third graders had a net with an opening of five inches, the sixth and ninth graders had an opening of four and one-half inches in diameter, and the college subjects had a net with an opening of four inches diameter. The size of the ball remained constant for all groups. Each subject had fifteen trials, scored at one point for each successful catch.

Testing Procedure

Each subject, prior to performing the four tasks of hand-eye coordination, was given a 180 second pre-test on the pursuit rotor to familiarize her with the instrument as well as to bring her over the initial stages of learning.

At the time of the pre-test, the subject was shown the pursuit rotor and told in simple terms how the researcher was attempting to use it in measuring hand-eye coordination. The researcher then showed the subject the Hunter Clock and, demonstrating on the pursuit rotor, explained that it measured the time to .01 seconds the subject maintained contact with the target light as she followed the light in its circular pattern with the stylus on the surface of the machine. A few of the younger subjects were interested in the mechanism and were shown or told the principle of the photocell. Then the subject was asked to take the probe in her hand and make several practice attempts. When the researcher saw that the subject understood the technique, the machine was cut off. The researcher asked the subject to wait while the machine was turned on, and the signal "Ready" was given. This procedure was necessary in order to reset the Hunter Clock and stopwatch. Then the researcher gave the signal "Go" at the same time starting the stopwatch, and the subject began her pursuit of the target light. At the end of sixty seconds, the subject was stopped and her score read to her. She was given three trials in all with no more than fifteen seconds between any trial. Scores for each subject were recorded on individual score cards. (See Appendix for a copy of the score card.)

After a lapse of not less than one week and no more than two weeks, each subject was again tested on the pursuit rotor, and in addition, performed the three hand-eye coordination tasks of aiming, throwing, and catching previously described.

The testing period which lasted about twenty minutes, was divided into four units. The first unit was a sixty second warm-up trial on the pursuit rotor, the score of which was not counted. The second unit began with the aiming task. The subject was asked to stand before the middle and largest of three rings which were suspended perpendicularly from a movable horizontal bar adjusted to the subject's height. The correct adjustment was established when the ring was opposite the subject's elbow when her arm was hanging loosely at her side. The correct distance from the target was established when the subject could reach with outstretched arm about three inches past the rings. Upon the signal "Ready," the subject lined the probe up with the target, coming no closer to it than approximately one foot, and at the signal "Go," she made a vigorous thrust toward the ring. When three attempts had been made for the large ring, the subject moved in front of the next size ring which was situated to the left of the large one. The same procedure for thrusting was followed. After three attempts were made for this ring, the subject stepped in front of the smallest ring which was suspended to the right of the largest ring. The same procedure was followed in thrusting. At the completion of this task, the subject was tested on the pursuit rotor for two consecutive trials of sixty seconds, with no more than twelve seconds intermission between the two trials.

The third unit of time began with the throwing task. The subject was asked to sit with her back to a chair which was situated with its back legs fifty-five inches from the target board. The subject was asked to throw a small ball into the holes in the target numbered from One to Five. She was instructed to try for the holes in numerical order and proceed around the whole target three times at her own rate. At the end of this task the subject had two more trials on the pursuit rotor in the manner already described.

The fourth unit began with the catching task. In this task the subject stood beside the researcher before a wall. The researcher threw a plastic ball at the wall above the subject's head, and the subject attempted to move a net which she held in her hand into position to catch the ball as it rebounded from the wall. The subject was free to move in any direction. The researcher made no attempt to place the ball in the same spot on each throw, although she was careful to throw so that the ball would not rebound toward herself, thus causing interference with the catch. If a rebound for some reason did not behave in a manner typical of the usual rebound, the throw was repeated unless the subject had caught the ball successfully. This task of catching was followed by two trials on the pursuit rotor in the manner already described, which concluded the testing period.

The researcher on all the tasks except the pursuit rotor gave verbal encouragement and acknowledgment of success. For the pursuit rotor the researcher provided knowledge of scores after each trial which may have provided incentive to stick with the rather fatiguing task in trying to meet or better the score of the previous trials. During the pretest on the pursuit rotor, verbal encouragement was given freely to all subjects during the trials. Knowledge of scores was also provided.

The researcher felt that the interpolation of the three gross motor tasks between the blocks of trials on the pursuit rotor was beneficial in alleviation of boredom and fatigue. At no time did these tasks exceed three minutes in time.

Treatment of Data

The statistical procedure used in this study was as follows:

1) Product-moment coefficients (15:355-360) were computed using raw scores of the four tasks among each grade level.

2) Product-moment coefficients were computed for the total group of subjects using the raw scores of each of the four tasks.

3) The Fisher's "t" Test for significance of difference among small, uncorrelated groups (15:378) was used with the various grade levels to compare the mean scores of each task in determining whether any differences in the groups should be attributed to chance or whether the differences were statistically significant.

CHAPTER V

ANALYSIS AND INTERPRETATION OF DATA

The purposes of this study were 1) to investigate in girls the relationship between hand-eye coordination as measured by the Illuminated Target Pursuit Apparatus and skill level in three motor skills involving hand-eye coordination; and 2) to investigate the differences in the hand-eye coordination of girls at different age levels.

I. PRESENTATION OF FINDINGS

Using the performance scores of four groups of subjects selected according to grade level, the researcher attempted to find the following information:

1) whether there was any significant relationship between the total scores of each group on the various tasks;

2) whether there was any significant relationship between the scores on the four tasks within each age group;

3) whether there was any significant difference among the means of each group on the various performance tasks. This could indicate whether age as indicated by grade level affected performance skill.

Total Group Scores

In order to find the relationship between the total scores of each group on the various tasks, the researcher used the formula for the correlation of data from raw scores. As is indicated in Table I (page 26), all of the relationships were low and positive except for the correlation coefficient between the Aiming task and the Throwing task which was low and negative (-.04). The highest of the correlation coefficients was that between the Pursuit Rotor and the Throw (.54). None of these relationships were statistically significant.

Scores among Groups

In order to compare the results of the four tasks of hand-eye coordination at each age level, the mean and standard deviation for each grade level were computed from the scores on each of the four tasks. The data in Table II (page 27) indicated that on every task but the Throw, the mean score of the ninth graders was higher than the college level. On the Throw, the ninth grade was higher than both the third and sixth grades. The mean score of the ninth grade was the highest on the tasks of Aiming and Pursuit Tracking. The mean score of the college group was highest on the task of Throwing. The third grade had a higher mean score on the task of Aiming, and the mean score of the sixth grade exceeded both that of the third grade and the college group on the Catching task.

TABLE I

CORRELATION COEFFICIENTS FOR THE TOTAL GROUP AMONG THE FOUR TASKS OF HAND-EYE COORDINATION AND AMONG EACH GRADE LEVEL USING THE SCORES OF THESE TASKS

		PR	AIM	THROW	CATCH
Total Group N 60	PR	———	.12	.54	.20
	Aim	———	———	-.04	.06
	Throw	———	———	———	.25
3rd Grade N 15	PR	———	.14	.19	.39
	Aim	———	———	-.26	.02
	Throw	———	———	———	.12
6th Grade N 15	PR	———	.30	.17	-.02
	Aim	———	———	.13	.57
	Throw	———	———	———	.36
9th Grade N 15	PR	———	.33	.57	.41
	Aim	———	———	.34	.11
	Throw	———	———	———	.31
College N 15	PR	———	.30	.06	.13
	Aim	———	———	-.27	-.16
	Throw	———	———	———	.07

TABLE II

MEANS AND STANDARD DEVIATIONS OF EACH AGE GROUP ON THE FOUR TASKS OF HAND-EYE COORDINATION

	Grade	N	M	S.D.
PURSUIT ROTOR				
	3	15	62.23	28.24
	6	15	118.47	24.40
	9	15	171.28	36.58
	C	15	168.54	33.01
AIM				
	3	15	6.60	3.57
	6	15	4.78	1.82
	9	15	6.73	3.15
	C	15	5.53	3.24
THROW				
	3	15	2.47	1.67
	6	15	4.33	2.18
	9	15	5.27	2.46
	C	15	5.53	2.03
CATCH				
	3	15	8.53	2.75
	6	15	10.87	3.20
	9	15	10.73	2.69
	C	15	8.60	2.42

The relationship among the scores of each age level on the various tasks was also found by using the correlation formula for raw scores. These data are also shown in Table I. The coefficients were low and positive with the exception of the Aiming/Throwing tasks' correlation coefficient for the third grade which was low and negative (-.26) and for the college level which also was low and negative (-.27). The Pursuit Rotor/Catching tasks' correlation coefficient for the sixth grade was also low and negative (-.02), as was the correlation coefficient for the college level which was also low and negative (-.16). The highest correlation coefficients occurred at the ninth grade level on the Pursuit Rotor/Throw (.57), the Aim/Catch at the sixth grade level (.57), and the Pursuit Rotor/Catch (.41). None of the correlation coefficients were statistically significant.

Mean Difference among Groups

The mean difference among groups was ascertained by using the Fisher's "t" test of significance of difference for small, uncorrelated groups. Performance between grade levels three and nine as well as three and college differed significantly at the .05 level of confidence on the Pursuit Rotor task. The data from the Pursuit Rotor showed no other significances of difference in performance between the other grade levels. Neither the Aiming Task nor the Throwing Task scores showed any significances of difference at any grade level. Though the scores on the tasks of Catching indicated some performance differences, these differences were not significant at the .05 level of confidence. The Catching task did not show any significance of difference in scores, either.

II. INTERPRETATION

The lack of significant relationships between total group scores as well as scores among groups may indicate that the tasks are measuring either different phenomena, or different aspects of one phenomena, hand-eye coordination. The higher correlation coefficient between the Pursuit Rotor/Throwing Tasks indicated there might be some possibility of using these tasks together in predicting hand-eye coordination ability related to throwing or tracking.

The tests for significance of difference (Table III, pages 30 and 31) generally indicated that for these four tasks of hand-eye coordination, performance ability did not change to a great degree from one grade level to the next, or that chance rather than ability played a role in several of the tasks. The only significant difference in performance was found between the third grade and both ninth grade and college levels. This indicated that, within the limits of this study, ability on the Pursuit Rotor improved significantly between the third and ninth grades. This conclusion is also the researcher's subjective opinion based on observation, as well as the general indication of the research literature. It is interesting to note from Table II that

TABLE III

FISHER'S "t" TEST FOR SIGNIFICANCE OF DIFFERENCE AMONG THE MEANS OF THE VARIOUS GRADE LEVELS ON THE FOUR TASKS OF HAND-EYE COORDINATION

	M	"t"
PURSUIT ROTOR		
Grade 3	62.23	
Grade 6	118.47	1.5143
Grade 3	62.23	
Grade 9	171.28	2.1698*
Grade 3	62.23	
Grade C	168.54	2.1515*
Grade 6	118.47	
Grade 9	171.28	.9281
Grade 6	118.47	
Grade C	168.54	.8916
Grade 9	171.28	
Grade C	168.54	.4181
AIM		
Grade 3	6.60	
Grade 6	4.87	.7103
Grade 3	6.60	
Grade 9	6.73	.0149
Grade 3	6.60	
Grade C	5.53	.4042
Grade 6	4.87	
Grade 9	6.73	.7698
Grade 6	4.87	
Grade C	5.53	.3021
Grade 9	6.73	
Grade C	5.53	.4572

TABLE III (continued)

	M	"t"
THROW		
Grade 3 Grade 6	2.47 4.33	1.2267
Grade 3 Grade 9	2.47 5.27	1.6035
Grade 3 Grade C	2.47 5.53	1.7374
Grade 6 Grade 9	4.33 5.27	.4611
Grade 6 Grade C	4.33 5.53	.5881
Grade 9 Grade C	5.27 5.53	.1205
CATCH		
Grade 3 Grade 6	8.53 10.87	.6042
Grade 3 Grade 9	8.53 10.73	.5778
Grade 3 Grade C	8.53 8.60	.0197
Grade 6 Grade 9	10.87 10.73	.0315
Grade 6 Grade C	10.87 8.60	1.8300
Grade 9 Grade C	10.73 8.60	.5611

the ninth graders performed better than the college level subjects on all tasks but the Throw. This could be due to the possibility that the ninth grade group was unusually skilled as indicated by their physical education teacher. It may have been possible also that many of the college age subjects, all of whom were sophomores and residents of North Carolina, had not had physical education since their sophomore year in high school until they came to the University of North Carolina at Greensboro, where physical education is required for freshmen and sophomores. The ninth graders, on the other hand, had been exposed to a physical education program throughout their school years at Curry.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Four groups of girls from grades three, six, nine, and college sophomores comprising fifteen subjects each, were given four tasks involving hand-eye coordination. Their raw scores on these tasks--Aiming, Throwing, Catching, and Pursuit Tracking--were used to determine if there was any significant relationship between the tasks for the total group, and between the tasks among groups. The means of each group were calculated in order to compare them for significance of difference using the Fisher's "t" for small, uncorrelated groups.

The following results were obtained:

1) There were no significant relationships between any of the tasks for the total group.

2) There were no significant relationships for any of the tasks within grade groups.

3) Performance differed significantly only on the Pursuit Rotor task between grades three and nine and three and college level. However, the scores indicated that performance did improve as age level increased, up to the ninth grade, although these increments were not statistically significant. In every task except the Throw, the scores for

the ninth grade exceeded those of the college group. In no case except one, however, was the score of the college group lower than the scores of the third or the sixth grades. On the Aiming task, the scores of the third graders exceeded both the sixth grade and the college level.

On the basis of the results obtained, the following conclusions can be drawn:

1) According to the correlation between scores on the Pursuit Rotor and tasks designed by the researcher, there were no statistically significant relationshipw either among the total group or among the four groups divided according to grade level.

2) Though there was little statistical significance, there was indication that performance within the limits of this study improved with increasing age up to the ninth grade level, with the exception of the Throw which showed improvement through the college group. There was a statistically significant difference in the scores of the third and ninth graders and the third graders and college sophomores on the task of the Pursuit Rotor, which indicated that between the third grade and the ninth grade, performance ability on the Pursuit Rotor increased or hand-eye coordination, as measured by the Pursuit Rotor, improved.

This investigation suggests that further study might involve refinement of the tasks as well as the study of additional task relationships. Factors such as handedness, eye dominance, and other motor and visual variables provide possibility of further study.

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APPENDIX

THE ILLUMINATED TARGET PURSUIT APPARATUS

The Illuminated Target Pursuit Apparatus was comprised of a target light of adjustable diameter (three-eights of an inch to one inch) which was projected upon the translucent surface of the machine from within the apparatus. The target light was at the end of an adjustable (four inches to six inches) radius arm which moved in a circular, clockwise path at sixty rpm. The path of the target was not centered on the rectangular surface, but lay more toward the rear of the apparatus. For this study, the radius arm was four and one-half inches in length.

A metal case housed the assembly, a sixty rpm motor, and a photo cell amplifier. Located at the front of the metal case was the On-Off switch, an on-target buzzer switch, two binding posts for connection of timers and clocks for readout, and a dial for control of the sensitivity of the photo cell. At the rear of the metal housing, the fourteen inch probe, a Lucite light-pipe and photo cell assembly of adjustable sensitivity, inserted into a metal jack.

It is suggested by the researcher that if this apparatus is to be used near overhead lights or a window with a great deal of sunlight, the sensitivity be set lower than if it is used in a darker atmosphere, for at some settings bright light will activate the photo cell mechanism causing the readout device to record. For this study, sensitivity was set at seventy. It is also suggested that the amount of lighting in the room be controlled by eliminating light from windows, for the amount of light can change the apparent size of the target somewhat.

The translucent fiberglass top was secured by Velcro fastener strips and was easily removed for adjustment of the size or radius of the target. The researcher suggests cleansing this top often with soap and water. She found that by leaving a film of soap on the top there was less friction between the probe and the fiberglass surface of the instrument. This facilitated pursuit as well as causing less wearing of the top. Care should also be taken to clean the end of the Lucite light pipe, as an accumulation of dirt could affect the sensitivity.

For this study, the machine was lowered twelve inches for the third graders because of their shorter height.

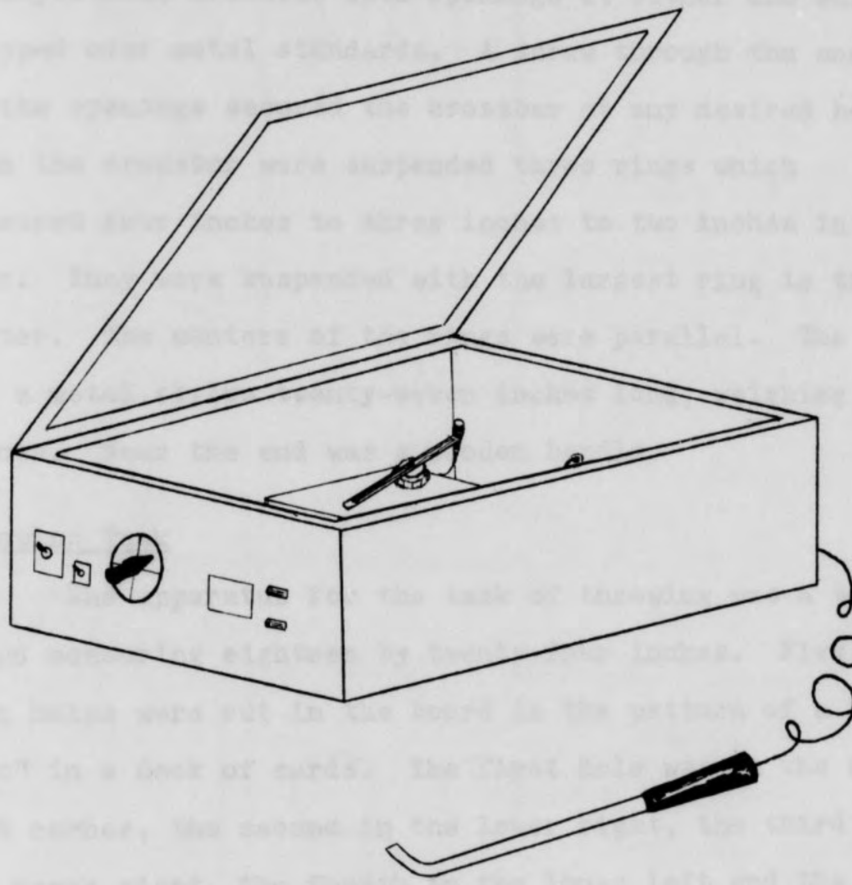

FIGURE 1

ILLUMINATED TARGET PURSUIT APPARATUS

Aiming Task

The apparatus for the task of aiming consisted of an adjustable crossbar with openings at either end which slipped over metal standards. A screw through the enclosure of the openings secured the crossbar at any desired height. From the crossbar were suspended three rings which measured four inches to three inches to two inches in diameter. They were suspended with the largest ring in the center. The centers of the rings were parallel. The probe was a metal stylus twenty-seven inches long, weighing eight ounces. Near the end was a wooden handle.

Throwing Task

The apparatus for the task of throwing was a target board measuring eighteen by twenty-four inches. Five four-inch holes were cut in the board in the pattern of a "five spot" in a deck of cards. The first hole was in the upper left corner, the second in the lower right, the third in the upper right, the fourth in the lower left and the fifth in the center of the board. The board was placed on a table twenty-five and one-half inches from the floor and tilted at a slight angle against a three and one-half inch projection from the wall. The board was set six inches from the back edge of the table which was flush with the wall. A chair with its seat eighteen inches from the floor was placed with its back legs fifty-five inches from the target. Small cork balls three quarters of an inch in diameter were used in throwing.

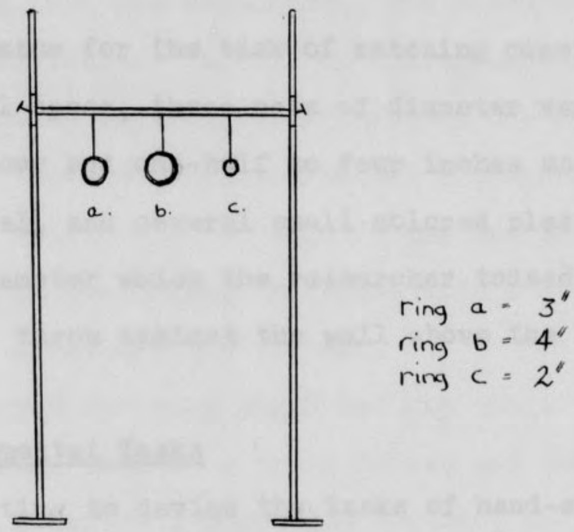

FIGURE 2

AIMING TASK

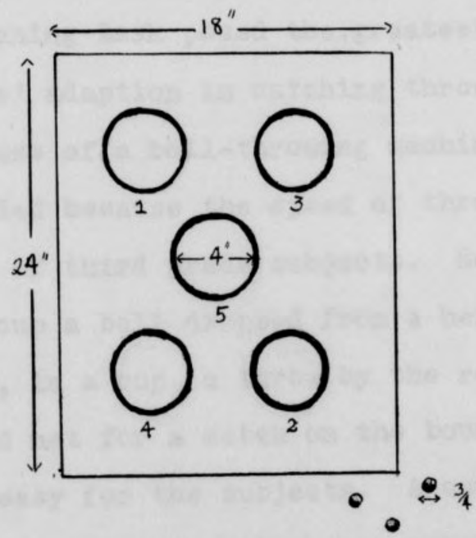

FIGURE 3

THROWING TASK

Catching Task

The apparatus for the task of catching consisted of clear smooth wall space, three nets of diameter varying from five inches to four and one-half to four inches used according to grade level, and several small colored plastic balls two inches in diameter which the researcher tossed with a gentle underhand throw against the wall above the head of the subject.

Pre-Study Experimental Tasks

In attempting to devise the tasks of hand-eye coordination, the researcher conducted several informal pilot studies to determine general effectiveness of the tasks in measuring hand-eye coordination and attaining a workable distribution of scores at each grade level.

The catching task posed the greatest problem because of the subjects' adaption in catching thrown or rebounding objects. The use of a ball-throwing machine was considered, but was discarded because the speed of throw was too great for the safety of third grade subjects. Several other tasks, catching in a cup a ball dropped from a height, a throw to self and catch, in a cup, a throw by the researcher to a wall or rebound net for a catch on the bounce were all discarded as too easy for the subjects. A catch using a net and a small ball rebounding from the researcher's throw at a wall above the subject's head was finally selected.

A striking task was considered, but discarded as having too many variables. A task of aiming was devised after experimentation with different heights and sizes of targets. A dart throw was considered and discarded in favor of an instrument which could be held in the subject's hand for the duration of the trial. A thrust with a probe through rings of several diameters was devised.

The throw for accuracy which had the subject seated and throwing a small ball at a small target was selected after discarding a softball throw for accuracy as involving too gross body movement for the purposes of the researcher.

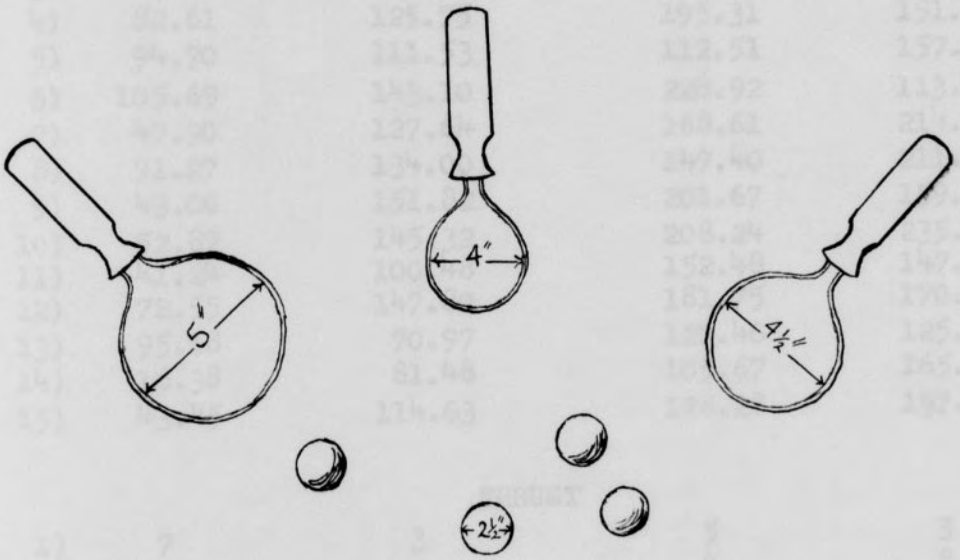

FIGURE 4

CATCHING TASK

RAW SCORES

	Third Grade	Sixth Grade	Ninth Grade	College
		PURSUIT ROTOR		
1)	86.57	83.46	169.42	152.77
2)	16.94	122.27	178.24	141.48
3)	43.05	116.82	220.28	184.54
4)	82.61	125.75	195.31	151.86
5)	94.70	111.53	112.51	157.02
6)	105.69	143.10	228.92	113.62
7)	47.90	127.64	168.61	214.04
8)	91.27	134.00	147.40	211.36
9)	43.06	151.82	201.67	159.07
10)	52.87	145.32	208.24	235.79
11)	41.24	100.48	152.48	147.47
12)	72.55	147.80	181.75	170.89
13)	95.18	70.97	120.46	125.31
14)	16.38	81.48	105.67	165.35
15)	43.45	114.63	178.28	197.55
		THRUST		
1)	7	3	5	3
2)	10	7	8	8
3)	8	4	2	8
4)	15	7	7	6
5)	4	6	3	4
6)	12	7	11	4
7)	8	5	7	5
8)	6	4	13	2
9)	2	3	6	2
10)	7	5	10	10
11)	5	8	9	6
12)	1	6	6	0
13)	4	4	6	5
14)	4	2	1	7
15)	6	2	7	13

RAW SCORES (continued)

	Third Grade	Sixth Grade	Ninth Grade	College
		THROW		
1)	0	3	3	9
2)	1	4	6	3
3)	4	3	4	5
4)	1	5	6	4
5)	5	2	3	1
6)	3	6	8	7
7)	2	11	4	6
8)	5	5	3	8
9)	3	3	11	4
10)	0	5	5	6
11)	1	4	8	8
12)	1	3	5	6
13)	4	3	3	6
14)	4	6	2	6
15)	3	2	8	4
		CATCH		
1)	5	14	14	7
2)	10	12	13	5
3)	4	8	14	8
4)	10	15	8	8
5)	12	10	10	10
6)	9	15	11	11
7)	8	13	6	12
8)	11	8	10	11
9)	8	4	13	7
10)	7	8	11	9
11)	13	13	13	4
12)	8	14	13	7
13)	12	10	11	12
14)	4	12	5	11
15)	7	7	9	7

NAME GRADE AGE

	1 x	2	3 x	4	5 x	6	7	Total
P-R 60 sec								

	A 1	2	3	B 1	2	3	C 1	2	3	
Thrust 18 ft.										

	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Throw 15 ft.																

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Catch 15 ft.																

FIGURE 5

SAMPLE SCORECARD