1982

Brain growth: Intuitive and scientific

Karen Marie Patterson
University of Northern Iowa

Brain growth: Intuitive and scientific

Abstract

Developmental processes of the brain have long been considered the last frontier by scientists as well as educators. There has been much speculation concerning how and when the mind grows and if intellectual growth appears at the same time the skull and brain are physiologically and neurologically growing. Prior to recent research many educators assumed that learning, or intellectual advancement, occurred in an almost continuous manner. Educators felt children built skill upon skill and constantly moved from one stage of cognitive development to the next higher level of cognitive development. Traditionally, educational systems have been based on this concept of continuous intellectual development.

BRAIN GROWTH: INTUITIVE AND SCIENTIFIC

A Research Paper

Presented to

the Department of School Administration

and Personnel Services

University of Northern Iowa

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

---

by

Karen Marie Patterson

December 1982

This Research Paper by: Karen Marie Patterson

Entitled: BRAIN GROWTH: INTUITIVE AND SCIENTIFIC

has been approved as meeting the research paper requirement for the Degree of Master of Arts in Education.

Norman McCumsey

11/22/82
Date Approved

Director of Research Paper

Norman McCumsey

11/22/82
Date Received

Graduate Faculty Adviser

Robert Krajewski

12/7/82
Date Received

Head, Department of School Administration and Personnel Services

Table of Contents

List of Figures

CHAPTER ONE

Introduction

Developmental processes of the brain have long been considered the last frontier by scientists as well as educators. There has been much speculation concerning how and when the mind grows and if intellectual growth appears at the same time the skull and brain are physiologically and neurologically growing.

Prior to recent research many educators assumed that learning, or intellectual advancement, occurred in an almost continuous manner. Educators felt children built skill upon skill and constantly moved from one stage of cognitive development to the next higher level of cognitive development. Traditionally, educational systems have been based on this concept of continuous intellectual development.

Some educators have speculated that children do not learn in a continuous manner. There has been, however, insufficient evidence available to substantiate the theory. The question arises that possibly children do not learn in an uninterrupted style but rather experience times of brain growth and brain periodization which correlate with intellectual growth and intellectual periodization.

The problem of whether intellectual development is linked to physiological and neurological growth periods of the skull and brain has been an intriguing question which has puzzled educators for some time. Although there appears to be specific times when individuals are more ready to advance intellectually, until recently, little or no scientific data has been available to document the theory.

Using library research and ERIC the author found a limited amount of information on the topic of human brain growth periods. Considerable laboratory studies have been conducted on lower species of life, particularly those members of the Rattus family. Numerous laboratory studies have also been conducted on Anthropoids. Juxtaposed to those numerous studies were studies that involved humans, particularly studies involving children from birth through formal schooling age. The studies cited regarding humans are significantly relevant to the problem posed in this research paper.

Purpose of the Research

The purpose of this research paper is to determine whether there are sufficient scientific studies indicating periods of skull and brain growth which correspond to periods of intellectual growth. In this

research, studies are cited concerning data collected showing periodic skull size increase, brain weight increase, and electroencephalograph results. Studies concerned with higher degrees of intellectual growth during skull and brain periods are also cited.

Studied in this research paper is the question of whether intellectual growth periods are inadvertently coupled with actual skull and brain increase periods. Is there some correlation between what educators call readiness and actual physiological and neurological growth periods? If so, does that correlation result in suggested implications for educators to necessitate a look at present educational strategies and curriculum development?

Importance of the Research

Research and documentation of scientific studies that correlate skull and brain growth with intellectual growth periods in the child is of utmost importance in this study. Given those correlations, the author questions whether a child's success, or lack of success, in school is contingent upon those periodic stages of learning when assimilation of higher cognitive skills are more appropriate.

If educators accepted that periodic skull and brain growth in children coincided with learning ability, then

is there sufficient evidence to change the traditional educational system? Is there a child-concerned need to revamp the timetable of the educational system, cycling it periodically rather than continuously? Several questions arise with this topic along with a multitude of possible solutions.

Limitations

Limitations of this research paper, as noted earlier, resulted from lack of scientific and educational research on the topic. Some of the research studies that have been compiled were unavailable for use in the research paper.

It was also necessary to interpret translated research as well as to interpret highly scientifically documented studies.

The above limiting factors restricted, to a degree, generalizations that were concluded.

Definitions of Terms

The following definitions were adhered to throughout this research paper in order to differentiate specific meanings of terms that are commonly interchangeable.

Brain growth. Physical and/or neurological increase in the mass and/or energy of nerve tissue located within the skull.

Cognitive. Skills of a particular type in content. Knowledge of the physical world.

Higher Cognitive Level. A series of skill structures called levels gradually increasing in complexity; one designated skill built directly on a specific skill from the preceeding level.

Intellectual/Mental Growth. Terms used interchangeably indicating advancement in higher cognitive ability.

Phrenoblysis. "Phreno" meaning related to the skull and/or mind, "blysis" indicating the increasing of matter.

Readiness. Opportune time or state when an individual was ready for higher cognitive challenges and/or skills.

CHAPTER TWO

Review of Literature

Brain Growth

As early as the year 1929 the concept of periodic phrenoblysis was questioned by innovative scientists and educators.

Alfred Whitehead, through experience while working with children, felt that just as there was periodic physical growth in the body, so too was there mental growth that was periodic in nature. Whitehead suggested that children did not learn in a continuous manner, but rather experienced times of mental growth. The "Rhythm of Education" (38) explained Whitehead's differentiating by age the types of studies and levels of higher skills in learning that children should undertake. Whitehead suggested there were cyclic recurrences in the child's ability to learn that corresponded to mental growth. As an advocator of teaching the child at the most opportune moment, Whitehead intuitively felt and concretely experienced that the child learned at certain age-linked times in the child's life. Those periods occurred during the first years of life, about age three, and again about age seven (38).

Approximately the same time, although continents apart, Soviet psychologist, Lev Vygotsky, in agreement with Whitehead, noted what he called critical periods of rapid change in children. Vygotsky observed intellectual development took place during those critical periods and that there was a remarkable correlation to the results of the Piagetian studies (35). Critical periods resulted in higher degrees of distinctiveness and specificity within the child's cognitive abilities.

Contrary to more recent studies, Vygotsky advanced his theory by coupling the times of periodization with the child's development of personality. Vygotsky noted that periodization times of childhood were based on a division of the intrinsic characteristics of childhood itself; and, that the complexities in the child's development of personality did not necessarily parallel the levels designated in the traditional educational system (38).

This unique concept of periodic learning was not seriously considered until the 1960's. Study of the neural processes, periodic increases in brain wieght, and skull development confirmed Whitehead's and Vygotsky's intuitive observations that learning was not continuous but rather suggested growth occurred at discrete periods during the child's life. Just as the studies indicated there were times the brain grew in spurts, they also

implied times of periodization when the brain was not growing at as fast a rate.

Sufficient scientific facts evidenced that brain growth was not merely a theoretical notion. The question remained was it age-linked? If it was age-linked, was it an expression of biological and neurological development of the child, or cultural influences upon the development of the child? The later interpretation was quite unlikely as Dasen showed by studies conducted in several countries which were culturally quite different (11). The results of Dasen's studies inferred that brain growth was age-linked and an expression of the biological and neurological development of the child and not that of cultural influences. If brain growth periods were not linked to cultural influences, then was there scientifically documented physical and neurological data to suggest age-linked periods?

In reviewing the available literature dealing with brain growth, the name of Herman T. Epstein continually reappeared as the authority in this area and was cited consistently in this writing.

Epstein, through his studies, suggested that modification of the brain did not take place continuously but occurred at discrete periods during life which could be identified as stages of brain growth or brain spurts.

His findings indicated brain growth occurred during the age intervals of three to ten months, two to four years, six to eight years, ten to twelve or thirteen years, and fourteen to sixteen or seventeen years (15).

Using the six to eight year growth period as an example, Epstein suggested that the duration of the growth took place for about six months. It began sometime after the sixth year and concluded by the eighth year (13). Epstein found age-linked stages correlated with the child's mental growth.

Further, his findings closely correlated brain growth spurts with the classical stages of intellectual development described in writings of Jean Piaget (6, 15) with the exception of the fourteen to sixteen or seventeen year brain growth period which did not have a Piagetian counterpart.

Epstein suggested that the brain growth period from three to ten months corresponded to the Piagetian sensorimotor stage. The two to four year period corresponded to the transition from the sensorimotor to the preoperational stage. The brain growth spurt from age six to eight coincided with Piaget's transition from preoperational to concrete operational. The years from ten to twelve or thirteen coincided with that period when children moved from the concrete to the formal operations stage (6, 15).

It should be noted that findings from recent studies by Patricia Arlin with young adults showed there possibly was a fifth stage of cognitive development. Just as Epstein's first four brain growth periods closely corresponded to the Piagetian stages of development of intelligence, Arlin suggested that the last brain growth period also had its intelligence counterpart. This fifth stage was characterized by creative thought and the envisioning of new questions. It characteristically involved development of unproven arguments; thus the discovery of new heuristics in the young adult (1).

The problem with the correlation of the Piagetian intelligence development stages with brain growth development was that it was not proven that the Piagetian stages of development had been universally accepted. To scientifically draw a correlation between the Piagetian stages and the stages of brain growth was difficult. However, the author continued to find research that indicated children displayed various Piagetian stages at given ages which paralleled extremely close with the pattern of brain growth stages and those periods were age-linked.

Periodic Skull Growth

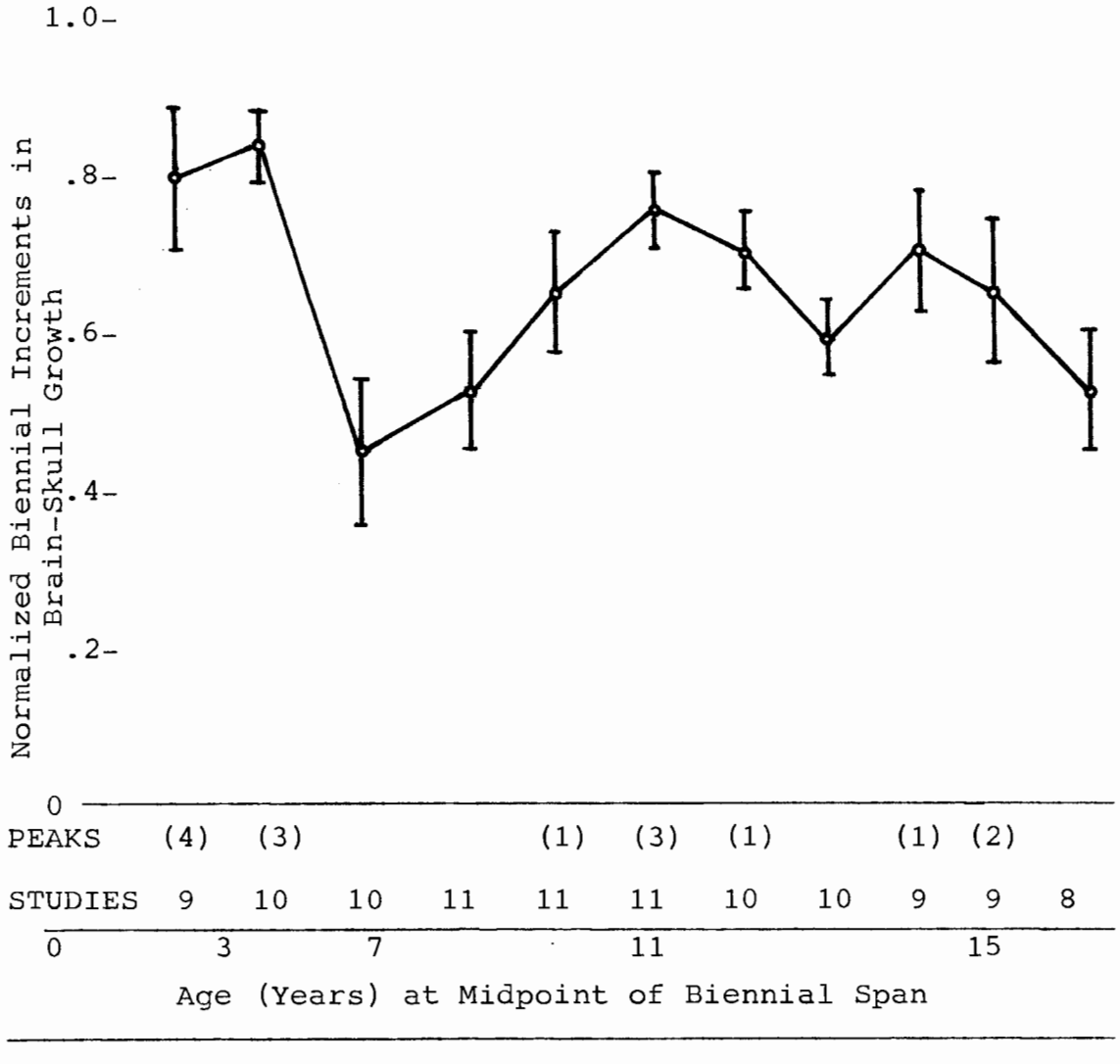
The author began by researching the biological and neurological aspects of implications of brain growth. In order for the brain to have available room to grow there

must be some evidence that the brain and skull increased in size. Those increases indicated a time of growth which exhibited brain and skull increases at about the ages of seven, eleven, and fifteen. The following figure graphically showed the available studies as tabulated by Epstein (17). The eight research projects involved one hundred and eight separate studies which measured biennial increments in brain-skull development. Subjects ranged from age six to age sixteen. The standard error for each age was given. The figure was self-explanatory, however, it should be noted that the numbers in parentheses indicate the number of studies that had main peak growth at that particular given age.

Prior to this work of Epstein, Winick and Rosso suggested through their research involving accident victims that there was a correlation between brain weight and head circumference in children. Winick and Rosso's studies involved children from birth up to the age of one year and three months (41). In agreement with Winick and Rosso, Meredith in his study of infants up to the age of two years showed the growth in head girth was most rapid during the first year (30). During that time he suggested the increase in head circumference was about four inches. The following year the increases in the child's skull increased about an inch. These

Figure 1

Brain and Skull Growth Spurts
in Humans



studies seemed to indicate a physical growth in the skull that corresponded with Epstein's mental growth period during the three to ten month period.

Bayley, by measuring the exterior of the skull, also inferred brain growth. His studies encompassed children from birth through the young adult stage. Particularly noted were children between ages three and five which he considered to experience a juvenile spurt period of growth (3).

Periodic Cellular Development and Brain Weight Increase

Just as the skull circumference increased periodically, research showed the cellular development and weight of the brain increased. Through this recent work in the neuro-sciences scientists were now better able to provide a more concrete explanation for acception of the concept of phrenoblysis.

In research conducted by Herman Epstein and Erika Epstein results showed that for both normal and malnourished children the brain essentially preserved its growth. It appeared to grow independent of the state of health experienced by the child (19). That study further stated the shape of the brain was ellipsoidal in nature and maintained that basic shape throughout life regardless of nutrition.

Dobzhansky, in his studies of brain size, concluded that in relationship to body size compared with anthropoids, man had a much larger brain. Although he did not conclude that this larger brain size unquestionably set levels of intelligence, he did suggest, cautiously, that with larger brains there were more numerous dendrites present which in turn permitted more interconnections between cells within the neuro-network, allowing for greater memory retention (12).

Blinkov, in his work with weight and volume of the brain, cited that there was no distinction between boys and girls, regardless of their body size, concerning the rate of growth of their brains (4). As an example, in both sexes, during the prenatal period the body length increased by about eighty percent. Body weight increased almost seven hundred percent. During that time the weight of the brain increased close to five hundred and sixty percent which was almost an increase at the same rate of the body. Through his further investigations of Soviet scientific studies he concluded that during the intrauterine period there was intensive growth in weight at about the third lunar month which slowed down during the fifth month and increased again at the end of the pregnancy. He cited that after birth the weight of the brain increase was not almost equal to, but

much slower than the weight increase in the body (4). With those findings in mind it was possible to infer that as well as age-related brain growth periods after birth, there might possibly be scientific data to accept a brain growth spurt during the prenatal period.

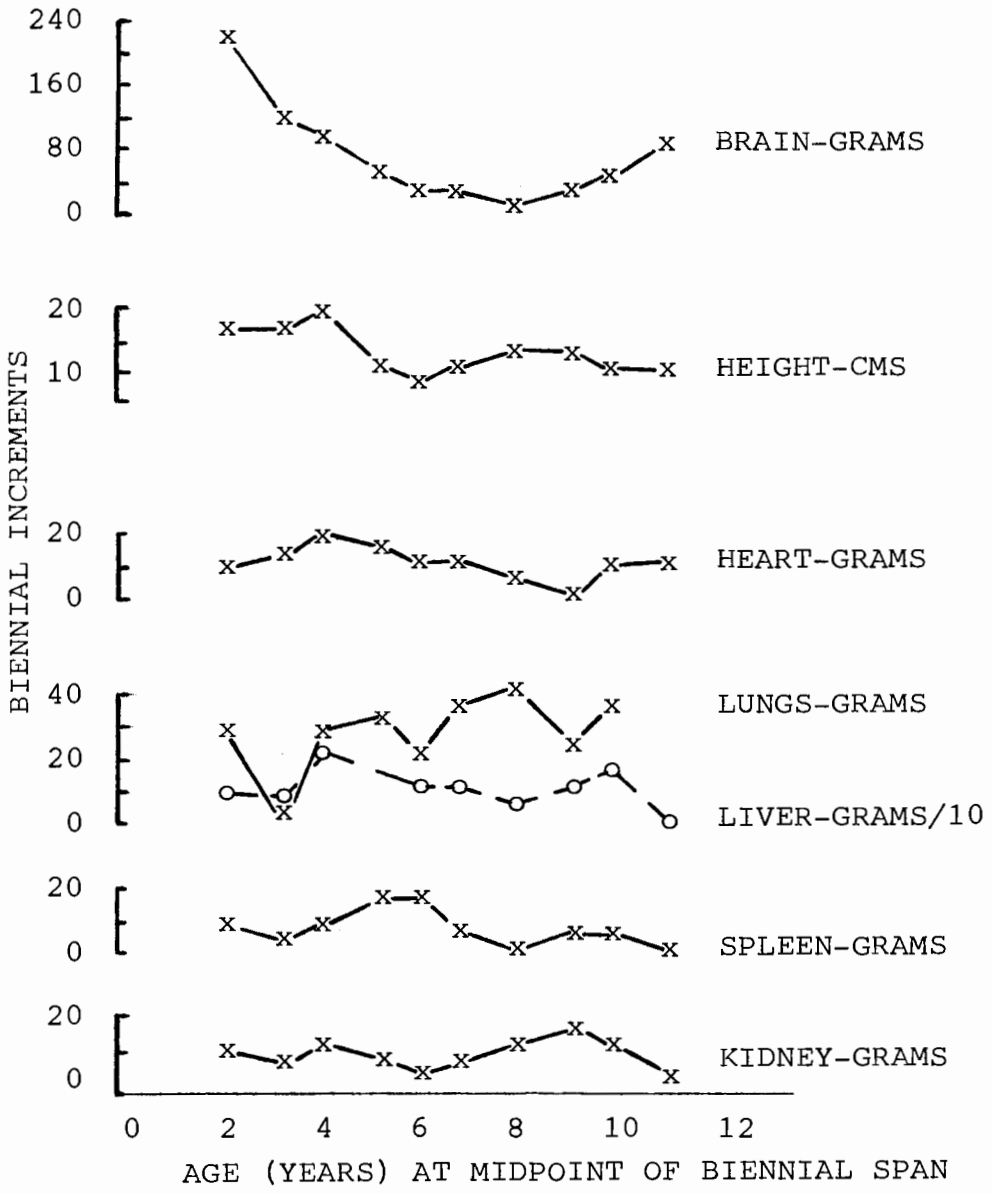
The work of Sheldon White suggested a connection between mental growth and physical growth of the body. He suggested a close relationship between increased intellectual ability and biological growth at ages five to seven (37). Using White's studies one might think body growth and brain growth happened simultaneously. The research of Epstein negates that theory (18).

Epstein, in agreement with J. M. Coppoletta and S. B. Wolbach, suggested with the exception of growth in the female heart at the age of eleven and liver at the age of seven, there was no correlation after birth with brain development and growth in body length, the lungs, liver, heart, or kidneys (10, 17). Those body developmental times were inversely related to Epstein's periods of mental growth.

The following figure (Figure 2) shows studies conducted on children up to the age of twelve. Citings done by measuring biennial increments by Coppoletta and Wolbach clearly substantiate that periods of body growth

Figure 2

Biological Growth of Body Organs



(10, 17)

do not generally coincide with Epstein's characteristic mental growth periods.

In order to further clarify the correlation between physical skull and brain growth and mental growth periods Epstein compiled a table of ten separate scientific studies which clearly showed skull/brain growth periods at ages seven, eleven, and fifteen. Brain growth periods were symbolized by (+); brain periodizations were symbolized by (-). Those periods which were questionable because of lack of conclusive evidence available were symbolized by a question mark (see page 18).

The author appended to the table the age-linked times Epstein believed children were ready and actually experienced mental growth periods.

Study of this table clearly showed biological evidence corresponded with Epstein's age-linked theory of phrenoblysis.

Both Ann Brown and Roger Webb observed periods of brain growth which resulted from biological factors and were closely linked to chronological age. Webb conducted studies which involved children aged six to eleven with I.Q.'s of one hundred and sixty and mental ages which ranged from ten to eighteen years. Evidence was found that no child reached the Piagetian stage four (formal operations) until the subject reached close to the age

Figure 3

Periodic Growth of Brain and Skull

	Age at Midpoints of Beinnial Span						
Reference	3	5	6-7	8-10	11-12	13-14	15-17
Boas, 1912							
Hebrews			+	-	+	-	+
Central Europeans				+	+/-		+?
Sicilians			+		+/-		+
Coppoletta and Wolbach, 1933			+	-	+		
Schuttleworth, 1939			+	-	+	-	+
Vickers and Stuart, 1943	+						
Simmons, 1944			+	-	+	-?	+
Reynolds and Scheen, 1947			+	-	+	-	+
Westrop and Barber, 1956	+						
Dokladal, 1959	+?	-	+	+/-	+		+
Bayley and Eichorn, 1962			+	-	+	-	+
Dullemeijer, 1971	+	-	+	-	+	-	+

(17)

Age of Epstein's Brain Growth Periods in Children

2-4	6-8	10-12/13	14-16/17

(15)

of eleven years chronologically (36). Of interest in this research was that children with high I.Q.'s reached maturation within a few months after the eleven year chronological attainment while children with normal I.Q.'s sometimes took up to a year or two to reach stage four. Brown's similar study showed children reached the Piagetian stage three (concrete operations) at about the age of seven (9).

Along with research which involved increases in skull development by measuring skull circumference, and, brain weight, was recent research using the electroencephalogram (EEG). Results of that research showed there was a sharp increase in the total EEG energy that appeared in the alpha frequencies during the stages of brain growth. Those sharp increased energy periods were also age-linked.

Biological development of the brain suggested that the development of brain cells ceased early in life. Recently collected data indicated the cessation took place by about the first year and a half. Subsequently, although brain cells did not increase, brain weight increased by about thirty-five percent. This weight increase appeared in three ways: branched axons and dendrites of the brain became more extended, there was increase in fatty insulation (myelination) of axons, and there was an

increased input of energy due to an increase of blood to the brain. Both the elongation axons and dendrites and the increase of the fatty insulation on the myelin sheath caused a substantial change in the neurological action of the brain (14). This neurological phenomena has been recorded through use of electroencephalograms by both E. R. John, and, M. Matousek and I. Peterson. Their findings showed there was sharp increase in alpha frequencies that periodically occurred and were closely correlated to Epstein's age-related brain growth periods (28, 29).

Review of the aforementioned literature substantiated the physiological and neurological bases which validated the theory of periodic brain growth. Similar to other organs in the body, the brain experienced highly chronologically predictable growth spurt periods. Continued investigation of available research indicated that during those growth periods the brain was ready for higher levels of functioning or attainment of higher cognitive skills (18).

Periodic Intellectual Growth

Epstein's findings confirmed that alternated with brain growth periods there were brain plateau periods. During those plateau periods individuals demonstrated lesser success in attainment of higher cognitive skills (18).

Limited research has been conducted to verify Epstein's contention. The author found no completed studies on the elementary age child. At either end of the brain growth/brain periodization spectrum, the author found minimal research available. Studies have been compiled which involved pre-school children and adolescents. Those studies reflected results of Epstein's two to four year and twelve to thirteen or fourteen year brain plateau periods. Results confirmed individuals attained lesser degrees of mental growth during brain plateau periods as compared with brain growth periods.

Epstein researched effects of the four to six year brain plateau period by working with culturally disadvantaged pre-school children. Discussed in the study were results of child success by individuals in the Head Start Program and the Milwaukee Project. Suggested in those studies was the possibility of denied success for some children due to factors other than those of program or staff involvement. Epstein advised if intervention programs were to be implemented, it would be wise to use as a basis the biologically demonstrated brain growth periods. Epstein cautioned that intervention programs attempted during this pre-school time were less successful than programs attempted during earlier or later brain growth periods (13).

Conrad Toepfer collaborated with Epstein, as well as worked independently, on research which involved the twelve to fourteen year adolescent plateau period. Consensus was that approximately eighty-five percent of children between the ages of twelve and fourteen had virtually no mental growth (20). Comparison was made between the ten to twelve or thirteen year brain growth period and the twelve to fourteen year brain plateau period. Mental growth data indicated a forty month increase in mental age during the ten to twelve or thirteen year brain growth period. Contrary to that forty month increase was a seven month increase in mental age during the twelve to fourteen year brain plateau period (20).

Michael James approached the twelve to fourteen year brain plateau period from a much too frequently untapped source: the student. In analyzing writing done by adolescents, James surmised the adolescent plateau period was one of emotional upheaval for the individual (27).

In agreement with James, Toepfer astutely observed adolescence as full of complexities. Toepfer maintained transformation occurred during this time in the adolescent's physical, social, emotional, and intellectual realm. Toepfer further cited this period was "the most traumatic and perilous time of one's life" (33).

Toepfer gathered data from cumulative records of students who completed high school or dropped out before graduation. The study was divided into two separate sets of data. Two thousand-five hundred case histories of individuals with I.Q.'s of one hundred-twenty or more and one thousand-two hundred case histories of individuals with I.Q.'s of one hundred to one hundred-ten were statistically noted (33).

In the first group of two thousand-five hundred case histories, all students had maintained a B+ average prior to adolescence. During adolescence, approximately thirty percent experienced a C- average or lower. Twenty-three percent of those C- students maintained a C- average in college; sixteen percent maintained a C- in non-college programs; and, seventeen percent dropped out of high school prior to graduation.

The second group of one thousand-two hundred case histories revealed even more conclusive data. All students maintained a B average in achievement up to age twelve. Thirty-six percent of that group dropped to a C- or below average during the adolescent period. Twenty-two percent achieved a C- average in non-college programs while eighteen percent achieved a C- average in vocational/technical programs. Similar to those students with higher I.Q.'s, nineteen percent dropped out of high

school prior to graduation (33). Toepfer's statistics clearly indicated the lack of academic success the adolescent experienced during the twelve to fourteen year brain plateau period.

Epstein graphically showed the adolescent brain plateau period as well as the preceeding two year brain growth period by tabulating thirteen separate research projects concerned with mental growth. The ages at which there were peaks, or brain growth, were symbolized by (+). The plateau periodization times were symbolized by (-) (18). The table clearly confirmed Toepfer's contention that mental growth between the ages of twelve and fourteen was indeed limited. (See Figure 4, page 25.)

Curriculum Development

Additional review of literature indicated that acceptance of physiological, neurological, and intellectual coinciding periodic phyrenoblysis indicated a need to re-evaluate traditional curriculum. That need to re-evaluate curriculum was approached from several points of views. Of the writings available, all researchers were in agreement as to the relevancy of the need but there was little or no consensus as to possible solutions.

J. Merrell Hansen concluded that curriculum implementations were purely accidental in nature. Hansen contended reorganization needed to be based on the

Figure 4

Ages of Peaks or Periodization in Mental Growth

Reference	Age Span (Yr) 2-4	6-8	8-10	10-12	12-14	14-16
Jones and Conrad, 1933				+?	-	+
Freeman and Flory, 1937				+	-?	+
Shuttleworth, 1939		+?		+	-	+
McNemar, 1942						
S.D.IQ	±	+	-	+	-	+
Vocabulary test				+	-	+
Memory test	+?	+		+	-	+
Ebert and Simmons, 1943		+	-?	+	-	+?
Sanford, Adkins, Miller, and Cobb, 1943				+	-	+
Werner and Kaplan, 1950				+		
Bayley, 1949	+	+		+		
Sontag, Baker, and Nelson, 1958		+	-			
Stevenson, Hale, Klein, and Miller, 1968				+	-	
Rosenthal and Jacobson, 1968		+		+		
Kennedy, 1969				+	-	+
Cattell, 1971				+	-	

(18)

Age of Epstein's Brain Growth in Children

2-4	6-8	10-12/13	14-16/17

(15)

student's articulation of meaningful goals and objectives rather than periodic innovative educational practices. Hansen further expounded on how educators shaped the child to fit the curriculum and not how the curriculum was shaped to fit the needs of the child that appeared periodically during life (23).

Kimball Wiles, in agreement with Hansen, felt curriculum balance must be fitted to the child's school experience. This balance was decided upon by teachers who observed behavioral patterns of the child which indicated periods of readiness (23, 40).

Jon Whitney Wiles's periodic stages encompassed a comprehensive curriculum. According to Wiles, comprehensive curriculum was based on the Piagetian stages of intellectual development. Comprehensive curriculum included the learning environment; the roles of the students, teachers, and principal; and, administrative concerns (39).

Continuance of traditional curriculum was berated by Leslie Hart. Hart cited that curriculum development was "at least seventy-five years out of date" (24). Hart admonished that educators were killing learning in children. Hart advocated that curriculum not be based on the ruinous graded classroom, but rather be compatible with the child's unique style of periodic learning (24).

Bill Horst and Rebecca Johnson concentrated their observations on middle school curriculum. In recognition of Epstein's twelve to fourteen year brain plateau periodization in the adolescent, Horst and Johnson recommended adolescence was a time to define and redefine educational activities and methods (26). In agreement with Toepfer, Horst and Johnson found the adolescent faced unique changes "socially, physically,...psychologically", as well as intellectually (26, 33).

Toepfer indicated implications for learning needed to be differentiated between for those children during the brain growth period and those experiencing a brain plateau period. Lateralization by teaching new cognitive information rather than new skills was Toepfer's recommended solution to plateau periods of the brain, particularly for the adolescent twelve to fourteen year brain plateau period (34). Toepfer's theory was in complete agreement with Epstein's findings.

Epstein felt teacher sensitation was imperative in order to match children with curriculum. That sensitization involved understanding concepts of cognitive stages and their cognitive levels in conjunction with the relationship of those stages and levels with brain growth periods. Epstein maintained curriculum needed revision based on the

child's cognitive level demand (16). That theory was recently tested by Epstein, however, results were not available at this writing.

CHAPTER THREE

Analysis of Research

Scientific researchers approached the question of brain growth from a factually documented focal point. Systematically, the author was able to cite data which succinctly provided statistics indicating growth periods in skull size, brain weight, and brain energy. In equating data substantiating those three independent or concurrent periodic occurrences confidence was held that there was adequate scientific evidence to accept the physiological and neurological brain growth theory.

Analysis of research which indicated that mental growth periods occurred at approximately the same time the brain was growing physiologically and neurologically was quite interesting. Research showed less conclusive, although highly convincing, data for that correlation. Although fewer documented studies were available, that which was available provided useful information. Analysis of the cumulative research indicated there was a distinct correlation between the physiological and neurological growth periods of the brain and the intellectual growth periods of the brain.

Less clear was research which applied to the re-development or reorganization of the traditional curriculum

in view of the available scientific and educational data. Analysis of that research indicated authors conclusively held that there was a confirmed need to develop a curriculum that was more child-centered and less dogmatically oriented.

Analysis of individual studies did not present an ultimate solution, but rather suggested individual solutions to the problem of the direction curriculum planners should take when considering redevelopment and reorganization. Researchers agreed this approach to curriculum should be holistic.

CHAPTER FOUR

Summary and Recommendations

Summary

Review of literature offered no conclusive documented statistics or data regarding intellectual brain growth spurts in children of elementary school age. Sufficient studies documented brain growth/brain periodization times for all children during pre-school times and the adolescent period. There appeared to be lesser attention directed to the elementary school age child.

One plausible explanation of the lack of research involving school age children was that there were fewer obvious changing behavioral patterns at those periods of the child's life. Children at the pre-school age were in the process of learning highly denotable motor and sensorimotor skills. On the other end of the spectrum, children in the adolescent period were experiencing pubertal metamorphosis. Both those periods lended themselves to testable studies of obvious behavioral patterns which reflected either growth or plateau periods of mental growth. For educators it was far easier to accept mental growth or periodization when evidence reflected growth or lack of growth in the body. To lend credence to the proposed theory of brain growth and brain periodization the obviously observable times have been most researched.

Little scientific data substantiated the concept of correlating readiness with a child's brain growth period; however, the author contended that it was indeed a valid correlation. Child-centered teachers seemed to intuitively sense when a child was ready to progress to the attainment of higher cognitive skills. Remarkably, those intuitively observed readiness times correlated closely with scientifically substantiated phrenoblysis.

Recommendations

What has been learned in this research is that there was scientific data to correlate periodic physiological and neurological brain growth with intellectual growth. Suggested correlation with the above was the intuitive readiness in children during brain growth periods. Continued research and study of those correlations was seen as imperative. In order to obtain a more universal picture the author recommended on-going and extensive scientific and educational research of brain growth/brain periodization be conducted.

Continued investigation of curriculum development appeared to be crucial and also of high priority. Those implications of continued investigation of curriculum did not advocate dismissal of the present traditional curricu-

lum but rather the periodically staging and leveling the present curriculum to meet the needs of the child.

The myth of continuous intellectual growth can now be dismissed. The important question which remains is: How will educators utilize this crucial information?

BIBLIOGRAPHY

1. Arlin, Patricia K. "Cognitive Development in Adulthood: A Fifth Stage?" Developmental Psychology, II (1975), 602-606.

2. Athey, Irene J. Educational Implications of Piaget's Theory. Watham, Mass.: Finn, 1970.

3. Bayley, N. and D. Eichorn. "Growth in Head Circumferences from Birth through Young Adult." Child Development, 33 (1962), 257-271.

4. Blinkov, N. and I. I. Glezer. The Human Brain in Figures and Tables. N.Y.: Basic Books, 1968.

5. Blumenthal, Arthur L. The Process of Cognition. Englewood Cliffs, N.J.: Prentice-Hall, 1977.

6. Brainerd, Charles J. Piaget's Theory of Intelligence. Englewood Cliffs, N.J.: Prentice-Hall, 1978.

7. Brockes, Jeremy. "Suppression of Foreign Synapses." Nature, 260 (1976), 281.

8. Brooks, Rick. The Relationship Between Piagetian Cognitive Development and Cerebral Cognitive Asymetry. U.S., Educational Resources Information Center, ERIC Document ED 160 224, 1978.

9. Brown, Ann L. "Conservation of Number and Continuous Quantity in Normal, Bright, and Retarded Children." Child Development, 44 (1973), 376-379.

10. Coppoletta, J. M. and S. B. Wolbach. "Body Length and Organ Weights of Infants and Children." American Journal of Pathology, 9 (1933), 55-70.

11. Dasen, Pierre R. "Cross-Cultural Piagetian Research: A Summary." Journal of Cross-Cultural Psychology, (1972), 23-29.

12. Dobzhansky, Theodosius. Mankind Evolving: The Evolution of the Human Species. New Haven and London: Yale University Press, 1962.

13. Epstein, Herman T. "A Biologically-Based Framework for Intervention Projects." Mental Retardation, (April 1976), 26-27.

14. _____. "EEG Developmental Stages." Developmental Psychology, (1980), 629-631.

15. _____. "Growth Spurts During Brain Development: Implications for Educational Policy." 1978 Yearbook of the National Society for the Study of Education II, Chicago: University Chicago Press, 1978.

16. _____. "Learning to Learn: Matching Instruction to Cognitive Levels." Principal, (May 1981), 25-30.

17. _____. "Phrenoblysis: Special Brain and Mind Growth Periods. I. Human Brain and Skull Development." Developmental Psychobiology, (May 1974), 207-216.

18. _____. "Phrenoblysis: Special Brain and Mind Growth Periods. II. Human Mental Development." Developmental Psychobiology, (May 1974), 217-224.

19. _____, and Erika B. Epstein. "The Relationship Between Brain Weight and Head Circumference from Birth to Age 18 Years." American Journal of Physical Anthropology, (1978), 471-473.

20. _____, and Conrad R. Toepfer. "A Neuroscience Basis for Reorganizing Middle Grades Education." Educational Leadership, (May 1978), 656-660.

21. Fischer, Kurt W. "A Theory of Cognitive Development: The Control and Construction of Hierarchies of Skills." Psychological Review, (Nov. 1980), 477-531.

22. Fischer, Roland and John Rhead. "The Logical and the Intuitive." Main Currents in Modern Thought, 31 (1974), 50-54.

23. Hansen, J. Merrell. "The Accidental Curriculum: The Unplanned Nature of Curricular Implementations." National Association of Secondary School Principals Bulletin, 65 (March 1981), 16-21.

24. Hart, Leslie A. "Classrooms Are Killing Learning." Principal, (May 1981), 8-11.

25. Hooton, Ernest A. "The American Criminal." English Journal, 7 (1938), 74-75.

26. Horst, Bill and Rebecca Kelch Johnson. "Brain Growth Periodization and its Implications for Language Arts." English Journal, (Jan. 1981), 74-75.

27. James, Michael A. "What is Unique About the JH/MS Student?" English Journal, (March 1981), 77-78.

28. John, E. R. Functional Neuroscience. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

29. Matousek, M. and I. Peterson. Automation of Clinical Electroencephalography. N.Y.: Raven Press, 1973.

30. Meredith, H. V. "Physical Growth from Birth to Two Years. II. Head Circumferences." Child Development, 17 (1946), 1-16.

31. Restak, Richard M. "The Other Difference Between Boys and Girls." Educational Leadership, (Dec. 1979), 77-78.

32. Roche, A. F. "Increase in Cranial Thickness during Growth." Human Biology, 25 (1958), 81-92.

33. Toepfer, Conrad R. "Brain Growth Periodization - A New Dogma for Education." Middle School Journal, (Aug. 1979), 3, 18-20.

34. Toepfer, Conrad R. Brain Growth Periodization in Young Adolescents: Some Educational Implications. U.S., Educational Resources Information Center, ERIC Document ED 187 755, 1980.

35. Vygotsky, Lev, trans. "Vygotsky's View about the Age Periodization of Child Development." by Mary A. Zender and B. F. Zender. Human Development, 17 (1974), 24-40.

36. Webb, Roger A. "Concrete and Formal Operations in Very Bright Six to Elven-Year Olds." Human Development, 17 (1974), 292-300.

37. White, Sheldon. "Some General Outlines of the Matrix of Developmental Change Between Five and Seven Years." Bulletin of the Orton Society, 20 (1970), 41-57.

38. Whitehead, Alfred North. The Aim of Education and Other Essays. N.Y.: Macmillin, 1929.

39. Wiles, Jon Whitney. "Developmental Staging: In Pursuit of Comprehensive Curriculum Planning." The Clearing House, 50 (Feb. 1977), 274-277.

40. Wiles, Kimball. "Seeking Balance in the Curriculum." Childhood Education, (Oct. 1959), 70.

41. Winick, M. and P. Rosso. "Head Circumference and Cellular Growth of the Brain in Normal and Marasmic Children." Journal of Pediat., 74 (1969), 774.