AN ABSTRACT OF THE THESIS OF

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Title: THE RELATIONSHIP BETWEEN KINDERGARTEN EXPERIENCE AND FINE-MUSCLE EYE-HAND COORDINATION ABILITIES OF FIRST GRADE CHILDREN

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The purpose of this study was to investigate the relationship between kindergarten experience and fine-muscle eye-hand coordination abilities of first grade children.

The subjects were 181 first graders in the public schools of Albany, Corvallis, and Salem, Oregon. The mean age of the sample was 76.69 months with a standard deviation of 3.75 months. The kindergarten group attended schools in Corvallis, Oregon, and numbered 92. The non-kindergarten group attended schools in Albany and Salem, Oregon. They numbered 89.

Socio-economic status was determined by the Hollingshead Two-Factor Index of Social Position. Ninety percent of the sample were classified as lower middle class (Class IV), with the other ten percent in the lower limits of the middle class (Class III).

Fine-muscle eye-hand coordination was considered in its

broadest sense and was measured by The Moore Eye-Hand Coordination Test, a speed and accuracy test using marbles; and The Frostig Developmental Test of Visual Perception, Test I, Eye-Motor Coordination, a measure of eye-hand coordination involving drawing.

The Full-Range Picture Vocabulary Test was used to measure mental age, and The Metropolitan Readiness Test was used to estimate school readiness. All tests were administered during the months of September and October.

Two null hypotheses were tested: Hypothesis I: Comparison of scores for the kindergarten and non-kindergarten groups will yield no significant differences in fine-muscle eye-hand coordination abilities; Hypothesis II: Prediction of school readiness will not be improved by the addition of the coefficients of the selected variables used in this study: experience, sex, age, handedness, height, weight, glasses, mental age, and the fine-muscle eye-hand coordination measures.

Results of the t-tests applied to the first hypothesis indicated that there were significant differences beyond the .025 level in favor of females and those children who had had kindergarten experience when measured by the Moore Eye-Hand Coordination Test. A significant t-value beyond the .01 level was found in favor of the kindergarten group when measured by the Frostig Test.

It was concluded that kindergarten experience did improve fine-muscle eye-hand coordination, thus the null hypothesis was rejected.

Hypothesis II was tested by the stepwise multiple linear regression analysis program. Four variables; experience, mental age, Frostig Test, and the Moore Test generated significant F-values. These variables were the only variables that contributed to R^2.

An analysis of variance on the four variables which were included in the final regression model had an F-value of 42.23. Since this exceeds the F-distribution by 12 times, the fitted equation can be rated a satisfactory prediction tool. The model was tested for linearity, allowing the rejection of the assumption that a linear relationship between the $\underline{y}$ and $\underline{x}$'s might not exist.

A coefficient of determination value of .49 was considered adequate in light of the tests performed. Consequently the null hypothesis was rejected, and it was concluded that we may predict school readiness with some confidence.

The Relationship Between Kindergarten Experience and Fine-Muscle Eye-Hand Coordination Abilities of First Grade Children

by

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THE RELATIONSHIP BETWEEN KINDERGARTEN EXPERIENCE AND FINE-MUSCLE EYE-HAND COORDINATION ABILITIES OF FIRST GRADE CHILDREN

INTRODUCTION

In recent years, and particularly since the advent of Project Head Start, 1965, the attention given to Early Childhood Education seems to have increased significantly. The Educational Policies Commission (1966) felt originally that all children should receive pre-school training, but subsequently modified its position by saying that only those children coming from disadvantaged families should be included. The reasoning behind the revised statement appears to assume that all children will have access to educational experiences (namely kindergarten) prior to entering first grade.

Deutsch (1964b) postulates that a child from any circumstance, who has been deprived of a substantial portion of the variety of stimuli to which he is maturationally capable of responding, is likely to be deficient in the equipment required for school learning.

To carry the concept of pre-school experience further, Deutsch emphasizes the need for a compensatory program for children, starting at three or four years of age. Such a program might serve to minimize the effect of the lack of continuity between the home and school environment: this will, in turn, enhance the child's functional adjustment to school requirements. In a similar vein, Hunt (1964) suggests the need to govern the encounters children have with the environment, in order to help children practice and develop their maturing abilities. Hunt's view is that early experience with perceptual and intellectual functions is of basic importance since stunted intellectual growth seems so difficult to reverse.

The difficulty of reversal may be substantiated in part by the findings of Bloom (1964) in analyzing the data found in longitudinal studies. In part, Bloom reports that fifty percent of a child's educational achievement is complete by the age of nine, or approximately the third grade. Certainly the early educational experiences coupled with environment are powerful and effective sources of development.

The need for kindergarten or other preschool experiences has been well-substantiated. In light of the stated needs, a major concern of any program is the curriculum to be offered. Theories of early childhood education advocate varied approaches to curriculum structure.

Robison and Spodek (1965) state that in the kindergarten, the learning of key concepts could become the intellectual goals of the grade, supplementing physical, social, and emotional goals. Without teaching reading and without formal instruction, the teacher will encourage and stimulate the child's interests and efforts, thus helping the child to perceive and conceptualize more clearly.

The theory that young-child education appears to follow in more or less definite patterns in relationship to curriculum building is based upon a compatible relationship between the socialization theory, developmental theory, and instructional theory. Davis (1963) believes that today's kindergartens have added a fourth theory, the multifused, which is a modification of one or more of the former.

Regardless of the theoretical approach that is supported in respect to curriculum, various developmental aspects are emphasized. One which is given considerable emphasis is motor development (Read, 1966; Headley, 1965; Gardner, 1964; and Davis, 1963).

Dinkmeyer (1965) relates that the developmental theorists believe that growth and learning are two phases of the same process of change. The process is so complex that no satisfactory distinction can be made between the two. Learning implies modification, and the individual is constantly changing. The task of the school is to facilitate change.

Changes in motor skill ability are enhanced by providing educationally sound materials which provide opportunities for the development of fine and gross motor skills.

Brenner (1958) states that early in life (2 to 5) the child's world and behavior undergo a marked change. Up to that age, sensorimotor experiences, tactile, visual, auditory perceptions, feelings, imagining, and thinking are one undifferentiated act or experience. Eventually a gradual breakdown begins; the fused oneness opens up and a singling out of components takes shape. Motor activities, sensations, perceptions, emotions and insight become distinguishable behaviors.

Fine-muscle eye-hand coordination studies have received little emphasis in recent years. Attempts have been made to correlate fine-muscle eye-hand coordination to readiness (Williams, 1952), school adjustment (Radler and Kephart, 1964) and reading prediction (Keogh, 1964). Keogh's study involved many aspects of the perceptual-motor realm, consequently fine-muscle eye-hand coordination skills received little emphasis.

Lillie (1966) felt the investigation of gross motor and fine-motor proficiencies as separate entities appear to have more value for diagnostic remediation of motor deficiencies than the investigation of total motor proficiency.

Bakwin and Bakwin (1960) found that a considerable proportion of children with reading disabilities were abnormally clumsy. Their movements were jerky, uncoordinated, and bungling.

Kephart (1960) highlights the importance of eye-hand coordination in preparing children for more complicated tasks required in the school learning environment. Kephart indicates that many of the children who present learning problems in elementary classrooms appear to suffer from some of the basic difficulties of eye-hand coordination, laterality, and directionality. Since many of the complex activities which are presented to these children involve these basic skills, the child continues to meet failure and frustration.

Gardner (1964, p. 121) states:

> People who think seriously about children have tended, unfortunately, to separate the child's mind from his body and have thought of these as somewhat independent aspects of the child. The physical body and its development have been regarded, too often, as a subject for discussion quite apart from such mental attributes as thinking, feeling, perceiving, and valuing. Today's child-development specialists are aware of the complex interrelations of physical development with the so-called mental aspects of the total child.

Dinkmeyer (1965) finds that an awareness of the significance of the individual rate of development leads to a better idea of the appropriate time to introduce educational tasks. The task of the school is to facilitate change. It appears that kindergarten is an experience that helps enhance or modify this change in a developing child. The emphasis on this study was dictated by the need to investigate the actual role of kindergarten and its influence on fine-muscle eye-hand coordination abilities in regard to predicting the child's readiness for the introduction of educational tasks. Edwards (1966) found that scores on fine and gross motor coordination measures seem to provide distinctive information about development that is not included in measures of intelligence and conceptual abilities.

Definitions of Terms Used

In order that terms used frequently throughout this study may be properly understood, definitions of each term as used in this study follow:

Fine-muscle--the movements of the body's segments through space with emphasis on hand-finger manipulation, while the body's center of gravity remains fixed, and the larger muscles of the body act as stabilizers.

Eye-hand coordination--the ability to use the eyes and hands together in such activities as fixating, grasping, and manipulating objects.

Kindergarten--an educational section of a school system, devoted to the education of four to six year olds, with emphasis on providing the necessary environment, materials, curriculum, and programs to aid child growth and development.

The Purpose of the Study

The purpose of this study was to investigate the relationship between kindergarten experience and fine-muscle eye-hand coordination abilities of first grade children. Two groups of children were evaluated: children having had kindergarten, and those who had not. Fine-muscle eye-hand coordination was viewed in a broad sense and measured by:

1) The Moore Eye-Hand Coordination Test--a speed and accuracy test.

2) Developmental Test of Visual Perception--Test I,

Eye-Motor Coordination--a measure of eye-hand coordination involving drawing.

Hypotheses and Analysis

The study was designed to compare the two groups on an *ex post facto* basis. Thus, the kindergarten group became the experimental group and the non-kindergarten group was termed control. In comparing the experimental and control groups, the following specific hypothesis was tested:

Hypothesis I. Comparison of scores for the kindergarten and non-kindergarten groups will yield no significant differences in fine-muscle eye-hand coordination abilities.

The analysis of this hypothesis is focused on a comparison of the mean scores (t-test) between sex, experience, and sex versus experience.

The predictive value of fine-muscle eye-hand coordination scores as related to school readiness leads to the following hypothesis:

Hypothesis II. Prediction of school readiness will not be improved by the addition of the coefficients of the selected variables used in this study: experience, sex, age, handedness, height, weight, glasses, mental age, and the fine-muscle eye-hand coordination measures.

Prediction of readiness will be determined by the stepwise multiple linear regression analysis.

Basic Assumptions

1) The Moore Eye-Hand Coordination Test is a valid measure of speed and accuracy.

2) The Developmental Test of Visual Perception--Test I, Eye-Motor Coordination is a valid measure of eye-hand coordination involving drawing.

3) Girls will perform the Moore Test faster than boys (Moore, 1969 and 1947; Williams, 1952).

4) All variables except sex, handedness, and glasses are considered linear for the ages of the children in this study.

REVIEW OF LITERATURE

The review is organized into two major areas and their related sub-topics. Kindergarten's purposes and achievements are discussed initially. Subsequently, fine-muscle eye-hand coordination is discussed with its related areas of physiological considerations, related motor ability studies, socio-economic status, motor training, and sex differences.

Kindergarten

Purposes

Anne Hoppock (1959) discusses six areas which may be the basis for the kindergarten program. They include: to aid children in feeling adequate in the new world of the school; to aid children in learning to understand and live intelligently in their world; to facilitate sturdy growth through provision of space, freedom, and needed equipment; to protect children from hazards to health and safety; to aid children in finding a comfortable and contributing place in his group; and to aid children in learning to manage themselves, their materials, the routines of the day, to take initiative in planning and doing things.

According to Gans, Stendler, and Almy (1952), the major purpose of education at the kindergarten and primary level is to meet the interests and needs of the pupil. Lambert (1958) considers that the kindergarten is progressive to the extent that it applies the findings of modern biological and psychological science to the education of children so that they can more effectively develop their potentialities as individuals and as responsible members of our society.

The primary purposes of kindergarten emphasized so far look favorably upon the social, emotional, physical, and intellectual aspects of the experience. The obvious is to ask if the kindergarten experience achieves these goals.

Careful examination of research dealing with the benefits of kindergarten, shows that in this question, as in so many dealing with the humanities, general statements and judgments are made on empirical data and observations. Adequate controlled studies have not yet been performed to solve the problem. A further note of caution is delivered by Anderson (1947). Evaluation of the nursery school and kindergarten experience cannot be made except in terms of how the child as a learning, growing, developing organism, utilizes and benefits from the experiences provided.

Achievements

Benefits of kindergarten in relation to success in school have long been under consideration by researchers. Goetch (1926) found the grade means of reading scores higher for those children who had attended kindergarten than those who had not. Lee, Clark, and Lee (1934) found the scores achieved on the Lee-Clark Readiness Test by children with kindergarten experience was a better predictor of a child's ability to learn to read than those children who lacked the kindergarten experience. Lee's major conclusion is that a background of common experience is an asset to a formal reading situation.

Almy (1949) supported the work of kindergarten by stating a significant positive relationship exists between children's beginning success in reading and their earlier response to all sorts of reading stimuli. Almy makes no case for any formal reading program, but stresses the importance of exposure to the awareness of the function of printed words in everyday life.

Fast (1957) in a carefully controlled experiment with 180 children of kindergarten age discovered that the kindergarten-trained children achieved significantly higher in grade one when evaluated by tests of silent reading, paragraph reading, and learning capacity than similar children who did not attend kindergarten. Socio-economic home backgrounds were carefully controlled in this research but significant reading achievement differences were still found in favor of kindergarten-trained children.

Research by Fox and Powell (1964) was based on the administration of the Lee-Clark Readiness Test to two groups of first graders; those with kindergarten experience numbered 179 and those without kindergarten experience totaled 115. The hypothesis that kindergarten experience enhanced school readiness could not be supported. A second hypothesis in this study posed the question that kindergarten experiences stimulate intellectual curiosity. The California Achievement Test was given to the same children and again the hypothesis could not be supported.

Research studies by Fuller (1961) suggest that kindergarten children surpass non-kindergarten children more in arithmetic reasoning than in the use of basic skills in numbers. Fast (1957) found that not only did kindergarten attendance facilitate performance in grade one, but evidence of this facilitation could be found as late as grade eleven. Evaluating the ratings of teachers, principals, and school psychologists, Hammond and Skipper (1962) found fifty-three percent of the children having high adjustment status had attended kindergarten. Twenty-five percent of those having had kindergarten had low adjustment.

From a review of 157 research studies Fuller (1960) concludes that a full appraisal of the contribution of pre-primary education was impossible. But the findings offer some evidence that pre-primary education has a favorable influence on personality, and provides an opportunity for acquiring skills needed for intelligent behavior.

Deutsch (1964a) states that children who have had a preschool and kindergarten experience are more likely to cope appropriately with the kinds of things the school demands intellectually than are children who have not had this experience.

The majority of writers have found that kindergarten seems to provide experiences that enable children to adapt and perform better in formal learning situations. It is not the concern of this review of literature to evaluate various programs, but to state that benefits are derived from the experience.

Fine-Muscle Eye-Hand Coordination

Controversy has existed over what particular abilities have been involved in delineating fine-muscle eye-hand coordination. The most practical method of determining the necessary abilities is through factor analysis of various gross physical and fine manipulative tests.

To better understand the broad definitions of gross and fine motor tasks, Cratty (1962, p. 213) makes the following distinctions:

> Gross motor task. . a gross motor task is defined as one which involves movement of the entire body through space, through large muscle activity. The body's center of gravity changes position through locomotion. It may be accompanied by fine adjustment of the head and/or the extremities.
>
> Fine motor task. . a fine motor task involves movements of the body's segments through space, while the body's center of gravity remains fixed. A fine motor task may involve arm and leg movement, exclusive of, or accompanied by hand-finger manipulation. The larger muscles of the body generally act as stabilizers during the performance of such a task.

Hempel and Fleishman (1955) analyzed the intercorrelations of the interdependence of abilities contributing to individual differences. Using Thurstone's centroid factor analysis, loadings of .30 or greater were considered significant.

Fifteen factors were determined, ranging from gross body coordination to finger dexterity. Summarizing their results and conclusions, it was found that:

a. abilities contributing to performance on gross physical tasks are quite independent of those contributing to fine manipulative skill.

b. the nine factors identified dealing specifically with physical performance fit into five general categories: strength, flexibility, balance, gross body coordination, and energy mobilization.

c. four factors were identified in dealing with the manipulative category, including; manual dexterity, finger dexterity, arm-hand steadiness, and aiming.

Guilford (1958) also factor analyzed existing motor proficiency tests. The basic motor factors identified by Guilford were fine and gross. The fine motor factor includes finger speed, arm steadiness, arm and hand precision, and hand-finger dexterity. Included in the gross skills are static balance, dynamic precision, gross body coordination, and flexibility.

Jones and Seashore (1944) relate to the general characteristics of tests. Reference is made to manipulative speed, and its measurement by simple motor tests involving rapid and repetitive action, as in placing pegs in a pegboard. Jones and Seashore feel that these tests are so specialized that skill with fingers does not correlate well with the use of tweezers on the same type test.

The basic consideration here is that we are involved with two completely different functions of the fingers, with differing muscles being used. To help clarify the differences as to the type of tasks, the factorial studies help in designating what manipulative skills are involved.

Finally, Ayres (1963) notes that perceptual-motor is the accepted term to use for eye-hand coordination.

Physiological Considerations

All vertebrates possess manipulative ability. Man has certain advantages in that he has an upright posture, a larger thumb, increased flexibility, and control over individual digits, which allows for considerable manipulative ability. Coghill (1929) was first to point out the trend from generalized to specific activity. Mass actions are succeeded by increased differentiation and subsequent integration of movement. Development also tends to progress in cephalo-caudal and proximo-distal directions. Hurlock (1960) refers to this as the "law of developmental direction." The occurrence of this development is orderly and predictable.

McCandless (1961) deals with the developmental patterns more specifically:

cephalocaudal principle. . growth and motor development proceed, in general, from the head to the tail end of the human organism.

proximodistal principle. . growth and motor development proceed from the axis of the body outward to the periphery.

general to the specific action patterns, and from general gross to specific refined control. . this aspect appears to be conjecture and arguments exist as to whether the development proceeds from specific to general or general to specific. McCandless concludes that the most obvious or conspicuous development is from the general to the specific, but development in the other direction does occur. A complimentary relationship exists between the two.

motor chaining. . motor chaining is efficient motor activity brought about by practice. Inappropriate muscle sequences drop out, and those that remain become smoother and more effective in accomplishing their purposes.

During the early months most children are ambidextrous. Sixty-five percent of American children at one year of age are right-handed; at two years, 87 percent; and six years, 95 percent (Beery, 1967). Mussen, Konger, and Kagan, (1963) found girls to show improvement in coordination and motor accuracy until age 14, with boys improving until age 17. Boys usually surpass girls in motor ability.

Most of the learnings of the child during the first three years are motor in character with the child giving major attention to locomotor and prehensive skills (Rarick, 1961). This may be integrated with Piaget's (1952) theory of the sensory-motor basis for intelligence. The child first interacts with the world on a sensory-motor foundation, usually restricted to the physical manipulation of objects that he sees. Following this stage, according to Piaget, the child begins to perceive structures, or relationships among objects. In the final stage the child conceptualizes the structure of objects.

Deach (1950) found that motor control passes from gross movements to fine coordinations and from total body action to individuation of parts. The patterns of performance increase in complexity with increased maturity. This finding reaffirms Halverson's (1931) work which analyzed motion pictures of infants reaching for and grasping cubes. Halverson differentiated ten stages. These range from a primitive squeeze without taking hold firmly at 20 weeks, to the final stage where the development of prehension, thumb and forefinger function together, which is very similar to the grasping ability of an adult.

Patterns of performance become more complex with increased maturity. Difficulty is encountered by trying to assign them specific age levels. Children normally pass through each stage of the developmental sequence in the same order although they need not necessarily reach these stages at the same chronological age, nor do they remain in the same phase for equal periods of time. To help clarify this, Rarick (1961) distinguishes between motor and skill learnings. Motor learnings represent but one phase of development, but it necessitates the utilization of great time and energy on the part of the child. Skill implies an approach to perfection of movement in which waste motion is reduced to a minimum. These movements occur with ease and efficiency, minimizing the possibilities of strain or damage to the muscles and joint structures. The latter certainly would be more characteristic of movements which would tend to be termed gross.

The role of motor development has been found to relate to the ability to communicate. Edwards (1966) finds that during the early years, the young child learns to communicate his needs by using his body. This growth is a continual process of organization. Even in adulthood, thinking processes are not without motor accompaniments. As the central nervous system mediates all organized behavior, it could be expected that variations in levels of functioning would be more clearly revealed as tasks demand increasing coordinative and integrative abilities.

Kephart (1960) has been a leader in developing a diagnostic-treatment program for slow learners based upon the idea that reading, writing, and arithmetic skills depend first upon the orderly development of motor patterns. He emphasizes the difference between the term "movement" and "motor." Movement is an observable response, while motor is an internalized event related to the motor "output" system. Motor activity is inherent and constant while movement patterns such as walking, sliding, and skiing are not.

Edwards (1966) found there to be a highly significant (.001) positive relationship between neonatal scores (one minute and five minute Apgar scores) and four year measures. The magnitude of the correlation between physiological condition at birth and later development was higher in connection with fine and gross motor coordination than in connection with intelligence and conceptual abilities. Birth weight was not significantly related to the four year measures. The data analyzed by Edwards certainly must take into consideration environmental factors which could preclude many of the results generated by the research.

Deach (1950) limited her results on the basis that the development of motor skills at the levels included in her study (two-six years) are probably influenced by all-around educational opportunities such as home-play, amount of equipment available, educational status of parents, and preschool experience.

The importance of Edward's study is that the variables of the Apgar scale - birth weight, heart rate, respiration effort, muscle tone, reflex irritability, and color - all contain important predictive indices of later development. But muscle tone may serve as the most direct measure of central nervous functioning. The question then arises, what is the real role of various environmental effects upon fine-muscle eye-hand coordination development, particularly in light of the significant correlations. The sample used in the Edwards study came from lower socio-economic statuses, consequently environmental factors would appear to be less than desirable. The real importance of Edward's work is that it sheds new light on the physiological aspects of development concerning motor abilities. It would appear to conflict and negate the importance of the early work done by Meredith (1943), Simmons and Wingate (1938), and Bakwin, Bakwin, and Milgram (1934), who concerned themselves with height and weight aspects in relationship to various elements of development.

Specifically, the cerebellum seems to coordinate the actions of the various muscles involved in a specific act. Conel (1939, 1941) suggests that the motor cortex may be first to develop and that cortical development continues in the cephalocaudal direction well into the teen-age years. If this is correlated with the Edwards findings, then the physiological aspects of development are far more influential in the development of eye-hand coordination than environment.

Finally, Kephart (1960) observes that eye-hand coordination involves control over the initiation of the action. It involves aiming or sighting behavior and guiding a motor movement toward the sighted goal. Simply, a single visual control over a motor activity. The child establishes perceptual control first and performs the motor movement second. Thus the total body must always be considered in a voluntary movement. Body image, posturing, and awareness of laterality and direction all have significant effects upon hand movement.

Related Motor Ability Studies

The major portion of the studies investigating motor abilities have been comparative studies with school achievement. On this specific point the literature seems contradictory. Early studies by Gates and Bond (1936), Kendall (1948), and Potter (1949) do not support the relationship. Recently however, studies by Frostig, et al. (1964), Barrett (1965), and Gill, Herdtner, and Lough (1968) favor the relationship.

Bateman (1966) reports five to fifteen percent of the school population has serious difficulty in reading, two to ten percent as having speech problems, and twenty to thirty percent as having less than adequate motor development. Since the motor development lag seems to be the most prominent, it would be reasonable to assume that a relationship could exist between it and other learning difficulties.

Cohen (1966, 1966-67) utilized 155 low achieving first graders, 97 boys and 58 girls, who were matched for sex, intelligence, chronological age, and socio-economic status. The groups were divided, with the experimental group receiving ten consecutive weeks of exercises, activities, and worksheets suggested by the Frostig Program for the Development of Visual Perception (1964). The control group was exposed to conventional classroom seatwork. The major findings of Cohen's study include;

a) The data did not support the major hypothesis of a significant correlation between improvement in visual perception and reading achievement.

b) Perceptual training appeared to decrease the handicap of visual deficits in visual perception and reading.

c) Significant relationships were found between motor development and intelligence; motor development and visual perception; and between motor development and reading achievement for the total sample.

Durrell (1956) indicates the only motor abilities that have a demonstrated relationship to learning to read are the writing and copying of letters. Some reading systems emphasize the need for writing prior to reading. This is generally referred to as the kinesthetic method, where tracing of letter forms is utilized to aid in word analysis. Durrell continues by pointing out that the development of motor abilities is of high importance in education and will be given a higher place in the elementary curriculum, but it does not appear to be important for success in beginning reading.

de Hirsch (1957), in referring to research in the last ten years, finds it reveals a close relationship between perceptual and motor functioning. The very young child normally has difficulty in breaking up the totality of a pattern; his perceptual organization is somewhat diffuse; single parts are poorly differentiated. However, understanding of the essential relationship is a necessity in reading. de Hirsch continues, we usually direct our attention first to those who have trouble with integration. Movement, like perception, requires patterning. A certain level of motor skills is not only essential for learning to write and print, but it is also indicative of the child's over-all maturity.

In a 1966 study, de Hirsch, Jansky, and Langford used 53 kindergarteners in a short longitudinal study concerned with the prediction of reading failure. All subjects were tested in kindergarten and again at the end of the second grade. The specific results of those tests dealing with fine motor patterning show correlations of: Pencil use and overall reading Performance Index, .34; Pencil use and writing, .46; Pegboard Speed Index and writing .27; spelling, .23. Pencil use and writing was significant at the .01 level and the other correlations are significant at the .05 level. These results would tend to confirm Durrell's previous statement, in that the relationship between motor skills and reading seems to lie in the ability to write and to copy letters.

According to O'Donnell (1968) motor coordination along with a knowledge of letter forms and names, visual perception, ability to follow directions, and listening are all parts of a constellation of factors that relate to readiness for reading. Radler and Kephart (1960) have stressed that the developmental lag in eye-hand coordination may well lead to emotional, social, as well as perceptual difficulties, which may in turn lead to poor school adjustment and so affect reading ability.

Keogh (1963) found that visual motor maturity of kindergarten and third grade children, as measured by the Bender-Gestalt, was a better predictive measure for children who were potential good readers than for those children likely to be poor readers. In a study of motor characteristics of underachieving boys Keogh and Benson (1964) found that a substantial number of boys in the ten to twelve year age group had serious remedial needs in terms of motor performance.

The role of motor abilities in reading achievement appears to be quite confusing. Condensing the studies mentioned above, motor abilities do not appear to be independent, consequently their role in predicting achievement is questionable. Interaction between motor abilities and other variables would appear more conducive to predicting achievement.

Socio-Economic Status

Another important consideration in this study is the aspect of socio-economic status and its relationship to fine-muscle eye-hand coordination. Like achievement prediction, there appears to be some controversy as related by the research. Cohen (1967) concludes that perceptual development of culturally deprived children at the beginning grades is severely impaired. He suggests that Head Start programs or kindergartens should emphasize perceptual training. Gill, Herdtner, and Lough (1968) hypothesized that significant differences in perception exist among groups varying in socio-economic levels. The hypothesis was supported in every case except for the subtest that examined eye-motor coordination. In conclusion, Gill, Herdtner, and Lough state that at the first grade level, lower class children's perceptions are more poorly developed than those of middle class children. Few, if any, differences in perception, as investigated, can be attributed to race directly. Special directed experiences are clearly beneficial to perceptual development. Finally, considering the strong correlations among many of the perceptual tasks and reading and arithmetic (particularly for girls), one may better understand the disadvantage lower class children face in academic competition.

Knights and Moule (1968) conducted a detailed study utilizing the following instruments: Pencil Maze, a test of kinetic tremor;

Graduated Holes, a test of static tremor; and the Lafayette Pegboard, a test of fine manipulative speed and coordination. Comparison was made between two different socio-economic status groups as determined by the Hollingshead scale. The groups included Class II and Class IV. The major findings of the study were:

1. No definite class patterns appeared in the four significant scores. Lower class children tend to perform the tasks less carefully and more rapidly than the upper class children, but the differences were not significant because of the increased amount of errors by the Class IV children.

2. The magnitude of the correlations between intelligence and motor scores was generally under .30, thus indicating that intelligence is not highly related to the subjects' motor performance.

When mental age and motor test scores are compared for children ages one to fifteen months, Bayley (1965) found that the behaviors which are developing during the first fifteen months of life, whether they are motor skills or the early perceptual and adaptive forms of mental abilities, are for the most part unrelated to sex, race, birth order, geographical location, or parental ability. In some instances, Negro babies tend to be more advanced.

Motor Training

Major emphasis throughout the years has been given to motor training. In most instances, the training itself does not seem conducive to increased abilities, for possibly the maturational effects become an overwhelming variable. In a study by Hilgard (1932), two-year-old children were given training in climbing a ladder, buttoning abilities, and the use of scissors. The experimental group exceeded the control group at the end of twelve weeks in all tests. However, with one week's practice during the thirteenth week, the control group was able to approximate the scores achieved by the experimental group.

Like Hilgard, Hicks and Ralph (1931) found that children between the ages of twenty-four and forty months who were trained in threading the Porteus Diamond Maze did no better after seven weeks of training than an untrained group. The experimental and control groups began the experiment with a score of twenty-three points. The experimental group had two trials per week and the control group had none. At the end of the seven week period the average score for the experimental group was 31.8 and for the control group 32.1.

More recently, Lillie (1966) worked with three groups of culturally deprived kindergarten children. The experimental group received 65 diagnostic motor lessons. Control group one received the traditional kindergarten program, and control group two stayed home. Utilizing the pre-test post-test method, the following results were found:

a) Post-test results indicated all three groups made significant gains in the gross-motor items, but these gains were not statistically significant. It appears that running, jumping, balancing, and climbing opportunities available in the home and neighborhood are sufficient for developing gross motor skills.

b) The post-test results indicated that only the experimental and control group one made significant gains in fine-motor development, with the experimental group significantly (.05) better than the kindergarten contrast group.

In a study dealing with the effects of practice upon speed and accuracy in performing a simple eye-hand coordination task, Smith and Harrison (1962) found little significance to the concept of practice. The lack of any significant findings might lie in the fact that the subjects were 60 male college students with a mean age of twenty years. This would tend to confirm Mussen's, Conger's and Kagan's (1963) statement that coordination and accuracy in boys improve until the age of 17.

The research has pointed out that intervention and premature practice prior to the onset of readiness does not hasten the emergence of these skills. Training beyond a child's current state of developmental readiness can result in unstable and transitory gains. When motor skills are emphasized in programs which deal with perceptual and sensory abilities, their integration appears to be complimentary.

Frostig, Lefever, and Whittlesey (1961, 1963) investigated five areas of perceptual-motor function; eye-motor coordination, figure-ground perception, form constancy, position in space, and spatial relations. Frostig discovered that these areas could be disturbed independently in children. The hypothesis was supported by the low inter-correlations that were generated. She concluded that the five areas of visual perception develop relatively independently of each other. On the basis of this research, Frostig developed the Frostig Program for the Development of Visual Perception (1964) and the Frostig MGL Program (1969). Similar programs for the development of visual perception have been supported by the Winter Haven Lion's Club (1964).

The Dayton, Ohio Public Schools (Sloan, 1969) have instituted a program for developing sensory and motor skills in three, four, and five year old children. Emphasis is given to all motor skills, gross and fine. Initial research findings have indicated some improvement. The research is being done on a matched basis holding age, sex, and environment background constant.

Sex Differences

Specific studies dealing with sex differences in relationship to fine-muscle eye-hand coordination abilities are lacking. Sex differences have been ancillary considerations in studies by Gill, Herdtner, and Lough (1968), Frostig, Lefever, and Whittlesey (1963, 1961), and Williams (1952).

The question of sex differences appear to favor girls in speed prehension and boys in speed asynkinesia (Stachnik, 1964). The factor of speed in relationship to girls is substantiated by Moore (1969) and Sloan (1955).

Summary

Summarizing a review such as this has many inherent problems created by the varying subtopics being considered. All of the topics are relevant to the study, and the assessment of each is essential if the true role of the kindergarten and fine-muscle eye-hand abilities is to be considered.

There appears to be general agreement from most of the research cited that kindergarten is a beneficial experience. The values to children from kindergarten experiences have been the subject of a sizeable amount of research. The early emphasis on achievement only is now being supplemented by research concerned with development. Limitations in sampling and the inappropriateness of assessment techniques employed are still major flaws.

It appears that motor abilities are relatively specific and no general motor factor or ability has been determined. Correlations between fine and gross motor skills indicate very little relationship. This is also true in correlations generated between tests of fine-muscle abilities. It appears that physiological development plays a far greater role in determining fine-muscle abilities than do socio-economic background, sex, environment, or directed intervention.

There is general agreement among researchers that perceptual-motor ability and mental and reading skills are somehow related. There is disagreement, however, about the degree of the relationship between these variables. Fine-muscle skills seem to correlate even lower than other aspects of the perceptual-motor realm.

From the literature reviewed, it seems logical that more attention should be directed toward investigating the ability of fine-muscle eye-hand coordination to predict readiness for formal education, namely first grade. This seems particularly feasible in light of the unstable results of research that has concerned itself with the role of motor skills and achievement and mental abilities.

METHOD

Subjects

The data analyzed in this study were collected from 181 September enrolled first graders in selected public schools of Albany, Corvallis, and Salem, Oregon. These cities rank seventh, fourth, and third respectively in population in the state. Complete information regarding population figures of the cities and school districts is shown in Table 1.

Table 1. Summary of City and School Populations

City	Population	Average Daily Membership of School District
Albany	18,500	2,241
Corvallis	35,905	7,790[a]
Salem	63,300	22,229[a]

[a]Serves area outside city limits.

Selection of the schools included in this study was made by the local administration, based on the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957). According to this scale, the classes are as follows: class I is upper; II, upper middle; III, middle; IV, lower middle; and V, lower. The individual school principals deleted those children who had repeated the first grade, those who had gross physical disabilities, or those children whose socio-economic status would be higher than those utilized in the study. The mean age of the subjects in the sample was 76.69 months, with a standard deviation of 3.75 months.

All of the subjects were Caucasian, and according to the school health records were in good health. Final determination of the sample's socio-economic status was made by the Hollingshead Index. Ninety percent of the subjects were classified in social class IV, with the other ten percent in the lower limits of social class III. For the complete distribution see Table 2.

Table 2. Summary Distribution of Socio-Economic Status

	Kindergarten				Non-Kindergarten				
	M	%	F	%	M	%	F	%	
I	0	0	0	0	0	0	0	0	
II	0	0	0	0	0	0	0	0	
III	2	1	4	2	6	3	7	4	
IV	52	29	34	19	43	24	33	18	
V	0	0	0	0	0	0	0	0	
Totals	54		38		49		40		181
		30		21		27		22	100

A total enrollment of 193 children was made available to this investigator. However, 12 of the subjects were eliminated from the study for the following reasons: 1) it was determined that ten of the children had been retained in the first grade. This was not determined immediately because of incomplete records during the initial screening; 2) two of the children were eliminated because of their absence during the period of administration of the Metropolitan Readiness Test and the height and weight checks.

The remaining 181 children were then classified into groups on the basis of having attended Kindergarten (K) or not having attended Kindergarten (NK). The K group included a sample of 92; 54 males and 38 females. Their mean age was 76.82 months, with a standard deviation of 3.45 months. The NK group was comprised of 89 subjects; 49 males and 40 females. Their mean age was 76.56 months with a standard deviation of 4.06 months.

The children in the K group had all attended kindergarten for a full year in the public schools of Corvallis, Oregon. State support for kindergartens is not given in Oregon, so consequently Corvallis is one of the few school districts that provides this service. This is the major reason for utilizing this district in the study. The kindergarten experience could be considered conventional, with no special emphasis placed on motor skill development, as far as the investigator could determine. The children in the NK group came from public schools in Albany and Salem, Oregon.

For simplification, the K group was credited with ten months of experience. This was done after verification that all of the children had attended kindergarten for the full year. As far as the investigator could determine, this was the only experience these children had before entering the first grade. The NK group was also void of any type of pre-school experience.

Instruments

A total of four instruments was used in this study. Two of the instruments were used to determine the subject's eye-hand coordination. These instruments were the Moore Eye-Hand Coordination Test and the Marianne Frostig Developmental Test of Visual Perception, Test I, Eye-Motor Coordination.

The Full-Range Picture Vocabulary Test was administered to determine the subject's mental age based on verbal comprehension. The final instrument used was the Metropolitan Readiness Test, Form A.

The Moore Eye-Hand Coordination Test

The Moore Eye-Hand Coordination Test (EHCT), distributed by Joseph E. Moore and Associates, was used to provide an estimate of the subject's speed and accuracy when coordinated small muscle movements involving eye-hand activity are needed (Moore, 1949).

The test consists of a black box with eight compartments, four of them square marble containers and four rectangular compartments with holes for eight marbles each. Scores are determined by the elapsed time it takes the subject to perform the test three times. In this study, the primary form was used. This is based on just half of the test, consequently the subject's elapsed time was based on three trials involving sixteen marbles in each trial.

The total raw score is the number of seconds taken to complete the primary form three times. For purposes of this study, the raw score was utilized because of the norm design. The primary norms are only useful for children up to the age of 77 months. Since this study had subjects above and below this age, the investigator selected the primary form and interpreted the data on the basis of the raw score (seconds).

The advantages of the instrument are as follows: 1) the instrument has a high interest value, consequently it is a good rapport-establisher; 2) it is quick and easy to administer; 3) simplicity of scoring and interpretation is easily derived; 4) special training on the part of the investigator is not required; 5) scoring is completely objective, and is accomplished in a matter of seconds; 6) a brief manual accompanies the instrument giving directions for administering, scoring, reliability and validity.

The reliability of the primary form was obtained from 81 pre-school children utilizing the test-retest method with an interval of one week. According to the manual this correlation was .95.

Utilizing the test-retest method, a coefficient of .95 was found for 187 subjects (elementary, high school, college students, and adults) after an interval of one week.

Validity of the Moore Test is reported in the test manual. A total of 298 subjects, whose chronological ages ranged from 24 months to 71 months, showed a positive correlation of $.63 \pm .02$ between the children's speed scores and their mental ages as determined by the Stanford Revision of the Binet Test.

Moore (1969) has indicated the following correlations between the Moore and the Metropolitan Readiness Test; reading readiness .25, number readiness .39, and total readiness .36. The basis for these correlations was 133 first graders from high, middle, and low socio-economic statuses.

Eye-Motor Coordination Test

Test I, Eye-Motor Coordination (EMCT), was taken from the Developmental Test of Visual Perception developed by Marianne Frostig and published by Consulting Psychologists Press.

The Eye-Motor Coordination Test utilizes paper and pencil in testing eye-hand coordination involving the drawing of continuous straight, curved, and angled lines between boundaries of various widths, or from point to point without guide lines (Frostig, Lefever, and Whittlesey, 1966).

For purposes of this study, Consulting Psychologists, Inc. gave the investigator permission to reproduce the instrument. Consequently, the EMCT involved five pages. An individual test was made available for each subject. In addition, the investigator provided #2 primary pencils for the administration of the test. A #2 primary red pencil was used in item number nine. The same brand pencils (Venus Scribbler #324, and Classmate #83) were used for all subjects.

The administration of the instrument is somewhat more complicated than the previous instrument described in this study. Procedures and techniques were developed for the administration of the EMCT on 20 children during the summer, 1969.

The EMCT was administered to each subject following the directions in the manual explicitly (Frostig, Lefever, and Whittlesey, 1966). Scoring of the EMCT takes approximately five minutes. Scoring is done objectively, though careful adherence to the instructions is mandatory. For items ten through sixteen, plastic scoring stencils are provided.

The advantages of the instrument are as follows: 1) small children find it interesting and challenging; 2) no oral responses are required; 3) with careful preparation by the examiner it is easily administered and scored; 4) a thorough comprehensive set of manuals is available, which include scoring keys, instructions for administration, and information concerning standardization, validity, and reliability.

The raw scores earned may be converted to a perceptual age or scale scores $\left(\frac{\text{perceptual age}}{\text{chronological age}} \times 10\right)$. The raw scores earned by the sample were used in the interpretation of the data in this study. Standardization of the instrument was carried out in 1963 with a sample of over 2,100 unselected nursery and public school children between the ages of three and nine.

Since the EMCT assesses visuo-motor functioning, test-retest correlations may be expected to be low (Frostig, Lefever, and Whittlesey, 1966). The EMCT subtest is effected much more than the other subtests by the physical condition and emotional state of the child existing at the moment of testing, as well as by environmental influences (Frostig, et al., 1964).

Test-retest reliability coefficients for 50 children with learning difficulties was .98. The tests were given three weeks apart and this correlation is for the entire test.

In Spring, 1961, Frostig, et al. (1964) tested two groups, 70 first graders and 70 second graders, using alternate administrators. The product-moment correlation coefficient for the entire sample was .80. For the EMCT, test-retest correlations have been reported as .33 for 55 kindergarteners and .40 for 72 first graders.

The EMCT has been validated by its wide use and acceptance in numerous research studies. Specifically, teacher ratings of classroom adjustment, motor-coordination, and intellectual functioning was done on 374 kindergarten children. The correlations between these ratings and the Developmental Test of Visual Perception are as follows; classroom adjustment, .441; motor coordination, .502; and intellectual functioning, .497.

Further validity data presented were concerned with the Developmental Test of Visual Perception and the Goodenough Draw-a-Man Test.

	N	r
Kindergarteners	299	.460
First Graders	202	.318
Second Graders	214	.366

These correlations are somewhat low but indicate some overlap. Frostig et al. (1964) feels the low coefficients may also reflect the relatively low reliability of the Goodenough Intelligence Quotient of .77.

Full-Range Picture Vocabulary Test

The Full-Range Picture Vocabulary Test (FRPV) is distributed by Psychological Test Specialists. It is devised to measure verbal comprehension through recognition vocabulary (Blatt, 1959).

The FRPV consists of two forms, in which no reading or writing is required. The test includes sixteen cards on which appear four cartoon-like drawings. The testee is asked which one of the four drawings best represents the particular word given by the examiner. The testee responds by pointing to the picture of his choice.

Scoring is based on the response for each word. The total number correct is the sole determination of the score. A testing session ends when the testee fails to correctly answer three words consecutively.

The standardization of the FRPV was carried out on a population of 589 children and adults, with the following variables being controlled: age, sex, grade placement, and socio-economic status (Ammons and Huth, 1949; Ammons and Rachiele, 1950; Ammons and Manahan, 1950).

For purposes of this study, the raw scores for forms A and B were converted to mental age (years) after interpolation as provided by the test manual (Ammons, 1969).

The advantages of the FRPV include: 1) an excellent rapport-establisher, because of the cartoon-like drawings; 2) small children find it easy and interesting; 3) it is quickly administered and easily scored; 4) no oral responses are required; 5) extensive specialized preparation on the part of the examiner is not required; 6) the stated reliability and validity of the FRPV are well-documented in the manual.

Reliability for the FRPV, as reported in the manual, is relatively high. A correlation of .90 for 90 child reading cases was found when using forms A and B. Ninety Negro children were given forms A and B, and the resulting correlation was .96. All of the correlations reported in the manual ranged from .86 to .99, with a median of .93.

The validity of the FRPV with other measures of mental age is satisfactorily high. For 90 child reading cases, a correlation of .82 was found between the FRPV and the WISC. Ammons and Huth (1949) report the following correlations for Forms A and B: .67 and .69 with the Binet Vocabulary for 360 school children; .85 and .83 with the full Binet for 20 preschool children; and .96 with the Binet Vocabulary for 52 school children.

Kimbrell (1966) reports correlation between the FRPV, PPVT, and the Revised Stanford-Binet to be: FRPV and PPVT, .57; FRPV and Binet, .55. These correlations were based on a sample of 63 adolescent educable mental retardates.

Metropolitan Readiness Test (Form A)

The Metropolitan Readiness Test (MRT), published by Harcourt, Brace, and World, Inc. was developed to measure the extent to which skills and abilities have developed for readiness in the first grade. The test is composed of six subtests; word meaning, listening, matching, alphabet, numbers, and copying. The MRT was administered by the regular classroom teachers to the sample involved in this study. It is assumed by the investigator that the directions, scheduling, and materials were provided as required by the manual (Hildreth, Griffiths, and McGauvran, 1969).

The advantages of the MRT include; 1) a quick indication of readiness for each pupil to do first grade work; 2) identification of specific areas of weakness of readiness; 3) an objective and reliable means of initial grouping; 4) a thorough and comprehensive manual is available, that includes scoring keys, instructions for administration, and information concerning standardization, validity, and reliability.

Standardization of the MRT was done in 1964 using 15,000 first graders. From this standardization, the raw scores may be interpreted in any one of three ways; 1) percentiles, based on the total raw score of the test; 2) stanines, also based on the total score; 3) quartiles, which may be utilized in the interpretation of the subtest scores.

Construct validity for the MRT correlates quite highly; .80 with the Murphy-Durrell Reading Readiness Analysis; .70 for 294 first graders on the Lee-Clark Reading Readiness Test; and .67 with the Stanford-Binet for 277 first graders.

Predictive validity of the MRT is also available. This correlates the MRT score and later achievement, usually at the end of the first grade.

The Stanford Achievement Test: Primary I was administered in May to 9,497 first graders. The correlations with the MRT, based on the subtests, ranged from .57 to .67. An overall estimate of the prediction level is .60, a value considered good when realizing this is generally the first group test administered to first grade children.

Reliability of the MRT was established by administering the test to May-enrolled kindergarteners and again when these students were October-enrolled first graders. Involved in this study were seven different school districts. The coefficients ranged from .90 to .95.

Other reliability studies are referred to in the manual. The correlations noted range from .66 to .80. The period of time between tests was five months.

Procedure

Establishing Rapport With Subjects

In order to obtain reliable results, testing was not begun until the second week of school in September. Prior to testing at each school, the investigator visited each class, was introduced, and observed the classes for what was thought to be a reasonable period of time. It was felt that this observation would help establish better rapport for the testing situation, particularly in light of the sex of the investigator. No difficulty of any type was encountered during the collection of the data.

Administration of the Instruments

Administration of the instruments began during the second week of September and was completed in mid-October. All subjects were tested using the four instruments. The MRT was given by the classroom teachers. The order of administration was the same for all children: the FRPV, the EMT and the EHCT.

The participating school principals provided separate rooms for the administration of the instruments. At one Corvallis school, a far corner of the library was partitioned off, and the testing was done there. In all cases the space available was devoid of any extraneous noise or interference. Primary tables and chairs were utilized at all of the schools.

A composite eight page test booklet was used for each subject involved in the study. The test booklet contained a general information sheet, one section for the EHCT, two pages for the FRPV, and five pages for the EMCT. School cumulative and health records were used in filling out the general information sheet.

All tests were administered and scored by the investigator. Test administration took approximately 20 minutes per child. All three instruments were administered at one sitting. This procedure was determined to be feasible on the basis of the variety of the instruments and the experience of the summer sampling carried out by the investigator.

Limitations of the Investigation

A primary limitation of concern at this stage of the study is the male image of the investigator and its possible implications. Though careful procedures were taken to establish rapport with the subjects, performance by some of the individuals may have been affected during the testing sessions.

Finally, any instrument utilized to group individuals according to socio-economic levels is not infallible. Though the Hollingshead Two-Factor Index of Social Position is highly regarded, the constellation of variables involved in determining socio-economic levels may not be encompassed by determination of the head of the household's education and occupation. Since the family is the most important mediating agency for children of the age included in this study, individual differences in families within specific socio-economic levels must be considered.

ANALYSIS OF RESULTS

Findings of the Study

The purpose of this study was to investigate the relationship between kindergarten experience and the development of fine-muscle eye-hand coordination abilities of first graders. The first hypothesis of this study was tested by the t-test in regard to sex, experience, and sex versus experience.

The second hypothesis in this study was an attempt to predict school readiness from the variables: experience, sex, age, handedness, height, weight, glasses, mental age, and the fine-muscle eye-hand coordination measures. The stepwise multiple linear regression analysis technique was employed to aid in predicting one characteristic from the other characteristics.

To provide a more complete background of the sample, information regarding mental age and school readiness are presented in Tables 3 and 4. Table 9 in Appendix A gives further information concerning the sample's age, height, and weight.

Table 3 presents the summary of the t-test when applied to the pooled means in respect to the FRPV. None of the t-values are significant; therefore it may be concluded that the sample does not differ in their mental abilities when measuring verbal comprehension through recognition vocabulary.

Table 3. Summary of t-tests for the Comparison of Pooled Means for Sex, Experience, and Sex versus Experience, on the Full-Range Picture Vocabulary Test.

Source	Mean Values	Mean Values	t*
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Sex	$\bar{\bar{x}}_{1,2} = 7.16$	$\bar{\bar{x}}_{3,4} = 7.05$	.647
	$(\bar{x}_1 + \bar{x}_3)$	$(\bar{x}_2 + \bar{x}_4)$	
Experience	$\bar{\bar{x}}_{1,3} = 7.24$	$\bar{\bar{x}}_{2,4} = 6.97$	1.49
	$(\bar{x}_1 + \bar{x}_4)$	$(\bar{x}_2 + \bar{x}_3)$	
Sex X Experience	$\bar{\bar{x}}_{1,4} = 7.15$	$\bar{\bar{x}}_{2,3} = 7.06$	.534

*No t-values significant.

$\bar{x}_1$ = Male (K), n = 54, mean = 7.34
$\bar{x}_2$ = Male (NK), n = 49, mean = 6.98
$\bar{x}_3$ = Female (K), n = 38, mean = 7.13
$\bar{x}_4$ = Female (NK), n = 40, mean = 6.96
$\bar{\bar{x}}$ = Pooled Means

Table 4 presents the summary of the t-test when applied to the pooled means in respect to the MRT. One of the t-values associated with experience is significant beyond the .01 level. This would appear to indicate that the kindergarten experience relates to qualities which enhance readiness at the first-grade level.

Table 4. Summary of t-tests for the Comparison of Pooled Means for Sex, Experience, and Sex versus Experience, on the Metropolitan Readiness Test.

Source	Mean Values	Mean Values	t
Sex	$(\bar{x}_1 + \bar{x}_2)$ $\bar{\bar{x}}_{1,2} = 56.85$	$(\bar{x}_3 + \bar{x}_4)$ $\bar{\bar{x}}_{3,4} = 59.65$	1.19
Experience	$(\bar{x}_1 + \bar{x}_3)$ $\bar{\bar{x}}_{1,3} = 67.12$	$(\bar{x}_2 + \bar{x}_4)$ $\bar{\bar{x}}_{2,4} = 49.37$	7.52*
Sex X Experience	$(\bar{x}_1 + \bar{x}_4)$ $\bar{\bar{x}}_{1,4} = 58.55$	$(\bar{x}_2 + \bar{x}_3)$ $\bar{\bar{x}}_{2,3} = 57.94$	.258

*Significant at the .01 level.

$\bar{x}_1$ = Male (K), n = 54, mean = 66.02

$\bar{x}_2$ = Male (NK), n = 49, mean = 47.67

$\bar{x}_3$ = Female (K), n = 38, mean = 68.21

$\bar{x}_4$ = Female (NK), n = 40, mean = 51.08

$\bar{\bar{x}}$ = Pooled Mean

Tests of Hypotheses

Hypothesis I

Hypothesis I: Comparison of scores for the kindergarten and non-kindergarten groups will yield no significant differences in fine-muscle eye-hand coordination abilities.

Table 5 summarizes the t-values for the pooled means in regard to the EHCT. A significant t-value at the .01 level was found to be associated with sex. In light of the reviewed literature, this finding confirms the fact that girls perform speed prehension tasks more rapidly than boys. Whether the level of significance obtained in this study is higher than would normally be expected would only be conjecture on the part of the investigator.

Table 5. Summary of t-tests for the Comparison of Pooled Means for Sex, Experience, and Sex versus Experience, on the Moore Eye-Hand Coordination Test.[a]

Source	Mean Values	Mean Values	t
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Sex	$\bar{\bar{x}}_{1,2} = 78.35$	$\bar{\bar{x}}_{3,4} = 74.36$	2.85**
	$(\bar{x}_1 + \bar{x}_3)$	$(\bar{x}_2 + \bar{x}_4)$	
Experience	$\bar{\bar{x}}_{1,3} = 74.66$	$\bar{\bar{x}}_{2,4} = 78.05$	2.24*
	$(\bar{x}_1 + \bar{x}_4)$	$(\bar{x}_2 + \bar{x}_3)$	
Sex X Experience	$\bar{\bar{x}}_{1,4} = 75.68$	$\bar{\bar{x}}_{2,3} = 77.03$	.891

[a]Scores are based on elapsed time, lower means indicate better performance.

*Significant at the .025 level.
**Significant at the .01 level.

$\bar{x}_1$ = Male (K), n = 54, mean = 75.98
$\bar{x}_2$ = Male (NK), n = 49, mean = 80.71
$\bar{x}_3$ = Female (K), n = 38, mean = 73.34
$\bar{x}_4$ = Female (NK), n = 40, mean = 75.38
$\bar{\bar{x}}$ = Pooled Means

The main effect of kindergarten experience on fine-muscle eye-hand coordination was significant at the .025 level. This indicates that significant differences in fine-muscle eye-hand coordination, as measured by the EHCT, do favor the children who have experienced kindergarten. The specific areas of value in the kindergarten program which cause this difference are not determinable from this data.

Table 6 summarizes the t-values for the pooled means in regard to the EMCT. The only significant value generated by this test was for experience. The t-value is significant beyond the .001 level and favors those children who have had the benefit of kindergarten.

Unlike the EHCT, sex was not a differentiating factor on the EMCT. Table 6 also indicates that there is no significant interaction of sex and experience.

The results of the t-tests on the EHCT and EMCT allow us to reject the null hypothesis. A conclusion which may be drawn is that a significant difference exists between children's fine-muscle eye-hand coordination abilities when comparing groups of children at the first-grade level with and without the kindergarten experience.

Table 6. Summary of t-tests for the Comparison of Pooled Means for Sex, Experience, and Sex versus Experience, on the Frostig Subtest, Eye-Motor Coordination.

Source	Mean Values	Mean Values	t
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Sex	$\bar{\bar{x}}_{1,2} = 12.04$	$\bar{\bar{x}}_{3,4} = 12.36$	.335
	$(\bar{x}_1 + \bar{x}_3)$	$(\bar{x}_2 + \bar{x}_4)$	
Experience	$\bar{\bar{x}}_{1,3} = 13.56$	$\bar{\bar{x}}_{2,4} = 10.68$	6.02*
	$(\bar{x}_1 + \bar{x}_4)$	$(\bar{x}_2 + \bar{x}_3)$	
Sex X Experience	$\bar{\bar{x}}_{1,4} = 12.07$	$\bar{\bar{x}}_{2,3} = 12.14$	.062

*Significant at the .01 level.

$\bar{x}_1$ = Male (K), n = 54, mean = 13.46
$\bar{x}_2$ = Male (NK), n = 49, mean = 10.61
$\bar{x}_3$ = Female (K), n = 38, mean = 13.66
$\bar{x}_4$ = Female (NK), n = 40, mean = 10.75
$\bar{\bar{x}}$ = Pooled Means

Hypothesis II

> Hypothesis II: Prediction of school readiness will not be improved by addition of the coefficients of the selected variables used in this study: experience, sex, age, handedness, height, weight, glasses, mental age, and the fine-muscle eye-hand coordination measures.

The second hypothesis was tested by the stepwise multiple linear regression analysis. To provide a clearer understanding of this analysis a brief description of the program and its workings is included.

The stepwise program computes a sequence of multiple linear regression equations in a stepwise manner. At each step one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in the error sum of squares. Specifically, the stepwise program functions in the following manner; a) the stepwise procedure starts with the simple correlation matrix (Appendix B) and enters into regression the independent variable most highly correlated with the response (dependent variable); b) using the partial correlation coefficients as before, the next variable is selected to enter the regression.

As each variable enters, said variable has the highest partial correlation with the dependent variable partialed on the variables which have already been added. Equivalently, it is the variable which, if it were added, would have the highest F-value.

Variables can be forced into the regression equation and automatically removed when their F-values become too low. Regression equations with or without intercepts may be selected. The stepwise program is very similar to the Wherry-Doolittle Method (Garrett, 1966).

Using the following model:

$$Y_i = \beta_0 + \beta_1 E'_i + \beta_2 R_i + \beta_3 A_i + \beta_4 S_i + \beta_5 H'_i + \beta_6 H_i + \beta_7 W_i + \beta_8 G_i + \beta_9 M_i + \beta_{10} F_i + E_i$$

where Y_i is the performance of n^{th} individual, i^{th} experience, i^{th} FRPV, i^{th} age, i^{th} sex, i^{th} handedness, i^{th} height, i^{th} weight, i^{th} glasses, i^{th} EHCT, and i^{th} EMCT.

β_0 is the overall mean when X's are equal to zero.

β's are the regression coefficients which furnish measures of the linear relationship between the dependent variable, Y_i, and the independent variables, X's.

E' is experience where E' = 0, 1. (0 = NK 1 = K)

R is FRPV where R = 1, 2, . . . , 181.

A is age where A = 1, 2, . . . , 181.

S is sex where S = 1, 2. (1 = male 2 = female)

H is handedness where H = 1, 2. (1 = left 2 = right)

H' is height where H' = 1, 2, . . . , 181.

W is weight where W = 1, 2, . . . , 181.

G is glasses where G = 1, 2. (1 = yes 2 = no)

M is EHCT where M = 1, 2, . . . , 181.

F is EMCT where F = 1, 2, . . . , 181.

E_i is the error due to the failure of the model to completely specify the response.

Table 7 presents a summary of the order of variable entry, F-value, R^2, and t-values for the regression run utilizing the model described previously.

Table 7. Summary Table of the Stepwise Multiple Linear Regression Analysis.

Step No.	Variable Entered	d. f.	F-Level	R^2	t
1	EMCT	179	63.01	.26	3.78*
2	FRPV	178	29.33	.36	4.96*
3	Experience	177	27.96	.45	5.25*
4	EHCT	176	13.14	.49	3.21*
5	Glasses	175	1.59	.49	1.46
6	Sex	174	1.02	.50	.838
7	Age	173	.54	.50	.631
8	Handedness	172	.31	.50	.504
9	Height	171	.29	.50	.711
10	Weight	170	.22	.50	.470

*Significant beyond the .01 level.

At step four, the last significant F-value is generated by the stepwise program. It is also the step where R^2, the coefficient of determination no longer increases significantly. The equation $R^2 = .26 + .10 + .9 + .4$, indicates that 26 percent is the contribution of the EMCT, ten percent is contributed by the FRPV, nine percent by experience, and four percent by the EHCT.

The coefficient of determination is:

$$R^2 = \frac{\text{sums of squares due to regression}}{\text{total sums of squares}} \text{ or } \frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} .$$

It measures the proportion of the total variation about the mean $\bar{y}$ explained by the regression. Thus, the best regression equation for prediction is

$$y_i = b_0 + b_1 E'_i + b_2 R_i + b_9 M_i + b_{10} F_i + e_i$$

and will explain forty-nine percent of the total variation.

Table 8 shows the analysis of variance for the significance of the new regression model. From this analysis of variance we may assume that the model is plausible, one which has not been found inadequate by the data to this point.

Table 8. Summary of Analysis of Variance Applied to the Regression Model.

Source of Variation	SS	DF	MS	F
Regression on E', R, M, and F	28548.72	4	7137.18	42.23*
Error	29747.30	176	169.02	
Total	58296.02	180		

*Significant at the .01 level.

Draper and Smith (1966) make use of the "four times" rule as a current expedient for assessment of regression equations. The rule states that the observed F-ratio of regression means square/residual mean square or $\frac{MS(R|b_0)}{EMS}$ should not exceed merely the selected percentage point of the F-distribution, but about four times the selected percentage point. Thus, for our data, $F(4, 176, 0.99) = 3.32$.

The observed F-ratio for this analysis of variance is 42.23, which exceeds the F-distribution by 12.7 times. Thus the fitted equation can be rated a satisfactory prediction tool.

The significant F-value (Table 8) and the t-values shown in Table 7 for the independent variables E', R, M, F, permit the rejection that $b_1 = b_2 = b_9 = b_{10} = 0$, and the rejection of the assumption that a linear relationship between the y and x's might not exist, thus indicating that our beta values are operating in this model and they assume any actual value other than zero. Therefore our model is linear.

The new model takes on the following values for prediction:

$$\hat{y} = 36.77 + 11.70(E_1') + 4.15(R_2) - .379(M_9) + 1.23(F_{10}).$$

The summary table (Appendix C) for the actual, predicted, and residual values for the study's sample allow for the plotting of the residuals (e_i) against the predicted score ($\hat{y}_i$) as shown in Figure 1.

The horizontal band indicates no abnormality and the least squares analysis would not appear to be invalidated. To further verify the plotting of the residuals we may plot the average error mean square versus the number of independent variables in the first model to find the best estimation of σ^2 to be 168.5, thus $s = 41$.

We may assume (Draper and Smith, 1966) that $E_i \sim N(0, \sigma^2)$, so that $E_i/\sigma \sim N(0, 1)$. Examination of the overall plot (Figure 1) will

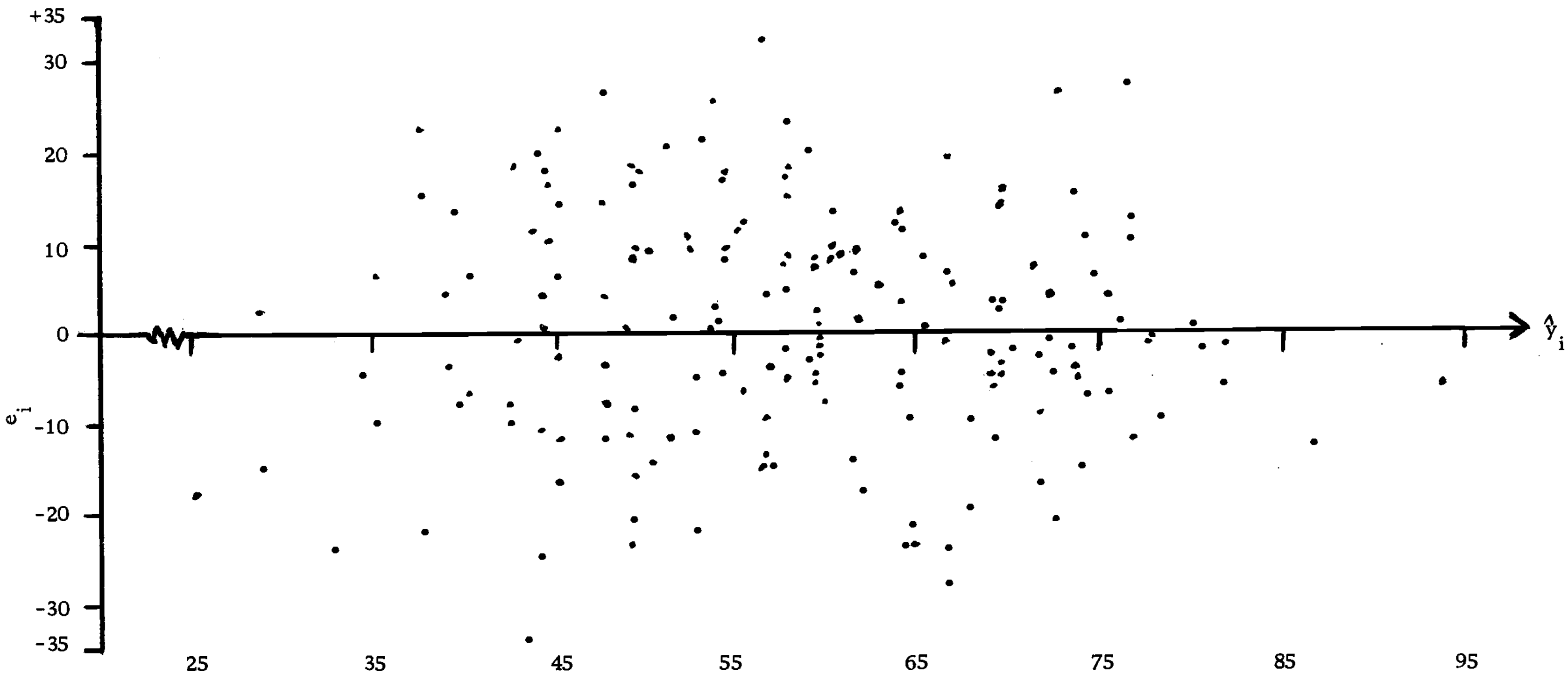

Figure 1. Plot of Residuals Against Predicted Values for the Final Model.

allow us to see if the assumption $E_i/\sigma \sim N(0,1)$ is wrong. At the 95 percent level, a normal distribution with mean equal to zero and variance equal to one lies between the limits -1.96 and 1.96. For this specific data $-1.96 < \frac{-34}{41} < +1.96$ and $-1.96 < \frac{+33}{41} < +1.96$ thus $\frac{\epsilon_i}{\sigma} \cong \frac{e_i}{s}$.

The horizontal band of residuals indicates that our error variance is the same everywhere, and that we did not miss any important variables, thus supporting the relative validity of the model.

The selected model appears to be the best for prediction considering the number of independent variables, the largest R^2, smallest mean square error, and significant F-level.

This discussion of the sample's data and the stepwise program indicates that a model for prediction of school readiness is possible, and that the null hypothesis may be rejected.

Summary of Results

In each instance the test of the hypothesis resulted in the ability to reject the null hypothesis. Therefore, it may be concluded that kindergarten experience relates to qualities that enhance fine-muscle eye-hand coordination at the first grade level.

Prediction of school readiness is possible as determined by the stepwise multiple linear regression analysis program when a model including the independent variables; experience, FRPV, EHCT, and EMCT is utilized. The corresponding coefficient of determination is able to explain 49 percent of the total variation about the mean $\overline{y}$.

SUMMARY AND CONCLUSIONS

Summary

Research dealing with the benefits of kindergarten has shown that in general the experience will enhance achievement, reading ability, personality, and social skills. Children with kindergarten experience generally can cope more adequately with intellectual and social demands required in a formal learning situation. Readiness seems to be the most important contribution of the kindergarten experience.

Research on fine-muscle eye-hand coordination abilities has concerned itself with a number of important areas, the primary ones being the prediction of achievement levels and reading ability. Usually this type of research investigates the entire perceptual-motor realm, but because motor abilities per se do not appear to be independent, the role of predicting achievement is questionable based solely on motor abilities. The perceptual abilities include closure, figure-ground, form constancy, position in space, and spatial relations. Attempts to relate motor-abilities to reading achievement have not provided conclusive results, particularly when fine-muscle skills seem to correlate lower than other aspects of the perceptual-motor realm.

It appears that motor abilities are relatively specific and no general motor factor or ability has been determined. Correlations between fine and gross motor skills indicate very little relationship. This is also true in the correlations generated between tests of fine motor abilities. Physiological development appears to play a far greater role in determining fine-muscle abilities than do socio-economic background, sex, environment, or directed intervention.

Since there appears to be controversy in the results of recent research it seems justifiable to investigate the role of fine-muscle eye-hand coordination abilities as a predictor of readiness rather than achievement. Thus the primary objective of this study was to investigate the relationship between kindergarten experience and fine-muscle eye-hand coordination abilities of first grade children.

The subjects were 181 first graders enrolled in the public schools of Albany, Corvallis, and Salem, Oregon. The mean age of the sample was 76.69 months with a standard deviation of 3.75 months. The kindergarten group attended schools in Corvallis and numbered 92. The non-kindergarten group attended schools in Albany and Salem. They numbered 89.

Socio-economic status was determined by the Hollingshead Two-Factor Index of Social Position. Ninety percent of the sample was classified as lower middle class (Class IV), with the other ten percent in the lower limits of the middle class level (Class III).

Fine-muscle eye-hand coordination was considered in its broadest sense and was measured by the Moore Eye-Hand Coordination Test (EHCT), a speed and accuracy test using marbles; and the Frostig Developmental Test of Visual Perception, Test I, Eye-Motor Coordination (EMCT), a measure of eye-hand coordination involving drawing. Mental age was determined by the Full-Range Picture Vocabulary Test (FRPV). The Metropolitan Readiness Test (MRT), Form A was used as a measure of school readiness.

The following hypotheses were tested:

Hypothesis I: Comparison of scores for the kindergarten and non-kindergarten groups will yield no significant differences in fine-muscle eye-hand coordination abilities.

Hypothesis II: Prediction of school readiness will not be improved by the addition of the coefficients of the selected variables used in this study: experience, sex, age, handedness, height, weight, glasses, mental age, and the fine-muscle eye-hand coordination measures.

Results of the t-tests applied to the first hypothesis indicated that there were significant differences beyond the .025 level in favor of females and those children having had kindergarten experience when measured by the EHCT. A significant t-value beyond the .01 level was found in favor of the kindergarten group when measured by the EMCT.

It was concluded that kindergarten experience did improve fine-muscle eye-hand coordination abilities for children from these socio-economic levels after they attended kindergarten for ten months. Therefore, the null hypothesis was rejected.

Results of the stepwise multiple linear regression analysis program, when applied to the second hypothesis, determined a model for prediction including the independent variables of experience, mental age, and the two fine-muscle eye-hand coordination measures. An analysis of variance of these four variables produced an F-value of 42.23, thus indicating the fitted model can be rated a satisfactory prediction tool. Tests for linearality were run, and found to be significant. The coefficient of determination, R^2, for the model was .49, and was considered adequate.

Therefore, the null hypothesis was rejected. It was concluded that school readiness could be predicted by the selected variables in the model.

Discussion

A limited amount of research has been conducted in the area of fine-muscle eye-hand coordination abilities and their relationship to school readiness. Few, if any, attempts have been made to predict school readiness by means of fine-muscle eye-hand coordination ability measures.

This study recognized fine-muscle eye-hand coordination in its broadest sense, using Cratty's (1962) definition as a basis, and then attempted to assess the relationship between kindergarten experience and fine-muscle eye-hand coordination abilities, as well as determining whether prediction of school readiness could be accomplished with these scores. Since low correlations exist between various fine-motor measures, two instruments were used involving different actions and materials.

Similarities between this study and studies done by Moore (1969), Williams (1952), and Gill, Herdtner, and Lough (1968) existed. The major differences accounted for were the controlling of socio-economic status and grade placement of the subjects. The instruments or their combination varied, but the EHCT or the EMCT were used in all of the studies.

Moore (1969) did a three year study utilizing 133 first graders from various socio-economic levels who were ranked the poorest and best performers in writing and reading by their teachers. When comparing these two groups on total readiness Moore found a significant t-value of .001 favoring the more able student. A basic concern of this research is the inequalities of the groups studied. More information would be needed concerning the make-up of the socio-economic levels, and the children's abilities in each level. Differences favoring one group over the other would appear to negate the value of the findings, particularly if we employ Deutsch's (1964b) statement that a child who has been deprived of a substantial portion of the variety of stimuli to which he is maturationally capable of responding, is likely to be deficient in the equipment required for school learning. Children from varying socio-economic levels would have had exposure to differing environments, possibly accounting for the findings attained.

Williams' (1952) research was part of a longitudinal study being carried out at the University of Michigan. The only part of the study that would be applicable to the present study is the fact that Williams found there to be a correlation of .41 between reading readiness and the EHCT for 17 kindergarten children. The size of the sample is extremely limiting, thus the suggested tendency for children who perform well on the reading readiness sections of the Metropolitan Readiness Test to perform the EHCT more rapidly must be viewed with suspect.

The Gill, Herdtner, and Lough (1968) study dealt with perceptual differences at nursery school, kindergarten, and first grade levels for lower and middle class children. Differences in perception existed among groups varying in socio-economic levels, special instruction, and sex except when applied to the EMCT. The authors also found that none of the Frostig Developmental Test of Visual Perception Scores for males correlate very strongly with the Metropolitan Achievement Test, and only a little better for the females in the study.

Since the findings of these three studies are not conclusive, nor the results generated consistent, it was the intention of this study to emphasize only the motor aspects and to see how they relate to readiness. In essence, no replication was done, but the three previously mentioned studies aided in determining the instruments to be used and guidelines to follow.

It was noted in the review of literature that work done by Edwards (1966) and Conel (1939, 1941) suggest that the physiological aspects of development are far more influential in the development of eye-hand coordination than environment. The results of the data presented in this study cannot contradict this statement, but it does appear that the environment provided in the kindergarten does enhance eye-hand coordination abilities.

No attempt is made to elucidate on the cause and effect relationship of these findings, particularly when the study was done on an _ex post facto_ basis. It is quite possible that physiological considerations are apparent to a certain age. Past this age, the environmental influences may become a dominating factor. When these environmental influences are complimented by earlier physiological characteristics, this combination may provide a readiness to perform such eye-hand coordination skills.

Further support for the environmental effects of kindergarten is that no significant differences were found between the physiological variables of age and weight for the two groups. A significant t-value for height was found favoring the kindergarten group (Appendix A). The effect of this significance on the findings cannot be substantiated.

It is also apparent (Appendix B) that the physiological variables; age, height, weight, handedness, and glasses do not correlate highly with the eye-hand coordination measures or the MRT, nor do they contribute significantly to the prediction model (Table 7).

It is entirely possible that the time when the data was collected could have affected the results. The school environment would be new to the non-kindergarten group. During the first six weeks of school, particularly in a formal learning situation, the child may feel threatened, and performance in all areas could be affected. Thus it is entirely possible that the school environment precipitated unknown psychological aspects that affected the non-kindergarten group.

The predictive ability of the model presented in this study appears to be relatively adequate, though it could be limiting because of its burdensome nature. That is, prediction of school readiness would be generated by the application of three instruments and knowledge of whether or not the child has attended kindergarten. This raises the question as to whether this means of determining readiness for formal learning is feasible because of the cost involved and time expended.

The EMCT had the largest correlation, .51 with the MRT, and also produced the largest coefficient of determination; 29 percent. Improvement of the predictive value of the model may be enhanced if interaction between variables were tried. It is quite possible that a combination does exist that would explain a larger percentage of the variance. If this were the case, then the time and money expended might be beneficial.

The results of this study are encouraging since fine-muscle eye-hand coordination abilities do not seem prone to directed intervention, but it is enhanced by the experience of having kindergarten. Further, the findings seem to indicate that fine-muscle eye-hand coordination is closely related to maturation, thus readiness seems to be a logical outcome.

Conclusions

The following salient conclusions may be drawn from this study:

1. Kindergarten experience provides an environment that is conducive to increased abilities in fine-muscle eye-hand coordination when measured at first grade entrance for the sample studied.
2. Girls perform prehension tasks more rapidly than boys.
3. Prediction of school readiness is possible, as determined by the stepwise multiple linear regression analysis, and that the measures of fine-muscle eye-hand coordination

accounted for thirty percent of the variance.

4. The physiological measures of height, weight, age, and knowledge of whether the individual wears glasses or his handedness provided no significant information for predicting school readiness.

Limitations of the Study

Some limitations inherent to this study were discussed at the close of the third chapter. The following limitations must be kept in mind concerning the results.

Inability to Sample Randomly

The inability to sample randomly detracts from the ability to generalize from the results obtained. Simply, a random sample would have given every element in the population an equal chance of being included in the sample. It also makes the selection of every possible combination of the desired number of cases equally likely.

Instruments Used

The instruments used in this study force a narrow conceptualization of fine-muscle eye-hand coordination. The EHCT emphasized speed and accuracy, yet at the same time it may have involved a gross arm movement. In placing the marbles, the subject is required to move the marble from the holder to the next hole, which increases in distance. The last hole is approximately eighteen inches from the marble holder. There could be some arguments presented that this actually involves a gross movement, thus placing some reservations on the practicality and usefulness of the instrument in studies such as this.

The EMCT emphasizes that all work should be done from left to right regardless of the child's handedness. Special notations should be made if the child draws the lines from right to left, or from bottom to top. Gesell and Ames (1946) found that ninety-five percent of the time children will draw lines horizontally left to right, and vertically, top to bottom. They conclude that directionality trends suggest neuromotor predisposition determined by the maturity of the child. If directionality was not a concern of the EMCT, the possible findings could lead to more information as to maturation, adaptability, and readiness abilities of the subject.

Screening of the Subjects

Screening of the subjects in regard to experience was done by the school principal, thus it is assumed that the school records were accurate for this determination. This is an inherent weakness of an *ex post facto* study, since control over the experience variable is not always possible. Every effort was made to limit the groups as to the experience factor, but the possibility of error does exist.

Suggestions for Further Research

Further research at different socio-economic levels might provide further verifications as to the benefits of kindergarten and the practicality of predicting school readiness on the basis of fine-muscle eye-hand coordination measures.

A study utilizing the same instruments, but emphasizing the pre and post test method may provide data as to whether differences between groups still exist at the end of first grade. This may give some indication as to the role of the school environment, maturity, and readiness, and what time is most appropriate for measuring eye-hand coordination abilities for prediction.

Variations in the utilization of the EHCT and EMCT may prove beneficial. Performance of the EHCT vertically rather than horizontally, plus various changes in directionality on the EMCT, may give further insight in various motor differences that are not explained when the instruments are administered conventionally.

Finally, the possibility of developing an instrument similar to the EMCT may prove feasible, but with greater emphasis on vertical and diagonal exercises. Utilization in group testing would be most practical.

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APPENDICES

APPENDIX A

Table 9. Summary of t-tests for the Comparison of Kindergarten Experienced and Non-Kindergarten Experienced Children with Respect to Age, Height, and Weight.

Source	Mean Values	Mean Values	t
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Age	$\bar{\bar{x}}_{1,2} = 76.77$	$\bar{\bar{x}}_{3,4} = 76.50$	.015
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Height	$\bar{\bar{x}}_{1,2} = 47.31$	$\bar{\bar{x}}_{3,4} = 46.46$	2.41*
	$(\bar{x}_1 + \bar{x}_2)$	$(\bar{x}_3 + \bar{x}_4)$	
Weight	$\bar{\bar{x}}_{1,2} = 50.27$	$\bar{\bar{x}}_{3,4} = 48.37$	1.46

*Significant at the .02 level.

$\bar{x}_1$ = Male (K), n = 54, means = age, 77.06; Ht., 47.33; Wt., 50.48

$\bar{x}_2$ = Female (K), n = 38, means = age, 76.47; Ht., 47.29; Wt., 50.05

$\bar{x}_3$ = Male (NK), n = 49, means = age, 77.14; Ht., 47.12; Wt., 50.96

$\bar{x}_4$ = Female (NK), n = 40, means = age, 75.85; Ht., 45.80; Wt., 45.78

$\bar{\bar{x}}$ = Pooled Means

APPENDIX B

Table 10. Simple Correlations Between Variables: Original Model.

	Experience	FRPV	Age	Sex	Metropolitan	Handedness	Height	Weight	Glasses	EHCT	EMCT
Experience	-	.121	.034	-.037	.494	.074	.166	.096	.104	-.166	.414
FRPV		-	.173	-.005	.412	.025	.275	.268	-.045	-.254	.184
Age			-	-.125	.153	.159	.358	.259	.040	-.317	.295
Sex				-	.059	-.018	-.147	-.162	-.126	-.185	.009
Metropolitan					-	.096	.212	.180	.130	-.436	.510
Handedness						-	.124	.186	-.063	-.176	.048
Height							-	.688	.151	-.234	.266
Weight								-	.114	-.119	.206
Glasses									-	-.085	.094
EHCT										-	-.400
EMCT											-

$r > .159$, significant at .05 level; $r > .208$, significant at .01 level.

APPENDIX C

Table 11. Summary Table of the Actual Scores, Predicted Scores, and Deviations for the Final Model.

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
1	55	53.86	1.14
2	87	93.23	- 6.23
3	64	54.21	9.78
4	58	68.91	-10.91
5	43	66.84	-23.84
6	83	75.09	7.91
7	63	68.17	- 5.17
8	58	48.82	9.18
9	44	65.59	-21.59
10	53	65.64	-12.64
11	62	47.96	14.04
12	72	72.60	- .60
13	64	68.24	- 4.24
14	68	77.43	- 9.43
15	86	69.44	16.56
16	31	61.74	-30.74
17	56	57.17	- 1.17
18	52	51.09	.91
19	66	66.71	- .71
20	61	59.73	1.27
21	59	73.80	-14.80
22	55	71.68	-16.68
23	66	69.31	- 3.31
24	61	58.40	2.60
25	80	81.64	- 1.64
26	65	76.45	-11.45
27	42	56.64	-14.64
28	75	81.68	- 6.68

Table 11. (Continued)

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
29	77	63.32	13.68
30	43	56.34	-13.34
31	78	76.18	1.82
32	73	69.33	3.67
33	87	76.69	10.31
34	79	76.28	27.18
35	67	73.01	- 6.01
36	49	55.94	- 6.94
37	69	75.31	- 6.31
38	69	71.58	- 2.58
39	68	72.32	- 4.32
40	86	66.30	19.70
41	79	80.83	- 1.83
42	76	57.64	18.36
43	55	64.22	- 9.22
44	48	67.76	-19.78
45	89	73.07	15.93
46	58	59.42	- 1.42
47	75	63.22	11.78
48	67	63.99	3.01
49	72	73.11	- 1.11
50	47	61.87	-14.87
51	63	61.72	1.28
52	43	64.44	-21.44
53	69	60.86	8.14
54	64	68.62	- 4.62
55	72	68.85	3.15
56	39	66.18	-27.18
57	71	74.44	- 3.44
58	77	72.06	4.94
59	99	72.60	26.40
60	81	57.88	23.12

Table 11. (Continued)

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
61	73	66.62	6.38
62	73	57.81	15.19
63	69	70.16	- 1.16
64	80	75.41	4.59
65	52	72.07	-20.07
66	53	56.34	- 3.34
67	81	74.19	6.81
68	35	42.60	- 7.60
69	66	65.01	.99
70	47	56.57	- 9.57
71	64	72.79	- 8.79
72	77	77.09	- .09
73	74	86.74	-12.74
74	57	63.54	- 6.54
75	45	44.64	.36
76	72	51.31	20.69
77	79	71.31	7.69
78	59	63.65	- 4.65
79	52	57.38	- 5.38
80	68	73.19	- 5.19
81	87	63.12	23.88
82	58	67.00	- 9.00
83	84	73.37	10.63
84	72	66.10	5.90
85	69	60.50	8.50
86	68	62.19	5.81
87	80	79.95	.05
88	76	77.45	- 1.45
89	67	58.03	8.97
90	75	63.44	11.56
91	89	76.11	12.89
92	89	56.50	32.50

Table 11. (Continued)

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
93	84	69.97	14.03
94	63	44.45	18.55
95	29	45.86	-16.86
96	61	42.59	18.41
97	48	48.02	- .02
98	61	56.70	4.30
99	38	48.21	-10.21
100	34	45.38	-11.38
101	8	25.82	-17.82
102	9	32.42	-23.43
103	33	42.44	- 9.44
104	71	61.66	9.34
105	47	56.52	- 9.52
106	62	59.34	2.66
107	68	45.07	22.93
108	15	37.37	-22.37
109	52	47.01	4.99
110	20	44.22	-24.22
111	44	47.64	- 3.64
112	32	39.86	- 7.86
113	14	28.98	-14.98
114	47	52.52	- 5.52
115	10	43.01	-33.01
116	55	59.96	- 4.96
117	52	45.78	6.22
118	57	59.29	- 2.29
119	29	49.33	-20.33
120	34	40.60	- 6.60
121	25	48.61	-23.61
122	16	37.93	-21.93
123	34	44.46	-10.46
124	32	47.08	-15.08

Table 11. (Continued)

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
125	66	58.40	7.60
126	43	45.85	- 2.85
127	44	61.81	-17.81
128	31	52.06	-21.06
129	42	52.80	-10.80
130	52	59.42	- 7.42
131	36	47.19	-11.19
132	47	40.44	6.56
133	74	65.41	8.59
134	60	45.70	14.30
135	52	38.28	13.72
136	63	54.29	8.71
137	73	69.48	3.52
138	67	55.56	11.44
139	74	60.72	13.28
140	79	53.57	25.43
141	61	44.17	16.83
142	66	49.13	16.87
143	67	61.25	5.75
144	55	43.42	11.58
145	66	68.75	- 2.75
146	50	54.05	- 4.05
147	65	50.91	14.09
148	57	53.27	3.73
149	60	50.17	9.83
150	55	44.23	10.77
151	74	52.51	21.49
152	65	54.81	10.19
153	53	37.43	15.57
154	66	57.66	8.34
155	68	49.75	18.25
156	58	49.10	8.90

Table 11. (Continued)

Student	Actual (y)	Predicted ($\hat{y}$)	Deviation
157	74	47.85	26.15
158	66	57.24	8.76
159	64	54.75	9.25
160	67	55.78	11.22
161	75	57.65	17.35
162	30	34.38	- 4.38
163	70	60.85	9.15
164	63	57.98	5.02
165	42	43.11	- 1.11
166	42	35.42	6.58
167	38	58.27	-20.27
168	72	54.84	17.16
169	40	47.95	- 7.95
170	40	51.96	-11.96
171	36	39.83	- 3.83
172	26	35.30	- 9.30
173	36	50.44	-14.44
174	40	49.85	- 9.85
175	43	38.98	4.02
176	31	28.38	2.62
177	65	44.25	20.75
178	40	64.97	-24.97
179	53	58.63	- 5.63
180	49	44.97	4.03
181	53	53.05	.05

Deviation mean = .00000000547

Sum of deviations squared = 29076.6526