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SKELETAL AGE AS A PREDICTOR OF SCHOOL READINESS

IN "PROJECT HEAD START" CHILDREN

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CHAPTER I

INTRODUCTION

The purpose of this study is to investigate the usefulness of skeletal age as a predictor of school readiness.

Throughout the United States, the present educational system is organized so that a child of chronological age six years is automatically considered eligible for school. Not only is he considered eligible, but barring any serious illnesses or extenuating circumstances, his enrollment in the first grade is mandatory. While from a pragmatic point of view this is a useful method of estimating the advisable time for school entrance, it is basically a very crude one and seems to ignore the developmental characteristics and rates of the individual in favor of the average. Little consideration, if any, has been given to the child's readiness on any grounds other than his chronological age. The assumption is made that the child has a mental age falling within the average or above average range. Thus, intellectual level and chronological age are presently the primary and most often the only criteria necessary or considered in placing a child in the first grade. However, there is a considerable

amount of data revealing that many children of average intelligence have a great deal of difficulty in the first grade and seem either to develop or have concomitant emotional difficulties. The first grade is the foundation of many processes and functions for a child, the acquisition of which involves more than his intellectual sphere. The educational system does not evaluate a child's overall level of maturity or his overall readiness for school.

This research has as its basic premise that the overall level of maturation is an important factor in the ability to make use of certain experiences. As such, it may be valuable in evaluating the time of school entrance for each child. Within recent years, educators have become aware of the need for flexibility in the school entrance age for any given child. Essentially, the increasing concern with this has been stimulated by the awareness of developmental differences among children in relationship to the degree of learning they can attain (Weiss, 1962; Wickens & Meyer, 1961).

The purpose of this research is to investigate one possible technique of evaluating the readiness of a given child to assimilate the experiences provided during the first grade.

The author arrived at the present study on the basis of several available sources of data which lead to five general principles applicable to developmental psychology. First, the concepts of "maturation" and "readiness" are legitimate ways of conceptualizing the progression of a child (Ausabel,1958). There is enough evidence on both an animal and human level to support the significance of maturation. Second, skeletal age seems to be an extremely good index of

the rate of maturation, but is used relatively little in practical work with children (Johnston, 1963; M. C. Jones, 1965). Third, during the past fifteen years, a growing literature has accumulated demonstrating the behavioral correlates of the rate of physical maturation in adolescents and the continuation of these personality traits on into adulthood (Eichorn, 1963; Jones and Bayley, 1950). Fourth, many studies have illustrated the low but positive relationship between the rate of skeletal maturation and intelligence (Eichorn, 1963). Fifth, several new studies have dealt with and obtained positive relationships between the level of maturation and certain school achievement measures (Weiss, 1962). The following is a review of the literature in these five areas.

The Concept of Maturation

Maturation has been a central issue since the very inception of developmental study. The meaning of this concept has been ambiguous, clouded by various interpretations and endowed with a diversity of connotations, since it was first introduced (Frank, 1950; Hebb, 1958; Wickens & Meyer, 1961). Initially, one would think that a multitude of references could be found under the heading "maturation." This is not the case, however, and under "maturation" the Psychological Abstracts in 1964 and 1965 had only 5 and 9 listings, respectively. However, throughout the literature one frequently finds the term used without specification, without any operational definition and often used as if synonymous with the terms "growth" and "development." All three terms have a good deal in common and all refer to the general

concept of some on-going process in a child but they are technically different terms (Frank, 1950). Ausabel makes the distinction in these terms relatively clear. He states that maturation should be used to refer to that portion of an increase or change in capacity due to "genic influence and/or incidental experience" (1958, p. 81).

The confusion often found between maturation and growth stems out of the failure to distinguish between two entirely independent dimensions of development. On the one hand, there is the dimension of development which occurs with the participation and primarily as a result of specific practice. On the other hand, there is the kind of development that has at its core genetic influences and possible incidental experiences. The latter dimension of development is what will in this paper be called maturation. The former dimension of development is what is usually referred to as progress through the learning processes. For Ausabel, "Growth may be used to designate relatively permanent changes in the neuroanatomical and neurophysiological substrate of behavior" (1958, p. 81). Growth, however, refers only to substrate correlates of overt developmental change, whether due to learning or maturation. Development is a term then that should be used to encompass both of these dimensions of increment in capacity, due to either or both maturation and growth, without any implications about the importance of these interacting variables. Growth is actually a measurement of maturation.

This confusion of the three terms has at times become so great that some have advocated doing away with two of the terms, maintaining that they are redundant (Frank, 1950). Frank (1950)

attempts to justify the use of the term "maturation" viewing it as reflecting an aspect of the overall ongoing process of a child which can be differentiated from growth and development in a way similar to Ausabel's differentiation, previously cited.

The human organism is clearly not static but is continuously undergoing change and movement. This change appears to be, within boundaries, an orderly, regular and relatively predictable process (Frank, 1950; Greulich, 1950; Hofstaetter, 1951; H. Jones, 1958; McCandless, 1961). This process involves growth, development, maturation, involution, and aging, which are operating from conception to death. Each child will grow in weight, height, various capacities, etc., but each child will do so at a rate unique to him. This rate is the crux of the concept of maturation. In many respects, growth is a qualitative or quantitative way of measuring the maturation process. Frank states, "Maturation merits recognition and study as implying a dynamic operation which has no terminal point or fixed norms but is progressively at work. Maturation is a series of transformations through time" (1950, p. 22). Olson (1949) states that "maturation" refers to the development of an organism in response to internal stimuli impelling it toward growth. Wickens and Meyer (1961) state that maturation implies that the underlying structural changes that can be observed in the organism are biologically determined and are relatively independent of environmental forces.

Wetzel states that the maturation process is related to an inherent impulse to growth, and he writes, "maturation is not directly related to age, size, but to a more fundamental and critical property

viz. maximum deceleration of growth and development, and through this only indirectly to age" (1941, p. 1188). One can talk about the growth of a child's skeleton in size terms, but this is just one phase of progress toward maturity. Measuring the size of various bones, etc., and arriving at a measurement (for example, of height), involves a quantitative dimension (Krogman, 1950). However quantity is not enough and the quality of the child's progress toward the ultimate condition is necessary to gain a total picture of any given organism. In this sense, Krogman states, "We use skeletal age not as a correlate, but as a measuring unit, a standard against which morphological (dimensional and observational) maturity can be measured" (1950, p. 26).

Ausabel (1958) states that three kinds of empirical data support the occurrence of maturation. The first is the evidence that there can be developmental progress when the opportunity for practice is experimentally or otherwise restricted.

The second kind of empirical evidence Ausabel suggests attesting to the occurrence of maturation, is that specific practice has no effect on development until a certain stage of readiness is reached in the absence of intervening practice. Thirdly, when one excludes intervening practice, training is more efficacious at a later age than it would have been at an earlier age.

There are numerous experiments with both animals and humans that illustrate observable behavior which can be attributed to the maturational process in the organism (Harlow, 1959; Hebb, 1958; Hudson, 1940; Strayer, 1930).

Any research utilizing the concept of maturation must make

explicit the meaning applied to the term and define it operationally. Ausabel's definition of maturation is the approach assumed in this research. Ausabel states, "maturation refers to any instance of development (i.e. change in the status of underlying process of a behavioral trait) that takes place in the demonstrable absence of specific practice experience" (1958, p. 81). The proposed index of maturation in this study, skeletal age, meets the prime requirement of this definition, since specific practice can logically be excluded as influencing the rate of anatomical development. The concept of maturation has inherent in it the assumption that changes can take place in the organism which are primarily a result of and paced by its physiological and genetic makeup. The notion that these changes are primarily but not totally a function of genetic makeup is basic to the concept because all change in the underlying substrate of behavior is also in part a product of environment.

Hebb (1958) points out that maturation as a concept does not exclude environmental influences such as pre and postnatal chemical and nutritive surroundings. It refers, as Ausabel states, to instances where specific practice can be excluded. The absence of specific practice is in no way excluding environmental influences.

The second concept this research must define is "readiness." Ausabel also provides this, stating:

> Readiness is a term which signifies that the current developmental status of an organism is such that a reasonably economical increment in capacity may be anticipated in response to adequate stimulation . . . irrespective of how this status is achieved or the type of stimulation that is applied" (1958, p. 81).

Accepting the concept of maturation implies the assumption that certain behavior will not occur until the necessary structural changes have developed. It further has inherent in it the implication that within limits, learning is more efficient when structural growth is at an optimum level than it is when growth is less advanced. Thus, if we are to take advantage of maturational influences, investigations into the factors that reveal any aspect of the maturational status of the individual is necessary and justified (Jersild, 1960).

Maturation has many implications for the learning process. A well recognized determinant in learning is the motivation of the child. Studies in "readiness" reveal that children learn with more zest, more efficiently and with more secondary gain when they are at the right stage of maturation for a given task. Research indicates that if a child is exposed to a situation before he is ready or capable of making adequate progress to lead to some self-satisfaction, he may develop unfavorable attitudes toward this situation and others related to it. When a child is not able to assimilate a given set of experiences and is consequently unable to achieve at his level of ability, he tends to withdraw, with resultant lowering in intent and motivation (Weiss, 1962).

Thus emerges from this literature the first generalization that can be made. Maturation is an important concept in developmental psychology and is crucial to "readiness" and learning in general. Any study leading to a better understanding of the role maturation plays in school readiness will be a valuable contribution to this field.

Indices of Maturation

Traditionally, chronological age has been one of the most popular ways of classifying a child's level of maturation. The relationship between chronological age and the ability to develop specific skills or to assimilate certain experiences was, of course, recognized centuries ago (Wickens & Meyer, 1961).

Chronological age is a useful method for developing norms as to when the average child sits, walks, speaks, etc. However, chronological age represents only one aspect of growth, and does not provide a physiological, neurological, or anatomical picture of the individual. Eichorn (1963) states that it is now axiomatic among students of development that over the span from conception through adolescence, chronological age becomes a progressively poorer predictor of an individual's size, weight, etc., and many other characteristics. Evidence for the progressive inadequacy of chronological age as an index of maturation has been provided by a large number of studies and various methods of expressing maturation have been proposed as substitutes for, or adjuncts to chronological age (Eichorn, 1963; Falkner, 1962; McCandless, 1961).

A common method of comparing children and establishing some index of maturation as an adjunct to chronological age has been in terms of their weight and height. Usually, if a child is about as tall and as heavy as the average child of his chronological age, it is assumed that his development is proceeding satisfactorily. However, the use of weight and height, at least in this country, becomes a doubtful measure because of the genetic diversity and differences in

nutritional level. Weight and height are highly influenced by parental size, etc., and the kind of diet a child has had, so that a norm might fit a given group of children but be totally unsuitable for another group (Johnston, 1964).

In discussing the problem of finding a dependable indicator of the rate of maturation Greulich and Pyle state:

> As a people, however, we are very heterogeneous in national and, to some degree, racial origin. Even among the White population of this country there are such diverse types as short-statured Mediterranean people, taller, heavier Scandinaveans, and more moderately-sized people of Central European origin, to mention only a few. In addition, and perhaps more important, there is almost every possible mixture between these and the numerous other strains that compose the population of the United States. It is this genetic diversity, plus significant differences in nutritional level, that are largely responsible for the fact that in this country height-weight-age tables, while fitting the particular group of children on whom they were originally based, are seldom wholly satisfactory when applied to other groups.
>
> There is another factor which makes it difficult to determine the developmental status of children from their height, weight and age alone. The existence of early-maturing as well as late-maturing strains in our population makes for a wide difference in the age at onset of puberty and, consequently, in the age at which the maximum annual increment in height -- the so-called preadolescent spurt of growth--occurs. Because of this variability, the chronological age of a child during the early part of the second decade of life is often but little more than a measure of the length of time he or she has lived; it bears no necessarily close relationship to the amount of progress which the child has made toward attaining adulthood.
>
> The difficulties which these and other variables of bodily growth create for those who attempt to appraise the developmental status of children have led to a search for some dependable indicator of maturity which would, within reasonable limits, be independent of bodily size. The developmental status of the skeleton

> as disclosed by an X-ray film of the hand and wrist appears to meet this need (1959, p. 1).

Of the many methods employed to measure maturation, dentition, anthropometric measurements, physiological growth in various organs, etc., skeletal analysis is one of the most accurate and widely used methods (Flory, 1936; Greulich, 1950; Horrocks, 1962; Johnston, 1963; Jones, 1965; Krogman, 1950; Todd, 1937; Woodrow & Lowell, 1922). Greulich (1950) emphasizes that skeletal age is far superior to height and weight as a nuance of the maturational progress of a child. He states that the correspondence between the maturative changes in the reproductive and skeletal systems is so intimate that it is possible to predict when the menarche will occur on the basis of an X-ray of the hand and wrist during the pre-puberal period. The method of skeletal analysis uses the degree of ossification measured by X-ray techniques to determine the individual's level of skeletal maturity. The use of this method as an index of the rate of maturation dates back to the beginning of the present century (Hicky, 1906; Rotch, 1908). There have been several attempts at developing the techniques for establishing skeletal age by means of carpal X-rays and in formulating the norms upon which comparison could be made. (Flory, 1936; Greulich and Pyle, 1959; Todd, 1937). Greulich and Pyle are the most recent and seem to be the standards used by the newest studies. Eichorn (1963) also reports in a review of the literature that the high correlates between skeletal maturation and other measures, such as the appearance of secondary sexual characteristics and growth spurts in height, have been well documented. Jones (1965) compared skeletal

maturation as an index with many other measures of physical maturation and found skeletal age to be the most consistent and to have the highest overall correlation with the other measures.

Rate of Maturation and its Behavioral Correlates

There have been many studies demonstrating the relationship of the rate of maturation and various psychological variables. M. C. Jones, 1957; Jones and Bayley, 1950; Jones and Mussen, 1958; Mussen and Jones, 1957, at the University of California (The Oakland Growth Study), have reported data on a longitudinal study of late and early maturing boys and girls. The first of a series of papers emerging from this longitudinal study dealing with the social and psychological correlates of the rate of maturing began with a paper by Jones and Bayley (1950).

Jones and Bayley (1950) selected out of a group of 90, the 16 most consistently skeletally accelerated and the 16 most skeletally retarded boys, and studied them intensively over a period of four and one-half years. The boys ranged in age from 13 through 15. The skeletally accelerated boys were significantly taller, heavier, showed more advanced pubic hair development and were advanced in genital growth. On personality measurements, the two groups were again found to differ significantly. The skeletally retarded boys were rated by adults (on a scale called the Institute of Child Welfare ratings) as lower in physical attractiveness, less masculine, less well groomed, and more childish. The skeletally immature children were further found to be less "matter of fact," sought attention more, were con-

sidered less mature in heterosexual situations, more uninhibited and more tense. There were no significant differences in the area of popularity, leadership, or social effect on a group as judged by adults and peers during junior high school.

However, Jones (1958) found that by senior high school the two groups could be distinguished on these bases. Over half the early maturers acquired either the distinction associated with outstanding athletic abilities or were elected to important student offices. The late maturing group had only one athlete and one student officer.

Mussen & Jones (1957) administered the TAT to a group of late and early maturing boys. The late maturers had more negative or derogatory self-concepts, blamed their parents for their status more, and felt relatively weak, alone and helpless in comparison to the early maturers. The late group had higher affiliative needs.

M. C. Jones (1957), reports on a follow-up study of a group of 40 men, age 33, who were divided as adolescents into early and late maturers. Although the physical differences had disappeared, so that on a skeletal or physiological level the groups could not be distinguished, they could be differentiated on several personality dimensions. The men who were early-maturing boys scored higher than those who were late-maturing boys on measures of "good impression" and "dominance." The early maturers were less rebellious, less impulsive, less self-indulgent and less "touchy." The men who were late maturing boys scored significantly higher on a test of "succorance" (the tendency to look for help and support from others).

Ames (1957) found that skeletal age as an index of rate of maturation predicted social behavior at the age of 33 better than any social measure obtained for the subjects when they were adolescents. Ames also found that 15 of the 40 men followed up held occupational positions in which they supervised or directed the work of subordinates. Of this group, only three were late maturers. Eight held some type of office in a lodge or civic group, and all were early maturers. The Ames study further demonstrates that the influences of rate of maturing is not confined to extreme groups, but is found within the mid-range as it progresses from late to early maturers.

The adult personality differences were also investigated by Jones (1957), using the California Personality Inventory and the Edwards Personal Preference Schedule. Although the physical discrepancies found as adolescents between the late and early maturing group had been markedly reduced, the behavioral characteristics that distinguished them as adults seemed to remain.

Kinsey's statistics (Eichorn, 1963) on adult sexual activity demonstrate behavioral differences between early and late maturers continuing long after adolescence. The early maturers were more sexually active and married earlier. The index of maturation Kinsey used was the onset of puberty.

Jones (1965) reports on a follow-up of the people used in the Oakland Growth Study. The subjects were in their late thirties and they were asked to estimate whether they were late or early maturers and for their retrospective memories during adolescence. Most individuals estimated their rate of maturing in accord with the

skeletal age measurements taken during adolescence. Their estimates of their progressive size, strength, weight, growth of pubic hair and genitals were extremely close to the real measurements that had been taken without their knowledge of results. Jones states that the somatic aspects of maturing must play an important part in producing the psychological picture that emerges for any given individual. The kinds of memories that these men reported were also significantly different for the early and late maturers. Those who were late maturers during their developmental years reported a significantly greater number of memories concerning their heterosexual or social-sexual development. Without exception their protocols contained significantly more memories and concern about peer rejection, shyness, and general ineptness. The early maturing group reported significantly more memories of enjoying social activities.

Many studies have demonstrated that early and late maturing groups were significantly different in height, weight, body build, secondary sexual characteristics, athletic performance and basal metabolic rate (Eichorn 1955, 1963). For the most part the physical discrepancies increased to a maximum at age 15 and diminished after that. However, where the groups were followed into adulthood the various personality traits and social orientation persisted. Thus, it appears that once such differentiation is established, somatic factors such as a shift toward a mature body build, etc., for the late maturer, do not necessarily produce concomitant shifts in his social status, personality organization and reputation among peers. A legitimate question to be raised is at what stage of development in

the late maturer do these behavioral variables, as concomitants of physical retardation, become influential and subsequently "fixed." The need for such developmental research, especially with younger age groups, becomes apparent. The investigation into the relationship between the rate of maturing and behavioral variables has essentially been carried forward from early adolescence. Eichorn (1963) expresses the need for research to begin with the same kind of study but at much earlier ages.

Maturation and Intelligence

It is fairly well accepted that in certain types of mental deficiency, such as cretinism, there is a dramatic accompaniment of arrested physical growth. Many studies have correlated various physical measurements with intelligence, using children of "normal" intelligence ranging in age from 2 through 17 years, and report a low but positive correlation (Abernethy, 1936; Bayley, 1940; Eichorn, 1963; Mussen & Conger, 1956).

Terman (1925, 1947) has illustrated the relationship at the other end of the scale and reports that intellectually superior children were also superior throughout their developmental years in height, age of walking, weight, strength of grip, athletic abilities, and general health. In thinking about these studies, and the measurements they have taken, it becomes clear that they are in essence dealing with the "rate of maturation."

Several investigators have explored the relationship between intellectual and physical growth by means of skeletal age as the physical

index. Abernethy (1925, 1936), Ascher (1949), Flory (1936), A. T. Jones (1958), and Klausmeier (1959) all state that there is a positive correlation between mental and physical development. Kugel (1963) using a population of 879 mentally retarded children found a highly significant positive relationship between mental and physical development. Flory (1936) found that skeletal growth as measured by carpal bone X-rays shows that mentally defective boys matured at a slower rate and for a longer period of time. The mentally deficient boys of this population also manifested a greater variability in skeletal growth. There was a progressive difference in the degree of skeletal retardation among the various degrees of mental retardation. For example, the profoundly mentally retarded were more skeletally retarded than the severe, etc.

Mosier, et al.,(1965) carried out a cross sectional survey of ten physical measures on a population of 2,472 institutionalized mentally defective people. They found that for both sexes body weight, crown-heel height, symphysis heel height, biacranial diameter and bicristal diameter were significantly smaller in the retarded population than in a normal population. Further, the degree of impariment in physical growth was related to the degree of IQ deficit.

Maturation and School Readiness

The notion of utilizing a measure of maturation to supplement chronological age and mental age in placing a child in a particular grade in school was suggested in the early part of this century. (Chiles, 1910; Rotch, 1910; Woodrow & Lowell, 1922). Each of these

investigators postulated that "school grading" should be determined, at least in part, in terms of the "anatomical age" of an individual. These authors further maintained that the entire concept of "mental age" was really meaningful only when considered in relation to anatomical age. Rotch stated:

> We should investigate physiologic and anatomic conditions in our quest for a reliable standard of development. A standard based on anatomic development is more simple than one based on physiologic development, and is less liable to be mistaken for anomalous conditions and variation. The normal anatomy of the wrist is the best part of the skeleton to use as a standard index (1908, p. 1198).

Despite these suggestions of the need for a measure of maturation other than chronological and mental age when placing children in school, little additional research has been done, and certainly our educational system has rarely if ever used any such measures in first grade enrollment procedures. Within recent years, there has begun to emerge an increasing awareness of the need for greater flexibility in the age of school entrance. The need for some measure of optimal time for any given child to enter school has led to several investigations directly involving maturation and school achievement.

Most of the studies in this specific area have used chronological age as the index of maturation. Baer (1958) compared children who entered kindergarten in September with birthdates making them five years old during the months of September through November (which was termed the underage group), with children whose fifth birthdate was in the months of January and February before the September enrollment (average group). Thus there was approximately a nine or ten-month

difference between the average of these two groups. The groups were matched for socio-economic level and for IQ. The IQ range for both groups was 101 to 127. The two groups were followed through high school. As a group, the average children made better school progress than the underage children. The average group made significantly higher grades from kindergarten on to the tenth grade. The average children scored significantly higher on achievement tests in reading and arithmetic, and were consistently rated significantly higher by their teachers on "desirable personality traits." Their progression from grade to grade was significantly more regular than the underage group.

Carter (1956) compared the achievement of 100 children who had entered the first grade in the Austin Public School System in September, 1947. At the time of enrollment half of these children were under six and half over six and were matched for sex and IQ. They were followed throughout elementary school and were periodically given achievement tests. As a group the chronologically older children obtained significantly higher scores on the achievement tests than the younger children. Of the younger group, 87% never attained the achievement level of the older group. Carter's findings further suggest that the age factor is more influential in boys than in girls. Similar findings are reported by Carroll (1963) using third grade children from five public schools in New York State. The average children made consistently higher scores than their younger classmates on achievement tests.

These studies used chronological age as the independent

variable in differential school achievement. As previously stated, chronological age is a measure of maturation, but a relatively gross one which almost totally ignores individual differences in the rate of maturation. In spite of this there apparently exists a definite relationship between the level of maturation and the ability to assimilate school experience. In each of these studies, the groups differing in level of maturation were equated for IQ implying equal intellectual ability. However, the maturational factor is only partially considered in the concept of IQ. A child in the underage group might be chronologically 5 years, 9 months, have an MA of 5 years, 9 months, and consequently have an IQ of 100. A child in the over-age group may have a chronological age of 6 years, 3 months, a Mental Age of 6 years, 3 months, and an IQ of 100. These two children are now equated for IQ. But the child with a Mental Age of 6 years, 3 months, is maturationally advanced six months, and just on this basis could be expected to function at a higher level. A more precise evaluation of the maturational element involved, in the chronological age concept, can be obtained by matching the groups for MA rather than IQ. Then the younger age group will be superior to the average group in IQ.

Such a study was done by Weiss (1962). Weiss had three groups. One group of normal age children with average Stanford Binet IQ's; one group of underage children (younger than the normal group by an average of eight months) of average Binet IQ's, and a third group of underage children of superior IQ's. The third group was matched for MA with the normal age group, thus having significantly higher

IQ's. The underage group of superior intelligence still scored lower on grades, personality test scores and social status ratings than the normal age group of average intelligence. The older children were more popular at the end of the school year than the younger group. Thus there seems to be some factor other than intellectual level at work, presumably a physical maturational factor associated with chronological age.

Gleason and Klausmeier (1958) found that among third grade boys uneven growth in height, weight, and carpal bone development tended to be accompanied by uneven and low achievement in reading, arithmetic and language development.

Karlin (1957) dealt directly with carpal bone development and its correlation with reading readiness, reporting that late skeletal maturers scored lower on the reading readiness test than the early maturers.

Simon (1959) used body configurations as a measurement of maturity. It is possible by taking many varied measurements of a child's body to compare him with a norm and separate out an immature and mature group. Simon obtained the 50 most successful and the 50 most unsuccessful first grade students from five public schools. It was found that these two groups were not significantly different in IQ scores, but they were significantly different in their level of maturity as judged by body configuration. The unsuccessful group had significantly more body indices associated with immaturity than the successful group.

Boverman et al.,(1964) attacked the problem of relating the

rate of maturation to other variables by utilizing the cognitive style as a measure. Cognitive style can be viewed as an individual's characteristic way of organizing and structuring a given aspect of his world. Boverman found that the degree of "automatization - cognitive style" was highly related to various physical measures and the rate of physical maturation.

Summarizing this literature provides the five principles upon which this research is based:

1. There is a maturational factor operative in human development from conception to maturity.

2. The most widely used measure of maturational level is chronological age. However, chronological age is a poor measure, not taking individual differences into account. Skeletal age is an excellent index of maturation providing much data which chronological age does not.

3. Early and late maturers can be distinguished on behavioral variables during adolescence. These behavioral differences persist into adulthood even though the physical differences are no longer significant.

4. There is a high correlation between physical retardation and "mental retardation" and a positive but low correlation between physical maturation and intelligence in normals.

5. Maturation seems to play a crucial role in the learning process and appears to be an important factor in school achievement.

Assuming these five principles it seems very plausible to seek something more than chronological age as the criteria for kindergarten or more specifically for first grade admission. The need for such criteria becomes even more important when dealing with children from underprivileged environments. Anyone who has administered intelligence tests to children from low socio-cultural and economic environments

has experienced the inability of these children to express themselves adequately on these tests. Children from these environments frequently appear retarded in mental age. However, the usual intelligence tests are based on the universality and commonality of experience which automatically places children from underprivileged and deprived environments at a disadvantage. Attempting to establish school readiness on the basis of mental age with these children is of doubtful validity. The mental age derived from present intelligence tests is too influenced by experience and does not represent maturational factors. It is not really an indicant of potential to assimilate experiences. This is particularly pronounced in deprived children who score low on intelligence tests. The low score could be either a product of the cultural deprivation, retardation, mental deficiency or all of these.

Chronological age is an arbitrary standard. Perhaps the unique maturational potential of each child should determine the rate at which he is provided with specific developmental experiences. What would be the result if a child who was two years behind in skeletal development and who appeared two years behind in mental development did not enter school until skeletally six years old, regardless of his chronological age at that time? If placed in school when chronologically six, he might well experience repeated failure, possibly setting the pattern for the rest of his academic life. With proper developmental treatment appropriate to his rate of maturation, rather than his chronological age such a child may well reach an average level of functioning. This is an unanswered issue and it is not known what

would happen under these circumstances.

As a consequence of the research reviewed, it is felt that maturational age should predict the child's ability to assimilate the experiences of "Project Head Start" and therefore be more ready for the first grade at the end of the Project than at the beginning. While several studies have dealt with readiness and maturation (Karlin, 1957; Simon, 1959), they have studied the two factors prior to any actual experience. The unique contribution of this paper is to relate maturational age to the ability to assimilate experiences designed to prepare a child for first grade.

CHAPTER II

PURPOSE

The purpose of this research was to investigate the usefulness of skeletal age as a predictor of school readiness in a group of "Project Head Start" children. Specifically there were four hypotheses tested.

Hypotheses

1. Early and late skeletal maturers will not differ significantly on the Goodenough Draw-A-Man Test (DAM) administered prior to Project Head Start (Goodenough, 1954).

2. Early and late skeletal maturers will not differ significantly on the Metropolitan Readiness Test (MRT) administered prior to Project Head Start (Hildreth, et al., 1965).

3. Early skeletal maturers will show a significantly greater improvement on the Goodenough Draw-A-Man Test administered during the first and last weeks of Project Head Start, than will Late skeletal maturers, when age and sex are controlled.

4. Early skeletal maturers will show a significantly greater improvement on the Metropolitan Readiness Test administered during the first and last weeks of Project Head Start than will Late skeletal maturers, when age and sex are controlled.

Investigation of these four hypotheses served the purpose of attempting to relate skeletal maturation to a child's ability to assimilate and make use of kindergarten kinds of experiences, thus making him ready for the first grade.

CHAPTER III

METHOD

The subjects for this research were enrolled in Project Head Start in Cleveland County, Oklahoma. This provided a relatively homogeneous economic group since enrollment in Project Head Start was limited to families under a given income level. While the economic level was constant throughout the sample it included subjects from both rural and urban areas. All subjects were Caucasian children born in the United States (Greulich & Pyle, 1959). Studies have been reported (Eichorn, 1963) which demonstrate that certain kinds of pathology interfere with the normal growth of the skeleton, and including such cases might bias the sample and contaminate the results. Therefore, on the basis of a medical-social history obtained by a Public Health nurse, any child with a known endocrinological difficulty, glandular malfunctioning, or history of any other serious illness known to effect skeletal growth was excluded from the sample. The decision to exclude any such child from the sample was made after consulting a pediatrician who evaluated the child's medical history in terms of possible influencing factors on skeletal growth.

The final sample consisted of 40 males and 40 females ranging in age from 5 years 4 months to 6 years 10 months.

Procedure

The first phase of data collection consisted of obtaining an X-ray of the left wrist of each child in the study. There is a close correspondence in the skeletal status of the right and left hand so that only one wrist need be used (Dreizen, 1957; Greulich & Pyle, 1959). Following the procedure usually used in studies involving carpal X-rays the left wrist was X-rayed in the present study.

The X-ray machine was provided by the Cleveland County Public Health Center in Norman, Oklahoma and met all the specifications for safe X-ray procedures. The machine and conditions of use were approved by the medical director of the Center. The films were taken and developed by a trained X-ray technician. The usual protective measures were used during the procedure with the addition of an X-ray apron placed over the child's body.

The X-rays were read for skeletal age according to the Greulich and Pyle norms, by a Diplomate of the American Board of Radiologists. As a control the Radiologist did not know the birthdate of the given child and a skeletal age was assigned blindly. After randomizing the X-rays the Radiologist chose every third X-ray to re-assess as a reliability measure. There was disagreement on the second reading for only one X-ray which was subsequently not used in the study because of the anomalous nature of the child's wrist. For a further discussion of the applicability of the Greulich and Pyle norms and technique to this sample see Appendix A.

In this sample 155 of the 160 subjects X-rayed fell within plus or minus two standard deviations of the corresponding Greulich

and Pyle means. The average skeletal age for this sample was 6.6 months below the average chronological age with a standard deviation of 15.6. For the purposes of this study any subject whose chronological age was greater than his skeletal age was placed in the Late Maturing group. Any subject whose skeletal age was greater than his chronological age was placed in the Early Maturing group. Although these two groups represent early and late skeletal maturers in that their skeletal age deviates from their chronological age, they can be considered essentially a normal rather than a pathological group in terms of skeletal maturation.

From the total sample of 160 subjects it was possible to have 17 subjects at each level of skeletal maturation, chronological age and sex, for a total of 136 subjects. However, after this research had been designed and approval obtained from the Cleveland County Head Start Director, one school district refused to allow administration of the Metropolitan Readiness Test to their group. The principal of the school wanted to use this test for these pupils when they entered the first grade and felt that having them take the test during Project Head Start would influence his results. In addition, illnesses at the time of the administration of one of the tests and withdrawal from the Project reduced the original sample to 87 subjects who took both the Goodenough Draw-A-Man Test and the Metropolitan Readiness Test. In order to have equal groups it was necessary to eliminate 7 subjects. This was done by using a table of random numbers (Wallis & Roberts, 1956) and reduced the total sample to 80 subjects.

Materials

To test the four hypotheses two instruments were used.

The first was the Goodenough Draw-A-Man Test (DAM). A meeting was held with the Cleveland County Head Start Teachers and they were instructed as to the day the DAM was to be administered and the method to be used. The instructions were provided on a mimeographed form and were exactly those suggested by Goodenough (1954). The teacher put the date of administration and the child's name on each drawing. The first drawings were obtained on the third day of the first week of the project and the second drawings on the third day of the last week of the Project. The same teachers administered the pre and post tests in the same classroom under the same set of directions.

The DAM tests were independently scored by the author and by another advanced graduate student in clinical psychology. Both scorers were thoroughly acquainted with the scoring system. On any drawing where there was not complete agreement as to IQ and MA it was re-evaluated by both scorers and a third advanced graduate student in clinical psychology, until there was agreement. Thus a reliability coefficient was not necessary since there had to be complete agreement on each drawing. In one case, agreement could not be reached and the subject was eliminated. The drawings were scored without the knowledge of which "maturation" group the given subject was in.

Goodenough (1954) reports a .937 $\pm$ .006 correlation between the original scores earned by 194 first grade children on the DAM and the scores on a retest on the following day. The probable error of estimate

of a "true IQ" earned on the DAM is reported as approximately 5.4 points at all ages from five through ten years (Goodenough, 1954). The correlation between the IQ obtained on the DAM and the Stanford-Binet IQ is reported as .699 $\pm$ .035 and .832 $\pm$ .025 for five and six year old children respectively.

The second set of material used for the study was the Metropolitan Readiness Test (Hildreth, et al., 1965). This test (MRT) was designed to measure the degree to which school beginners have developed in various abilities thought to be prerequisites for first grade instruction. It was devised to test children at the end of kindergarten or upon entering first grade.

The MRT was particularly applicable to the testing of Hypotheses 2 and 4. It provided a measure of "readiness" prior to and after the Head Start experience for both Late and Early Maturers. This permitted a direct comparison of the benefit both groups had derived from the Project. The test is divided into six sub-tests designed to measure vocabulary, visual-perceptual skills, alphabet recognition, numerical concepts, listening comprehension, and preceptual-motor skills.

Because the intercorrelations for all of these subtests are relatively high and positive, only the total score was used in the analysis. The total score reliability between the two Forms of the test is reported "as above .90" (Hildreth et al., 1965).

The group form of the MRT was administered in the classroom by the Project Head Start Teachers on the fourth day of the first week and the fourth day of the last week of the Project. The MRT

has two forms, S and R. Half the subjects were given Form R and half Form S on the pre-administration. On the post testing the Form was opposite to the pre Form for each subject. The teachers were instructed in the administration of the test and were provided with an instruction manual which has the precise directions to be given. The tests were scored by the author of this dissertation using the scoring key provided. A final readiness score was obtained by counting the total number of correct responses.

Statistical Treatment of the Data

The primary statistical analysis for this study was an analysis of variance. The basic design of this study is presented in Figure 1. This design involved the effects of five factors each at two levels, chronological age (A), skeletal age (C), "test" (T), "measurement" (M), and sex (S). The chronological age factor consisted of ages five and six, skeletal age consisted of early and late skeletal maturers, "test" was made up of the DAM and MRT, "measurement" consisted of the pre and post Head Start testings, and sex represented males and females which made up the sample. Since the DAM and MRT had different means and standard deviations, all scores were transformed to yield a distribution having a mean of 50 and a standard deviation of 10 (Nunnally, 1964).

In addition to the analysis of variance several correlations are presented for further clarification of the data collected. All original scores are presented in Appendix B.

Draw-A-Man Test

	Males				Females			
	CA 5		CA 6		CA 5		CA 6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Early Maturers								
Late Maturers								

Metropolitan Readiness Test

	Males				Females			
	CA 5		CA 6		CA 5		CA 6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Early Maturers								
Late Maturers								

Fig. 1. Basic design of this study involving the effects of five factors

CHAPTER IV

RESULTS

The four hypotheses are restated below with their statistical tests. The primary statistical analysis was an Analysis of Variance, described in Chapter III. The total sample consisted of 80 children, 40 males and 40 females. There were 10 subjects at each level of skeletal maturation, sex, and chronological age. The mean squares, degrees of freedom, F values and their significance levels are presented in Table 1.

Hypothesis 1

Early and late skeletal maturers will not differ significantly on the DAM test administered prior to the Head Start Project.

Table 2 presents the mean IQ scores and standard deviations on the first administration of the DAM.

Table 1

Analysis of Variance of Sex (S), "Test" (T), Chronological Age (A), Measurement (M), and Skeletal Age (C)

Source of Variation	Mean Squares	df	F	Signif. .01 level
S	136.50	1	.807	
T	9.40	1	.079	
C	346.53	1	2.050	
M	1342.49	1	47.390	*
A	246.75	1	1.460	
ST	136.50	1	1.149	
SC	100.13	1	.592	
SM	1.27	1	.051	
SA	73.15	1	.432	
TC	6.33	1	.053	
TM	209.52	1	7.228	*
TA	1228.53	1	10.341	*
CM	6.22	1	.291	
CA	229.50	1	1.358	
MA	53.10	1	1.875	
STC	60.38	1	.508	
STM	1.24	1	.042	
STA	1.38	1	.011	
SCM	2.39	1	.084	
SCA	299.70	1	1.773	

Table 1 (Continued)

Source of Variation	Mean Squares	df	F	Signif. .01 level
SMA	2.80	1	.099	
TCM	41.44	1	1.429	
TCA	47.28	1	.397	
TMA	1.43	1	.049	
CMA	8.03	1	.283	
STCM	14.76	1	.509	
STCA	28.13	1	.236	
STMA	1.12	1	.038	
SCMA	9.97	1	.352	
TCMA	59.85	1	2.064	
STCMA	24.41	1	.842	
ASC(R)	168.98	72		
ASC(RT)	118.79	72		
ASC(RM)	28.33	72		
ASC(RTM)	27.98	72		

Table 2

Mean IQ Scores and Standard Deviations for the Early and Late Maturing Groups on the First Administration of the DAM

	Males		Females		Total	
	Mean	S. D.	Mean	S. D.	Mean	S. D.
Early Maturers (n=40)	87.4	2.14	87.6	17.1	87.3	19.3
Late Maturers (n=40)	90.6	10.6	91.4	15.3	91.0	13.1

Hypothesis 1 was tested by the TCM interaction. The F value for the interaction was 1.429 which is not significant. Therefore Hypothesis 1 is supported. The STCM interaction tests the significance of the male versus the female means for both Early and Late Maturers. The F value for STCM was .509 which is not significant. Thus males and females in both maturation groups did not differ in IQ score on the first administration of the DAM.

There is a 6.2 difference between the standard deviations of the total Early Maturing Group and the total Late Maturing Group, Table 2, which yields an F max of 2.20 and is significant at the .01 level. This makes it appear that the Early Maturing Group showed greater variability on the first administration of the IQ test than did the Late Maturing Group. However, due to an extreme score in the Early Group a semi-interquartile range was computed which gives the variability within

the second and third quartiles and is a better indicant when the data include an extreme score. Taking half the distance between the second and third quartile for the Early Maturing Group yields a semi-interquartile range of 94. The Late Maturers have a semi-interquartile range of 98. The author does not know of any test of significance for the difference between these but it does not appear that they can be considered significantly different.

Hypothesis 2

Early and late skeletal maturers will not differ significantly on the MRT administered prior to Project Head Start.

This hypothesis was tested by the TCM interaction just as was Hypothesis 1. As stated the interaction was not significant and Hypothesis 2 is supported. The mean MRT scores and standard deviations on the first administration of the test are presented in Table 3.

Table 3

Mean Scores and Standard Deviations on the First Administration of the MRT

	Males		Females		Total	
	Mean	S. D.	Mean	S. D.	Mean	S. D.
Early Maturers (n=40)	58.1	13.3	56.9	13.8	54.8	13.4
Late Maturers (n=40)	58.4	19.1	50.7	16.6	56.2	17.3

Hypothesis 3

Early skeletal maturers will show a significantly greater improvement on the DAM administered during the first and last weeks of Project Head Start than will Late skeletal maturers, when age and sex are controlled. Table 4 contains the means, standard deviations ( ) and the difference between the means for both Early and Late Maturers at both levels of sex and age.

Table 4

Means, Standard Deviations and Differences Between the Means for the Pre and Post Head Start DAM Test Measurements

	Males			Females		
	Mean IQ. 1	Mean IQ. 2	Diff.	Mean IQ. 1	Mean IQ. 2	Diff.
Age 5						
Early Matur.	91.3 (18.1)	97.3 (12.9)	6.0	92.1 (17.7)	99.9 (8.6)	7.8
Late Matur.	95.3 (9.8)	98.1 (9.3)	2.8	94.5 (12.3)	94.6 (9.9)	0.1
Age 6						
Early Matur.	83.5 (23.6	85.7 (13.8)	2.2	82.6 (15.1)	84.6 (9.8)	2.0
Late Matur.	85.9 (9.2)	86.3 (13.0)	0.4	88.4 (17.0)	92.0 (13.3	3.6

Since chronological age, skeletal age, sex and measurement are all involved in this hypothesis the appropriate interaction to use to test it is the STCMA interaction. This yields an F value of .842

which is not significant. Thus on the basis of the analysis Hypothesis 3 is not supported. Because the analysis of variance is based on grouping early and late skeletal maturers without consideration of the degree of precocity or retardation a series of correlations was done to take this into account. Table 5 presents product-moment correlations computed from original measurements between the degree of early or late maturation and the degree of change between the two administrations of the DAM.

Table 5

Product-Moment Correlation Coefficients Between the Degree of Early and Late Maturation and the Amount of IQ. Change on the DAM

	Males	Females
Age 5	+.163 (n=20)	-.013 (n=20)
Age 6	+.147 (n=20)	-.254 (n=20)

None of the coefficients of correlation differ significantly from zero. Thus using the whole range of skeletal variation in the sample the correlations do not support Hypothesis 3 and there is no indication that skeletal age is related to improvement in IQ score.

Hypothesis 4

Early skeletal maturers will show a significantly greater improvement on the MRT administered during the first and last weeks of Project Head Start than will late skeletal maturers, when age and sex are controlled.

Table 6 contains the means, standard deviations and differences between the means for the pre and post administrations of the MRT for both Early and Late Maturers at both levels of sex and age.

Table 6

Means, Standard Deviations and Differences Between the Means for the Pre and Post Head Start MRT Measurements

	Mean Readiness 1	Mean Readiness 2	Diff.	Mean Readiness 1	Mean Readiness 2	Diff.
Age 5						
Early Matur.	56.7 (15.1)	66.7 (11.7)	10.0	52.3 (12.7)	60.6 (11.0)	8.3
Late Matur.	56.2 (15.2)	68.9 (13.3)	12.7	49.1 (15.2)	61.4 (12.2)	12.3
Age 6						
Early Matur.	59.5 (11.7)	68.0 (9.1)	8.5	49.1 (15.7)	57.7 (16.7)	8.6
Late Matur.	60.6 (23.0)	67.0 (23.0)	6.4	64.7 (17.3)	74.0 (15.4)	9.3

Hypothesis 4 is tested by using the STCMA interaction, Table 1. This is the same interaction that was applicable to testing Hypothesis 3. Again the F value was .842 which is not significant and Hypothesis 4 is not supported. None of the differences between the amount of gain made by the Early Maturers as opposed to the Late Maturers are significant. As with Hypothesis 3, a series of product-moment correlations

were performed relating the degree of early or late maturation to the amount of improvement on the MRT. These correlation coefficients are presented in Table 7.

Table 7

Product-Moment Correlation Coefficients Between the Degree of Early and Late Maturation and the Amount of Change on the MRT

	Males	Females
Age 5	-.041 (n=20)	-.300 (n=20)
Age 6	-.118 (n=20)	+.090 (n=20)

All of the coefficients approximate a zero correlation and thus, even when the degree of early and late maturation is considered, Hypothesis 4 is not supported and there is no indication of any relationship between skeletal maturation and the amount of improvement on the MRT.

The analysis of variance yields three sources of variation which are significant at the .01 level of confidence. Factor M has an F value of 47.39 Table 1. M refers to the pre and post measurements collapsing across both levels of sex, skeletal age, chronological age and test. Thus the significance of M indicates that there is a significant difference between the scores on the pre and post measurements for both tests added together. The second factor which is significant is TM which yields an F value of 7.228 (Table 1). TM clarifies the significance of the M factor. Both factors, T and M, have two levels represented by subscripts 1 and 2. Thus T_1 and T_2 refer to the DAM and

MRT, respectively. Likewise M_1 and M_2 refer to the pre and post measurements, respectively. The TM interaction can be analyzed into $T_1M_{1,2}$ and $T_2M_{1,2}$ which is presented in Table 8.

Table 8

Analysis of the Significant Sources of Variance in the Analysis of Variance

Source of Variation	F Value	p
$T_1M_{1,2}$	8.48	.01
$T_2M_{1,2}$	27.50	.01
$T_1A_{1,2}$	7.62	.01
$T_2A_{1,2}$	1.11	NS
$T_{1,2}A_1$	6.12	.05
$T_{1,2}A_2$	4.30	.05

This internal analysis allows a comparison between the mean pre and post measurements of the DAM as separate from the MRT. $T_1M_{1,2}$ yields an F value of 8.48 which is significant. Thus there was a significant amount of improvement between the pre and post mean IQ's for all subjects considered together. The significant difference is in a positive direction with the post mean IQ significantly higher than the pre measurement. This is presented graphically in Figure 2.

$T_2M_{1,2}$ yields an F value of 27.50 which is significant (Table 8). This indicates that on the MRT the sample as a whole performed significantly different on the pre and post measurements. The difference was

again in a positive direction with the post measurement being significantly higher than the pre measurement (Figure 2).

The mean values presented in Figure 2 are the transformed scores so as to make the comparison of the IQ and Readiness tests clearer.

The data indicates that on both tests the sample of Head Start children improved significantly between the first and second measurements. None of the interactions involving skeletal age are significant.

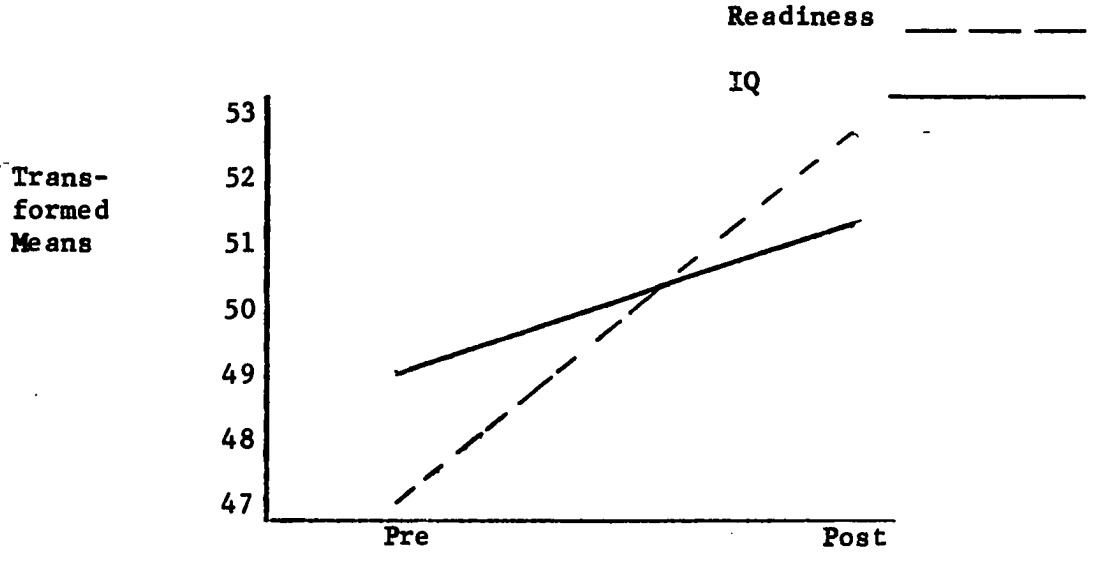

Fig. 2. Transformed Means for Pre and Post Measurements IQ and Readiness Test

The third interaction that was significant was TA which had an F value of 10.34. This indicates that when the pre and post measurements for both tests are combined there was a significant difference between the mean scores obtained by the 5 and 6 year old groups. In order to clarify these data further internal analysis of variance

of the TA factor was necessary (Table 8).

A test of the difference between the 5 and 6 year old groups on just the DAM, $T_1A_{1,2}$ yields an F value of 7.62 which is significant at the .01 level. The transformed mean for the 5 year old group was 53.2 and for the 6 year old group 47.5. This is shown graphically in Figure 3.

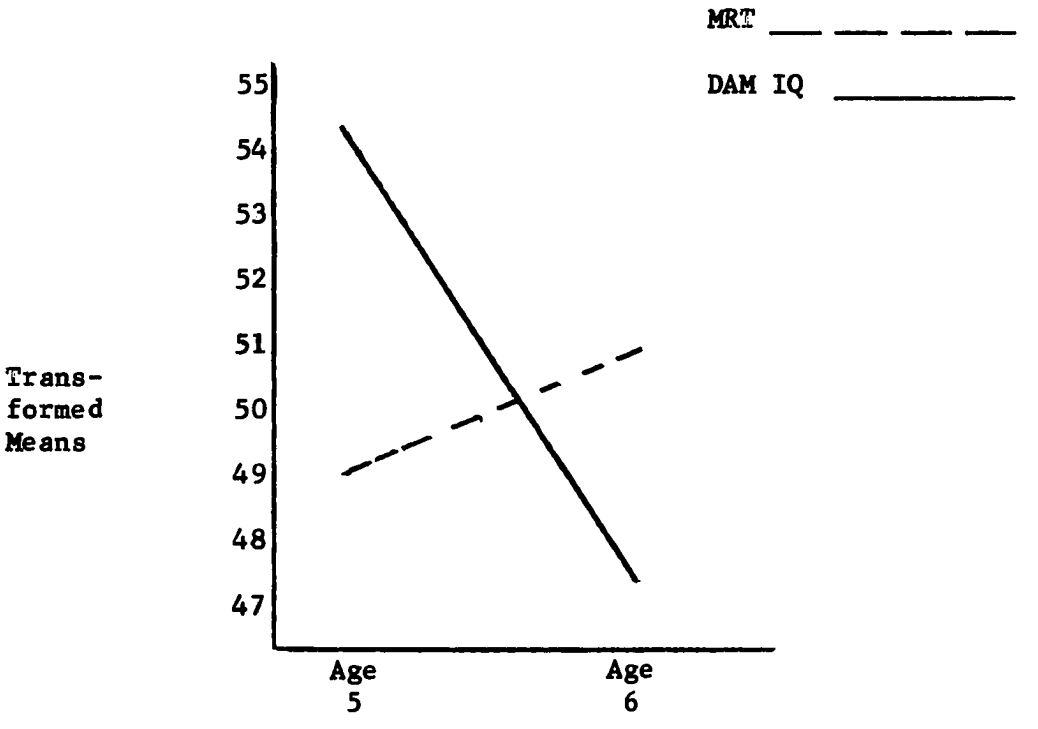

Fig. 3 Transformed Mean Scores for the 5 and 6 year Groups on the IQ Test and Readiness Test taking Both Levels of Measurement Together.

This interaction includes both the pre and post measurements added together. Since TMA is not significant it can be said that the two age groups did not differ significantly on either the pre or post measurements alone but when considered together there was a significant difference.

The test for the difference between the 5 and 6 year groups on the MRT, $T_2A_{1,2}$ yields an F value of 1.11 which is not significant. This indicates that there was not a significant difference between the two age groups on the MRT but there was on the DAM. In the case of the MRT the transformed mean for the 5 year group was 49.0 and for the 6 year group 51.1. While it seems to be in the direction of the 6 year group having the higher score, it is not significant.

Further internal analysis of the TA interaction permits a test of significance between the mean scores on the DAM and the MRT for both age groups. Since transformed scores were used for the analysis it becomes possible to compare the mean performance on the DAM with the mean performance on the MRT. For the 5 year group the mean IQ was 53.2 and the mean Readiness score 49.0. By getting an F value for $T_{1,2}A_1$ the significance between these means can be tested. The F value was 6.122 which is significant at the .05 level but not at the .01 level (Table 8). If the .05 level is accepted then the 5 year group scored significantly higher on the DAM than they did on the MRT.

Performing the same test for the 6 year group, $T_{1,2}A_2$, yields an F value of 4.303 which is again significant at the .05 level but not the .01 level. The mean transformed IQ score for the 6 year group was 47.5 and on the MRT 51.1. Thus at the .05 level the analysis indicates that the 6 year group did significantly better on the Readiness Test than on the IQ test. Figure 3 demonstrated the transformed mean differences for the two age groups on both tests.

Since the TM interaction (Tables 1 & 8) was significant, and the factors of sex, age, skeletal age did not have any bearing on the significant improvement that occurred between the pre and post measurements on both tests, a series of product-moment correlations between the original score obtained and the amount of change, were performed. The first considered is the DAM. Table 9, contains the correlation coefficients.

Table 9

Correlation Coefficients Between Original IQ and the Amount of Change on the Post Measurement

	r	p
Age 5 (n=40)	-.643	.01
Age 6 (n=40)	-.674	.01

In order to interpret these correlations accurately it is necessary to find the correlation coefficient between pre and post IQ scores. These are presented in Table 10 along with the means and standard deviations for each group.

On the basis of these correlations the lower the original IQ the greater was the increase in IQ score on the post measurement for both age groups. However, the correlation between the two measurements is significantly greater for the 6 year olds indicating that the 5 year old group made a greater change between pre and post measurements. From the previous analyses this change is in a positive direction.

Table 10

Means, Standard Deviations and Correlation Coefficients for Pre and Post IQ Measurements on the DAM

	IQ 1 Mean	IQ 1 S. D.	IQ 2 Mean	IQ 2 S. D.	r IQ 1 & IQ 2
Age 5	93.3	15.2	97.5	10.5	+.186
Age 6	85.1	17.2	87.1	12.9	+.619

Table 11 contains the product-moment correlations between the original MRT score and the amount of change on the post measurement.

Table 11

Correlation Coefficients Between Original MRT Score and the Amount of Change on the Post Measurement

	r	p
Age 5 (n=40)	-.402	.01
Age 6 (n=40)	-.411	.01

In order to interpret these correlations, as with the IQ change correlations, it is necessary to correlate the pre MRT scores with the post MRT scores. These correlation coefficients, means and standard deviations are presented in Table 12.

Table 12

Correlation Coefficients, Means and Standard Deviations for Pre and Post Readiness Test Measurements

	Readiness 1		Readiness 2		r
	Mean	S. D.	Mean	S. D.	
Age 5 (n=40)	53.5	15.1	66.9	12.5	+.850
Age 6 (n=40)	58.4	18.0	64.1	17.8	+.886

Using the correlations presented in Tables 11 and 12, it can be said that the lower the original score on the MRT the greater was the amount of change on the post measurement. Both groups appear to have changed about the same amount.

CHAPTER V

DISCUSSION

This research evolved from the increasing interest in the literature that chronological age may not be an efficient method of judging an individual's readiness or maturational level. Much evidence has been presented for the inadequacy of chronological age as an index of maturation, and the need for a substitute or adjunct method (Eichorn, 1963; Falkner, 1962; Jersild, 1960; Johnston, 1964; McCandless, 1961). The use of mental age or IQ has been the most common adjunct method of evaluating school readiness, but its effectiveness diminishes when the children of concern are from low socio-economic environments and may represent a culturally deprived group.

Hypotheses 1 and 2 stated that early and late skeletal maturers would not differ significantly on an IQ test (DAM) and readiness test (MRT) administered prior to Project Head Start. These hypotheses were supported. It was assumed that both the Early and Late Maturers of this Head Start Project were from a homogeneous environmental background. Therefore, both groups would have experienced essentially the same kind of cultural deprivation and would not have had the necessary experiences for the maturational factor to differentiate them. Had Hypotheses 3 and 4 of this research been supported, the interpretation of Hypotheses 1 and 2 would have been different.

However, all that can be legitimately said on the basis of the data collected in this study is that Early and Late Skeletal Maturers of chronological ages 5 and 6, from a low socio-economic enviroment, did not differ significantly on the DAM or MRT.

Hypothesis 3 predicted that the Early Maturers would differ significantly on the DAM administered at the end of Project Head Start. This hypothesis was not supported. The assumption underlying the hypothesis was that the Early group would be better able to assimilate the experiences of Project Head Start and consequently would manifest greater improvement (Jersild, 1960; Weiss, 1962).

Hypothesis 4 predicted that the Early Maturers would show more improvement on the MRT than the Late Maturers. The rationale behind this hypothesis was essentially the same as for Hypothesis 3. The assumption was that if early skeletal maturation reflected a situation of more "potential readiness," then with Project Head Start providing the necessary stimulation for this potential to be realized the Early Maturers should be more nearly ready for the first grade at the end of Project Head Start than the Late group. This hypothesis was not supported by the data.

This research has not demonstrated that early and late maturation as measured by skeletal age has any relation to the ability to assimilate the kinds of experience Project Head Start provided. As stated in Chapter 1, others have reported low but positive correlations between the rate of physical maturation and intelligence (Abernethy, 1925, 1936; Flory, 1936; Jones, 1958; Kugel, 1963; Mosier et al., 1965). These studies have dealt with two kinds of samples. Their

subjects were children of "average intelligence" from middle to upper socio-economic environments or institutionalized mental retardates. None has specifically been concerned with a sample from a low socio-economic stratum as has the present research.

Since in the present study there was no significant relationship between skeletal age and intellectual level, the crucial element may be the environmental situation of the sample. One could speculate that in an environment where there is a "normal" amount of experience available, early and late maturers do differentiate functionally. However, when there is a paucity of experiential possibilities, the opportunity for this differentiation may not be present. This is what was stated in Hypotheses 1 and 2 and was essentially supported. However, if a higher level of maturation reflects the potential for a higher level of functioning, there should have been a greater amount of improvement in the Early Maturers.

To make clearer the possible explanations of the results obtained, the additional findings will be presented first.

Project Head Start provided a situation in which children from socio-economically deprived families could have certain educational experiences. In an eight-week period, the children gained significantly on an IQ measure and a school readiness test. The correlations between original IQ and the amount of change that occurred on the second IQ measurement indicate that the lower the original IQ, the greater the change.

This is also the case for the MRT. Since there was not a significant difference between Early and Late Maturing groups, the re-

sults can be discussed in terms of chronological age groups. The standard deviation on both "tests" and for both age groups decrease from the pre to post measurements. Along with the negative correlations between original score and the amount of change, this can be interpreted as a "levelling" effect rather than a "regression toward the mean" (Anastasi & Foley, 1949). The results then indicate that those subjects with low DAM IQ's and low MRT scores improved more than those with high scores, and in some cases the high score subjects decreased in score on the second measurement.

One explanation of this is that Project Head Start is geared at a certain level and those subjects with higher IQ's and perhaps from less psychologically impoverished homes may have either been bored and not able to function adequately or were forced to adapt to a lower level of functioning to adjust socially to their peers and teacher. This raises the question of the advisability of differentially placing children in Project Head Start according to IQ. It is possible that there should be classes geared at higher levels for those children of higher IQ's in much the same way that some elementary schools are organized.

The 5 year old group had significantly higher IQ's than the 6 year old group on pre and post measurements considered together. However, the age groups did not differ significantly on the MRT even though 6 year olds did score higher. On the basis of previous research, (Baer, 1958; Carter, 1956; Hildreth et al., 1965; Weiss, 1962) the 6 year group should have scored significantly higher. None of these studies cited, however, used samples from socio-economically deprived environments.

Although the difference in the amount of change made from the pre to post measurements is not significantly different for the two chronological age groups, by referring to Tables 4 and 6, it can be seen that in each instance the 5 year group changed more than the 6 year group. This is true for both the IQ and Readiness tests. Since the differences are not significant, they can only be discussed as a trend or tendency toward significance.

Since the two age groups are from the same sample of children, it seems plausible to speculate that the environmental deprivation they have experienced has had a more profound effect on the children that have already reached the sixth year than it has had on those that are only 5 years old.

It has previously been well established empirically that environment can seriously interfere with intellectual growth and development. Therefore, it seems reasonable to conclude that the longer the exposure to a sterile and intellectually restricted environment the greater are the crippling effects. When the intellectual superiority of the 5 year olds over the 6 year olds is viewed in this light, it raises additional questions concerning possible differences between 5 year olds and younger children. Speer (1940) showed that children reared in impoverished homes by retarded mothers show a progressively decreasing IQ from age 1 to age 13.

This might indicate that even more rewarding results might be achieved by expanding Project Head Start or similar educational experiences to younger ages, assuming that such intervention could be carried out on a wide enough scale to compensate for the impoverishment

of the home.

It has been stressed throughout this paper that maturation can be interfered with by environment. If this is the case, it might very well be that the homogeneous backgrounds of the children in this study did not provide the essential factors which produce functional differences directly related to maturation. Since the cultural impoverishment was so pervasive, the Early Maturers might have had no real opportunity to realize the increased capacity resulting from advanced maturation. Perhaps this explains why studies dealing with higher socio-economic groups have found functional differences related to maturation.

In conclusion, skeletal age on the basis of this research does not seem to be useful as a predictor of school readiness for children between the chronological ages of 5 and 6 from low socio-economic environments. The research has demonstrated a decided difference in the functioning of the 5 and 6 year old groups. This difference is interesting and its implications important enough to warrant the suggestion of further study in this area.

CHAPTER VI

SUMMARY

The purpose of this research was to explore the possible usefulness of skeletal age as a predictor of school readiness. The literature suggests that maturation is a crucial variable in school readiness and the present educational system relies almost entirely on chronological age as the index of maturational level. This does not take into consideration the individual child and his unique rate of maturation. The need for an adjunct measure of maturational level is presented in the literature and finding a useful one clearly has wide implications for developmental psychology. Skeletal age is one of the best single predictors of the rate of physical maturation in a given child. Consequently, this research attempted to investigate whether it could be used also as an index of those aspects of maturation which go into making up school readiness.

The subjects for the research were 80 children between the ages of 5 and 6 enrolled in Project Head Start in Cleveland County, Oklahoma. On the basis of carpal X-rays, 40 Early and 40 Late Maturers were found and administered the Goodenough Draw-A-Man Test (DAM) and the Metropolitan Readiness Test (MRT) prior to and after the Project Head Start experience. The study predicted that the early skeletal maturers would be better able to assimilate the Head

Start experiences and would improve more than the late skeletal maturers. This hypothesis was not supported and the conclusion from this research is that with children from deprived socio-economic environments within the average range of intelligence between the chronological ages of 5 and 6, skeletal age is not a useful predictor of a child's readiness to assimilate first grade experiences.

The data collected indicate that Project Head Start served the purpose of providing these underprivileged children with the kinds of experiences that enabled them to improve significantly on both an IQ measure and a school readiness test from the first to last weeks of the Project. However, it also suggests that those with lower IQ's initially improved more than the higher IQ children. In some cases the higher IQ children decreased in performance on the second measurements. This raises the question of the advisability of differentially placing children in Head Start classes according to IQ.

A further finding of this research was that the 5 year old group had significantly higher IQ's and tended to benefit more from the Project Head Start experience than the 6 year old group. This suggests that the additional year of exposure to the culturally deprived environment that the 6 year old group has experienced has served to further decrease their intellectual level of functioning. Possibly, extending Project Head Start to include children younger than 5 might prove even more rewarding.

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APPENDIXES

APPENDIX A

Applicability of the Greulich and Pyle Method to This Study

It has been pointed out in the literature that the rate of skeletal development varies among people of different races, each seeming to have a different norm (Greulich & Pyle, 1959; Low et al., 1964). For this reason only Caucasian children born in the United States were included in the sample. The Greulich and Pyle standards are based on Caucasian children born in the United States of North European ancestry and mostly from slightly above average income families. However, Greulich and Pyle state:

> These standards can be expected to fit reasonably well other children of comparable genetic and environmental background . . . that is, the degree of skeletal development of such children will in general correspond rather closely to that illustrated by the standard of the same sex and chronological age in the Atlas. There is no reason to expect that they will fit exactly any other group, nor is it possible to construct standards that will do so, unless each is assigned so wide an age range as to reduce very seriously its value in the assessment of individual children . . . .
>
> Because of genetic differences, children grow and develop at different rates, even when adequately nourished and not handicapped by serious illnesses. There are early-maturing and late-maturing strains in our population, in addition to the great majority who are, in this respect, intermediate between them. These differences are, of course, reflected in skeletal development.
>
> In any chronological age group in a given popu-

> lation, the relative number of children who are fast, slow, or intermediate in their rate of physical development will determine the average, the mode, and range of skeletal age of that group. It is quite unlikely that these various rates of development will occur in the same proportions in representative groups of children of the same chronological age in any two or more different parts of the United States. Regional differences in the incidence of illnesses, and nutritional inadequacies that can retard the physical growth and development of children contribute further to producing a marked diversity in the skeletal status among children of the same sex and age in different parts of the country. It is not surprising, therefore, that no single set of skeletal standards will fit them all equally well.
>
> But standards do not have to fit in order to provide an adequate assessment of skeletal status. Even though they are somewhat or even much advanced or retarded as compared with the rate of skeletal development of a group of children to whom they are applied, one can still use them to determine how the skeletal status of any child in that group compares with the others of his age and sex, as well as with the children on whom the standards are based. It is often more important to know how a child compares developmentally with others in his own particular group than with children of our Research Series (1959, p. 40).

In this study the interest is in how a given child compares with his group and even though the sample chosen differs from the standardization sample, the technique is applicable. The Head Start sample used in this research is from low income families which is different from the economic status of the Greulich and Pyle standardization group. Greulich and Pyle (1959) report a study by H. C. Stuart at the Harvard School of Public Health in Boston, with children from a less privileged environment than their sample. Stuart's results compared well with those of the Greulich and Pyle study and with only one exception the values he obtained fell within two standard deviations of the corresponding means Greulich and Pyle obtained.

APPENDIX B

Table 13

Raw Scores on Both Administrations of the Metropolitan Readiness Test, Grouped According to "Maturation Level," Sex and Chronological Age

Females, Age 5, Early Maturers			Females, Age 5, Late Maturers		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
61	59	68	71	28	42
62	82	80	72	53	67
63	39	51	73	36	57
64	35	59	74	60	73
65	52	50	75	80	87
66	59	71	76	29	47
67	54	66	77	62	59
68	50	63	78	51	64
69	53	58	79	49	63
70	40	40	80	43	55
Females, Age 6, Early Maturers			**Females, Age 6, Late Maturers**		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
41	60	73	51	86	90
42	66	78	52	55	69

Table 13 (Continued)

Females, Age 6, Early Maturers

Subject's Code No.	Test I	Test II
43	45	45
44	52	58
45	31	46
46	14	20
47	59	68
48	69	73
49	49	52
50	46	64

Females, Age 6, Late Maturers

Subject's Code No.	Test I	Test II
53	32	65
54	58	65
55	45	45
56	76	82
57	57	73
58	83	79
59	84	86
60	71	86

Males, Age 5, Early Maturers

Subject's Code No.	Test I	Test II
1	33	61
2	31	52
3	69	82
4	65	73
5	74	77
6	45	46
7	49	55
8	70	77
9	68	74
10	63	70

Males, Age 5, Late Maturers

Subject's Code No.	Test I	Test II
11	22	34
12	46	66
13	54	65
14	44	71
15	62	67
16	81	88
17	58	77
18	64	71
19	67	74
20	64	76

Table 13 (Continued)

Males, Age 6, Early Maturers			Males, Age 6, Late Maturers		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
21	72	70	31	84	79
22	80	86	32	48	66
23	56	70	33	32	41
24	57	63	34	65	80
25	63	64	35	83	85
26	48	63	36	15	19
27	66	78	37	49	59
28	63	72	38	71	83
29	36	51	39	90	88
30	54	63	40	69	78

Table 14

Raw Scores on Both Administrations of the Goodenough Draw-A-Man IQ Test

Females, Age 5, Early Maturers			Females, Age 5, Late Maturers		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
61	124	92	71	76	95
62	117	110	72	106	103
63	97	86	73	100	110
64	75	94	74	88	86
65	101	103	75	112	96
66	91	101	76	111	108
67	91	97	77	85	78
68	69	101	78	81	83
69	69	118	79	86	92
70	87	101	80	100	93
Females, Age 6, Early Maturers			Females, Age 6, Late Maturers		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
41	109	95	51	104	97
42	68	70	52	80	81
43	88	97	53	77	83
44	103	92	54	90	104
45	65	85	55	69	74
46	60	82	56	116	121
47	92	90	57	113	97

Table 14 (Continued)

Females, Age 6, Early Maturers

Subject's Code No.	Test I	Test II
48	82	65
49	78	84
50	81	86

Females, Age 6, Late Maturers

Subject's Code No.	Test I	Test II
58	63	88
59	91	96
60	81	79

Males, Age 5, Early Maturers

Subject's Code No.	Test I	Test II
1	78	110
2	75	111
3	120	123
4	109	93
5	77	88
6	74	97
7	87	85
8	84	81
9	85	86
10	124	99

Males, Age 5, Late Maturers

Subject's Code No.	Test I	Test II
11	103	113
12	83	85
13	101	103
14	99	88
15	99	108
16	93	90
17	86	100
18	116	88
19	84	99
20	89	107

Males, Age 6, Early Maturers

Subject's Code No.	Test I	Test II
21	72	70
22	108	79
23	118	104
24	71	69

Males, Age 6, Late Maturers

Subject's Code No.	Test I	Test II
31	81	80
32	103	112
33	74	64
34	92	74

Table 14 (Continued)

Males, Age 6, Early Maturers			Males, Age 6, Late Maturers		
Subject's Code No.	Test I	Test II	Subject's Code No.	Test I	Test II
25	87	85	35	83	88
26	30	80	36	81	83
27	71	69	37	73	79
28	104	106	38	84	100
29	84	99	39	91	96
30	90	96	40	97	87

Table 15

Chronological Age and Skeletal Age

Subject's Code No.	CA Mos.	SA Mos.
1	69	81
2	68	69
3	70	81
4	69	75
5	70	75
6	69	75
7	69	75
8	68	69
9	71	81
10	68	81
11	70	57
12	69	33
13	68	57
14	70	69
15	70	69
16	71	69
17	70	57
18	70	63
19	68	57
20	71	69
21	75	81

Table 15 (Continued)

Subject's Code No.	CA Mos.	SA Mos.
22	78	81
23	79	81
24	76	81
25	76	81
26	73	81
27	76	87
28	72	75
29	72	75
30	77	87
31	81	57
32	73	39
33	73	33
34	75	57
35	80	57
36	78	75
37	74	57
38	79	75
39	76	57
40	74	69
41	77	81
42	80	81
43	75	87

Table 15 (Continued)

Subject's Code No.	CA Mos.	SA Mos.
44	76	81
45	79	81
46	75	81
47	78	93
48	77	87
49	77	81
50	78	93
51	75	69
52	83	63
53	74	69
54	73	57
55	79	57
56	75	51
57	72	69
58	76	57
59	79	75
60	78	53
61	70	81
62	69	81
63	68	69
64	68	81
65	68	81

Table 15 (Continued)

Subject's Code No.	CA Mos.	SA Mos.
66	69	75
67	69	75
68	68	69
69	68	69
70	69	75
71	71	69
72	71	69
73	69	57
74	68	63
75	67	57
76	70	57
77	71	63
68	70	63
79	70	33
80	68	57