To the Graduate Council:

I am submitting herewith a dissertation written by Joseph August Baust, Sr. entitled "Tooth Eruption/Cognitive Development/Arithmetic Computation." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Curriculum and Instruction.

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# TOOTH ERUPTION/COGNITIVE DEVELOPMENT/ARITHMETIC COMPUTATION

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

Joseph August Baust, Sr.

June 1976

## DEDICATION

I would like to dedicate this dissertation to the "spirit" of humanistic education and expectation that was so evident by the practices of Dr. Paul Burns, Dr. A. Montgomery Johnston, Dr. Donald Dessart, and Dr. John Ray in their understanding that the ability to do a "good job" as an advanced degree candidate goes beyond the criteria of test scores. It was because of their faith in my ability to achieve in the program that I am most grateful.

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## ABSTRACT

The problem of the study was to investigate whether readiness for beginning formal arithmetic, typified by the types of skills required by arithmetic computation, or the Conservation of Number could be predicted by the eruption of the permanent incisors, chronological age, or the combination of chronological age and tooth age.

Sixty-six children were randomly selected for the testing so that there were 33 boys and 33 girls in the sample. The children were first grade, middle-class, Caucasoids from Knoxville, Tennessee. The chronological age of each child was computed in months, and each child had his teeth photographed to check for the gingival eruption of the permanent incisors. An arithmetic computation test from the Wide Range Achievement Test, Level I, and the Conservation of Number task by Wohlwill and Lowe (1962) was administered to the entire sample population on an individual basis.

Bivariate and multiple correlations with an analysis of variance and a regression coefficient were used to test the two hypotheses and four augmentive research questions for (a) children, (b) boys, (c) girls.

In all instances the use of tooth age as a predictor of either arithmetic computation or the cognitive

level on the Conservation of Number task was not reliable. Chronological age as a predictor of arithmetic computation or the Conservation of Number task was not sufficient to warrant its use; however, significance was established in the case of boys and the entire group of children when chronological age was used as a predictor. Chronological age and tooth age used as a predictor of arithmetic computation scores or the Conservation of Number task proved equally inadequate for all of the subgroups. The amount of variance explained by either tooth eruption, chronological age, or both chronological age and tooth age was extremely low for both arithmetic computation scores and the Conservation of Number task.

The conclusions made from the research were that formal arithmetic readiness could not be attached to either a chronological age or a tooth age. It was also found that the level of cognition assessed by the Conservation of Number task could not be explained by the use of either a chronological age or a tooth age.

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## I. INTRODUCTION

Readiness, a term signifying finding an optimal time for learning and fitting the curriculum to children, should have a great significance in mathematical teaching and learning. It is this attempt to find a "best time" for undertaking tasks in mathematico-logical thinking that inspired Jean Piaget's research in the area of how children learn. The questions Piaget has addressed have been germaine to readiness for the types of formal computational and arithmetic activities children are confronted with during the course of their education. Lovell and Ogilivie (1961), Smedslund (1961), Wohlwill and Lowe (1962), Elkind (1961) and others, have continued the efforts toward the application of Piagetian concepts as they apply to readiness for particular subject areas and especially arithmetic.

Suydam and Riedesel (1972) stated from their review of general research in elementary mathematics that arithmetic should be taught on the basis of underlying readiness of the child. This suggests that the approach toward teaching and learning in the arithmetic curriculum should be in the direction of the concepts of Piaget and his followers.

If this be so, of prime importance is the assessment of readiness of children as they enter school for their first formal mathematical experiences. It is the years in school that set the precedent for future learning attitudes toward arithmetic. Because the early experiences are crucial, screening procedures need to be utilized that allow for a thorough understanding of the level of cognitive growth of each child.

Conventionally, children are assumed ready for the rigors of formal learning and teaching when they have reached the chronological age of six years. Usually the child must attend school when this age is reached. This assumes that all children at the chronological age of seventy-two months have reached a level of maturity to enable them to master arithmetic and other subject areas. Additional means of screening children for the types of activities required in first grade classrooms appear necessary.

Piagetian tasks are one means which have been used to assess readiness for formal number work. The identification of specific patterns of physical and cognitive growth as they join in the process of maturity is another means researchers have suggested. Olsen and Hughes (1942) refer to the "underlying unity" between the physical and the cognitive, and assert that there is a relationship between readiness for learning and growth factors of the child.

Piaget (1964) has suggested that intellectual development is dependent in part upon the physical development of the child as one of the four factors involved in total cognitive maturity. Thus, Olsen and Hughes (1942) and Piaget (1964) agree that cognitive growth as shown by the types of learning required by children in early arithmetic curriculum and physical growth may form the bonds of readiness.

Ilg and Ames (1964) point out that the eruption of permanent teeth may be a good supplemental indicator for school readiness, and a more specific means to observe a child's intellectual maturation level. Ilg (1975) thinks that by the eruption of the permanent, central and lateral incisors, this physical growth corresponds to the transition of the child from Piaget's Pre-Operational Stage, characterized by the inability of the child to perform in computational activities except in rote, to the Concrete Operations Stage, where the child is able to successfully embark upon the mathematics curriculum with understanding.

The premise suggested is the eruption time of the permanent, lateral and central incisors corresponds not only to the stages of cognitive growth and readiness ala

Piaget, but also to the child's ability to perform effectively in the arithmetic curriculum in the first grade.

## II. STATEMENT OF THE STUDY

The purposes of this study were (1) to assess whether formal learning readiness in beginning mathematical skills, arithmetic computation and performance on a selected Piagetian task could be predicted by the gingival eruption of the permanent, maxillary and mandibular, central and lateral incisors in first grade, middle class, Caucasians, and (2) whether chronological age alone or in combination with tooth eruption was more predictive than the aforementioned purpose.

The ease of using this method to supplement traditional means of screening children in the first grade for formal arithmetic work would make it a simple, objective instrument. Additional training is minimal to provide an accurate evaluation of the gingival eruption of the permanent teeth in children.

It was the preliminary hypothesis of this study that children who had first grade gingival eruption of their permanent, maxillary and mandibular, central and lateral incisors are able to perform better on an arithmetic computation test than those children who were non-eruptors or late eruptors.

It was further hypothesized that those children who had erupted their permanent, lateral and central incisors would be those who were entering Piaget's Concrete Operations Stage, while non-eruptors were in Piaget's Pre-Operational Stage, according to a Piagetian task score.

A check of chronological age in combination with tooth eruption and chronological age alone was made to assess whether arithmetic computation and a score on a Piagetian task was more predictable.

## III. PROCEDURES AND SOURCES OF DATA

This study was undertaken during the winter quarter of 1976. Since tooth eruption of the incisors is started in some groups at six years of age, the selection of the population from the first grade was the appropriate group for this study to analyze. The study chose one specific category of the population--middle-class, Caucasian children. This permitted a limitation of the variables to control for socio-economic status, race and age of the children. Middle-class children were chosen to control for malnutrition and deprivation, and the Caucasian race was used entirely because the growth rates of other races do not parallel the Caucasoids. Permission was granted by the Knoxville City Schools in Knoxville, Tennessee, to use their facilities to test students. Classrooms were chosen randomly and an initial list of children was provided by the school selected for the study. From this list, a random selection of pupils for the sample population was chosen.

The population was divided into two groups of thirty-three children each. Since Krogman (1972) and others have found that girls were usually ahead of boys both physiologically and in the cognitive skills, this justified splitting the sample population by sex. The procedure of the study was the following:

| | Phase I | Phase II | Phase III |
|---|---|---|---|
| Boys | Piagetian Task | *Wide Range Achieve-* | Photograph of |
| Girls | Piagetian Task | *ment Test* | S's Teeth |

Both groups received the same treatment and the data were analyzed both as a total population of children and separately by sex, whether male or female.

Since there are a number of Piagetian tasks, it was decided to use the test by Wohlwill and Lowe (1962) for the Conservation of Number. Their technique was placed in a standard form to be used by two raters in the analysis of whether the children were able or not able to Conserve Number. Each child's response was placed on answer forms by the raters, and the final determination was based upon the experimenter's interpretation of the number of correct responses made on the Piagetian task.

Each group was also given the computation portion of the Wide Range Achievement Test which provided for an individual approach for the assessment of computational abilities of each child. A photograph of each child's central and lateral incisors was taken using a Kodak Startech Dental Photography Kit with a one-to-one lens system. Two expert raters from the Department of Anthropology at The University of Tennessee assessed whether each child had achieved gingival eruption of their permanent incisors.

The individual sessions with each child began with some rapport building activities, using poker chips with the children. This enabled each rater to establish an initial one-to-one relationship with each child and to allay any fears the child had with regard to the procedures. The Piagetian task was given first because it allowed flexibility and permitted a getting acquainted time with each student. After the Piagetian task, the computational section of the Wide Range Achievement Test was given. The pictures of the teeth were last in the sequence, as this test seemed the most difficult. Because it was the last portion of the experiment, it did not influence or contaminate any of the verbal/cognitive responses.

Each child was tested for approximately one hour outside of his classroom.

The treatment and design of the experimental data used the suggested concepts of Guilford (1973) for parametric, correlational studies. Both bivariate and multiple correlational techniques with an analysis of variance and a regression coefficient were used to analyze the data.

The following null hypotheses were tested at the .05 level of significance:

$H_1$--There is no significant relationship between tooth age as assessed by gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and arithmetic computation of first grade (a) children, (b) boys, (c) girls.

$H_2$--There is no significant relationship between tooth age as assessed by gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls.

The following questions arose to clarify the original hypotheses.

Question one: Is there a relationship between chronological age as measured in months and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question two: Is there a relationship between chronological age as measured in months and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

Question three: Is there a relationship between the combination of chronological age and tooth eruption and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question four: Is there a relationship between the combination of chronological age and tooth eruption and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

## IV. DEFINITION OF TERMS

The definitions below are limited to those terms used throughout the report of this study and should not be interpreted as being an exhaustive list of terms in conjunction with dentition or cognitive growth.

<u>Central incisors</u>. Those teeth used for cutting food. They are located on either side of middle of the maxilla and mandible.

<u>Conservation.</u> The ability of a child to perform tasks and think logically even when perception changes the appearance of a problem.

<u>Conservation of number.</u> The ability to understand and verbalize that two groups or collections of objects

with the same number will not change when placed in varying group formations.

Eruption of the teeth. It is that moment when the tooth pushes through the gingiva or gum.

Gingiva. This is commonly known as the gum in the oral cavity.

Incisor. A group of teeth in man used for cutting food. They are located at the front entrance of the mouth and are a cluster of four teeth on the mandible and the cluster of four teeth on the maxilla.

Lateral incisors. Those teeth on either side of the central incisors.

Mandible. (Mandibular.) This is the lower jaw.

Maxilla. (Maxillary.) This is the upper jaw.

Occlusal plane. It is the point where the tooth meets with the other teeth to form a biting surface, thus bringing the maxilla and mandible together at this point.

Permanent teeth. Under normal circumstances these are the last or final teeth in the human species. After the loss of these, ordinarily no replacements are possible.

## V. ASSUMPTIONS

1. The schools chosen for the study are middle-class domains as reflected by their constituency and the

fact that the salary range is from ten thousand to thirty thousand dollars per year.

2. Chronological age as it appears on the permanent records of each subject is correct, and the information relayed to the experimenter by the teachers is correct.

3. The raters will follow all of the instructions given for each test and will not favor or assist the subjects.

## VI. DELIMITATIONS

Due to the fact that the population of the study consists of middle-class, Caucasian children of Knoxville, Tennessee, the generalizability of the study to larger populations outside of this framework is not justified. Other races and socio-economic groups outside of the middle class could not be considered in the analysis and summary of the data because these factors differed from population to population; therefore, no inferences can be made to these other populations.

The geographic regions represented in the South reflect specific cultural heritage, temperature, and climatic patterns, thus the data could not show any relationship except in the locale in which the study was undertaken. Ancestry also plays a part in the maturity and eruption of the teeth; and, therefore, the results of the study are pertinent only to the specific population of Knoxville, Tennessee, and its surroundings.

## VII. ORGANIZATION OF THE STUDY

Chapter I contains the introduction, statement of the study, procedures and sources of data, definition of terms, assumptions and delimitations.

Chapter II contains a review of the related literature and correlary research that clearly verify or amplify appropriate portions of the study.

Chapter III contains information and discussion of the sample selection, instrumentation, procedures adhered to, and data analysis.

Chapter IV contains the results and interpretation of the research.

Chapter V includes a summary of the study, results and interpretation of the data, and what implications and recommendations the study has evolved.

# CHAPTER II

## REVIEW OF RELATED LITERATURE AND RESEARCH

Presented in this chapter are the related literature and research that pertains to readiness as an indicator, the brain and achievement, other physical development and achievement, readiness and growth, dentition as a predictor, arithmetic computation readiness, and a synthesis and summary of this information as it relates to the investigated areas.

### I. READINESS AS AN INDICATOR

Learning tends to cluster about many factors related to the growth processes of the child (Olsen, 1949). For seventy-five years researchers have studied to find a specificity in the development of cognitive skills in children as it relates to growth. These efforts have been directed at the documentation through various formal, cognitive tests as the Metropolitan Reading Readiness Test, Otis-Lennon Intelligence Test; more subjective tests, as exemplified by Elkind (1961), Wohlwill and Lowe (1962), Copeland (1972), and Piaget (1952); and intricate assessments of readiness by Kohen-Raz (1969), Pryor and Thelander (1968), and Clark and Jarman (1961) to establish a corresponding relationship between mental and physiological growth in the child. All of these forms have approached testing children for readiness by assessing ability levels either in a total cognitive mode or a combination of physical growth and performance in cognitive skills.

Ogletree (1973) concluded readiness could be placed into two separate classifications: growth readiness where there is an awareness of human development and how it affects the cognitive processes, and cumulative learning model where the mind extracts from experience to build new concepts.

The concept of readiness expressed as a relationship between human growth factors has suggested an integration of when a child has learned effectively and efficiently and at what phase of physiological growth this was accomplished. Olsen (1949) expressed:

> . . . achievement as related to the total growth may be true both in situations where methods are ideal and those where they are less effective (p. 180).

The correspondence of achievement and growth lends credence to the concept of classroom outcomes in the subject areas being related to the growth process in all instances. The hypothesis that there is an "organismic age" despite the many variables that enter into the concept of learning has provided impetus toward the conclusion that the body functions as a system and not as a non-integrative whole.

The average score of a "total age" at a selected point in time is what Olsen (1949) has referred to as organismic age. His organismic theory has provided some reasonable notion to the overall development of the child as it relates to the orderly evolution of growth and the learning process.

Olsen and Hughes (1942) have suggested organismic age was the "underlying unity" between the cognitive processes and the growth of children. Krogman (1962) felt readiness was an optimal time for progress whereby a "best-time" existed for the total organism to express itself in a given task.

Brenner (1957) subscribed to the idea that "fundamental readiness levels" have had a large impact on the success in school for children.

Krogman (1972) stated:

> There is a bio-cultural continuum that there is a synchrony in total growth, that there is a correlation between the physically growing child and the behaviorally developing child, and moreover, that there are intercorrelations within the biological spheres and within the behavioral areas (p. 200).

Krogman (1962) believed that maturational age provided a picture of patterns and readiness for learning behavior. Holtzapfel (1975) expressed the opinion that learning was a process of "inner growth," thus associating the cognitive with maturation and the "organismic age" concept.

Jean Piaget (1952) suggested physical development was one of the areas of growth which contributed to intellectual development. He has provided a rationale for the correspondence of the cognitive and physical growth.

The objective of discovering a "prime-time" for learning via a physiological maturation age has been sought by establishing an indicator of the "inner-being" by means of an outward sign. Brenner (1957) found children who were forced into activity before they were able to undertake the activity were "stultified" accordingly. Tanner and Inhelder (1971) found acceleration of learning done with pigeons showed that those who were not ready to fly and were coerced to try to do so exhibited a proportionate amount of flight retardation. Thus the importance of readiness for learning by children has been placed in perspective by both Brenner (1957) and Tanner and Inhelder (1971).

Readiness has become an important aspect of understanding children and the cognitive processes. It has functioned as a means to identify a "best-fit" for the individual and the curriculum. Krogman (1972), Olsen (1949), and Olsen and Hughes (1942) have suggested readiness be based upon physical growth in concert with cognitive functioning as opposed to the use of chronological age alone as an indicator.

## II. THE BRAIN AND ACHIEVEMENT

There have been a number of studies investigating the relationship of the brain to readiness for cognitive skills and subject matter achievement. From these studies have been established general hypotheses about the growth of the brain and learning.

Nash (1970) emphasized nerve cells and the patterns of their evolvement in the nervous system were a possible key to cognitive conceptual growth. Halleck (1897) thought there was credence to the concept that the connective fibers of the brain were the basis for the association of ideas. He found there was a significant amount of difference between the connective fiber found in a 0.36 square millimeter in the cerebral cortex of a child sixteen months old and that of a thirty-three-year-old man. The "sensory tract for sight" also showed a great difference in the number of the connective fibers present. There was a general gradation of the number of connective fibers in the ages between sixteen months and thirty-three years, warranting a careful inspection of the physical readiness of children to perform certain tasks. These fibers function to relay messages in the brain, with the greater the number facilitating the ease of exchange (Halleck, 1897). Their importance in thinking and performing tasks was amplified by Halleck (1897):

> Do not try to develop the power of thinking faster than the brain furnishes the physical substratum (p. 843).

Jensen (1969) agreed that the factor of readiness was dependent on the growth stage of the brain:

> Not all of the brain's potential neural connections are physiologically functionable until at least seven or eight in the vast majority of children (p. 3).

Davis (1964) concurred with Jensen in thinking that before the seventh or eighth year, the brain was not ready for a number of cognitive as well as physical activities.

Folch-Pi (1955) concluded that the cerebral cortex of the brain in man is slow to develop, verifying man's long childhood. He found that the electroencephalograph patterns of the brain of young children were immature and continued this way for a number of the early growth years. This corroborated Folch-Pi's theory of slow neural development in man. Moreover, Folch-Pi (1955) felt that this measure provided reason for the distinguishing of an age of readiness to better provide for the individual child.

Massler and Kozlov (1961) recognized the brain as an important component in the learning processes. They found that children, as a normal procedure, have some brain damage as a result of the birth process. This is referred to as "aberrant behavior" or the final outcome of damage to the brain caused by delivery of the child. They included difficulty in performing in problem-solving situations, especially arithmetic problems, as an "aberrant behavior." This research has suggested a need for a predictor of child growth and development because of the effect of the physiological forces upon the ability of the child to function in the cognitive.

Jensen (1969), Halleck (1897), Folch-Pi (1955), Nash (1970), and Massler and Kozlov (1961) have successfully related readiness in the cognitive realm is a function of neurological maturation. This work implied specific learning behaviors are highly dependent on the development of the brain and its supportive network.

## III. OTHER PHYSICAL DEVELOPMENT AND ACHIEVEMENT

Boas (1941) surmised:

> The close relationship between anatomical and psychological traits in childhood must be interpreted as due to the influence of the tempo of physiological development over the body and its function (p. 340).

Malina (1968) stated:

> Much of what we observe and measure is simply the external manifestation of more profound physiological processes (p. 5).

Such statements have led to efforts to document a relationship between intelligence quotient and various physical measures as body stature, birthweight, head size, and chest measurement. It was thought by Olsen and Hughes (1942), Krogman (1962, 1972, 1975), Jensen (1969) that although the brain was not easily measured for readiness, the physical attributes associated with the growth process would adequately provide readiness and capacity tests of the underlying brain growth. The purpose of these efforts was to have a measure far more accessible and reliable for the diagnostician.

Other attempts have been made to show correlations between readiness for school and formal learning with either the eyes, ears, motor performance, or tooth eruption. Each has been directed in certain measurement techniques with regard to physical development, and all have been somewhat successful in providing an outward assessment of the inner being through an outward physiological mode.

Clark and Jarman (1961) found physical growth and physique were significantly more matured and developed in superiorally intelligent groups of children. Ketchum (1957) supported this with his study that concluded that gifted children displayed earlier and more pronounced physical and mental growth. This was detected by measuring height, weight, teeth, bone ossification, and grip scores and then correlating the results with scores on the Otis Self-administering Test of Mental Ability, the California Test of Mental Maturity, the Iowa Silent Reading Test, and pupil grade point average. Baldwin (1914) further suggested that tall, heavy boys and girls with good lung capacity were more advanced both physiologically and mentally than other children. Kohen-Raz (1969) found a substantial relationship between physical and mental growth in a group of fifth to eighth grade children when seasons of birth were controlled. In all of the aforementioned, researchers have attempted to distinguish different functioning levels of children both in the cognitive and the physical. The approach has been to measure the physical development of the child and predict readiness or achievement in school subjects.

A study for the National Institute of Education (1974) found there was a significantly different intelligence quotient score for children born weighing less than five pounds and those above that mark. It was established that children who initially weighed more than five pounds at birth performed much better on tests of arithmetic, reading, language and intelligence.

Cooke (1968) found a correlation between balance performance and intelligence quotients as measured by the Iowa Test of Basic Skills. Cooke's research has presented an even closer association between the brain's development and the ability of a child to think logically than other physical measures such as weight, height, et cetera. Pryor and Thelander (1968) reported there was a correlation between microcephalic children, those having head sizes two standard deviations below the norm, and the degree of mental retardation as measured by intelligence quotient. Thus the external features or performances as reported by Cooke (1968) and Pryor and Thelander (1968) confirmed that relationships of significance occur between certain brain related growth functions and the ability to perform in learning tasks.

Clerk (1916), in a study of the cardiovascular system of the child, found there was some merit in the use of professional measure of the blood pressure to assist in assessing the growth of children as it relates to readiness.

Other studies have further suggested that physical growth has a predictive nature for the cognitive. Wheeler (1929) concluded that children who were dull were below normal in all physical growth measures. Kirkendall (1968) discovered motor aptitude of children related with high, medium, and low intelligence groups. Rogen and Gain (1963) found children who had parents with large chest measurements had also significantly higher intelligence quotients.

Although this research has contributed to knowledge, it has not presented readiness and the cognitive as it related to physical growth for practical use.

Grunelius (1966) has taken the position that physical growth should not be a discriminator of intelligence such as Clerk (1916), Wheeler (1929), and others have concluded but should indicate when to make use of instruction wisely with individual children. Grunelius (1966) stated:

> In the human embryo the eyes are protected and the external physical light must not work upon their development. In the same sense external education must not endeavor to effect a training or influence the moulding of the memory before the change of the teeth (p. 43).

Luella Cole (1938) concluded that not more than 10 percent of five-year-olds were able to visually discriminate certain letters. Birch and Leffort (1963) established auditory memory, the type needed for successful school progress, was not in evidence until later than five years. Cole (1938) and Birch and Leffort (1963) agreed that for both visual and auditory discrimination to be sufficient for successful school experiences, the child had to be approximately seven to eight years old. The types of sub-features necessary for a child to be able to discriminate with the numerals nine and six, and various other portions of the arithmetic curriculum have thus been established by the efforts of Cole (1938) and others.

Since both the eyes and the ears were sensors of the brain, Moon, Moore, and Moon (1972) judged they would be an excellent external signal of the readiness of the cerebral cortex, the same segment of the brain that controlled the cognitive. Grunelius (1966), Birch and Lefford (1963), Moon, Moore, and Moon (1972) have suggested that many children need to have prerequisite physical abilities before the cognitive skills are attainable. They have also suggested that readiness is approximate in children and is dependent upon many internal as well as external variables. There was a general consensus among the group that, for the most part, readiness for the types of activities required in the early arithmetic curriculum is acquired at the ages of from seven to eight years.

## IV. READINESS AND GROWTH

Ogletree (1974) stated:

> . . . the child is not fully mature and ready for learning until age seven or eight. His brain is not fully developed, nor are his senses of hearing and sight (p. 409).

Krogman (1975) and Ogletree (1974) concluded that the chronological age of seven was often the point where the brain had reached 95 percent of its adult development. This fact has become a significant correlate of research for readiness in both the physical and the cognitive realms for children. It is at age seven that Piaget (1952), Elkind (1961), Copeland (1972), and Almy (1966) considered the child operational in thought. Thus there seems to be an overlapping of thought from the cognitive psychologists and the physiologists so far as a time for readiness for formal learning in arithmetic.

Ames (1966) suggested that many children enter school as a direct result of compulsory education instead of readiness. Therefore, a child in such a situation must have had the physical and mental equipment to perform in arithmetic, reading and other subjects or not be able to successfully compete with other children of the same approximate chronological age. Ames (1966) would have each child submit himself to three measures to assure that readiness for school had developed. This included a bone ossification test to examine the calcification of the wrist bones dentition test to establish the number of permanent teeth erupted in comparison with the norm, and as also suggested by Cole (1938), an eye examination to inspect the ability of the child to visually discriminate.

## V. DENTITION AS A PREDICTOR

Ilg and Ames (1964) reported:

> Those children who were ahead of schedule in teething, 96 percent were definitely ready for and could profit from academic school experiences. Of those children who were behind schedule in teething, 54 percent should have repeated, 22 percent of this group did repeat, and 40 percent would have profited by repetition (p. 238-239).

This has suggested there may be a tip-off with the inception of second dentition as a means of informing educators whether a child was ready for the type of learning required in an arithmetic curriculum in the first grade.

It has been concluded by Jensen (1969), Davis (1964), Burch and Leffort (1963), and Cole (1938) that the chronological age of seven to eight years is a time when children are capable of performing to their capabilities in the formal curriculum because physiological readiness is present. Ames (1966) implored teachers and school systems to use tooth age as a supplemental test to check for this readiness.

Bean (1914) and Bailett (1975) found the permanent median or central incisors gingivally erupted the maxilla in the ages of from six to nine years in German and American children.

Ilg (1975) stated:

> . . . when that seven-year-old Rubicon is crossed (Piaget's conservation of continuous quantities), I always take a glance at their teeth. If I see two well-erupted upper central incisors with holes on either side from the loss of the upper lateral incisors, then I know the child is nicely into seven years . . . (p. 1).

Rudolf Steiner, the founder of the Waldorf Schools in Europe, stipulated that the period between the loss of the first or "milk teeth" was a critical one because it indicated cognitive and conceptual maturity and was an indicator of where the physiological manifested itself in the cognitive. Steiner schools have screened children for school entrance by the loss of the deciduous teeth because it was felt that this was a positive index of maturation, both biological and mental. Steiner (1968) asserted:

> We begin to teach or educate the child between the changes of teeth and the ages of puberty (p. 41).

He emphasized there should be an integration of thought in all of the areas of physiology, anatomy, and the various other fields that constitute the "total child." This provided for the whole child, and would not constitute a detraction from other growth and development of the child.

Baust (1976) found that 83 percent of the Waldorf Schools in the United States used dentition, either as a partial criteria for readiness for school or as a guide to subject matter skills readiness. Sixteen percent of these schools used tooth age as the sole means of assessing readiness of children.

Steiner and the Waldorf Schools have emphasized there was a "oneness" in the development of the child, and the combination of all of the factors and variables have made an inseparable bond to provide a realization of cognitive growth and maturation.

Ogletree and Laverty (1973) found the eruption of permanent six year molars was related to intelligence quotients, Piaget's levels of growth, and achievement as assessed by teacher judgment.

Ogletree (1974) and Krogman (1975) have suggested second dentition showed the brain had reached to within 95 percent of its development. This has been corroborated by Bean (1914) and Bailett (1975) and their assertion that the incisors erupted in this period. This has additional congruence with the contentions of Jensen (1969) and others in their stand that the brain has developed considerably at the chronological ages of seven to eight years of age.

Attempts have been made to show that dentition was related to intelligence and achievement in schools. Barkla (1966) found mongoloid children under the age of twenty had a slower than normal dentitional pattern. These mongoloid children were also behind other children in cognitive skills. Kraus (1968) found there was a relationship between abnormalities of the dental crowns and mental retardation. Children who were retarded had twenty-nine times greater amounts of abnormal teeth. These children had sub-standard performances in the cognitive skills as well as tooth crown deficiencies. Kraus (1968) has shown that damage to the central nervous system can be mirrored by the growth of the teeth to represent levels of cognition.

Bailett (1975) concluded:

> Low birth weight seems to be associated with retarded permanent tooth eruption (p. 132).

Lathrop (1939) found there was a correlation between feeblemindedness and the eruption time of teeth in women. Sutow (1954) found a significant difference in the number of permanent teeth for the skeletally below and above average child. The skeletally advanced had the larger number of teeth as opposed to the below average group. Beik (1913) showed the time of the eruption of the teeth have a close relationship with overall bodily development. Cohen and Anderson (1931) discovered, in a group of children from five to fifteen years, that subnormal children had fewer permanent teeth at any age.

The teeth, as suggested by Kraus (1968) and Bailett (1975), indicate the total development of the child. Thus the external features of growth, the tooth eruption process, has been suggested as a means of focusing on inward growth. Schour (1960) has shown from research that the pituitary gland was important in the eruption of the permanent teeth. Rats having the hypophysis removed subsequently had a slowing down and cessation of tooth eruption. This malady has also been observed in hypopituitarism where the function of the pituitary was not proper. Moreover, these children who suffered from this had slow development both in the physiological and cognitive sense (Ogletree and Laverty, 1973).

Ogletree (1973) has recorded that the dentitional process, especially the eruption of the permanent teeth, signified the brain had completed growth for the most part, and permitted the forces of the body to concentrate on the thinking processes or Concrete Operations.

There have been studies by Dearborn (1935), Baldwin (1914), and Klausmeier, Check, and Feldhusen (1960) that have shown a low correlation between the number of teeth erupted and mental ages in school. All of these studies have reported correlations of from +.04 to ±.12. Despite these studies, Kraus (1968) and others have indicated a relationship did exist between the teeth and the development of the learning substrata and physiological functioning. Thus the teeth [through the eyes of Bailett (1975), Lathrop (1939), Ogletree (1973, 1974), Krogman (1972, 1975), and Ilg and Ames (1964)] have been suggested as the indicator of physiological, developmental, and cognitive ages of children while it acted as an indicator of overall health of the central nervous system and other supplementary systems.

The value of using the teeth as a developmental tool is elaborated upon by Bean (1914):

> The teeth are more convenient and more exact as a means of determinigg the physiological standard than stature or weight or the growth of the bones. . . . They may be of greater value than any other means that can be utilized (p. 612).

He felt that the identification factor was such that little experience was necessary for positive identification.

The use of the teeth as a predictor has been to associate their growth with achievement via a specific number of teeth erupted (Dearborn, 1935) or the eruption of specific teeth with achievement (Ogletree and Laverty, 1973). Relationships have been varied from very low (Klausmeier, Check, and Feldhusen, 1960) to significant correlations (Ogletree and Laverty, 1973).

Schoor (1960) and others have assigned the age of seven as the mean age for the eruption of the incisors, and this has been precisely the time when Jensen (1969), Ogletree (1974), Steiner (1968), Lovell (1968) have indicated the child's brain and conceptual thought processes were developed enough to function well in school subjects.

## VI. ARITHMETIC COMPUTATION READINESS

The identification of a time when a child is able to understand and assimilate the concept of number has been a critical area of inquiry. It has taken the form of three interrelated categories: (1) establishing readiness for arithmetic through a cognitive stage approach (Piaget, 1952), (2) showing a closeness between physical growth and arithmetic achievement, (3) providing for children in the arithmetic curriculum in a formal fashion at chronological age six.

Piaget (1952) paved the way for studies in the arithmetic application with his cognitive stages of growth. His discovery and research on four distinctive stages--(1) Sensory Motor, (2) Pre-Operational, (3) Concrete Operations, and (4) Formal Operations--placed an emphasis on logico-mathematical thinking that further exposed a pattern of thinking in children. This constructed a more definite time for each stage of development and a corresponding time when children were able to perform certain mathematical tasks. It has been suggested by Piaget (1964) that a critical element in the movement of the child from one stage to the next was physical maturation. Piaget (1952) asserted that there was an orderly process of movement through the stages of development and Copeland (1972), Almy (1966), and others have supported this concept of an orderly progression of evolution via stages of growth. Copeland (1972) has distinguished a child in the Pre-Operational Stage from a child in the Concrete Operations Stage by his inability to reverse thought patterns and perceptual cues. The tasks derived from Jean Piaget's concept of conservation, Wohlwill and Lowe (1962), Elkind (1961) have indicated that a child in the Pre-Operational Stage was not able to reconcile that a group of objects was invariant even when they were moved in several different positions. Those children that had progressed to the Concrete Operations Stage were able to recognize that the difference in appearance did not change the amount in the collection of items in the set. The transition from the Pre-Operational to the Concrete Operations Stage was dependent upon what Piaget (1952) has referred to as conservation or readiness. He felt this concept was the ability of a child to perceive the concept that two similar sets remain similar irregardless of their juxtaposition.

Copeland (1972) thought the Conservation of Number was necessary in order for a child to effectively understand the concept of addition. Copeland (1972) and Lovell (1968) have taken the position that this form of conservation, the Conservation of Number, was not often achieved until approximately seven or eight years of age. Piaget (1953) stated:

> Children must grasp the principle of conservation of quantity before they can develop the concept of number (p. 74).

Steffe (1966) concluded that children in the lower I.Q. group were the children who were in the lower end of the conservation of number task. These children did poorly in the test of addition as well as the Conservation of Number corroborating the fact that the Conservation of Number was necessary for the acquisition of numerical concepts and the arithmetic curriculum in the elementary school.

The importance of prerequisite knowledge has been shown an important factor in the acquisition of arithmetic skills. Messenger (1903) found that two groups of the same quantity may be perceived as different due to the arrangement, closeness, color and size and type of material in the sets.

Steffe (1966) has also acknowledged different patterns of sets have varying effects upon the perception of the child as to the recognition of number and conservation. This has been the same idea Piaget has discussed. The child who was ready for the formal logico-mathematical concepts would be the one who has been able to place sensual stimulation in its proper perspective. This included not being distracted by the variables mentioned by Messenger (1903), Steffe (1966), Piaget (1952, 1953), and others.

Elkind (1961), Lovell and Ogilvie (1961), Wohlwill and Lowe (1962) have all constructed tests based on the concept of conservation, a necessary prerequisite to the meaningful assimilation of arithmetic computation. Fogelman (1972) interpreted Wohlwill and Lowe's (1962) findings to conclude that 50 percent of the population successfully completed their tasks in the Conservation of Number at seven point five years of age.

According to Piaget (1952), the Concrete Operations

Stage has begun if the child was able to see the reversibility of a collection of items in a set when compared to a similar set of elements. This task has been a prime consideration of readiness for arithmetic and has usually been accomplished by children at the chronological age of seven years (Copeland, 1972).

Gates and Taylor (1925) discovered that practice in arithmetic, despite a temporary gain for those persons who had embarked on a program of drill, was not beneficial in the final outcome after several months had elapsed. Rohrs (1930) hypothesized training for skills when maturation had not been achieved was superfluous. Beilin (1970) felt if an arithmetic concept was brought to the attention of a child before the sub-structures were ready, the child would either learn in part or have an extremely tenuous grasp of the idea.

Piaget's classification and the research of others in the area of cognitive growth has indicated that children grow at an individual pace and learn when they are ready. It is the assumption of Piagetian researchers that readiness for arithmetic was predictable by the tasks derived from Conservation of Number. Copeland (1972) felt that the arithmetic curriculum should use these tasks as a means of providing for the individual child.

Other attempts have been made to show a relationship between physiological and cognitive growth in the specific subject area of arithmetic. Klausmeier, Lehmann and Beeman (1959) found children who were developmentally slow were the children who were low achievers in arithmetic. Krogman (1962) suggested from a review of research that boys' physical development levels were correlated significantly with arithmetic achievement. Ilika (1968) found that children who were late entrants in school did better in arithmetic achievement than early entrants.

Ross (1970) discovered that immaturity, abnormal physical conditions and other such maladies could be traced to a significant number of arithmetic underachievers. Dutton (1963) concluded that maturity was a factor in readiness for first grade arithmetic. He found that about one-third of each entering first grade class was ready for the types of formal activities required in the arithmetic curriculum.

Brown and Henderson (1965) reported there were many factors that influenced achievement prediction in arithmetic and other subjects. Physical growth, emotional development, and intelligence were all categories of importance.

## VII. SYNTHESIS AND SUMMARY

Inherent in the concept of conservation, maturation, and arithmetic readiness has been the idea that the child must be able to perceive through the external organs and be able to place the sensual stimulation in proper perspective. It has been suggested there are specific ages in which the visual and auditory stimulation "manifest themselves" and enable specific cognitive skills to be accomplished. These same senses are functioning at a level for success in arithmetic and other subject areas at the age of seven. If the child does not have these organs performing at a level that would allow the assimilation of various concepts, there would be a fixation in a specific cognitive level, due to this non-readiness.

Simultaneously, the brain is developing with the other body parts. It is at the approximate time of seven years that children have the capacity to function at the rate necessary for the types of understanding involved in formal arithmetic computation. The brain has reached 95 percent of its adult growth at age seven to eight years, the age when Jean Piaget's Concrete Operations Stage has progressed in children. The Concrete Operations Stage has indicated a readiness for more substantive arithmetic understanding. It has been for this reason children have been shown to perform substantially better when they have achieved the conservation of number task.

This is the same time when the Waldorf Schools suggested teaching children the various subjects in the classroom at the seven to eight years of age. The age of seven to eight has been selected by the Waldorf Schools as a time when the deciduous teeth are replaced by the permanent teeth, and this is often used as a means of screening children for the first grade. The teeth have been shown to provide some idea of growth of the child, and it has been hypothesized that the dentition may be a means of suggesting the growth and readiness of the body for the types of requirements a child is confronted with in the first several years of school. The incisors erupt the gingiva at approximately six to eight years, and these specific teeth have a growth pattern that, on appearance, corresponds with the conservation of number, school readiness, arithmetic readiness. All of these have a time similar to each other. The suggestion has been made that the teeth may be an outward manifestation of the inner readiness of the child both physically and mentally.

Agreement has abounded that readiness is a necessary element of teaching and learning in arithmetic and other subject areas in the classroom. Children develop at varying rates and are ready for specific tasks when their bodies have made the appropriate adaptations. Studies have suggested the teeth are a viable means of assessing readiness in children because they give an accurate picture of this development.

There is concurrence that intellectual development is dependent in part on physical development, as a necessary component of the total "organismic age" concept. The teeth have been a viable means of assessing physical development, and they may provide a predictor of cognitive readiness and formal arithmetic computational readiness.

# CHAPTER III

## DESIGN AND PROCEDURES FOR DATA COLLECTION AND ANALYSIS

This chapter contains a description of the design of the study, instrumentation, sample selection, data collection procedures, and a summary of the design and procedures incorporated in the study.

### I. DESIGN OF THE STUDY

The study sought to identify whether formal learning readiness in beginning arithmetic computation was predictable by the eruption of the permanent, maxillary and mandibular, central and lateral incisors in first grade, middle class, Caucasian children or whether a combination of both chronological age and tooth eruption was a better predictor. The design involved the comparison of scores of children on tests of arithmetic computation, cognitive growth, and tooth eruption. The following hypotheses were tested:

$H_1$--There is no significant relationship between tooth age as assessed by the gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and arithmetic computation of first grade (a) children, (b) boys, (c) girls.

$H_2$--There is no significant relationship between tooth age as assessed by the gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls.

There were questions identified to further check the hypotheses.

Question one: Is there a relationship between chronological age as measured in months and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question two: Is there a relationship between chronological age as measured in months and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

Question three: Is there a relationship between the combination of chronological age and tooth eruption and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question four: Is there a relationship between the combination of chronological age and tooth eruption and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

## II. INSTRUMENTATION

Two tests were given to the students to illicit arithmetic computation and cognitive growth scores. The arithmetic segment of the Wide Range Achievement Test, Level I, was used for individual assessment of computational ability. A Piagetian task for the Conservation of Number, Wohlwill and Lowe (1962), was used to assess the cognitive stage of each child. In addition, a photograph was taken of each child's front teeth, and a scale was developed to place a numerical value on the growth of the permanent teeth.

### Wide Range Achievement Test (W.R.A.T.)

The test consisted of several portions; however, only the arithmetic portion was used for the express purpose of gaining perspective into each child's computational abilities. Level I was used because it was constructed for children in the age range of five to eleven years eleven months.

There was no attempt to collect a national sample by the authors of the W.R.A.T., but norming of the test was achieved by using the data collected in a seven-state area. Since the information that was received from the test scores did not depend on the norming procedures, this factor was not critical.

The reliability of the test for six-year-old children was .959, and for seven-year-old children, it was .962, with a standard error of .98 in each case. The validity of the W.R.A.T. was computed by comparing it with scores on the Wechsler Intelligence Test. A correlation coefficient for the five- to seven-year-old children between the Wechsler and the W.R.A.T. was computed at .73. Another test for validity was computed by using a factor analysis to show the percent of variance in four categories. In the general factor there was a 28 percent variance, while the group factor totaled 44 percent. The specific factors had a 15 percent variance, and the error of measure was 13 percent, respectively.

From the evidence the test has both validity and reliability in sufficient quantities to warrant the use of the W.R.A.T. as an individual assessment instrument of arithmetic computational skill of first grade children.

Harper (1968), Washington and Teska (1970), and Seybold and Pedrino (1964) used the W.R.A.T. as an assessor of achievement and found it to be adequate. Robert Thorndike in the Seventh Mental Measurement Yearbook felt that the W.R.A.T. was a test that could be used in a "clinical or research" situation, where the abilities were diverse and individual assessment necessary.

Conservation of Number Test

Various tests have surfaced in the area of conservation, but due to the nature of the verbal responses, normed procedures have not been accessible. Beard (1963), Wallach and Sprott (1964), Wallach, Wall and Anderson (1967) and Wohlwill and Lowe (1962) have all adapted the concept of Conservation of Number associated with Jean Piaget into a test form used in research studies. Many of these have been presented in Fogelman (1970), Piagetian Tests for the Primary School.

Wohlwill and Lowe (1962) created a test in the area of Conservation of Number that closely mirrored Piaget's thought and was the test most easily replicated; therefore, this test was chosen as the test instrument.

This test solicited children's responses to physical instances presented in a one-to-one situation. Each activity viewed a child's perception of number and whether they were able to recognize that a number or group of things is invariant, regardless of how the objects are physically juxtaposed.

There were six activities in the task battery. The first activity was to have the child play with the chips provided. The tester asked the subject to make a tower and other such arrangements with the chips. The second activity consisted of the tester giving seven red chips to the subject and keeping seven blue subjects for himself. The chips were placed in rows, and the child was asked to count how many chips were in each group. Activity three, the experimenter placed the blue chips and the red chips horizontally in front of the child. The red chips were then spread out to create the appearance that the red group of chips had more than the blue row. The child was asked which row had more chips. The fourth activity consisted of placing the red group of chips into two groups of three and four and placing these rows side by side. The question was again asked whether one row was larger than the blue row of chips. In the fifth activity the red chips were placed in a verticle row in front of the blue chips. The question was asked if one group were larger than the other. The sixth and final activity was accomplished by placing the red chips into a hollow, opaque cylinder so the child could not see the chips. The question was asked whether one group had more chips than the other.

Each activity was given to an individual child by one of several raters. These raters followed the test procedures provided them, which replicated the test of Wohlwill and Lowe (1962). For each correct response given by the child, one point was awarded. If the response were incorrect, zero points were given for that particular activity and all of the succeeding portions of the test. When a correct response was given, the child went to the next activity, but an incorrect response called for a termination of further activities on this specific test.

A sum was computed for the activities of each child providing a numerical value. The sum total of points indicated how far the child had advanced toward Piaget's Concrete Operations Stage. However, the specific stage was not considered as important as the number of activities the child was able to perform correctly and thus obtain points on the derived scale.

### Tooth Eruption Test

Each child had two pictures taken of his/her maxillary and mandibular, central and lateral incisors, located at the entrance to the oral cavity. A Kodak Startech Dental Photography Kit with a one-to-one lens was employed to record and document each child's dentitional maturity in these specific teeth. The purpose was to assess whether gingival eruption of the permanent teeth had occurred and at what stage this process was during the time of collection.

A panel of two experts from the Department of Anthropology at The University of Tennessee evaluated the photographs for gingival eruption and checked to see whether each suspect tooth had reached the occlusal plane.

This was recorded in the Initial Chart for Permanent Teeth and forwarded to the investigator.

A point system was established to provide a tooth eruption score for eight specific teeth. The numerical value attached to each erupted tooth was as follows:

0 points--The primary tooth is in the mouth of the subject.

1 point--Space exists where the primary tooth was once positioned.

2 points--The permanent tooth has erupted the gingiva.

3 points--The permanent tooth has reached the occlusal plane.

Each subject's score was placed in the Tooth Eruption Chart and the values were computed. This provided a total score of the dentition of eight teeth and a means of comparing teething with other test scores.

## III. SELECTION OF A SAMPLE

A limitation of the population was necessary in this study because of the unique nature of the testing procedures. Due to the one-to-one factors in the study and the many variables involved, it was felt that a small and select sample was vital.

Three elementary schools in the Knoxville City Schools, Knoxville, Tennessee, were chosen because they met the criteria of having: (1) middle-class children with a constituency whose parents earned in the range of ten to thirty thousand dollars, (2) Caucasian children, (3) first grades, and (4) a sufficient number of students to collect a sample of sixty-six subjects.

Permission for the study was given by the administration of the school system, the school principals, and the teachers. One school was selected from the three on a random basis. This was the group from which the sample population was drawn. The school provided a list of Caucasian boys and a list of Caucasian girls in the first grade. From these lists a random sample was chosen with thirty-three in each group or a total of sixty-six in the sample population. The selection was done by assigning numbers to each name provided on the initial lists and using a table of random numbers.

All subjects had two tests and a photograph taken of their teeth. The Piagetian task and the Wide Range Achievement Test were administered by several raters. The collection, scoring, and evaluation were done by the investigator. A photograph was taken of each child's front teeth, and the pictures were analyzed by a panel of experts from The University of Tennessee's Department of Anthropology. After the initial judgment by the panel, the scoring was done by the experimenter.

## IV. STATISTICAL ANALYSIS

The University of Tennessee's Computer Center was used to compute the statistical data of the study.

Two hypotheses and four corresponding questions were tested using twelve bivariate and six multiple correlations with an analysis of variance and a regression coefficient. Within each hypothesis/question, three groups were studied: (a) children, (b) boys, (c) girls. Areas the study addressed itself to were tooth eruption and chronological age when compared with arithmetic computation and Piagetian task scores.

## V. SUMMARY

The study was designed to identify whether formal learning readiness in beginning arithmetic computation was predictable by the eruption of the permanent, maxillary and mandibular, central and lateral incisors in first grade, middle class, Caucasian children or whether a combination of both tooth eruption and chronological age was a better predictor.

Two tests were given and two photographs of the incisors were taken of each child -- the arithmetic computation segment of the *Wide Range Achievement Test,* Level I, and a Piagetian task, Wohlwill and Lowe (1962).

The two photographs were taken with a Kodak Startech Dental Photography Kit with a one-to-one lens attachment.

Three elementary schools in the Knoxville City Schools, Knoxville, Tennessee, were identified because they were middle class, Caucasian, and had a sizeable number of first grade students. A random selection was made to identify one school from the three. Lists of Caucasian boys and girls in one school were provided by the chosen school to facilitate the random sample of sixty-four students.

Each hypothesis was tested using a combination of bivariate and multiple correlational techniques. In all instances the .05 level of significance was used, and the statistical data were computed by the Computer Center of The University of Tennessee.

# CHAPTER IV

# PRESENTATION OF DATA

This chapter presents the data related to the two hypotheses and the four corresponding research questions.

## I. RESULTS

The hypotheses of the study were tested using 12 bivariate correlations and six multiple correlations. Sixty-six middle-class Caucasian children from Knoxville, Tennessee--33 boys and 33 girls--were chosen for the study. The tests used to obtain the data were the arithmetic computation segment of the Wide Range Achievement Test and a Piagetian task for the Conservation of Number (Wohlwill and Lowe, 1962). The children had their chronological age calculated in months. Tooth age was formed by summing a numerical assignment to the various stages of gingival eruption of the maxillary and mandibular central and lateral incisors.

### Chronological Age, Arithmetic Computation Score, Conservation Totals

The range of chronological age for all of the children tested was 77 to 100 months. The mean age was 84.10 months with a standard deviation of 5.51 for the 66 children. The boys had a mean chronological age of 84.90

months, and the girls mean age was 83.30. The tooth age minimal score was 0.0, which was equivalent to the concept that none of the investigated permanent teeth had erupted the gingiva, and the maximal value was 22.0 indicating that all of the permanent teeth had erupted. The mean tooth age for the 66 children was 8.75 with a standard deviation of 5.26. The boys had a mean tooth age of 9.24 with a standard deviation of 5.72, and the girls had a mean tooth age score of 8.27 with a standard deviation of 4.79. The boys' tooth age and chronological age had greater mean ages than the girls. The boys' mean chronological age was 1.6 months greater than the girls, and the boys' mean tooth age was .97 more than the girls (see Table I).

The total possible arithmetic score for the arithmetic computation segment of the Wide Range Achievement Test was 63. The children tested had a minimal score of 7 and a maximal score of 27 in arithmetic computation. The mean for both boys and girls was 21.28 with a standard deviation of 2.96. The boys had a mean score on the W.R.A.T. of 21.0 with a standard deviation of 3.55, while the girls had a mean score of 21.57 with a standard deviation of 2.25 (see Table II).

The Piagetian task for the Conservation of Number (Wohlwill and Lowe, 1962) had a possible total of 5 points.

TABLE I

MEANS, STANDARD DEVIATIONS, AND RANGE OF SCORES FOR CHRONOLOGICAL AGE AND TOOTH AGE FOR CHILDREN, BOYS, GIRLS

| Source | Mean | S.D. | Range of Scores |
|---|---|---|---|
| C.A./Children | 84.10 | 5.51 | 77-100 |
| C.A./Boys | 84.90 | 6.10 | |
| C.A./Girls | 83.30 | 4.81 | |
| T.A./Children | 8.75 | 5.26 | |
| T.A./Boys | 9.24 | 5.72 | |
| T.A./Girls | 8.27 | 4.79 | |

TABLE II

MEANS, STANDARD DEVIATIONS, AND RANGE OF SCORES FOR ARITHMETIC COMPUTATION SCORES FOR CHILDREN, BOYS, GIRLS

| Source | Mean | S.D. | Range of Scores |
|---|---|---|---|
| Children | 21.28 | 2.96 | 7-27 |
| Boys | 21.00 | 3.55 | |
| Girls | 21.57 | 2.25 | |

The children had a range of scores from 0, the number indicating a non-conserver classification, to 5 points, which implied the child was a conserver. The summation of scores for the boys was 50.0 and 61.0 for the girls. The mean score for the group of 66 children was 1.68 with a standard deviation of 1.51. The boys had a mean score on the Piagetian task of 1.84 with a standard deviation of 1.64, while the girls had a mean of 1.5, with a standard deviation of 1.37 (see Table III).

Hypothesis 1

Hypothesis 1 stated that there was no significant relationship between tooth age as assessed by the gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and arithmetic computation of first grade (a) children, (b) boys, (c) girls. The arithmetic computation segment of the Wide Range Achievement Test, Level I, was administered and a tooth age score was calculated. The two were compared using a bivariate correlation coefficient for the population of 66 children. The result was a correlation of .13 significant at .27 level of confidence. A regression analysis was performed to establish the prediction equation for the arithmetic computation score when tooth age was given. A supportive analysis of variance was calculated ($F = 0.17$, $p > 0.27$) lending credence to the hypothesis there was no significant difference found (see Table IV). The analysis of scores by

TABLE III

MEANS, STANDARD DEVIATIONS, SUMMATIONS, AND RANGE OF SCORES FOR THE PIAGETIAN TASK SCORE FOR CHILDREN, BOYS, GIRLS

| Source | Mean | S.D. | Summation | Range of Scores |
|---|---|---|---|---|
| Children | 1.68 | 1.51 | 111.0 | 0-5 |
| Boys | 1.84 | 1.64 | 50.0 | |
| Girls | 1.50 | 1.37 | 61.0 | |

TABLE IV

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH TOOTH AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 10.50 | 1.19 | 0.27 | 0.018 | .13 |
| Error | 64 | 561.02 | | | | |
| Corrected total | 65 | 571.53 | | | | |

$$Y_{\text{Arithmetic}} = 20.16 + .07 \times \text{Tooth Age}$$

the boys on the arithmetic computation compared with tooth age by a correlation coefficient was .26 significant at .13 level of confidence. A regression coefficient was computed for the prediction of arithmetic scores of boys when tooth age was given ($F = 2.35$, $p > 0.13$) proving there was no significant relationship found (see Table V). A correlation coefficient of -0.07 was calculated for the 33 girls in the population with a significance level of 0.67. An analysis of variance and a regression analysis were calculated to identify the prediction equation for arithmetic for girls when tooth age was given ($F = 0.17$, $p > 0.67$) providing the indication there was no significant relationship between tooth age and arithmetic computation score (see Table VI). The total amount of variance explained by tooth age as a predictor of arithmetic computation score for 66 children was 1.8 percent, 7 percent for the boys, and 0.5 percent for the girls.

Hypothesis 2

Hypothesis 2 stated there was no significant relationship between tooth age as assessed by the gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls.

A Piagetian task for the Conservation of Number

TABLE V

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH TOOTH AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 28.50 | 2.35 | 0.13 | 0.07 | 0.26 |
| Error | 31 | 375.49 | | | | |
| Corrected total | 32 | 404.00 | | | | |

$$Y_{\text{Arithmetic}} = 19.47 + .164 \times \text{Tooth Age}$$

TABLE VI

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH TOOTH AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.93 | 0.17 | 0.67 | 0.005 | -0.07 |
| Error | 31 | 161.12 | | | | |
| Corrected total | 32 | 162.06 | | | | |

$$Y_{\text{Arithmetic}} = 21.86 + -0.03 \times \text{Tooth Age}$$

(Wohlwill and Lowe, 1962) was administered to 66 children. The correlation coefficient was calculated for the Piagetian task with tooth age with a score of -0.02 significant at .84 level of confidence. An analysis of variance and a regression coefficient for the prediction equation for 66 children were computed ($F = 0.04$, $p > 0.84$), which supported the hypothesis that there was no significant relationship between the Piagetian task score and tooth age (see Table VII). The correlation coefficient for the boys on the Piagetian task compared with tooth age was 0.05, significant at .76 level of confidence. An analysis of variance and a regression coefficient were calculated to establish a prediction equation ($F = 0.09$, $p > 0.76$) endorsing the hypothesis that there was no significant relationship between the Piagetian task and tooth age for the boys (see Table VIII). A correlation coefficient was computed for the girls for their Piagetian task score compared with tooth age. The girls had a correlation of -0.16, significant at .36 level of confidence. An analysis of variance and a regression coefficient were derived to provide a predicting equation for the Piagetian task score when tooth age was given ($F = 0.86$, $p > 0.36$). This analysis followed the hypothesis that there was no significant relationship between the Piagetian task score and tooth age of girls (see Table IX).

TABLE VII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH TOOTH AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.09 | 0.04 | 0.84 | 0.0006 | -0.02 |
| Error | 64 | 148.22 | | | | |
| Corrected total | 65 | 148.31 | | | | |

$$Y_{Piaget} = 1.74 + -0.007 \times \text{Tooth Age}$$

TABLE VIII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH TOOTH AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.25 | 0.09 | 0.76 | 0.002 | 0.053 |
| Error | 31 | 85.99 | | | | |
| Corrected total | 32 | 86.24 | | | | |

$$Y_{Piaget} = 1.70 + 0.01 \times \text{Tooth Age}$$

TABLE IX

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH TOOTH AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 1.62 | 0.86 | 0.36 | 0.02 | -0.16 |
| Error | 31 | 58.61 | | | | |
| Corrected total | 32 | | | | | |

$$Y_{Piaget} = 1.90 + -0.04 \times \text{Tooth Age}$$

The tooth age score when correlated with the Piagetian task score accounted for .06 percent of the total variance for the population of 66 children. The variance accounted for by the scores of the boys was .2 percent and 2 percent for the girls. It was therefore concluded the predictability of the Piagetian task score or the arithmetic computation score, using tooth age as the predictor, was not reliable. This was verified with the boys, girls, and their combination.

## Question 1

Question 1 asked whether there was a relationship between chronological age as measured in months and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls. A correlation coefficient was computed comparing scores on a Piagetian task (Wohlwill and Lowe, 1962) with chronological age. The correlation for the group of 66 boys and girls was -0.003 significant at .97 level of confidence. An analysis of variance and a regression coefficient were calculated to establish a prediction equation (F = 0.0006, p > .97) supporting the hypothesis that there was no significant relationship between Piagetian task scores and chronological age for the total group of 66 children (see Table X). The correlation coefficient for the boys com-

TABLE X

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.001 | .0006 | 0.97 | 0.00001 | -0.003 |
| Error | 64 | 148.31 | | | | |
| Corrected total | 65 | 148.31 | | | | |

$$Y_{Piaget} = 1.75 + -0.0008 \times \text{Chronological Age}$$

paring the scores on a Piagetian task and chronological age was 0.01 significant at .93 level of confidence. An analysis of variance and a regression coefficient were computed to establish a prediction equation ($F = 0.006$, $p > 0.93$) confirming the hypothesis that there was no significant relationship between Piagetian task scores and chronological age for boys (see Table XI). The correlation coefficient for the girls on the comparison of the Piagetian task score with chronological age was -0.07 significant at .69 level of confidence. An analysis of variance and a regression coefficient were calculated ($F = 0.15$, $p > 0.69$) endorsing the hypothesis that there was no significant relationship between the Piagetian task and chronological age for the girls (see Table XII).

The Piagetian task score when correlated with the chronological age accounted for only .001 percent of the variance of the group of 66 children, .02 percent for the boys, and .51 percent for the girls. This verified that chronological age was a poor predictor of score on the Piagetian task by Wohlwill and Lowe (1962).

## Question 2

Question 2 asked whether there was a relationship between chronological age as measured in months and arithmetic computation of first grade (a) children, (b) boys,

TABLE XI

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.01 | 0.006 | 0.93 | 0.0002 | 0.01 |
| Error | 31 | 86.22 | | | | |
| Corrected total | 32 | 86.24 | | | | |

$Y_{Piaget} = 1.52 = 0.0003 \times$ Chronological Age

TABLE XII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.30 | 0.15 | 0.69 | 0.005 | -0.07 |
| Error | 31 | 59.93 | | | | |
| Corrected total | 32 | 60.24 | | | | |

$Y_{Piaget} = 3.21 + -0.02 \times$ Chronological Age

(c) girls. A correlation coefficient was calculated between scores on the arithmetic computation segment of the <u>Wide Range Achievement Test,</u> Level I and chronological age of children as measured in months. The correlation for the combined group of boys and girls was 0.26, significant at .02. An analysis of variance and a regression coefficient were computed for the 66 children (F = 4.95, p 0.02) repudiating the hypothesis that there was no significant relationship between arithmetic computation and chronological age for the group of 66 children (see Table XIII). The correlation coefficient for arithmetic computation with chronological age for

TABLE XIII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 41.09 | 4.95 | 0.02 | .07 | .26 |
| Error | 64 | 530.43 | | | | |
| Corrected total | 65 | 571.53 | | | | |

$$^{Y}\text{Arithmetic} = 9.15 + 0.14 \times \text{Chronological Age}$$

boys was .42, significant at the .01 level. An analysis of variance and a regression coefficient were calculated ($F = 6.73$, $p > 0.01$) contradicting the hypothesis that there was no significant relationship between arithmetic computation and chronological age for the boys (see Table XIV). The correlation coefficient for arithmetic computation with chronological age for the girls was .02, significant at the .90 level. An analysis of variance and a regression coefficient were computed ($F = 0.01$, $p > 0.90$) supporting the hypothesis that there was no significant relationship between arithmetic computation and chronological age for the girls (see Table XV).

These data support the conclusion that arithmetic computation scores on the Wide Range Achievement, Level I was predicted by chronological age in the case of boys and the total group. This relationship masked the fact that the amount of variability accounted for in this analysis was a total of 7 percent for the total group of 66 children, 17 percent for the boys, and .04 percent for the girls. Moreover, the data suggested that chronological age was a tenuous predictor of arithmetic computation despite the significance of the correlations for the total group of 66 children and the 33 boys.

TABLE XIV

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 72.09 | 6.73 | 0.01 | 0.17 | .42 |
| Error | 31 | 331.90 | | | | |
| Corrected total | 32 | 404.00 | | | | |

$Y_{Arithmetic} = 0.10 + 0.24 \times \text{Chronological Age}$

TABLE XV

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 1 | 0.07 | 0.01 | 0.90 | 0.0004 | .02 |
| Error | 31 | 161.99 | | | | |
| Corrected total | 32 | 162.06 | | | | |

$Y_{Arithmetic} = 20.76 + 0.009 \times \text{Chronological Age}$

Question 3

Question 3 asked whether there was a relationship between the combination of chronological age and tooth eruption and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls. A multiple correlation was used to assess the relationship between the combined scores of chronological age in months and tooth age with the scores on a Piagetian task by Wohlwill and Lowe (1962). The multiple correlation for the group of 66 children was .03 significant at .97 level of confidence. An analysis of variance and a regression coefficient were calculated ($F = 0.04$, $p > 0.84$) for the entire group of children which verified an answer to the question that there was no significant relationship between the combination of chronological age plus tooth age when compared with the score on the Piagetian task (see Table XVI). The correlation coefficient for the boys was .06 significant at .93 level of confidence for the comparison of chronological age plus tooth age with the Piagetian task. An analysis of variance and a regression analysis were calculated ($F = .07$, $p > 0.93$) providing the conclusion that there was no significant relationship between the combined scores of chronological age plus tooth age and the Piagetian task score for boys (see Table XVII). The correlation

TABLE XVI

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 0.13 | 0.02 | 0.08 | 0.97 | .03 |
| Error | 63 | 148.18 | | | | |
| Corrected total | 65 | 148.31 | | | | |

$Y_{Piaget} = 1.28 + (0.005 \times C.A.) + (-0.01 \times T.A.)$

TABLE XVII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 0.40 | 0.07 | 0.93 | 0.004 | .06 |
| Error | 30 | 85.83 | | | | |
| Corrected total | 32 | 86.24 | | | | |

$Y_{Piaget} = 3.09 + (-0.01 \times C.A.) + (0.03 \times T.A.)$

coefficient for the girls for the comparison of chronological age plus tooth age with the Piagetian task was 0.16 significant at .66 level of confidence. An analysis of variance and a regression coefficient were computed ($F = 0.41$, $p > 0.66$) that implied there was no significant relationship between the combined scores of chronological age plus tooth age compared with the Piagetian task for girls (see Table XVIII).

The amount of variability explained in the Piagetian task scores by chronological age plus tooth age was .4 percent for the boys and 2.7 percent for the girls. Thus a large amount of the variability was left unaccounted for by the combined scores of chronological age

TABLE XVIII

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE PIAGETIAN TASK WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 1.62 | 0.41 | 0.66 | 0.02 | 0.16 |
| Error | 30 | 58.61 | | | | |
| Corrected total | 32 | 60.24 | | | | |

$$Y_{Piaget} = 1.97\ (-0.0008 \times C.A.) + (-0.04 \times T.A.)$$

and tooth age when compared with the Piagetian task score. This implied their use as a predictor of the Piagetian task was inadequate as a self-sufficient indicator.

Question 4

Question 4 asked if there were a relationship between the combination of chronological age and tooth age and arithmetic computation for first grade (a) children, (b) boys, (c) girls. A multiple correlation was used to assess the relationship between the combined scores of chronological age plus tooth age and the arithmetic computation segment of the Wide Range Achievement Test, Level I. The calculated correlation coefficient for the entire group of 66 children was 0.27 significant at .08 level of confidence. An analysis of variance and a regression coefficient were computed ($F = 2.51$, $p > 0.08$) which implied there was no significant relationship between the combined scores of chronological age plus tooth age when compared with scores of arithmetic computation for the 66 children (see Table XIX). A correlation coefficient 0.43 significant at .04 level of confidence, was computed for the combined scores of chronological age plus tooth age when compared with arithmetic computation for the boys. An analysis of variance and a regression coefficient were calculated ($F = 3.45$,

TABLE XIX

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 66 CHILDREN

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 42.23 | 2.51 | 0.08 | 0.073 | 0.27 |
| Error | 63 | 529.29 | | | | |
| Corrected total | 65 | 571.53 | | | | |

$$Y_{\text{Arithmetic}} = 7.79 + (0.16 \times \text{C.A.}) + (-0.03 \times \text{T.A.})$$

p > 0.04) inferred there was a significant relationship between chronological age plus tooth age when compared with arithmetic computation for the boys (see Table XX). A correlation coefficient of .075, significant at 0.67 level of confidence was computed for the combined scores of chronological age plus tooth age when compared with arithmetic computation for the girls. An analysis of variance and a regression coefficient were performed ($F = 0.13$, $p > 0.87$) verifying there was no significant relationship between chronological age plus tooth age when compared with arithmetic computation for the girls (see Table XXI). The variance accounted for by the combination of chronological age plus tooth age when

TABLE XX

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 33 BOYS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 75.55 | 3.45 | 0.04 | 0.187 | .43 |
| Error | 30 | 328.44 | | | | |
| Corrected total | 32 | 404.00 | | | | |

$Y_{\text{Arithmetic}} = -4.56 + (0.31 \times \text{C.A.}) + (-0.08 \times \text{T.A.})$

TABLE XXI

ANALYSIS OF VARIANCE TABLE, CORRELATION COEFFICIENT, REGRESSION COEFFICIENT FOR DEPENDENT VARIABLE ARITHMETIC WITH CHRONOLOGICAL AGE PLUS TOOTH AGE FOR 33 GIRLS

| Source | DF | SS | F | Prob. F | $R^2$ | R |
|---|---|---|---|---|---|---|
| Regression | 2 | 1.47 | 0.13 | 0.87 | 0.009 | .075 |
| Error | 30 | 160.58 | | | | |
| Corrected total | 32 | 162.06 | | | | |

$Y_{\text{Arithmetic}} = 19.48 + (0.02 \times \text{C.A.}) + (-0.04 \times \text{T.A.})$

used to predict arithmetic computation was 7 percent for the entire group of 66 children, 18 percent for the boys, and .9 percent for the girls. The predictability of arithmetic computation scores from the combination of chronological age plus tooth age was negligible, despite the fact significance of .04 was found for the boys' scores. Moreover, the unexplained variability reached a maximum of 99.1 percent and a minimum of 72 percent, confirming that other factors are not accounted for in the combination of chronological age and tooth age as a predictor of arithmetic computation.

## II. SUMMARY

This study sought to find whether there was a significant relationship between tooth age and arithmetic computation, and tooth age and a Piagetian task score for the Conservation of Number for Caucasian (a) children, (b) boys, (c) girls in the Knoxville City Schools. The questions of the study sought to answer the questions (1) whether there was a significant relationship between chronological age and the score in arithmetic computation for first grade (a) children, (b) boys, (c) girls; (2) whether there was a significant relationship between chronological age and a Piagetian task score, the Conservation of Number, for first grade (a) children,

(b) boys, (c) children; (3) whether there was a significant relationship between the combination of chronological age and tooth age and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls; (4) whether there was a significant relationship between the combination of chronological age and tooth age and arithmetic computation of first grade (a) children, (b) boys, (c) girls.

Data for the study were processed by the Computer Center of The University of Tennessee. Data were analyzed using bivariate and multiple correlational techniques with an analysis of variance and a regression coefficient to assess whether significant relationships at the 0.05 level existed in each of two hypotheses and four questions.

The findings showed that there was no significant relationship between arithmetic computation or Piagetian task scores and tooth eruption for (a) children, (b) boys, (c) girls.

There was no significant relationship between chronological age and the score on a Piagetian task for (a) children, (b) boys, (c) girls.

It was found that there was a significant relationship between chronological age and arithmetic computation for the children and boys, but not for the girls.

There was no significant relationship discovered between the combination of chronological age and tooth age and the score on a Piagetian task for (a) children, (b) boys, (c) girls.

There was no significant relationship found between the combination of chronological age and tooth age and the score on arithmetic computation for children and girls; however, a significant relationship was found for the boys.

The inspection of the data showed that in spite of some significant relationships in the correlation coefficients, the amount of variability explained by the use of tooth age, chronological age, or the combination of the two to predict either arithmetic computation or the level of Piagetian cognitive thought as assessed by the Piagetian task, the Conservation of Number, was negligible. Moreover, the scores were more prone to chance occurrence and an unreliable predictor.

# CHAPTER V

# SUMMARY, FINDINGS AND CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Presented in this chapter are a summary of the study, report of the findings and conclusions and the implications and recommendations for research of a similar nature.

## I. SUMMARY

The problem of the study was to establish whether learning readiness for beginning arithmetic computation and the Conservation of Number could be predicted by the eruption of the permanent, maxillary and mandibular, central and lateral incisors of first grade, middle-class Caucasian children in the Knoxville City Schools. It was also the purpose to compare whether chronological age or tooth age was a better predictor of arithmetic computation and Conservation of Number, or whether the combination of chronological age plus tooth age would provide a more reliable indicator. Sixty-six first grade students were chosen randomly with 33 boys and 33 girls comprising the sampling population. The chronological age of each child was computed in months, and each child performed on an arithmetic computation test, and a

Piagetian task, the Conservation of Number. Every child had his teeth photographed to check for the gingival eruption of the permanent incisors.

The Wide Range Achievement Test, Level I and a Piagetian task by Wohlwill and Lowe (1962) were used to measure arithmetic computation and the level of cognitive growth. A Kodak Startech Dental Photography Kit with a one-to-one lens was employed to present evidence of the dentition of the permanent maxillary and mandibular, central and lateral incisors. A panel of two anthropologists from The University of Tennessee Department of Anthropology analyzed the photographs to assess gingival eruption of the permanent incisors. This information was recorded in the Initial Chart for Permanent Teeth. Point values were assigned for each level of growth of the permanent incisors, and this information was recorded in the Tooth Eruption Chart.

The Wide Range Achievement Test had a reliability for six- and seven-year-old children of .959 and .962, respectively. The validity of the W.R.A.T. was computed by comparing it with the Wechsler Intelligence Test. The Piagetian task (Wohlwill and Lowe, 1962) was administered according to the procedures followed in the original research.

The following hypotheses were tested:

$H_1$--There is no significant relationship between tooth age as assessed by gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and arithmetic computation of first grade (a) children, (b) boys, (c) girls.

$H_2$--There is no significant relationship between tooth age as assessed by gingival eruption of the permanent, maxillary and mandibular, lateral and central incisors and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls.

The following questions were formulated to augment the original hypotheses:

Question one: Is there a relationship between chronological age as measured in months and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question two: Is there a relationship between chronological age as measured in months and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

Question three: Is there a relationship between the combination of chronological age and tooth eruption and the score on a Piagetian task, the Conservation of Number, of first grade (a) children, (b) boys, (c) girls?

Question four: Is there a relationship between the combination of chronological age and tooth eruption and arithmetic computation of first grade (a) children, (b) boys, (c) girls?

Two hypotheses and four corresponding questions were tested using correlation coefficients. Twelve bivariate and multiple correlations with an analysis of variance and a regression coefficient were calculated to accomplish the statistical analysis. Each hypothesis compared the instruments with tooth age and chronological age for (a) children, (b) boys, (c) girls.

The Computer Center of The University of Tennessee was used to compute the data. The .05 level of significance was used in all instances to analyze the data.

## II. FINDINGS AND CONCLUSIONS

The first purpose of the study was to examine whether the score on the tooth eruption test establishing the growth of the permanent, maxillary and mandibular, central and lateral incisors would be a predictor of the achievement of a child on an arithmetic computation test. The test results implied there was no significant relationship between the two entities. Thus in all instances--(a) children, (b) boys, (c) girls--the hypothesis was not rejected.

The second purpose of the study was to determine whether the score on the tooth eruption test, which expressed the level of dentition for the permanent incisors, was related to the level of cognitive development on a Piagetian task for the Conservation of Number for (a) children, (b) boys, (c) girls. Data revealed there was no significant relationship between the score of tooth age and the Piagetian task for all groups.

Four questions were asked to augment the hypotheses. Question one asked whether chronological age was a predictor of the level of cognitive growth on Piaget's Conservation of Number task for (a) children, (b) boys, (c) girls. It was found that chronological age was not a reliable predictor of growth on the Piagetian task for all of the groups studied.

Question two posed the question of whether chronological age was related to scores of (a) children, (b) boys, (c) girls on an arithmetic computation test. The scores for the children and the boys suggested there was a relationship between chronological age and arithmetic computation scores; however, there was no reliability in predicting arithmetic computation for either group. The analysis of arithmetic computation scores with chronological age for girls showed there was no relationship and predictability for using chronological age.

Question three asked if chronological age plus tooth age was a predictor of the level of cognitive development on Piaget's Conservation of Number task for (a) children, (b) boys, (c) girls. None of the groups were found to show any significant relationship or reliability of prediction when chronological age plus tooth age were compared with the Piagetian task score.

Question four was concerned with predictability of arithmetic computation scores from the combined scores of chronological age plus tooth age of (a) children, (b) boys, (c) girls. Data for the children and the girls did not support the contention that chronological age plus tooth age was a reliable predictor of arithmetic computation. The boys showed a significant relationship between chronological age plus tooth age and arithmetic computation, but there was a lack of explained variability which supported the inference that reliability in the prediction of arithmetic computation scores was not sufficient.

The following findings and conclusions seem to be justified for those groups tested:

1. The use of tooth age, using the permanent incisors as indicators of arithmetic computation scores or arithmetic readiness does not seem to be of value for children, boys, or girls.

2. The three groups of subjects (children, boys, girls) showed there was little use in predicting cognitive development on the Conservation of Number task via the tooth age score, computed with the dentition levels of the permanent incisors.

3. The use of chronological age as an instrument of readiness for children to perform in arithmetic computation was unfounded. Though significant relationships were discovered for the entire group of children and the boys, there was not a sufficient amount of variability explained to warrant the use of chronological age as an accurate predictor of arithmetic computation readiness.

4. Chronological age was not a reasonable predictor of the level of cognitive growth according to the Conservation of Number task. Consequently, the idea of being able to identify oneness is not synonymous with the chronological age of the child.

5. Chronological age plus tooth age was not a reliable predictor of the level of cognitive growth of a child as assessed by the Conservation of Number task; therefore, an "organismic age" based on chronological age and tooth age was not an accurate indicator of readiness for the types of activities associated with the Concrete Operations Stage.

6. The use of chronological age plus tooth age to predict scores on arithmetic computation tests was not an accurate enough indicator to provide an assessment of a child's readiness for arithmetic computation.

7. The use of chronological age, tooth age, or both (as a predictor of readiness of children for either arithmetic computation or Conservation of Number) seems unfounded. Although correlation coefficients for the boys and the entire group of children showed a sporadic significance, it was shown that in every instance, prediction of readiness was of little value when using these factors.

## III. IMPLICATIONS AND RECOMMENDATIONS FOR THE STUDY

The findings of this study have suggested that the concept of "organismic age" in this study, the use of either tooth age, chronological age or both as a measure of readiness, was not a promising predictor. Yet the concept of the integration of physical development and readiness for cognitive skills, such as arithmetic, remains a viable theory. Since children enter school today at the age of six and sometimes earlier, they are being exposed to arithmetic curriculum in a formal manner from the outset of their first school experience. Inherent in this early introduction of formal abstractions in arithmetic to children should be a firm understanding of readiness which may include various physical and mental attributes. Because of the intricacy of the human organism, the juxtaposition of any number of factors may provide the formula for readiness for arithmetic.

Through its delimitations, this study has approached only a small population segment and, therefore, implies that further testing on a large scale be undertaken. Despite the non-significance of the findings, a population of greater magnitude may provide further insights into the idea that the eruption of the permanent teeth may be an indicator of readiness. This, coupled with the concept that teachers need to be able to distinguish various levels of a child's readiness for formal arithmetic in order to maximize the understanding and amount a child could achieve, provides an impetus for some measure that is both easily administered and especially reliable.

Since understanding is dependent on whether the child is capable of grasping particular concepts in arithmetic, there is importance in providing an environment conducive to the free acquisition of logico-mathematical concepts while providing for the individual differences and readiness levels each child brings from his experiences into the classroom.

The following recommendations are outcomes from the specific findings of this study. They include:

1. The concept of assessing readiness for mathematics and for the types of skills required in a Piagetian task, while not being predicted by tooth eruption of the permanent incisors, must not be entirely disregarded. Further study on the concept of "organismic age" as it relates to dentition and cognitive growth seems warranted.

2. The inclusion of kindergarten through sixth grades in a study should increase the predictability of both arithmetic computation scores and Piagetian task scores by the use of tooth age of the permanent incisors.

Further inspection of the permanent dentitional process in research using a population with a greater scope seems justified.

3. Since this study dealt entirely on Caucasian, middle-class children in the Knoxville, Tennessee area, research as to whether Negro and other cultures have similar outcomes is necessary. It is also suggested that other ethnic, racial, and cultural groups be represented in an inspection of the same nature as this study.

4. Measurement of students entering the first grade in the first quarter or three months of the year should be measured to see if tooth eruption may be a

predictor of either arithmetic computation scores or Piagetian task scores.

5. The use of six year molars combined with the permanent incisors may be another means of predicting arithmetic computation scores and Piagetian task scores. This would merit further research effort.

6. The use of tooth eruption or the dentition of the permanent incisors to predict arithmetic computation scores and the Piagetian task needs to be inspected further with a number of other variables to account for the unexplained variance.

7. A longitudinal study to establish the time of Conservation of Number and the dentition of the permanent incisors for a large population would seem appropriate.

8. The use of either chronological age or tooth age as a predictor for arithmetic readiness of first grade children, bearing in mind the delimitations of the study, is not in itself a means of successful assessment. It is implied that merely because a child enters school on a compulsory basis at six years, it does not necessarily connote that the child is ready for the rigors of a formal arithmetic program. It is in this area that more research needs to be focused. Moreover, a means of establishing readiness for each child in the arithmetic curriculum is tantamount for optimal achievement and individual growth.

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APPENDIXES

# APPENDIX A

## CONSERVATION OF NUMBER TEST

(Wohlwill and Lowe, 1962, cited in Fogelman, 1970) (pp. 48-49)

MATERIALS: Two groups of seven poker chips, one red group and one blue group.

DIRECTIONS: The following test is to be given to first grade students on an individual basis. There is no time limit, and strict adherence to the procedures and questions to be asked are an absolute necessity. If the child is unsure, repeat the exercise. If the child responds that the groups are not equal, further exercises are to be omitted. It is also necessary when the child responds in any manner, that a positive statement be made. An example would be, "That was sure smart of you!" Other such statements should be encouraged so children are not frustrated in this exercise, and responses are each child's, and no one else's.

PROCEDURES:

Activity 1: Place the poker chips on the table and let the child play with them for a minute or so. Tell each child to make a tower, or other such items. (This is a brief rapport time so other portions of the test will be easier for the child.)

Activity 2: Place the red chips in front of the child and the blue chips by the experimenter. Ask the child to count each group, the red and the blue group of chips.

Say: "I am going to give you some red chips, and I am going to take the blue chips. How many red chips do you have? How many blue chips do I have? (Wait for a response from the child. Encourage them to count the groups if they seem puzzled.)

| S's | E's |
|---|---|
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |

Activity 3: Take the red row of chips and spread them out from both ends so the red row appears twice as big as the other row of chips.

Say: "Who has more chips, you or I?" (Wait for a response!)

  0 0 0 0 0 0 0 E's

0 0 0 0 0 0 0 S's

Activity 4: Take the red row and divide it into two rows of four chips and three chips. Place these across from the blue set of chips.

Say: "Who has more chips, you or I?"

0 0 0 0 0 0 0 E's

  0 0 0 0
  0 0 0 S's

Activity 5: Place the red chips in a verticle row in front of the blue row of chips.

Say: "Who has more chips, you or I?"

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S's
0    0 0 0 0 0 0 0  E's
0
0
0
0
0
0
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Activity 6: Place the red chips into the hollow, opaque cylinder. Be sure that the chips cannot be viewed!

Say: "Who has more chips, you or I?"

# CONSERVATION OF NUMBER SHEET

Directions for Scoring:

1. If the child states that the two groups of chips are equal, place a 1 in the corresponding box under the appropriate activity.

2. If the child should state that the groups are not equal, one group has more than the other, place a 0 in the corresponding box under the appropriate activity. Since all other activities will end when the child has answered that one group has more than the other, place an X in all activities after this incorrect response.

| Student # | A. I | A. II | A. III | A. IV | A. V | A. VI |
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# INITIAL CHART FOR PERMANENT TEETH

DIRECTIONS: Place an "X" in the appropriate column of each tooth where the permanent tooth has erupted. If the permanent tooth has reached the occlusal plane, place an "O" next to the "X" already in the box. Therefore, if a child has had gingival eruption without the tooth reaching the occlusal plane, the appropriate symbol would be an "X". If the permanent tooth has erupted and has reached the occlusal plane, the symbols used are "XO".

| | | Maxilla | | | | Mandible | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Left | | Right | | Left | | Right | |
| NAME | Student # | Lat. | Cent. | Cent. | Lat. | Lat. | Cent. | Cent. | Lat. |
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# TOOTH ERUPTION CHART

Directions: Each phase of tooth development has a value attached to it. The following numerical quantities are used for the permanent, maxillary and mandibular, central and lateral incisors:

0 - The primary tooth is in the mouth of the subject.
1 - Space exists where the primary tooth was once positioned.
2 - The permanent tooth has erupted the gingiva.
3 - The permanent tooth has reached the occlusal plane.

| | Maxilla | | | | Mandible | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Left | | Right | | Left | | Right | | G. |
| Student # | Lat. | Cent. | Cent. | Lat. | Lat. | Cent. | Cent. | Lat. | TOTAL |
| | | | | | | | | | |
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TABLE XXII

COMPILED SCORES FOR 66 CHILDREN ON ARITHMETIC COMPUTATION AND PIAGETIAN TASK

| Student Number | Arithmetic Computation | Piagetian Task |
|---|---|---|
| G102 | 23 | 1 |
| G103 | 23 | 1 |
| G104 | 22 | 1 |
| G105 | 21 | 2 |
| G106 | 23 | 5 |
| G107 | 15 | 1 |
| G108 | 26 | 1 |
| G109 | 24 | 1 |
| G110 | 21 | 1 |
| G111 | 23 | 5 |
| G112 | 21 | 1 |
| G113 | 17 | 1 |
| G115 | 22 | 2 |
| G116 | 18 | 1 |
| G117 | 21 | 1 |
| G118 | 23 | 1 |
| G119 | 21 | 1 |
| G120 | 23 | 0 |
| G121 | 23 | 1 |
| G123 | 24 | 1 |
| G124 | 22 | 1 |
| G125 | 19 | 1 |
| G126 | 22 | 5 |
| G127 | 23 | 5 |
| G128 | 22 | 1 |
| G129 | 21 | 1 |
| G130 | 17 | 0 |
| G131 | 23 | 1 |
| G132 | 20 | 1 |
| G133 | 22 | 1 |
| G134 | 22 | 2 |
| G135 | 23 | 1 |
| G136 | 22 | 1 |
| B02 | 21 | 1 |
| B06 | 23 | 1 |
| B07 | 23 | 4 |
| B09 | 18 | 1 |

TABLE XXII (continued)

| Student Number | Arithmetic Computation | Piagetian Task |
|---|---|---|
| B10 | 20 | 0 |
| B11 | 21 | 0 |
| B13 | 21 | 0 |
| B14 | 21 | 4 |
| B16 | 23 | 1 |
| B18 | 23 | 1 |
| B19 | 24 | 1 |
| B22 | 22 | 4 |
| B25 | 20 | 0 |
| B27 | 24 | 4 |
| B28 | 7 | 0 |
| B29 | 22 | 1 |
| B30 | 22 | 4 |
| B31 | 24 | 5 |
| B32 | 19 | 1 |
| B34 | 19 | 1 |
| B36 | 20 | 1 |
| B37 | 18 | 1 |
| B40 | 19 | 4 |
| B41 | 16 | 1 |
| B42 | 18 | 1 |
| B43 | 21 | 1 |
| B44 | 23 | 4 |
| B45 | 26 | 1 |
| B46 | 26 | 5 |
| B48 | 27 | 1 |
| B49 | 22 | 2 |

Note: G = girls and B = boys.

TABLE XXIII

TOOTH ERUPTION CHART* FOR 33 GIRLS

| | Maxilla | | | | Mandible | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Left | | Right | | Left | | Right | | |
| Student # | Lat. | Cent. | Cent. | Lat. | Lat. | Cent. | Cent. | Lat. | Total |
| G102 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G103 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G104 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 5 |
| G105 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 14 |
| G106 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G107 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| G108 | 1 | 2 | 2 | 0 | 2 | 2 | 2 | 1 | 12 |
| G109 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G110 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G111 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| G112 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 8 |
| G113 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 3 |
| G115 | 0 | 1 | 2 | 0 | 0 | 2 | 2 | 1 | 8 |
| G116 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| G117 | 0 | 1 | 2 | 0 | 2 | 2 | 2 | 2 | 11 |
| G118 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 1 | 11 |
| G119 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 6 |
| G120 | 1 | 2 | 2 | 1 | 0 | 2 | 2 | 0 | 10 |
| G121 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| G123 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 6 |
| G124 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 14 |
| G125 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 5 |
| G126 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 0 | 10 |
| G127 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 5 |
| G128 | 0 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 10 |
| G129 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 13 |
| G130 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 1 | 11 |
| G131 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| G132 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 8 |
| G133 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 12 |
| G134 | 1 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 13 |
| G135 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 22 |
| G136 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 1 | 11 |

TABLE XXIII (continued)

*Directions: Each phase of tooth development has a value attached to it. The following numerical quantities are used for the permanent, maxillary and mandibular, central and lateral incisors: 0 - The primary tooth is in the mouth of the subject; 1 - Space exists where the primary tooth was once positioned; 2 - The permanent tooth has erupted the gingiva; 3 - The permanent tooth has reached the occlusal plane.

TABLE XXIV

TOOTH ERUPTION CHART* FOR 33 BOYS

| | Maxilla | | | | Mandible | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Left | | Right | | Left | | Right | | |
| Student # | Lat. | Cent. | Cent. | Lat. | Lat. | Cent. | Cent. | Lat. | Total |
| B02 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| B06 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| B07 | 0 | 2 | 2 | 1 | 1 | 2 | 2 | 0 | 10 |
| B09 | 0 | 3 | 3 | 0 | 2 | 3 | 3 | 2 | 16 |
| B10 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 5 |
| B11 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 8 |
| B13 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 8 |
| B14 | 1 | 2 | 2 | 1 | 0 | 2 | 2 | 1 | 11 |
| B16 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 5 |
| B18 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| B19 | 0 | 2 | 2 | 0 | 1 | 2 | 2 | 0 | 9 |
| B22 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 5 |
| B25 | 0 | 2 | 2 | 0 | 1 | 2 | 2 | 1 | 10 |
| B27 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 1 | 9 |
| B28 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 8 |
| B29 | 1 | 3 | 3 | 1 | 3 | 3 | 3 | 2 | 19 |
| B30 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 8 |
| B31 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 6 |
| B32 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 1 | 9 |
| B33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B35 | 0 | 2 | 1 | 0 | 1 | 2 | 2 | 2 | 10 |
| B36 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| B37 | 1 | 1 | 2 | 0 | 0 | 2 | 2 | 1 | 9 |
| B40 | 0 | 2 | 2 | 0 | 1 | 2 | 2 | 0 | 9 |
| B41 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 6 |
| B42 | 0 | 2 | 2 | 0 | 1 | 2 | 2 | 0 | 9 |
| B43 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 |
| B44 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 1 | 7 |
| B45 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 22 |
| B46 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| B48 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 19 |
| B49 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 22 |

TABLE XXIV (continued)

*Directions: Each phase of tooth development has a value attached to it. The following numerical quantities are used for the permanent, maxillary and mandibular, central and lateral incisors: 0 - The primary tooth is in the mouth of the subject; 1 - Space exists where the primary tooth was once positioned; 2 - The permanent tooth has erupted the gingiva; 3 - The permanent tooth has reached the occlusal plane.

APPENDIX B

LETTERS

From: Frances L. Ilg, M.D., Director Emeritus, Gesell Institute of Child Development, 310 Prospect Street, New Haven, Connecticut 06511, 2/21/76.

I have been retired for the past four years; however, I have been pursuing further studies along the previous lines. In any study I always include dentition. I find this inclusion both helpful and confusing. I thought there might be a simple correlation from our initial study at Weston, Connecticut, as reported in School Readiness; however, I have come to believe that much more definitive research needs to be done. I have tried to interest the dentists, but they are primarily interested in decay and alignment.

The variability of the patterns also need to be explored. Do the 6-year molars erupt first or the central incisors? When you have all 8 upper and lower incisors fully erupted at age eight or nine before any sight of a 6-year molar, I anticipate an unstable mechanism. Or, another extreme might be the eruption of the 12-year molars at age 11 with only 2 bicuspids beyond the 8 incisors. I feel it's going to take some time for this child to integrate.

I mention these extremes to emphasize the complexity of the problem, but I still feel the usefulness of the tooth age especially in the early school years of 5-8 years, and even more so when a child has a young birthdate for the grade he is eligible for. My cut-off date has now been put back to June 1st which means a kindergarten applicant would have to be 5 years 3 months at least and a first grader 6 years 3 months.

As for a more specific relationship to mathematical concepts, this is hard to say; but whenever I go into a second grade classroom when interest in math is so high for both boys and girls and when that seven-year-old Rubicon is crossed (Piaget's Conservation of Continuous Quantities), I always take a glance at their teeth. If I see two well erupted upper central incisors with holes on either side from the loss of the upper lateral incisors, then I know the child is nicely into seven years as far as tooth age is concerned. When I see no movement of the upper incisors, then I am concerned and want to examine the child to see if he is really a 6 year old and belongs in the first grade.

I wish I could be more helpful. Now it is for you to do the needed research.

. . . . . . . . . . . . . . . . . . . . . . . . . . . . .

Again, I apologize for not being altogether scientific, but often it is that subjective or intuitive thrust that leads us to the right question.

All I can say is good luck, and do let me know how your study comes out.

From: Mrs. A. V. Lombardi, Secretary to the Faculty Chairman, The Waldorf School, Cambridge Avenue, Garden City, New York 11530, 8/7/75.

Mr. Barten has asked me to answer your interesting request for information on the relationship between readiness for cognitive skills and dentition.

While our teachers of younger children try to be aware of the loss of "milk teeth," observations have not been consistent or acute enough to be used in a predictive manner. In so many cases other factors are present which confuse the issue.

Mr. Barten related to me one case history, however, which does seem to point to a clear connection. A student, Billy O., entered his class at age eleven, unable to read or spell. The boy seemed normal in all other respects and was a national model airplane champion. He had lost none of his "milk teeth"! The school doctor, who was in sympathy with Rudolf Steiner's views, induced a gradual loss of the "milk teeth" through medical means. As the second teeth replaced the baby teeth over one and a half years, Billy O. began for the first time to read. The boy and his family moved out of state after three years in the school, but Mr. Barten was notified of Billy's graduation from high school - on schedule. (Apparently the father and the grandfather of Billy had had similar experiences with both teething and reading occurring at an unusually late age.)

Recently we have also had a case of a child who has asked to repeat the first grade, a rare phenomenon in our school, because he was not ready to learn. He had lost no "milk teeth."

Our faculty is presently away for the summer and could perhaps provide a few more examples when they return. Your undertaking makes us conscious that we should try to document our observations more carefully. We hope and trust that you will be asking other Waldorf schools for their examples also.

We would be interested in the results of your study and will be happy to cooperate should you wish to direct our attention to the question in a more specific manner.

From: Virginia E. Paulsen, Faculty Chairwoman, The Rudolf Steiner School, 15 East 79th Street, New York, N. Y. 10021, 8/7/75.

Your letter of July 30th addressed to Henry Barnes has been referred to me as Mr. Barnes is at present on a leave of absence and out of town.

The losing of the baby teeth is an indication of a state of growth the young child has reached. The loss of teeth usually begins about the seventh year of life, that is between six and seven.

While we have not kept any "hard date" on the matter, it has been our observation that children who have not lost a tooth, still are very much in the imitative stage of their development and their thinking has a dreaming quality. These children may be very capable in artistic endeavor and their pictures can be full of beautiful colors, although they will be lacking in form. They will listen intently to stories, but the next day they will be unable to remember details on their own. When the story is retold by another, they will remember it then. They can copy faithfully from the blackboard, but are under a strain and become uneasy if asked to work on their own. They follow along happily when the class is reading as a group but are not yet ready to read on their own.

If a child is placed in first grade because he is the right age but he has not yet lost a baby tooth, he must be handled very carefully, lovingly and tactfully so that he does not think he is unable to do the work. He could become so unhappy and discouraged if academic pressure is put upon him that his attitude toward school and learning could be adversely affected for the rest of his school career. The retardation in the loss of teeth has nothing to do with his potential intelligence which will flower when the child is ready.

We have changed our age requirements for first grade just to avoid putting academic pressure on children too soon. We ask that children be six by October 1. October birthdays must be especially considered. If change of teeth has begun, the child may then be allowed to enter first grade. You might be interested to know that the Gesell clinic has from observation come to the same conclusions. Dr. Louise Ames visited our school a few years ago and informed us that they take the shedding of teeth as a very important indication of the child's readiness for first grade. She also told us that the Gesell and Ilg clinic had found that the majority of children comprising remedial reading classes were boys whose birthdays were in the last three months of the year. This was in schools whose admission rules were six before Christmas. In other words they began formal education before they were ready for it.

I hope this has been some help to you. The Education of the Child by Rudolf Steiner as well as other educational books of his dealing with the development of the child would be of help but Steiner is not to be read quickly or casually.

From: Henry N. Williams, M.D., Medical Advisor to the Faculty, Kimberton Farms School, Inc., Phoenixville, Pennsylvania, R.D. 2, 19460, 10/10/75.

Your letter of August 11th addressed to the Headmaster of Kimberton Farms School was handed to me today for answer. I do not have any "hard data" on the tip of my tongue, but will ask one individual who may have something which I will transmit to you.

At the present I can only say that Kimberton Farms School does not accept children into first grade if the change in teeth has not started. There are exceptions, but I do not know of any in the last few years.

<u>From: Dr. Virginia C. Sease, Director, The Waldorf Institute of Southern California, 17100 Superior Street, Northridge, California 91324, 9/11/75.</u>

Thank you for your recent letter. It is most interesting that you and Dr. Burns are conducting research to determine whether there is a relationship between cognitive readiness and dentition. The Waldorf Schools have worked with this concept since Rudolf Steiner first brought it forward over 50 years ago.

Whereas there are a number of factors which we take into account in determining a child's readiness for First Grade, which in the Waldorf Schools marks the beginning of organized cognitive learning, the change of teeth is an important one. The physical age is also important. In most Waldorf Schools the child must be six years old before entering First Grade, even though many children lose their first tooth a year or more prior to this time. As you have probably read in Rudolf Steiner's pedagogical works, the idea here is that forces of growth are "freed" at this time which then are redirected and channeled into a more formal learning process.

For additional information you may wish to contact: Mr. Werner Glas, Director, Detroit Waldorf Institute - 8469 E. Jefferson, Detroit, Michigan 48214, who is closer geographically than we are.

Please feel free also to contact me if you have further questions. Also I would appreciate very much a copy of your study when you have completed it.

<u>From: Dr. med. Walter Holtzapfel, Medizinische Sektion am Goetheanum, Dornach/Schweiz, Ch 4143 Dornach, 7/11/75.</u>

Thank you for your letter of June 27th. The theme of your research, the relation of biological growth to cognitive growth with special concern to the shedding of teeth is a very interesting one. As far as I know, there has been no statistical research on this theme, and it will be difficult to register this connection statistically, because the coming out of a tooth can be stated exactly, the occurrence of cognitive ability only by tests. And tests are one of these dubious methods for to seize mental conditions, in my opinion.

Growth and consciousness can be said to be reciprocally related: The lower the degree of consciousness proper to an organism, the greater is its ability to grow and regenerate (regeneration is partial growth), and vice versa.

Indeed there is an underlying relation between these two spheres: There is an unconscious wisdom at work in all growth; in consciousness there are processes of growth in the mental sphere. The process of learning, especially, may be experienced as a process of inner growth.

I am convinced that this relation between growth and consciousness is very closely connected to the problem of dyslexia. Is dyslexia also a point of your program of research?

I am sorry that I cannot give you any statistical foundation for your research, but I would be very interested in the results of your work.

From: Marta Harris, Faculty Chairperson, Sacramento Waldorf School, 3750 Bannister Road, Fair Oaks, California 95628, 10/24/75.

Thank you for your letter of August 26.

We view the loss of "milk teeth" as an indication as to whether or not a child is ready for first grade. We do not, however, have any "hard data" with which we can provide you. Certainly the loss of "milk teeth" is not the only criteria we use in deciding if a child is ready to start school.

We hope you have written to other Waldorf Schools throughout the world, as it is just possible that one of them might be doing an actual study in this area.

There are many books dealing with Waldorf Education that explain Steiner's reasons for delaying cognitive skills until after the loss of first teeth. I am assuming that you know these books. If you would like specific titles, please write to me again.

We would, of course, be interested in the results of your studies.

From: Gerald Altwies, Executive Director, The Detroit Waldorf School, 2555 Burns Drive, Detroit, Michigan 48214, 10/16/75.

Sorry for the delay in responding to your August 26th letter regarding the relationship between readiness for cognitive skills and dentition.

At the Detroit Waldorf School formal teaching begins only in the first grade, not before. It is in this grade that we look for certain physical signs of readiness in the children. After an interview between parents, child and the teacher, we usually accept children who are fully six years old and, although we will inquire about the child's teeth, if he is six (except in very special cases), we do not base our acceptance or necessarily judge his readiness on whether he has begun to change his teeth. However, in cases when the child is not quite six and in other ways only questionably ready for first grade, and has not begun to change his teeth, then it becomes a more decisive factor against his acceptance.

In other words, no new teeth is more indicative of lack of readiness than new teeth is of readiness. This has generally been our policy.

From: P. Bowron, The New School, Kings Langley, Herts, WD4 9HG, 9/5/75.

From our experience change of teeth takes place in a child at varying ages according to the individual. However we have a certain amount of experience that the subsoil of the different counties in this country tends to make this process earlier or later. For instance in the county of Hampshire it is generally true to say that the children have lost their teeth at 4 years.

Our school Doctor has been of the opinion over the last 30 years that the children should enter class 1 in September after they are six without regard to the change of the teeth.

On certain occasions we have taken children into the first class younger or older than six years. Although this does not affect the intelligent children in the first few years, by the time they are approaching puberty it is quite obvious that they are out of their age group and are experiencing a different soul life from their class-mates.

## APPENDIX C

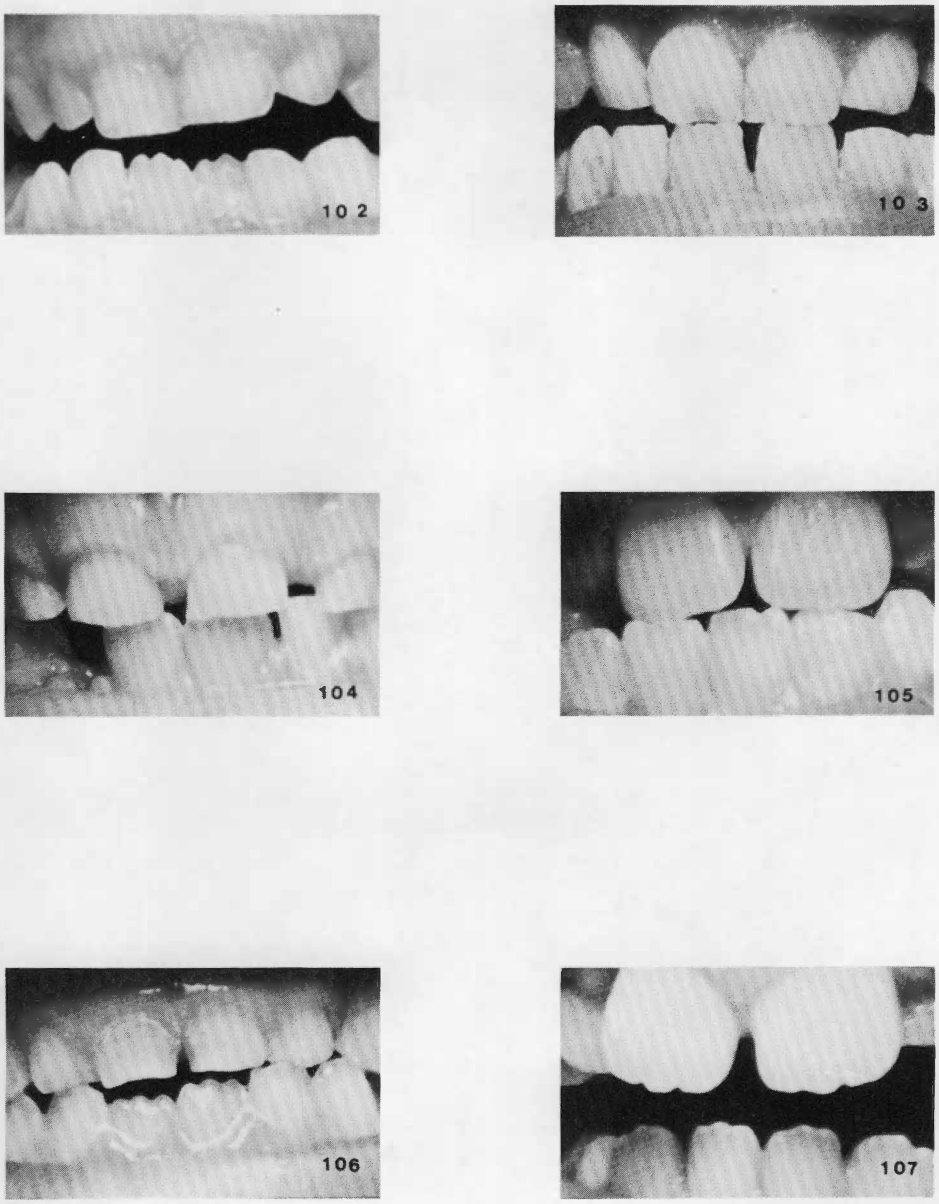
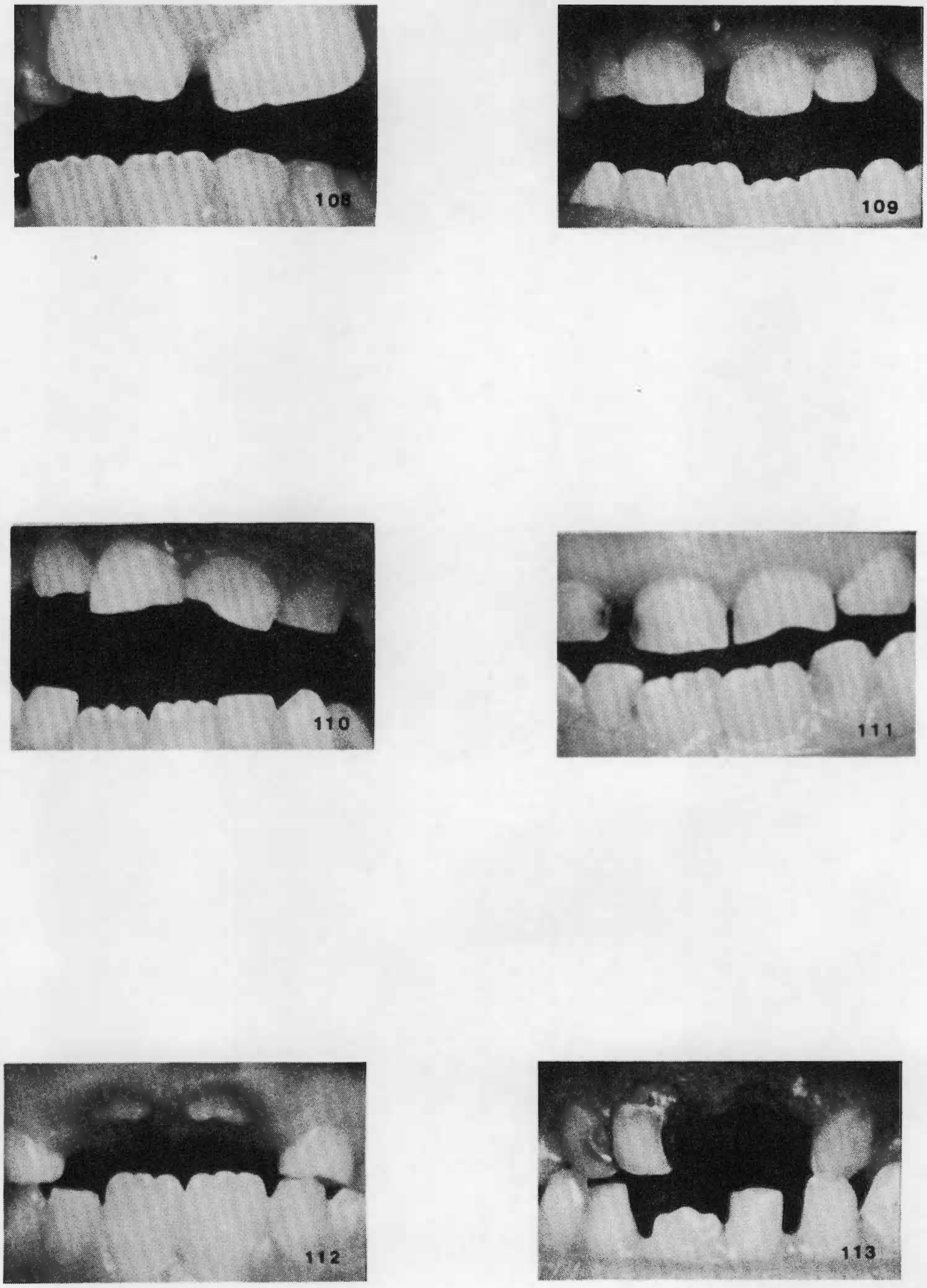



Figure 1. Dentition of the incisors of first grade Caucasian children (102-136) girls, (06-49) boys.

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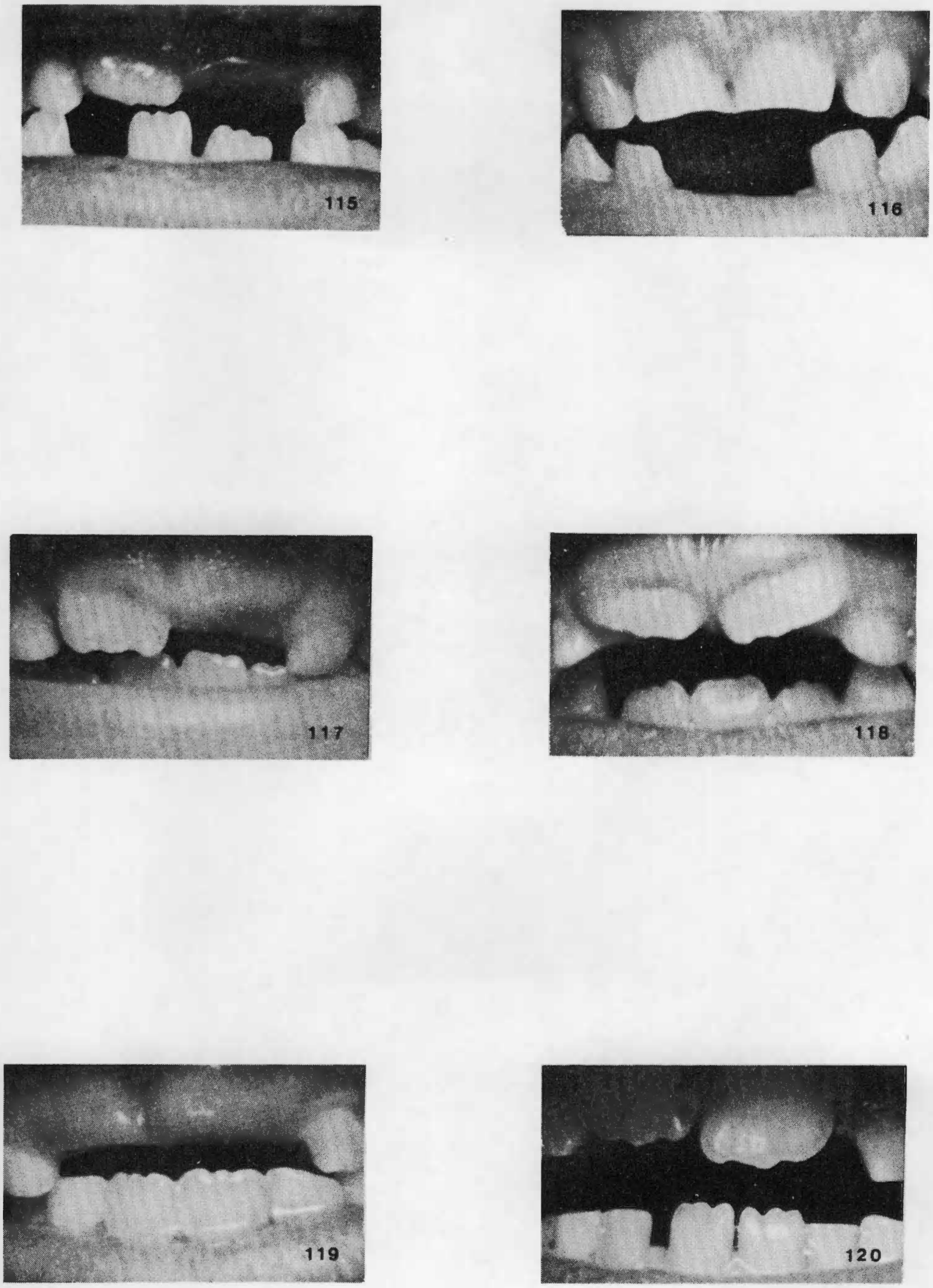


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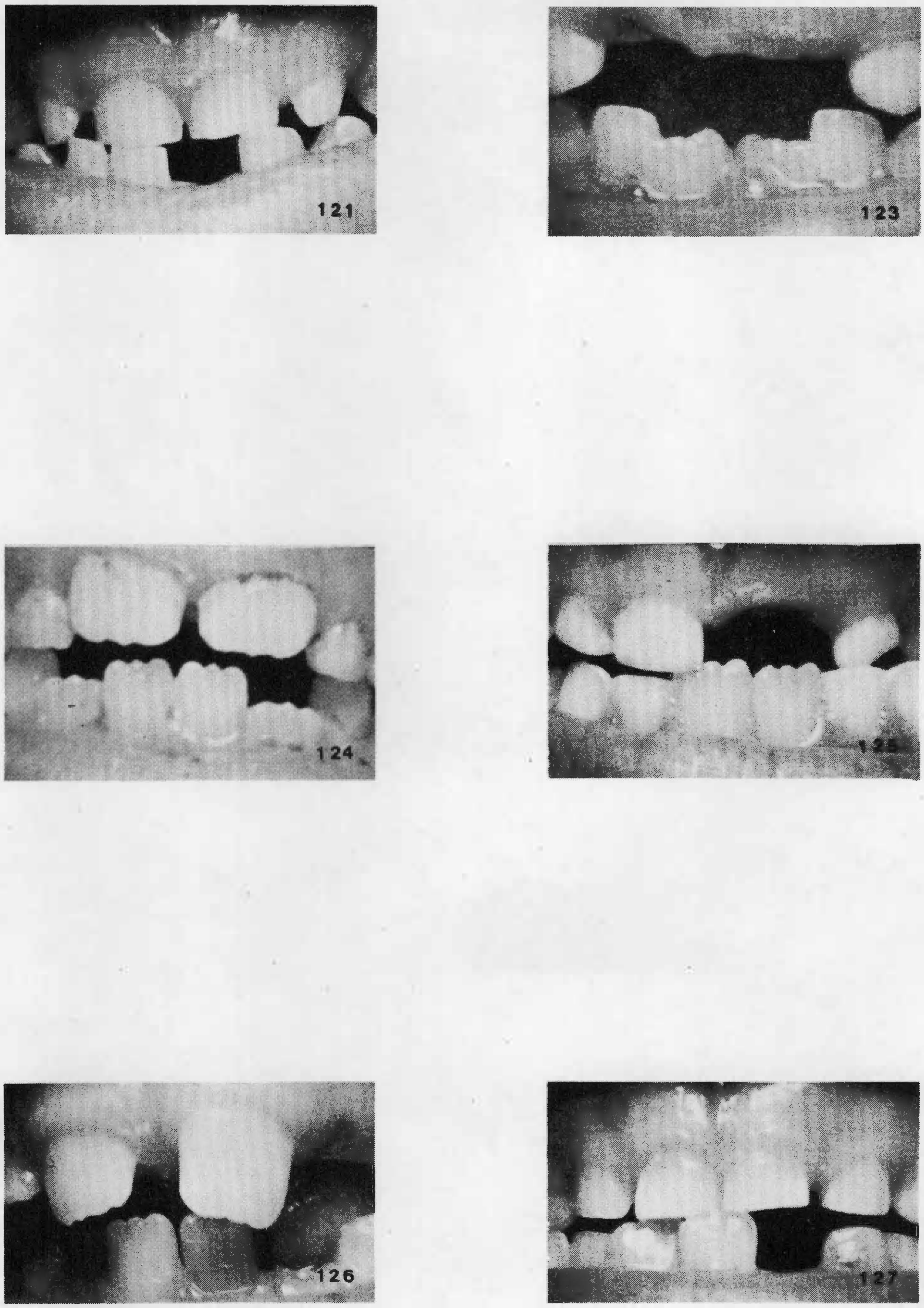


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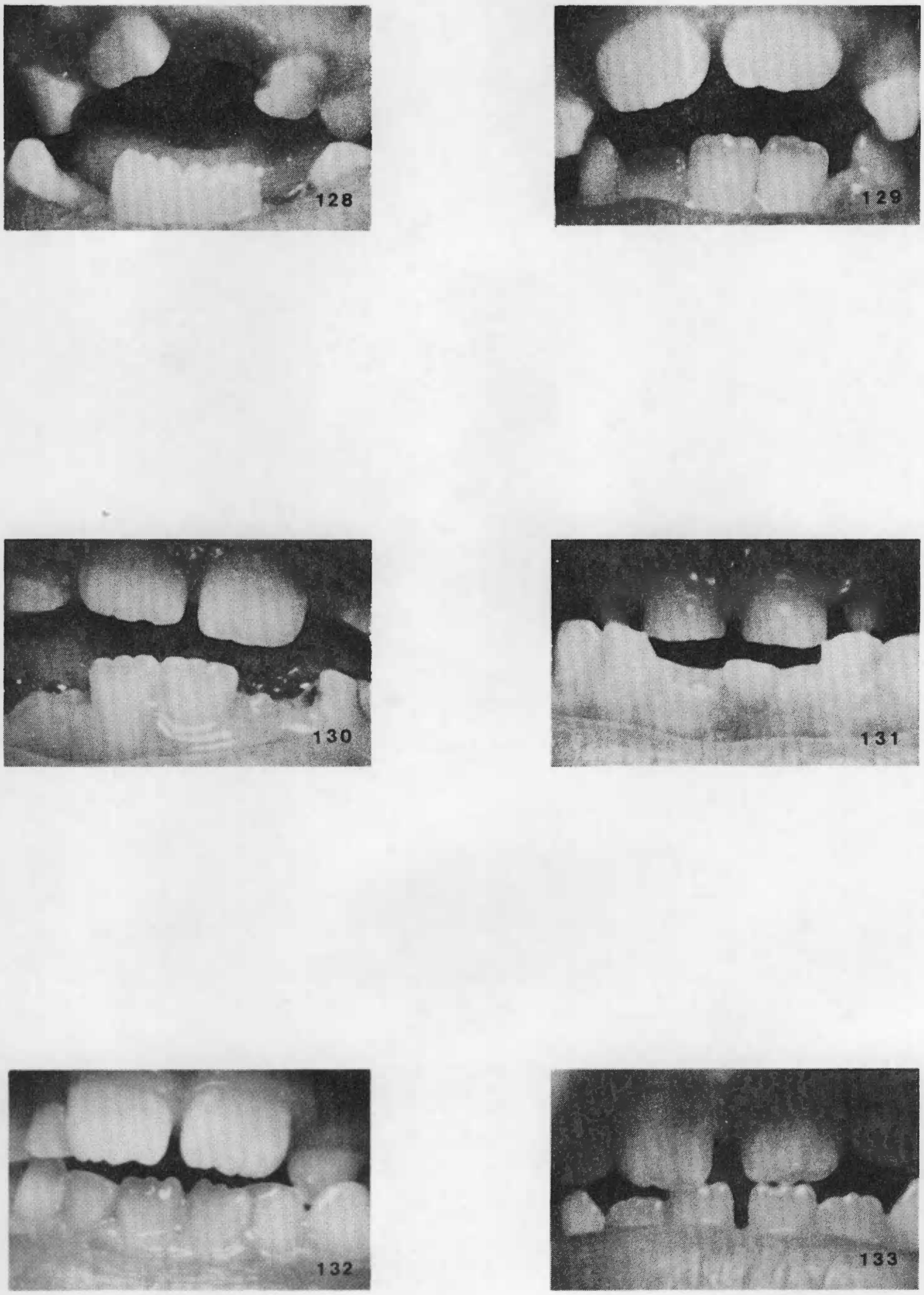


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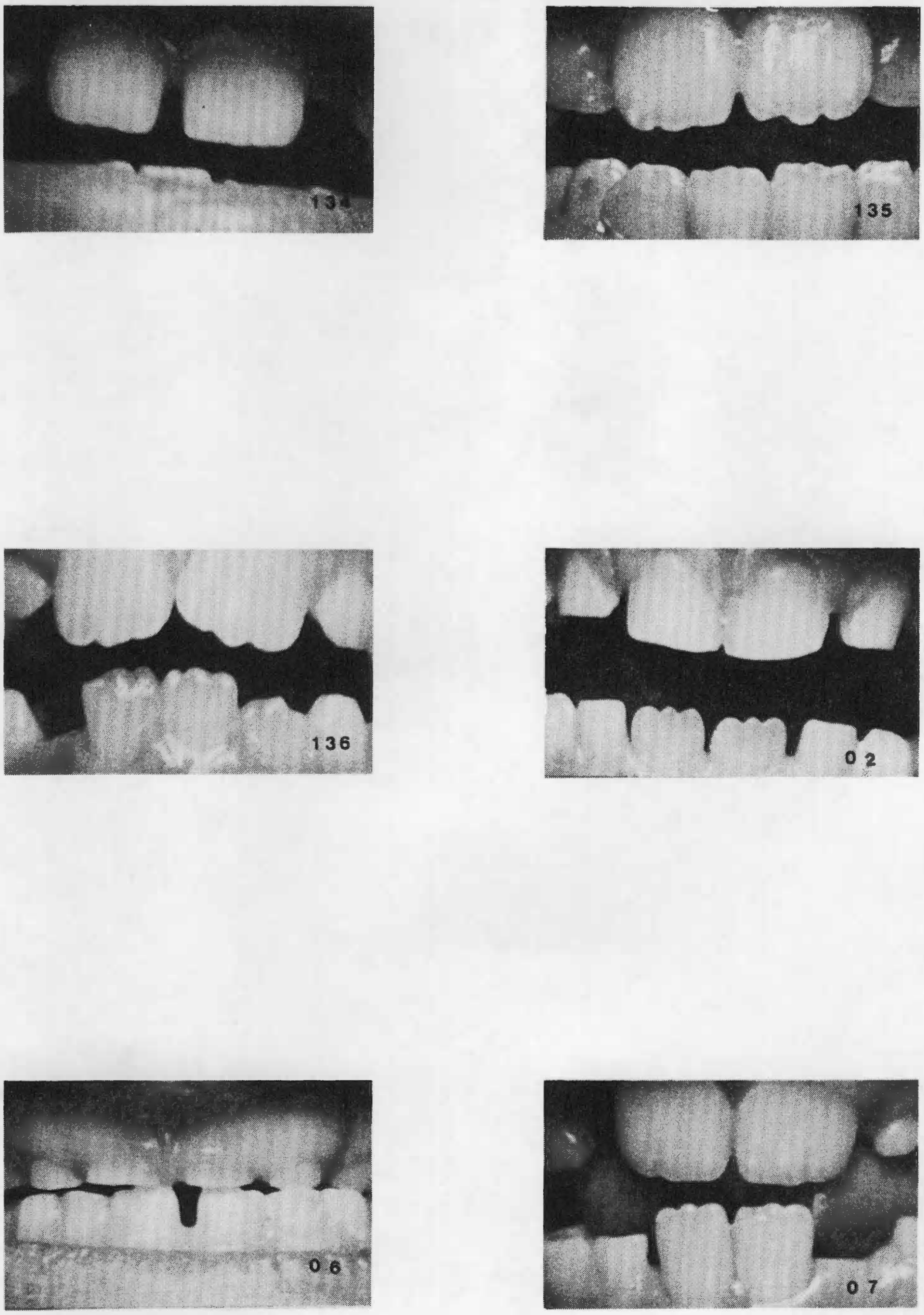
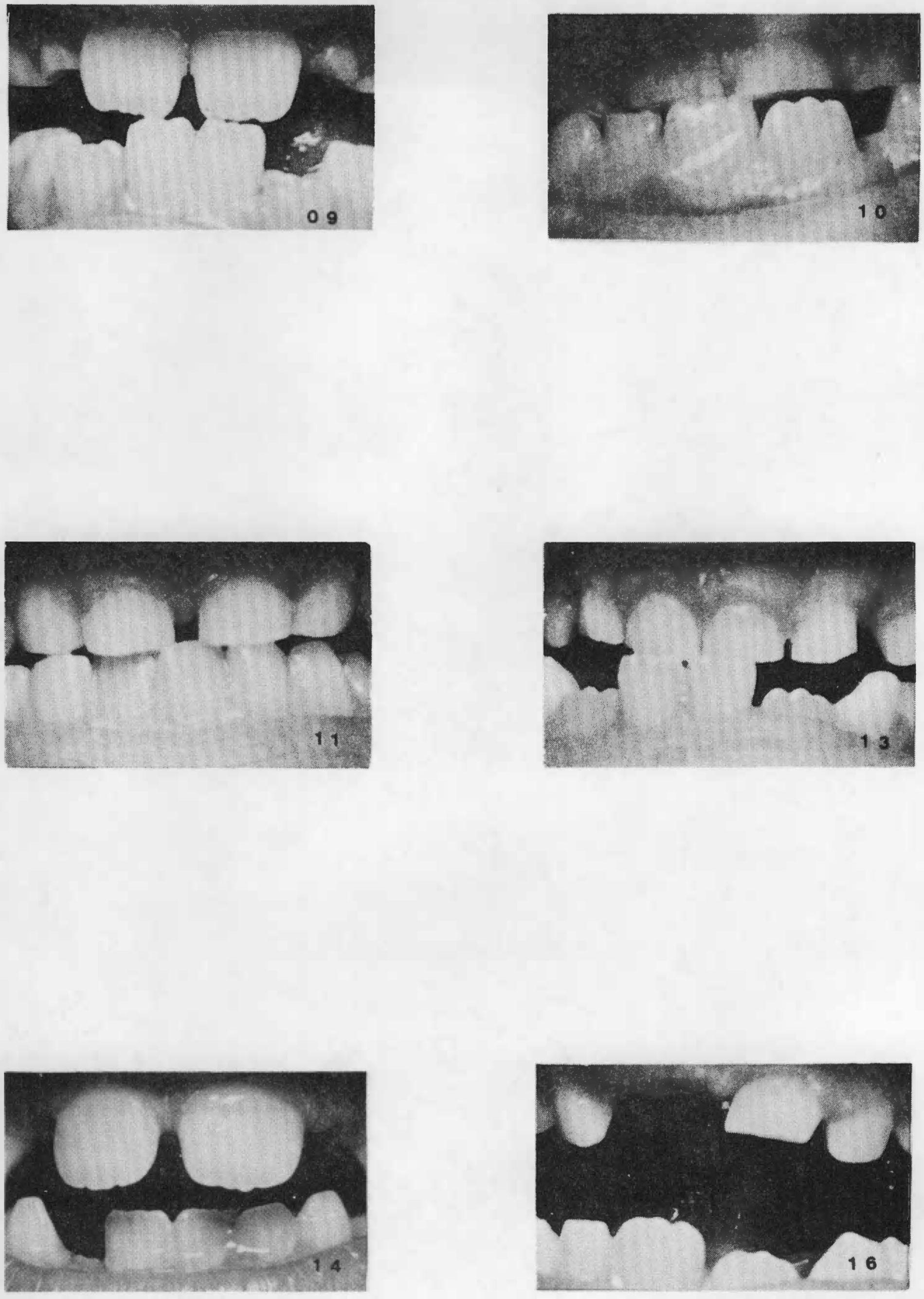



Figure 1.  (Continued)

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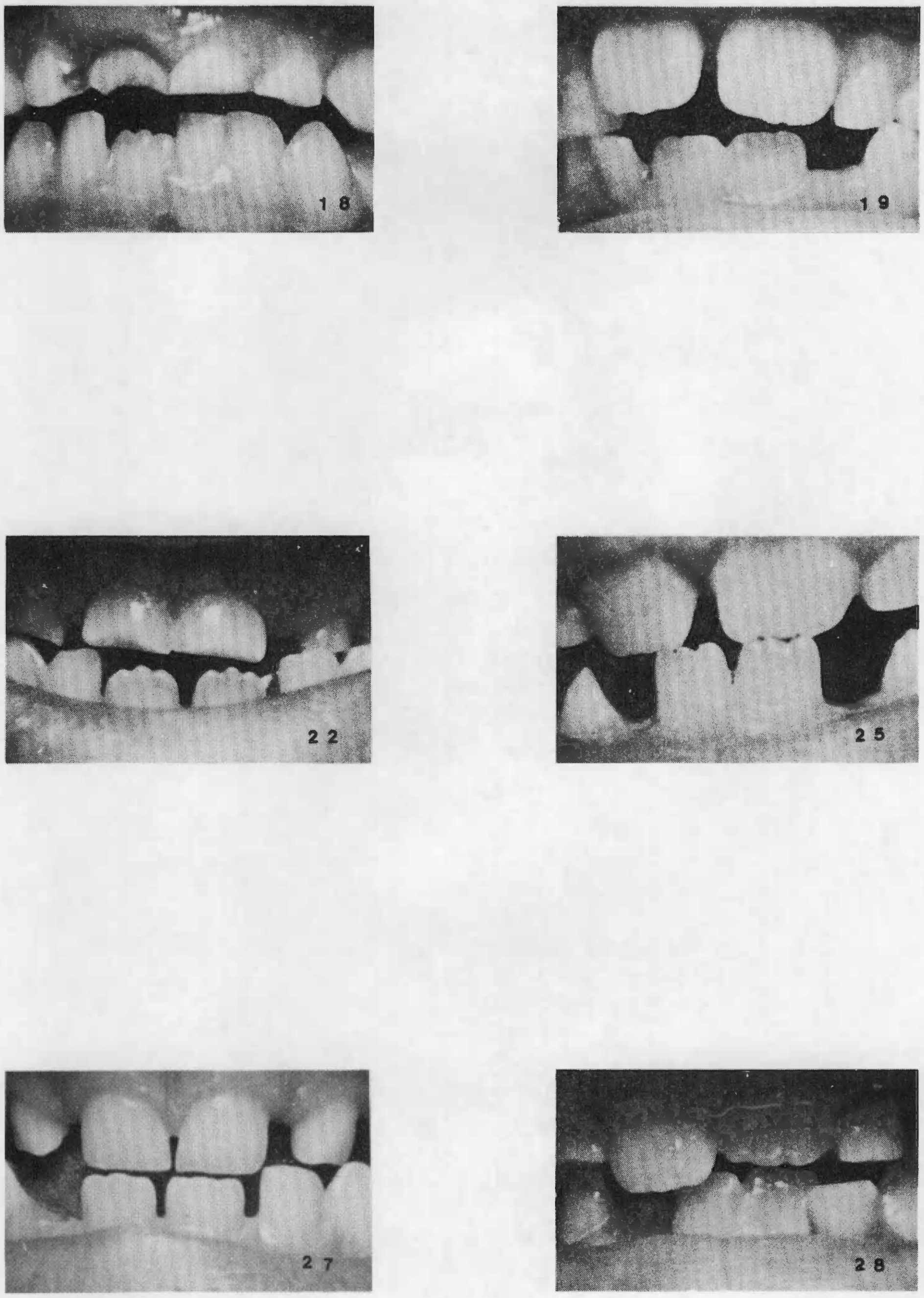


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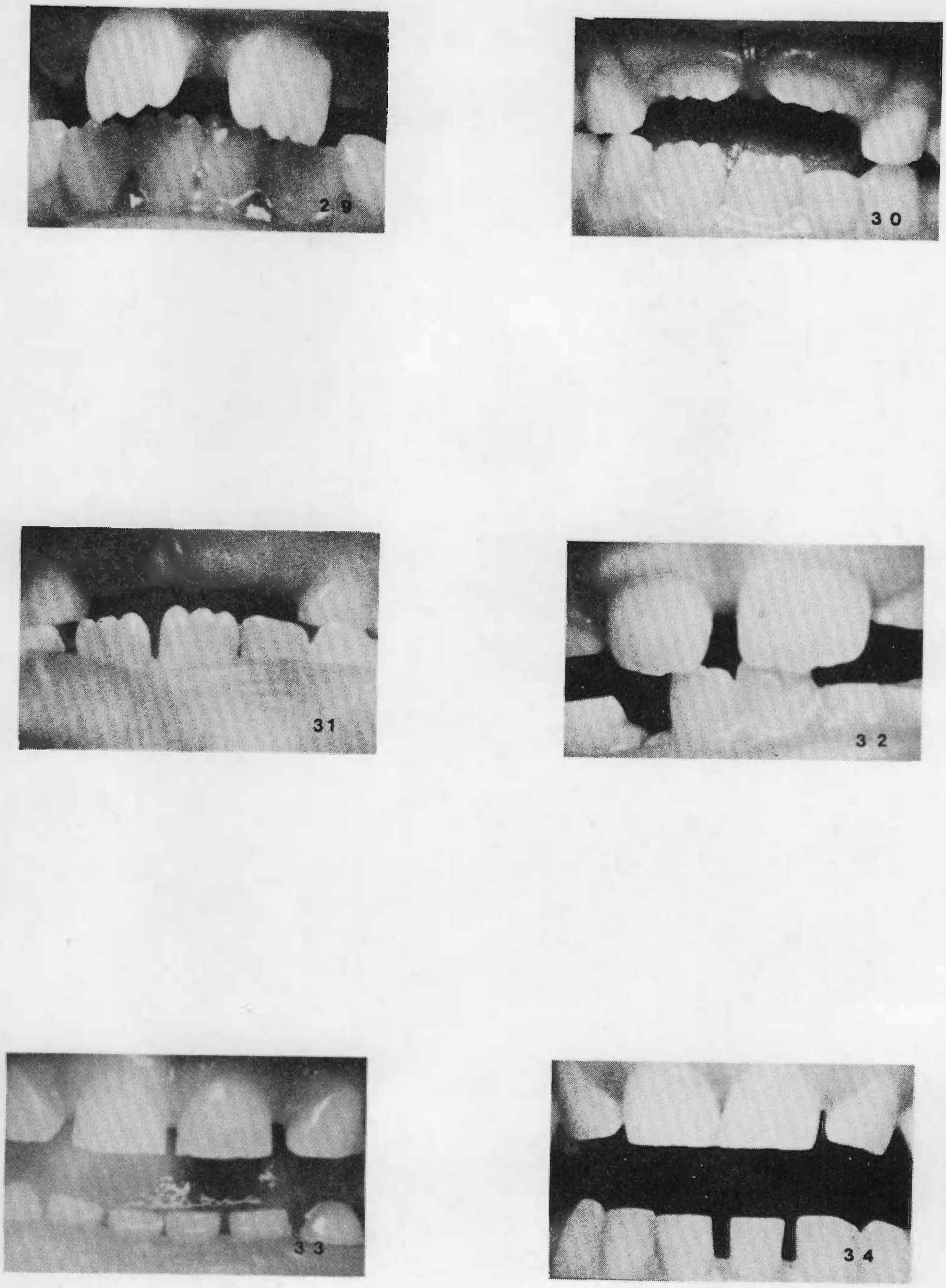


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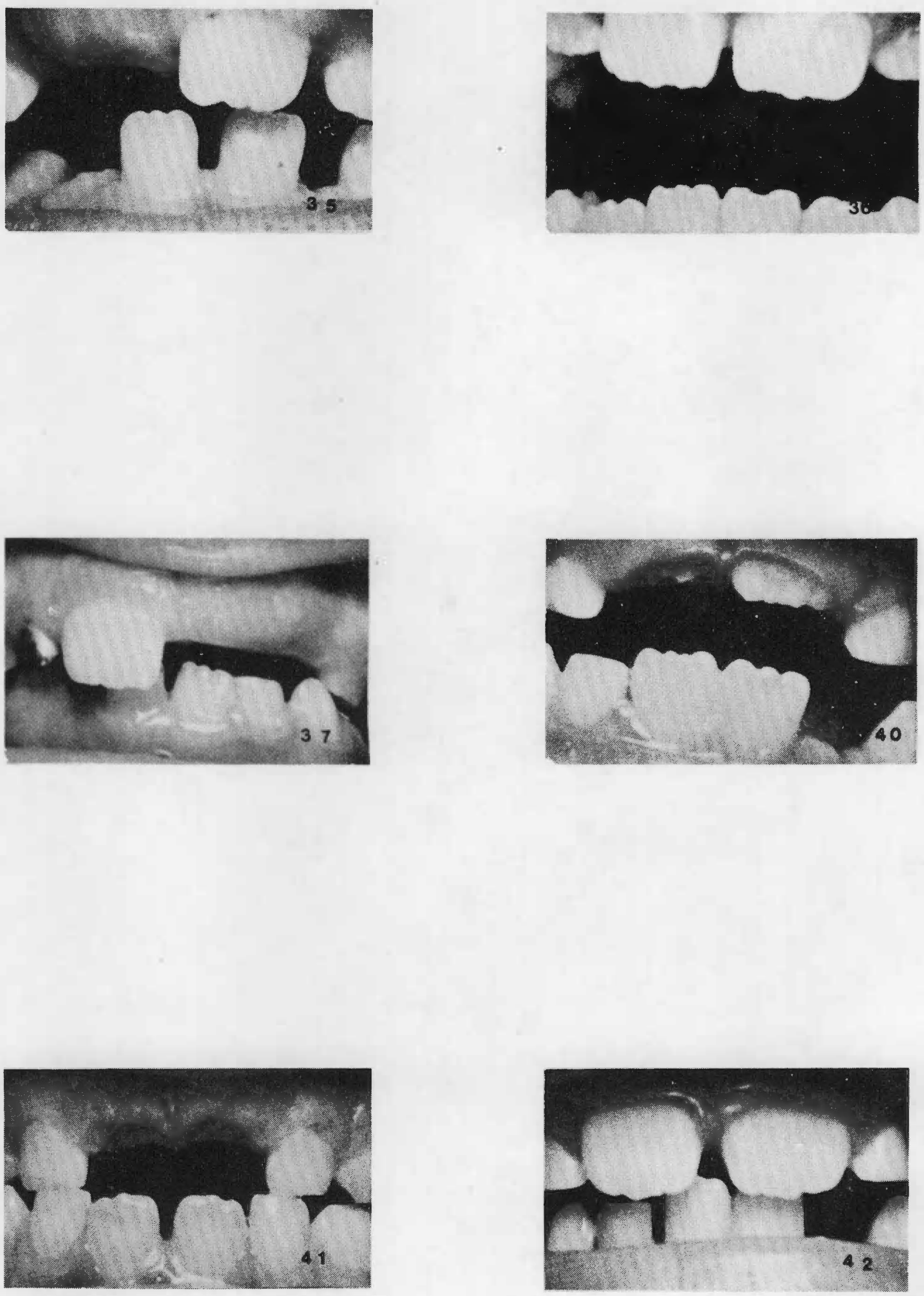


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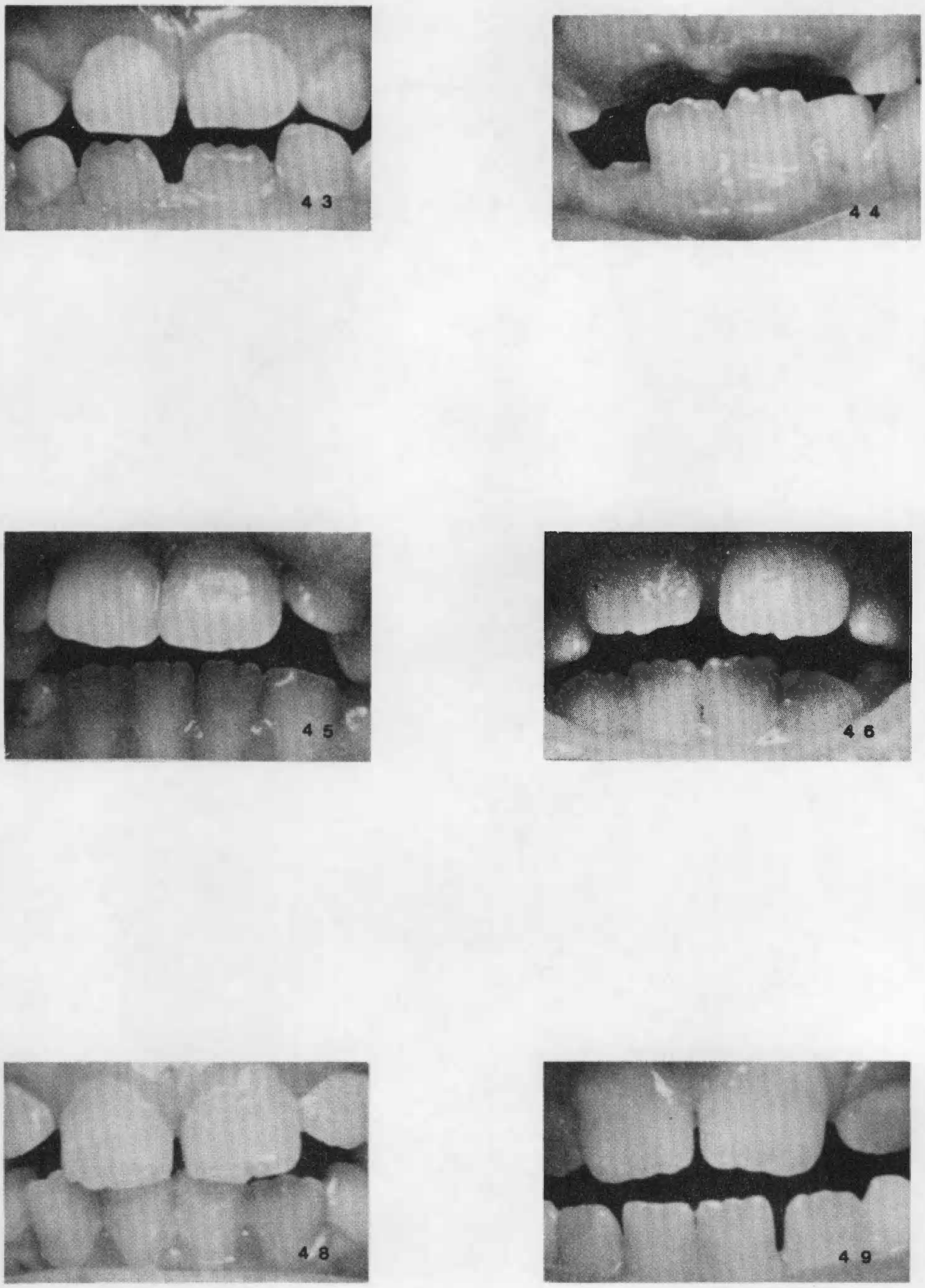


Figure 1. (Continued)

## VITA

Joseph August Baust, Sr., was born in Philadelphia, Pennsylvania, on March 5, 1949. He received his early education in the Philadelphia Public Schools where he was graduated from Northeast High School. He entered Memphis State University in the fall of 1966 where his major was elementary education. He received his Bachelor of Science in Education in the spring semester of 1970. He taught physical education and was a coach at Presbyterian Day School in Memphis, Tennessee, for kindergarten through sixth grades. He was awarded a Master of Education degree with a major in elementary administration and supervision from Memphis State University in 1971.

He taught fifth and sixth grades and was a mathematics coordinator in an elementary school in the Metropolitan Public Schools, Nashville, Tennessee. He entered The Graduate School of The University of Tennessee, Knoxville, and majored in Curriculum and Instruction with emphasis in elementary education. His collateral areas were elementary mathematics and continuing and higher education. He expects to complete all of the requirements for the Ed.D. degree by the spring of 1976. His dissertation topic is "Tooth Eruption/Cognitive Development/ Arithmetic Computation." He is currently a graduate assistant for the Dean of Research in the Office of

Graduate Studies and Research where his function is to provide faculty with prospective sources of funding for research projects. He is a member of Phi Delta Kappa, The Piaget Society, and the National Council of Teachers of Mathematics.

He was married to the former Marilyn Gail Morgan of Old Hickory, Tennessee, on July 5, 1969; they are the parents of one son, Joseph August, Jr.