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Abstract

This longitudinal study investigates brain growth periodization, also known as the brain spurts theory. The theory calls for maximum brain growth between the ages 2-4 years, 6-8 years, 10-12 years, and 14-16 years. For several decades researchers have observed fluctuations in the rate of growth for various areas of student achievement. These fluctuations occur in an extreme form from ages 8 - 14. The brain spurts theory asserts that there is also variation during this period in the rate of brain cell development. This researcher utilized a random sample of 50 students in a western New York school district where data was available for their scaled achievement scores on the Stanford Achievement Test battery. The sampled students come from both rural and suburban areas. They were all in the same grade level at the time of the study. The basic purpose of this study was to see if there was an explanatory fit between the fluctuations asserted by the brain spurts theory and the fluctuations observed in achievement scores for this sample.

An ancillary question that was investigated was whether or not a significant difference in mean performance existed between males and females on each of the sub-tests on the Stanford Achievement Test battery. Since this was a pilot descriptive investigation, the 90% confidence level was chosen as the level at which to test the significance of the difference between two independent group means. The decision to include this ancillary question also lead to stratifying the random sample of 25 males and 25 females. Male/female comparisons were made using a 2-sample t-test.

The scaled scores of the Math Application, Math Computation, Reading Comprehension, and Vocabulary portions of the Stanford Achievement Tests were used. A data base was created and all of the statistics utilized in this study were computed using the computer statistical package GB-Stat by Dynamic Microsystems, Inc. Graphs on growth for ages 8 - 14 were completed. The coefficients of determination were also computed.

Inconclusive evidence was found to either support or oppose the above stated theory. Inconsistencies were found in the growth patterns of the four areas tested. Two basically matched the growth pattern of the brain spurts theory and two did not. Possibilities for the inconsistencies are discussed in the conclusion.

It was found that the best coefficient of determination value for the scores achieved at 14 years was at an age level which was at the same point in the growth pattern of the brain spurts theory.

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Chapter I
Introduction

Purpose

This study investigates the brain spurts theory, also known as brain growth periodization. The theory states that the human brain has periods of rapid brain growth surrounded by periods of relatively slow growth. For several decades researchers have observed fluctuations in the rate of growth for various areas of student achievement. The brain spurts theory asserts that there is variation in the rate of brain cell development between the ages 8-14. This researcher utilized a random sample of 50 students in a western New York school district where data was available for their scaled achievement scores on the Stanford Achievement Test battery. The sampled students come from both rural and suburban areas. They were all in the same grade level at the time of the study. The basic purpose of this study was to see if there was an explanatory fit between the fluctuations asserted by the brain spurts theory and the fluctuations observed in achievement scores for this sample.

An ancillary question that was investigated was whether or not a significant difference in mean performance existed between males and females on each of the subtests of the Stanford Achievement Test battery.

Rationale

What is the Brain Spurts Theory? Patterson (1983) tells us that researchers in education, psychology, biology, and medicine contend that five growth spurts and four plateaus of brain periodization comprise the brain-stage theory which describes the pattern of brain growth.

Epstein (1978) identified that the brain, like other organs, grows, develops, matures, and qualitatively changes in a stage-wise fashion. These brain growth periods are seen as occurring at some point within the age 3 to 10 months, and 2 to 4 years intervals. Qualitative changes in the brain's development and maturation are seen as occurring during the interval of 6 to 8 years, 10 to 12+ years and 14 to 16+ years. As a corollary, periods of slower brain growth/development/maturation are seen to occur at some point within the age 4 to 6 years, 8 to 10 years, and 12 to 14 years intervals.

Toepfer (1981) states that research indicates that the brain grows in spurts occurring every two years or so and alternates with plateau periods in which the gains due to growth are consolidated.

Swaiman (1978) had the following to say about brain growth. The increase with maturation of head circumference reflects brain growth. The brain grows rapidly during the first two years and also during the middle years. The rate of growth recedes, but growth continues until the middle teens when the mature state is reached.

The following study was done to test the brain spurts theory described above. A longitudinal study with a sample of 50 ninth grade students was used. By using the student's Stanford Achievement Test scores for ages 8-14, this researcher attempted to determine whether or not the growth in scores reflected brain spurts. Do the scores remain relatively constant through the years or are there dips and peaks? If there are dips and peaks in the scores do they reflect the ages stated in the brain spurts theory? The theory suggests that the spurts would be in the intervals 3 to 10 months, 2 to 4 years, 6 to 8 years, 10 to 12+ years and 14 to 16+ years. Therefore, if the brain spurts theory is, in fact, true, this study should reflect a brain spurt in terms of greatest growth of Stanford Achievement Test scores somewhere in the interval of ages 10 to 12. Although this study does not have complete data for the spurt appearing in the interval of 6-8 years, the spurt should still be indicated here. The data for this study begins at age 8.

Definition of Terms

phrenoblysis- described by Epstein as special mind and brain growth or qualitative maturation periods. This was based on his study of both human brain and skull development and human mental development; "Phreno" comes from the Greek word meaning skull or mind, while "blysis" indicates a welling-up of matter.
(Epstein, 1974)

periodization- a specific interval of time

cognitive learning- the mental process of acquiring knowledge

cognitive skills- the techniques requiring thinking or use of the mind

Limitations of the Study

The sample size of 50 is a relatively small sample. For more conclusive results, a much larger sample would be necessary.

The scores used are from Stanford Achievement Tests (SAT) taken in May of each year. Scores were not available for the complete spurt occurring at the interval of 6-8 years. The data for this study begins at age 8. Many factors could influence an individual's score on any given day. Family matters, illness, state of mind, and test taking abilities are just a few of these factors.

The difference in student's individual I.Q. scores would influence their SAT scores. The I.Q. scores were not available for this study.

Differences in student's motivation and studying would also affect their SAT scores. Scores could also be affected by the different home life each student has.

Changes in individual scores, which therefore affect the mean score, can be influenced by the fact that the students could have attended one of three different elementary schools within the same school district. Differences in the quality of teaching and therefore learning, were not taken into consideration for this study.

Chapter II
Review of Literature

Introduction

The purpose of this study was to investigate the brain spurts theory. It states that children experience brain spurts at some point within the intervals 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16 years. This longitudinal study included children from ages 8 to 14. Their Stanford Achievement Test scores were recorded in the areas of Math Applications, Math Computation, Reading Comprehension, and Vocabulary. The mean scores, coefficients of determination, and t-tests were computed.

Research

There has been much research done in the area of brain growth periodization. A leading researcher in the area, Herman T. Epstein (1986) states that the human brain has 4 periods of rapid growth surrounded by periods of relatively slow growth. Epstein has related information about the physiological growth, development, and maturation of the brain to previously known information about the mind's capacity to grow in its ability to process information at progressively more difficult stages (Epstein, 1990).

Epstein (1978) described these growth/development/maturation episodes and identified that both physiological growth and qualitative changes in the brain fell into a stage-wise pattern for most humans. Epstein tells us that these physiological growth periods were seen as occurring at some point within the age 3 to 10 months, and 2 to 4 years intervals. Qualitative changes in the brain's development and maturation were seen as occurring during the intervals of 6 to 8 years, 10 to 12+ years and 14 to 16+ years. Periods of slower brain growth, development, and maturation were seen to occur at some point within the age of 4 to 6 years, 8 to 10 years, and 12 to 14 years intervals.

Another researcher of brain growth periodization is Conrad F. Toepfer, Jr.(1990). He has reviewed the postulation of possible relationships in the growth, development and qualitative maturation of the brain to the time at which learning stages appear and signify progressive changes in children's intellectual skills. He has considered the correlation of the biological growth of the brain with the Piagetian learning stages. According to Hutson (1984), both Epstein and Toepfer have claimed that brain size and intelligence spurt simultaneously during some two-year periods and plateau during other periods throughout childhood and adolescence.

Nellhaus (1968) has correlated brain growth with measurements of head circumference. He found spurts in head circumference growth in 98 percent of the youngsters between 1 to 10 months, 2 to 4 years, 6 to 8 years, 10 to 14 years, and 16+ years.

Epstein (1978) estimated that as many as 85% of children may experience the pattern of physiological brain growth, development, maturation and qualitative change. Epstein posited the relationship between brain and intelligence development in humans might well explain the developmental learning stages established by Piaget.

Other researchers have found their own periodization of child development. According to M. A. Zender and B. F. Zender (1974) Stern has found a singular criterion for periodization. He conceives of childhood as a stream with three parts. The first is the period of only play activity (up to 6 years of age). The second is the period of cognitive learning with a separation of play and work. The third is a youthful pubescence with the development of individual personality and a plan for the future (from 14 to 18 years).

M. A. Zender and B. F. Zender (1974) also wrote of Gesell's attempts to delineate childhood into periods by noting the changes in the internal rhythm and tempo of development and determining the general flow of the process. On the basis of mainly direct observations of changes according to age and rhythm of development Gesell divides all childhood into different periods or waves. These waves or periods are unified within themselves by a constant tempo that lasts for the duration of a given period. They are bounded from the other periods by a clear change in its tempo. Gesell views the dynamics of child development as a process of gradual deceleration. The most important phase in the development of the child ends, according to Gesell, in the first year during the first months of the infant's life.

Lev Vygotsky (1974) tells of the dynamics of transition from one stage to another. Vygotsky summarizes Blonsky as stating that the changes during growth can happen sharply and critically and can occur gradually and smoothly. Blonsky designates those epochs and stages of time in the child's life that separate one from the other during the critical times as an epoch (more critical) and a stage (less critical). He also calls the period of time that smoothly separates one period from another, a phase.

According to Vygotsky, development is characterized by a slow evolutionary or gradual flow at certain times. It is during the age of primarily smooth, frequently unnoticed internal changes in the child's personality that he is completing the course of rather insignificant molecular activity. Here, the entire personality of the child is transformed, without going through some kind of sharp displacement during an extended period of usually a few years.

In these relatively steady and stable periods the development of the child perpetuates itself on the whole. This is at the expense of microscopic changes in the personality of the child that follow some known course and then appear spasmodically as some kind of new formation. If one looks at these periods in regards to their context, the largest portion of the time is spent at school.

Vygotsky wrote that during the periods of crisis, that last for a relatively short duration of a few months to a year or two at the most, there are sharp displacements and much confusion that mark the changes and transformations in the personality of the child. Generally speaking the child changes the basic traits of his personality in a very short period of time. Development is exhibited as stormy, impetuous, and sometimes even catastrophic behavior. It is such turning points in the child's development that become the sharply defined crises.

The crisis of the 3-year-old is called the obstinate and stubborn phase. During this span of time which generally lasts for only a short interval, the personality of the child undergoes sharp and even sudden changes.

The 7th year in the life of a child is the transition between the preschool and adolescent periods. The child of 7 or 8 is neither a preschooler nor an adolescent. The 7-year-old is frequently viewed as a problem child in school.

The crisis of the 13-year-old child was studied and described as the negative phase of sexual puberty. As its name suggests, the negative character of the period has dominated it and perfunctory investigations have seemed to confirm this characterization of the period. The decline in academic achievement, a decrease in work performance, the conflicting personality moods, the loss of old interests, and the protesting character of behavior all allow some investigators to characterize this period as a stage of disorientation of the child's external and internal relationships. The child and the world are more at odds than at any other time.

The ages of Vygotsky's crisis periods correlate with the ages of Epstein's phrenoblysis. Vygotsky's approximate indications of ages for rapid change in intellectual functioning are during the first year of life, around 3 years, and around 7 years. Epstein calls for brain growth spurts at some point within the intervals of 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16 years.

What do these growth spurts and plateaus mean to educators?

Toepfer (1985) states that during episodes of rapidly increasing brain growth/development/maturation learners can more readily initiate and develop higher level thinking skills. They can learn new facts and information at those levels. Within an individual's plateau or slower growth/development/maturation periods, new facts and information are better learned by using previously initiated and developed thinking and learning skills. However, during those times many individuals will not readily be able to initiate new and/or higher level thinking and learning skills.

Toepfer (1981) writes that youngsters can learn new facts and information with good success during both growth spurt and growth plateau periods. The critical difference is that in the former, new facts and information can be attached to the learning of appropriate new and higher level thinking skills. During the growth plateau periods, new facts and information cannot be attached to new or higher level thinking skills. Facts and information are successfully learned during growth plateau periods when they are taught within the existing cognitive, thinking skill profiles initiated by learners during previous growth spurt periods.

According to an article written by Patterson (1983), the outstanding brain growth spurt experienced between 10 to 12 years provides teachers an opportunity to maximize the introduction of new and higher level cognitive skills. In addition to increasing the volume of facts and information presented, the teacher may expand the range of novel thinking skills. Information is acquired more efficiently and utilized according to the development of associative areas when teaching strategies are based upon cognitive levels and capacities of youngsters.

Epstein explains that it can be seen that there is a brain growth stage at the onsets of the Piagetian stages. Although many investigations challenge the stage linkage of these Piagetian stages, recent evidence shows that Piagetian stages are more firmly linked to age than supposed even by Piagetian followers themselves. It is important to note that the presumptive correlation of brain growth stages and the Piagetian stages requires a prediction that a new Piagetian stage will be found corresponding to the fifth and last brain growth stage around age 15 years (Toepfer, 1990).

Arlin (1975) has shown appreciable evidence for a fifth Piagetian stage, and her most recent data place the onset age as between 14 and 16 years, precisely as predicted. The nature of the Piagetian stages are such that there is a qualitative change in mental functioning at each of the onset stages. (See Chart A that follows titled "Brain Growth/Maturation and Slow Growth Periods in Piagetian Learning Stages.")

Toepfer (1990) believes that schools have to engineer learning opportunities that well serve the developmental needs of students educated at that school level. Middle level school curricula must provide the basis for defining school programs upon what individual learners can, instead of what they cannot do. The goal is to send the largest possible number of students to the high school with realistic chances for continued success in learning. This requires programs that provide opportunities for young adolescents to learn as fast as they can, or as slow as they must.

Chart A

Brain Growth/Maturation and Slow Growth Periods In Piagetian Learning Stages

Piagetian Stage Age Frames	Epstein Growth/ Maturation Periods	Epstein Slower Growth/Maturation Periods
Concrete Preoperational 2 - 7 years	2 - 4 years	4 - 6 years
Concrete Operational 7 - 11 years	6 - 8 years	8 - 10 years
Formal Operational 11 - 14 years	10 - 12 years	12 - 14 years
Arlin's Postulated Fifth Piagetian Stage	14 - 16 years	

(Toepfer, 1990 p. 5)

<u>Brain growth periodization is not without its critics.</u>

Patterson (1983) describes the views of two researchers on the theory. Dr. Peter Wolff, a professor of Psychiatry at Harvard Medical School, contends that there is no concrete proof of brain periodization and that there is an absence of physiological evidence to back the basic hypothesis of Epstein. Dr. Martin Hahn, Behavioral Biologist at William Paterson College, Wayne, New Jersey, finds through some studies on mice that the predictions by Epstein merit recognition. Hahn supports brain-stage theory while regarding Epstein's hypothesis as still at the formative stage.

Instruction must differ from grade to grade depending on whether students at that age are in spurt or plateau. Epstein and Toepfer suggest that during spurt periods, students be given intensive stimulation at higher cognitive levels (Hutson, 1984).

> The odds are rather discouraging - if each spurt lasts six months and only three spurt periods occur during the school years, then the student is receptive to new concepts for a *total* of less than two years (if school is in session when the student is ready). Teaching and learning might have to go on hold for years at a time: Epstein suggested in 1974 that because students at age 13 should be in plateau, "it might be worth postponing many learning activities until age 15," at which time the same input could be acquired "in about one-fourth the time." (Hutson, 1984 p. 36)

As far as this study is concerned, this researcher observed the sample of 50 students' scaled scores on the Math Application, Math Computation, Reading Comprehension, and Vocabulary portions of the Stanford Achievement Test for any fluctuations in growth throughout the years tested. The brain spurts theory calls for maximum growth between ages 6 to 8 and between ages 10 to 12. The theory would see growth plateaus at the ages 5, 9, and 13.

Chapter III
Methodology

Introduction

The purpose of this study was to investigate the brain spurts theory. It states that children experience brain spurts at some point within the intervals 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16 years. This longitudinal study included children from ages 8 to 14. Their Stanford Achievement Test scores were recorded in the areas of Math Application, Math Computation, Reading Comprehension, and Vocabulary. Mean scores, coefficients of determination, and t-tests were computed.

Subjects

The 50 students (25 boys and 25 girls) selected for this longitudinal study were chosen randomly from a group of students who maintained continuous attendance in the same school district from grade 2 through grade 9. The subjects, in general, shared relatively homogeneous cultural, demographic and socioeconomic characteristics living in a suburb of a city of approximately 200,000 people in upstate New York.

The population is primarily white middle-class. Each of the selected students was in each grade level for one full school year. At the time of this study the 50 subjects were in grade nine. They were assumed to represent a normal distribution of intelligence.

Procedures

The first step of this study involved a collection of the data. The raw scores of the 50 subjects on the Math Application, Math Computation, Reading Comprehension, and Vocabulary portions of the Stanford Achievement Tests (SAT) were recorded for grades two through eight. At the time of the testing the subjects ages were 8-14. The Stanford Achievement Tests were taken in May of each year. In grade two the subjects completed the Primary 2 SAT, form E; in grade three Primary 3 SAT, form E; in grade four Intermediate 1 SAT, form E; in grade five Intermediate 2 SAT, form E; in grade six Intermediate 2 SAT, form F; in grade seven Advanced SAT, form E; and in grade eight Advanced SAT, form F.

Using the Stanford Achievement Test Norms Booklet, the raw scores were converted to scaled scores. A data base was created and all of the statistics utilized in this study were computed using the computer statistical package GB-Stat by Dynamic Microsystems, Inc.

Chapter IV
Results

Introduction

The purpose of this study was to investigate the brain spurts theory. It calls for maximum brain growth between ages 6 to 8 and between ages 10 to 12. Growth plateaus should appear at ages 5, 9, and 13. Fifty students were tested using the Stanford Achievement Tests in the areas of Math Application, Math Computation, Reading Comprehension, and Vocabulary. The basic purpose of this study was to see if there was an explanatory fit between the fluctuations asserted by the brain spurts theory and the fluctuations observed in achievement scores for the sampled students.

Mean Scores and Growth

Following, on page 14, is Table 1 which is titled Mean Scores on Stanford Achievement Tests. In this table of mean scores 'MA' refers to Math Applications, 'MC' refers to Math Computation, 'RC' refers to Reading Comprehension, and 'V' refers to Vocabulary. The numbers 8-14 directly following these tested area names refers to the age at which each test was taken.

The other column that will be referred to is entitled 'MEAN'. It is the computed score of the 50 students as a group, of the four areas tested at the ages 8-14.

The growth was computed by finding the difference between the mean scores of two subsequent ages. The growth of the sampled students was computed and can be found on Tables 2, 3, 4, and 5 on pages 16-17.

MEAN SCORES
ON STANFORD ACHIEVEMENT TESTS

TESTED AREA	MEAN	STANDARD DEVIATION	VARIANCE	COEF. OF VARIATION
MA8	585.0599	34.88138	1216.711	0.05962
MA9	627.52	32.711	1070.009	0.05213
MA10	663.18	38.3255	1468.844	0.05779
MA11	690.6399	34.76379	1208.521	0.05034
MA12	705.42	35.90412	1289.106	0.0509
MA13	725.8799	34.98142	1223.7	0.04819
MA14	743.9	35.28904	1245.316	0.04744
MC8	617.88	49.86661	2486.679	0.08071
MC9	649.4399	35.15689	1236.007	0.05413
MC10	674.88	42.22227	1782.72	0.06256
MC11	709.8799	46.05038	2120.638	0.06487
MC12	728.2802	38.01397	1445.062	0.0522
MC13	730.2001	37.89243	1435.836	0.05189
MC14	756.5714	33.60431	1129.25	0.04442
RC8	608.3062	31.56487	996.3411	0.05189
RC9	635.8164	27.63126	763.4865	0.04346
RC10	654.2245	37.76587	1426.261	0.05773
RC11	673.653	32.94222	1085.19	0.0489
RC12	691.408	24.72847	611.4972	0.03577
RC13	698.6735	30.28433	917.1408	0.04335
RC14	703.9399	34.45934	1187.446	0.04895
V8	612.9401	34.82048	1212.466	0.05681
V9	638.8998	33.99775	1155.847	0.05321
V10	657.96	35.21478	1240.081	0.05352
V11	660.4401	22.48642	505.6391	0.03405
V12	693.26	32.21725	1037.951	0.04647
V13	695.58	24.83258	616.657	0.0357
V14	710.42	32.62532	1064.412	0.04592

Looking first at the mean scores of the Math Applications test (page 16, Table 2), one can see the mean score at age 8 is 585. This mean score increases each year and is 744 at age 14. In regards to the mean scores, the most growth in this area is seen at age 9, where there is a 43 point increase. This is contrary to the brain spurts theory which predicts a growth plateau here. The least amount of growth appears at age 12, where the mean score increases by only 15 points. According to the brain spurts theory, this is where the highest level of growth should occur. The area of Math Application does not follow the ideas of the brain spurts theory.

Looking next at the Math Computation segment (page 16, Table 3), one can see that the mean score at age 8 was 618. This score rose throughout the years to 757 at age 14. The highest level of growth was 35 points, appearing at age 11. This is an interval where, like the brain spurts theory, maximum growth occurs. The smallest level of growth was at age 13, where the mean score increased by only 2 points. This, as described by the brain spurts theory, is an interval of growth plateau. The area of Math Computation, in this study, follows the pattern of the brain spurts theory quite nicely.

The area of Reading Comprehension (page 17, Table 4) starts with a mean score of 608 at age 8. The mean score increases each year and is at 704 at age 14. The highest growth level of 28 points was at age 9. This is in opposition to the brain spurts theory which calls for a growth plateau at age 9. The least amount of growth occurs at age thirteen (7 points) and age fourteen (5 points). The brain spurts theory states that there will be a growth plateau at age 13.

Finally, looking at the tested area of Vocabulary (page 17 Table 5), with a mean score of 613 at age 8, increasing each year to 710 at age 14, one sees an outcome that does resemble the predictions of the brain spurts theory. The most growth, 33 points, is seen at age 12. According to the brain spurts theory, this is an interval where maximum growth should appear. The smallest level of growth is 2 points, seen at age 13, precisely where the brain spurts theory predicts.

GROWTH

TABLE 2

MATH APPLICATION

AGE	MEAN	GROWTH
8	585.06	
9	627.52	42.46
10	663.18	35.66
11	690.64	27.46
12	705.42	14.78
13	725.88	20.46
14	743.9	18.02

TABLE 3

MATH COMPUTATION

AGE	MEAN	GROWTH
8	617.88	
9	649.4399	31.56
10	674.88	25.44
11	709.8799	35
12	728.2802	18.4
13	730.2001	1.92
14	756.5714	26.37

GROWTH

TABLE 4

READING COMPREHENSION

AGE	MEAN	GROWTH
8	608.3062	
9	635.8164	27.51
10	654.2245	18.41
11	673.653	19.43
12	691.408	17.76
13	698.6735	7.27
14	703.9399	5.27

TABLE 5

VOCABULARY

AGE	MEAN	GROWTH
8	612.9401	
9	638.8998	25.96
10	657.96	19.06
11	660.4401	2.48
12	693.26	32.82
13	695.58	2.32
14	710.42	14.84

Growth Graphs

On pages 19-20 the growth of the sampled students, in regards to mean scores, can be seen on graphs in figures 1-4. Also included is a predicted growth graph of the brain spurts theory, as seen by this researcher (p. 21, Figure 5). This graph predicts growth for ages 8-14. It indicates the greatest growth at age 11 and the least growth at ages 9 and 13, as the theory predicts. In figures 6-9 on pages 22-23 the brain spurts theory graph is superimposed on each of the graphs of the areas tested. Using these graphs, one can compare how well the data of this study follows the predictions of the brain spurts theory.

Coefficient of Determination

Another statistic computed was r^2 - the coefficient of determination. This is the proportion of the variability in the dependent variable Y that is accounted for by the independent variable X. In regards to this study, one can see how well the scores of ages 8 through 13 predict the scores of age 14 in each of the four areas tested. Tables 6-9 include the r^2 tables and can be found on pages 24-25.

The scores of what age would be the best predictor of the score for age 14? In the Math Applications area (p. 24, Table 6), age 12 was the best predictor for age 14. The scores of the twelve year olds explain 52% of the variation in the age 14 scores. The other 48% is due to intervening variables.

Looking at Math Computations (p. 24, Table 7), age 10 is the best predictor of age 14. The scores of the 10 year olds explain 45% of the variation in the scores of age 14. The other 55% is due to intervening variables.

In Table 8 on page 25, age 12 is the best predictor of age 14 scores in Reading Comprehension. The age 12 scores explain 52% of the variation in the age 14 scores. The other 48% is due to unexplained variables.

In the tested area of Vocabulary (p. 25, Table 9) age 10 is the best predictor of age 14 scores. The scores at age 10 explain 61% of the variation in the scores at age 14. The other 39% is due to unexplained variables.

FIGURE 1

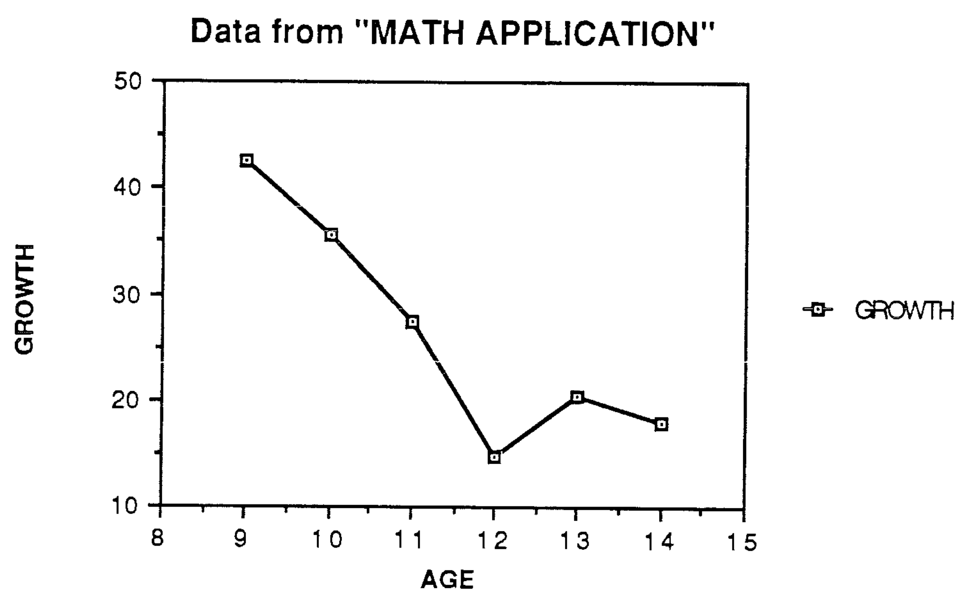


FIGURE 2

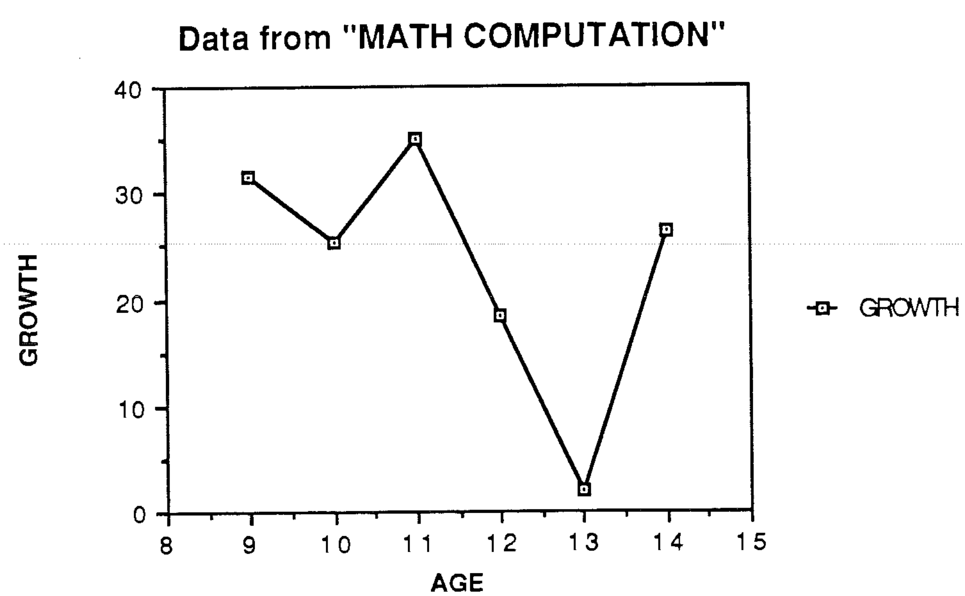


FIGURE 3

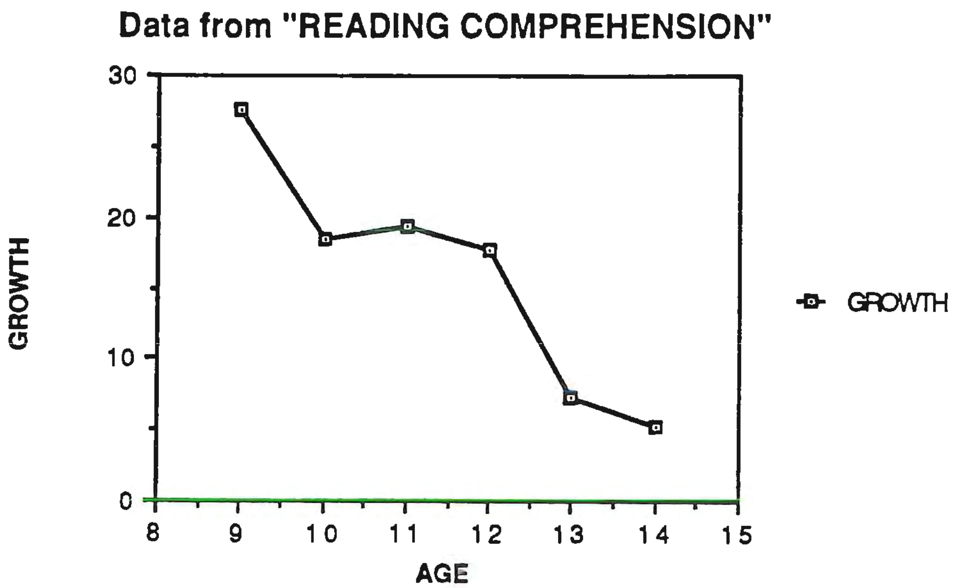


FIGURE 4

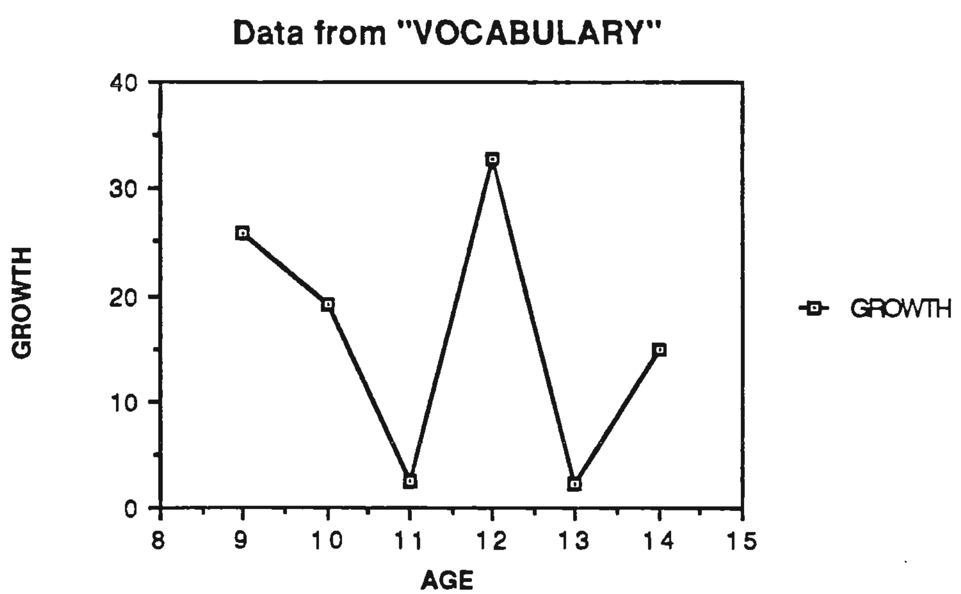
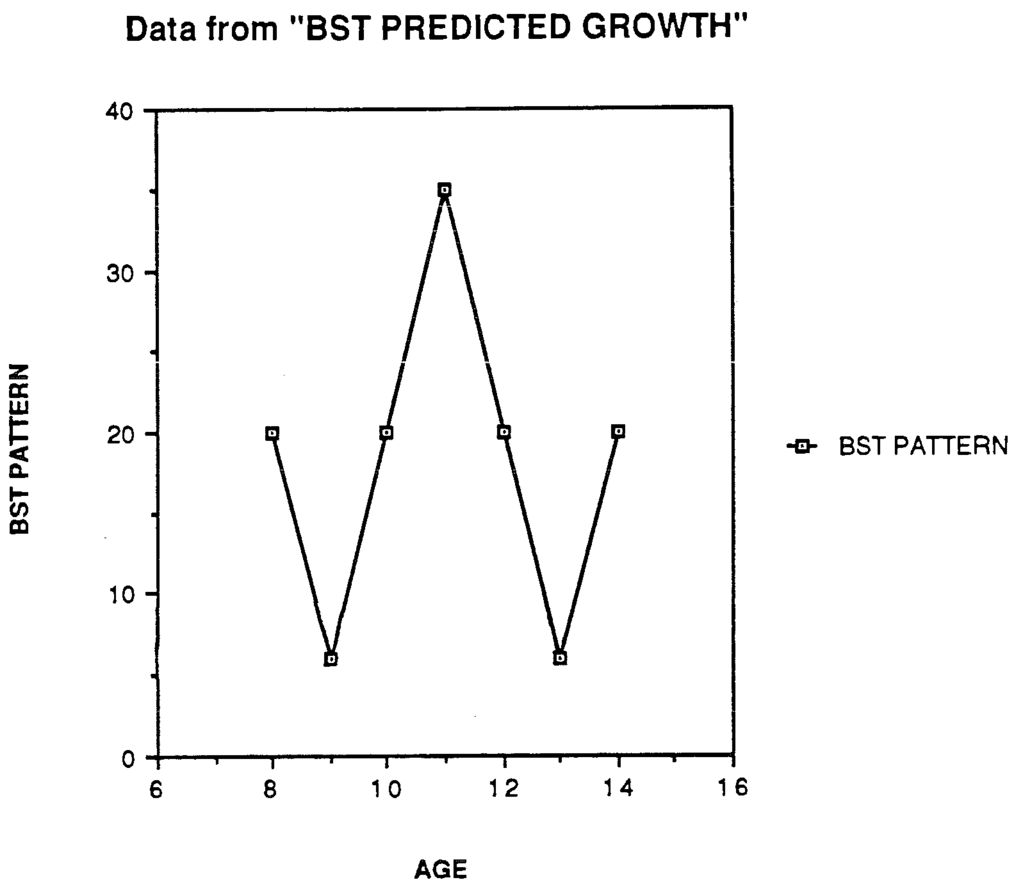


FIGURE 5



BST PATTERN = growth pattern of the brain spurts theory as predicted by this researcher

FIGURE 6

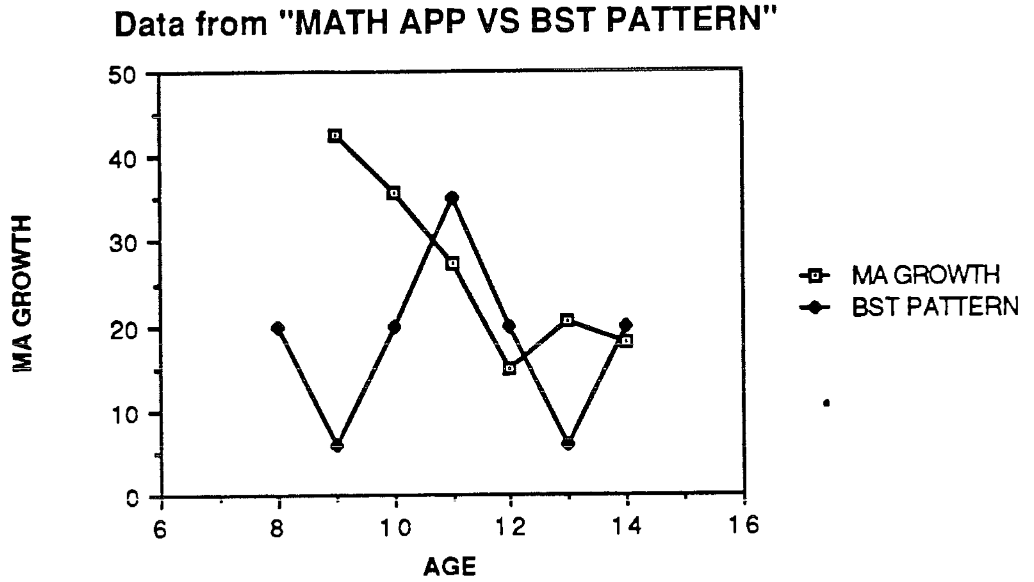


FIGURE 7

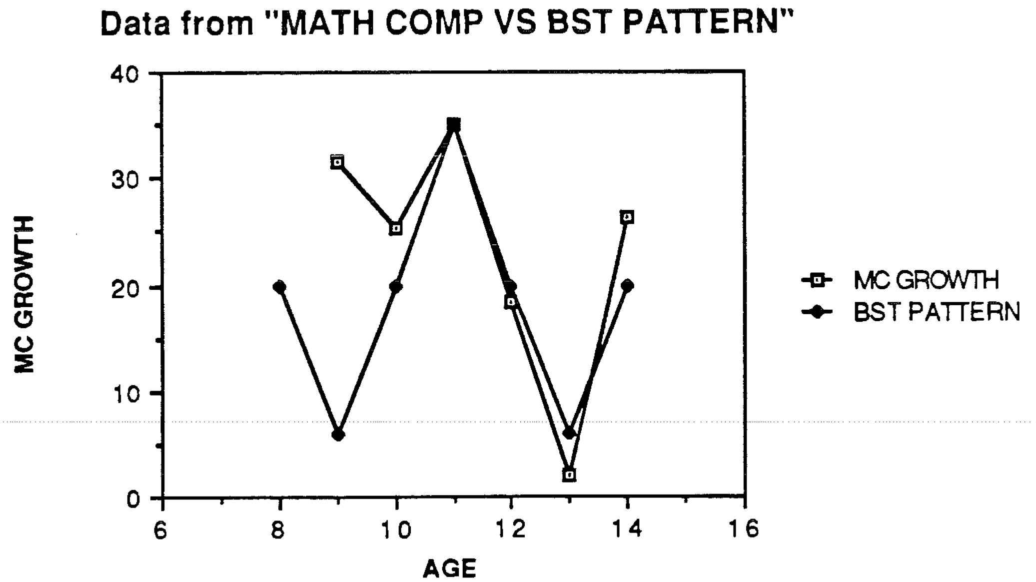


FIGURE 8

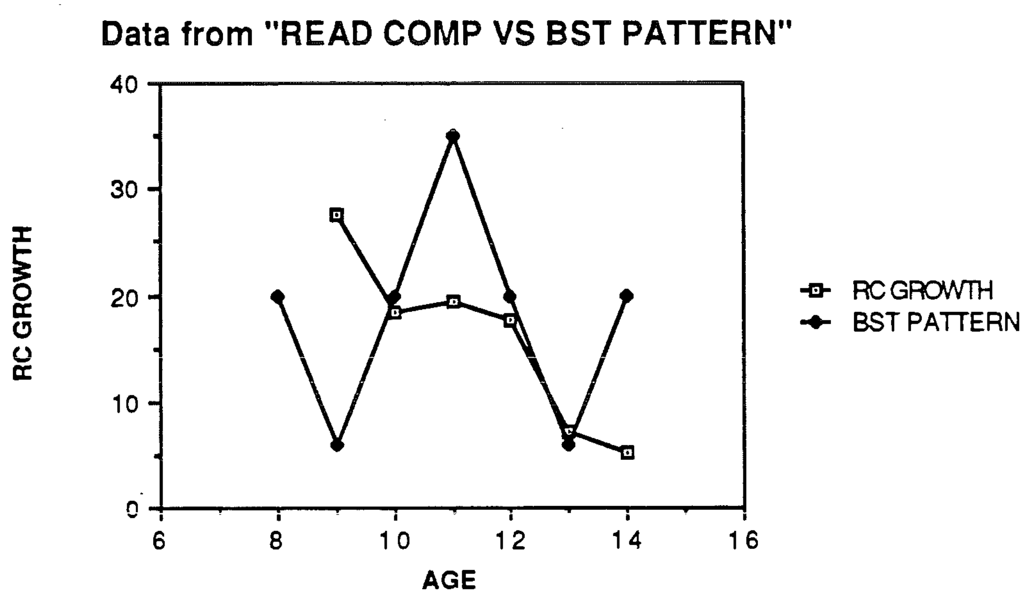
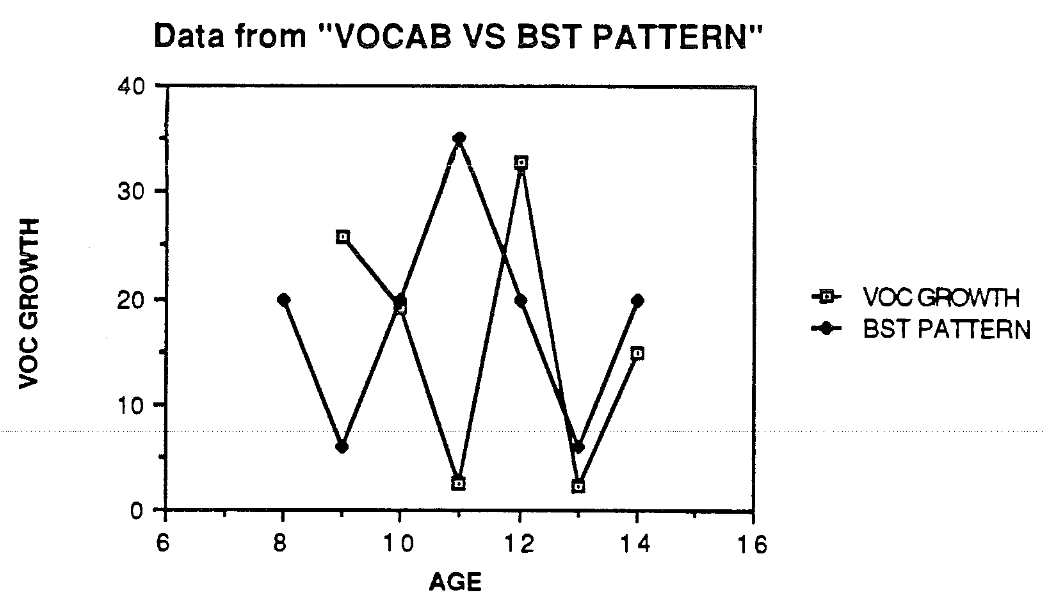


FIGURE 9



R^2 TABLE

TABLE 6

MATH APPLICATION		
AGE	R^2	
8	0.22	
9	0.24	
10	0.27	
11	0.39	
12	0.52	*
13	0.47	

TABLE 7

MATH COMPUTATION		
AGE	R^2	
8	0.16	
9	0.15	
10	0.45	*
11	0.33	
12	0.14	
13	0.39	

* best predictor of scores for age 14

r^2 TABLE

TABLE 8

READING COMPREHENSION

AGE	R^2	
8	0.1	
9	0.38	
10	0.41	
11	0.4	
12	0.52	*
13	0.5	

TABLE 9

VOCABULARY

AGE	R^2	
8	0.19	
9	0.49	
10	0.61	*
11	0.53	
12	0.45	
13	0.51	

* best predictor of scores for age 14

What does this have to do with the brain spurts theory? Age 14, according to the brain spurts theory is at the onset of a brain growth spurt. Perhaps the best predictor of this level would be made by another level in a similar brain growth interval. This occurred twice, both in Math Computation and Vocabulary, where the age 10 scores were the best predictor of the age 14 scores. Age 10, like age 14, is at the onset of a brain growth spurt.

In the other two instances, age 12 was the best predictor. Age 12, according to the brain spurts theory, is at the upper limit of a growth spurt. Looking at Figure 5 on page 21, you will see the growth pattern of the brain spurts theory as predicted by this researcher. In this graph the growth levels at ages 10, 12, and 14 are all equal. In this study, ages 10 and 12 were the best growth predictors of the growth at age 14.

Male-Female Comparisons

Another interesting observation was made in regards to male/female comparisons. In addition to the previous tests done, t-tests were also calculated to see if there was a statistically significant difference between the scores of the male and female students. Comparisons were made for each of the four Stanford Achievement Test areas at ages 10 through 14. This segment of time, according to the brain spurts theory, should include intervals of both brain growth and plateau. At the 90% confidence level a statistically significant difference between male and female scores was found in only 4 instances.

In the area of Math Applications, the male scores were significantly higher than the female scores at ages 10 and 12 (pages 27-28, Tables 10 and 11).

No statistically significant differences were found in the area of Math Computation.

In the area of Reading Comprehension, the female scores were significantly higher than the male scores at age 12 (page 29, Table 12).

In Vocabulary, the scores of the males were significantly higher than those of the females at age 13 (page 30, Table 13).

Tables 10-13 on pages 27-30 give details of these results.

TABLE 10

AGE 10 MATH APPLICATION

2-SAMPLE T-TEST

SUBSET	MALE	FEMALE
SIZE:	25	25
MEAN:	673.04	653.3201
SD:	39.1072	35.59461

F-RATIO (VAR):	1.207105
DF:	24 , 24
2-TAIL PROB:	.6476
T-VALUE:	1.864578
DF:	49.54614
2-TAIL PROB:	.0727
OMEGA SQUARED:	.047195
ETA SQUARED:	.065569

TABLE 11

AGE 12 MATH APPLICATION

2-SAMPLE T-TEST

SUBSET	MALE	FEMALE
SIZE:	25	25
MEAN:	714.8801	695.96
SD:	37.28641	32.48395

F-RATIO (VAR):	1.317539
DF:	24 , 24
2-TAIL PROB:	.5038
T-VALUE:	1.912977
DF:	49.04178
2-TAIL PROB:	.0617
OMEGA SQUARED:	.050503
ETA SQUARED:	.069438

TABLE 12

AGE 12 READING COMPREHENSION

2-SAMPLE T-TEST

SUBSET	MALE	FEMALE
SIZE:	25	25
MEAN:	685.3601	697.7084
SD:	22.43858	25.87676

F-RATIO (VAR):	1.329931
DF:	24 , 24
2-TAIL PROB:	.4966
T-VALUE:	-1.781596
DF:	47.37891
2-TAIL PROB:	.0825
OMEGA SQUARED:	.042484
ETA SQUARED:	.062787

TABLE 13

AGE 13 VOCABULARY

2-SAMPLE T-TEST

SUBSET	MALE	FEMALE
SIZE:	25	25
MEAN:	701.4	689.76
SD:	21.18962	27.19265

F-RATIO (VAR):	1.64686
DF:	24 , 24
2-TAIL PROB:	.229
T-VALUE:	1.688252
DF:	47.06931
2-TAIL PROB:	.0982
OMEGA SQUARED:	.035683
ETA SQUARED:	.057096

Chapter V
Conclusions and Recommendations

Summary

The purpose of this study was to investigate the brain spurts theory. It states that children experience brain spurts at some point within the intervals 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16 years. This longitudinal study included children from ages 8 to 14. Their Stanford Achievement Test scores were recorded in the areas of Math Applications, Math Computation, Reading Comprehension, and Vocabulary. In order for this researcher to draw conclusions on the research, a data base was created and all of the statistics utilized in this study were computed using the computer statistical package GB-Stat by Dynamic Microsystems, Inc.

Conclusions

The results of this study indicated to this researcher that there is inconclusive evidence to support or oppose the brain spurts theory. Looking at Figures 1-9 on pages 19-23, it can be seen that two of the tested areas, namely Math Computation and Vocabulary, basically follow the brain spurts theory pattern of growth. The other two areas, Math Applications and Reading Comprehension quite obviously do not follow the brain spurts theory pattern of growth.

The inconsistencies of the growth patterns among the four Stanford Achievement Test areas tested could have been for various reasons. The sample size was relatively small. To obtain more conclusive results, a much larger sample would have to be used.

The individual test scores could be influenced by different factors. Each student has a different level of motivation. The differences in the students' home lives would affect their test scores.

Another factor that would influence the outcome of this study is whether or not the Stanford Achievement Test is a stable measuring device. This is something that could be investigated in another study. The Stanford Achievement Test paradigm for developing scaled scores could also result in the altering of original scores, depending on the conversions.

Recommendations

A recommendation for a future longitudinal study of the brain spurts theory would be to obtain data for students for a longer time period. This study included test scores for students in grades 2 through 8. To be more conclusive, it would be best to have data for grades Kindergarten, or perhaps prekindergarten, through grade 12. A sample size larger that 50 would also be recommended. Data from other scholastic areas would also be useful.

It would be beneficial to have students in the sample who all attended the same school, perhaps even having the same teachers throughout the years. This would control the differences that might occur because of attending different school buildings within a district. It would also help control the quality of teaching by differences in teachers.

Overall, the brain spurts theory still leaves some questions unanswered. Therefore, it is essential that there be continued research in the area. The brain spurts theory is a relatively new idea in the field of education. Because of this, we will inevitably hear much more about it in the future.

My final recommendation would be to complete a study similar to this which takes students' I.Q. scores into consideration for the following reasons. Those with higher I.Q. scores may experience brain growth earlier than predicted, and those with lower I.Q. scores may experience brain growth later than predicted.

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