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(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: Does Age Have an Effect on
Short-term Memory of 6 to 18 Year Old
Students?

Candidate's declaration

If this declaration is not signed by the candidate the extended essay will not be assessed.

I confirm that this work is my own work and is the final version. I have acknowledged each use of the words or ideas of another person, whether written, oral or visual.

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Date: 16-01-08

"Does Age Have an Effect on Short-term Memory of 6 to 18 Year Old Students?"

May 2008

3840 words

Abstract :

This extended essay tested whether age had an effect on the short-term memory in children from 6 to 18 years of age. This was done in May 2007 at the International School of Geneva on two hundred and fifty students who were tested on their ability to memorise twenty pictures and twenty words. An experiment was devised where the students were given thirty seconds to try to memorise as many pictures as possible, then given thirty seconds in which to write them down. The process was repeated with the use of words instead of pictures.

The results showed that the largest overall change in the brain's memorising capacity was between second and fourth grade where the average amount of pictures remembered by the students increased by 67% and the amount of words remembered increased by 167%. Following this, the memory capacity slowed down considerably increasing only slightly per grade. The average maximum memory and recollection capacity of the brain seemed to be around twelve pictures for students in grade twelve, and the same students also remembered an average of nine words.

With age and brain development, the short-term memory area of the brain is capable of increasing its capacity for memorising objects. From the experiment it was concluded that it does this exponentially up to the child's age of ten, when they reach fourth grade, and then the development and increase regresses considerably. Another conclusion that can be drawn is that the brain has a larger capacity for storing pictures than for storing words. Therefore it can be seen that ageing is directly linked to brain development and memory progress.

272 words

Table Of Contents

| | |
|--------------------------------------|--------------|
| Introduction | pg 1 |
| - The Brain | |
| - Short-Term Memory | |
| Method | pg 3 |
| - Questionnaire | |
| - Testing Method | |
| Results | pg 5 |
| Analysis | pg 8 |
| Sources of Error/Improvements | pg 12 |
| Conclusion | pg 13 |
| Bibliography | pg 15 |
| Appendix | pg 16 |

Introduction :

"Memory is an organism's ability to store, retain, and subsequently retrieve information"¹.

The Brain

The brain, or the primary brain vesicle, "is subdivided into three irregular vesicles, the forebrain, midbrain and hindbrain."² Its main use is that it is "that part of the central nervous system within the cranium that is the organ of thought, memory, and emotion. It contains all the higher centres for various sensory impulses and it initiates, controls, and coordinates muscular movements in humans."³

Memory is controlled by the limbic system and the information gained is, once acquired, then stored in the medial temporal lobe of the brain, more precisely in the hippocampus in which new memories are formed.⁴ The hippocampus is the main area in which new information is processed before it can be stored in the cortex where long-term memory is stored.⁵

Short-Term Memory

Short-term memory is the capacity of one's brain to remember and store a small amount of objects, words or pictures for durations of approximately twenty seconds to a minute. It is said to be "held in interconnected nerve cells, and exists in the form of impulses passing around a circuit."⁶ Therefore it can be assumed that the loss of short-term memory can be due to the "decay of the electrical impulse, or by interference from newer memory circuits acquired subsequently."⁷ This means that the words or pictures taken in by an individual are quickly replaced by other such objects.

¹ "Memory." *Wikipedia, The Free Encyclopedia*.

² Clegg, J. (2000). *Advanced Biology Principles and Application*. John Murray Ltd.

³ "Brain," Microsoft® Encarta® Online Encyclopedia

⁴ "Memory." *Wikipedia, The Free Encyclopedia*.

⁵ Murray, B. "Understanding Brain Development And Early Learning."

⁶ Clegg, J. (2000). *Advanced Biology Principles and Application*. John Murray Ltd.

⁷ Ibid

The research question for this paper examines whether age has an effect on short-term memory of 6 to 18 year old students. The effects of age on short-term memory in children were analysed in order to see if there is a link between brain development in capacity for storing memory and physical development of a child with age. Memory on the whole, is an extraordinary thing and, as happens when children are growing and developing, and as they are going through school, some significant changes must be occurring as the brain keeps getting trained for memorising more and more throughout the years. After, and during these years, they are also expected to be able to recall this previously stored information. Therefore testing whether the brain indeed develops significantly with time as a child's level of schooling increases, seemed to be a very interesting experiment to undertake.

I tested only children for this experiment because, after a certain age, the brain will stop developing rapidly and will start being affected by other factors such as amnesia. Children however, are still at a stage where the brain is increasing in capability and where they're learning new things every day and are hence expanding their abilities to memorise. They are able to intake knowledge such as languages and new methods much faster than older people. In contrast to children who are still going through these changes, when they've reached an age of maturity (being eighteen years of age) their brain's memory capacity will possibly start to lag or even decrease, therefore my interests lay in the area where actual changes could be clearly visible.

Method:

Questionnaire

In order to test this research question an experiment was devised and undertaken on about forty individuals from each year group tested. The year groups tested were 2nd, 4th, 6th, 8th, 10th and 12th grade so as to have a variation of ages of children from 7 to 18 years of age allowing for a large span of ages, however, ensuring that the youngest ones of the group are able to fully read and write.

The experiment consisted of a preliminary series of questions in order to find out not only the age and gender of the subject but also whether any grades had been skipped or re-done in order to indicate a level of higher or lower learning prowess. Also was asked how many languages are spoken by the individual as this may also show a larger development in the capability of memorising objects or words, as this is more common and easier to the person in question. This information then allows for a more rounded profile of the individual taking the survey and, be there any particularities with their results, could account for them. It was also indicated that it was an anonymous, non-graded test, in order to ask and expect the students to be as honest as possible and not to cheat, though this was once again repeated at the beginning of the actual experiment. The questionnaire can be seen in Appendix 1.

Testing Method

All the individuals were told to have a pencil or pen at hand but to not touch it. They were then given two papers turned over, showing the back of them, one consisting of twenty pictures in black and white. The latter was done in order to ensure that not one colour or picture stands out more than the other and will therefore attract an individual more. The pictures were of mundane objects and included items such as a flower, an apple, a car, a light bulb and a star. On top of this paper was then placed a sheet with twenty lines horizontally across the page. The experiment can be seen in Appendix 2.

The students were told to wait till they were told to turn the papers over. When told to do so, and specifically not to touch their pens to prevent them from writing, they were given thirty seconds to study all the twenty pictures as carefully as possible. The time was taken using a stopwatch in order to get the most exact record of the time. After the thirty seconds was up they were told to turn back over the paper with the pictures and to start writing all the names of pictures they could remember in no particular order. They were asked to do this in complete silence in order to prevent either words being said out loud when students were thinking, or just generally distractions to the individuals. After this the surveyor collected all the papers with the pictures on them.

The students were allowed two full minutes to write down as many of the pictures as they could remember and were then asked to put their answer sheets under the original question paper in order to not only keep the papers in order but to also prevent them from writing down any answers remembered after the two minutes was finished.

Two other papers were then passed out once again in the same fashion, the first one however containing twenty different words. The list was a mix of words describing specific objects such as bike and corn but also ones describing abstract concepts such as idea or clue. Once again the students were asked to put their pens down and were then given thirty seconds to look at all the words. The experiment can be seen in Appendix 3.

After thirty seconds they turned over the papers and on the second sheet of paper given with again twenty horizontal lines on it (exactly the same as the first one given) they were asked to write down as many as they could remember, once again this had to be done in complete silence. The papers with the words were collected and, after two minutes, the students were asked to place the last paper they wrote on under the first two. All the papers were then collated.

All age groups ~~were~~ given the exact same amounts of time to look at the pictures and words even though it would be more difficult for a 7 year old to read twenty words quickly than it would be for a 17 year old. However, this had to be done in order to ensure the fairness of the test and to be able to compare the results.

Results:

Raw data can be seen in Appendix 4. Below is a summary of the average number of pictures and words remembered by each grade.

Table 1: Average Results of the Number of Pictures and Words Remembered by Each Grade

| Grade | Average Pictures Remembered | Average Words Remembered |
|-------------------|------------------------------------|---------------------------------|
| 2 (6-8) | 6* | 3 |
| 4 (8-10) | 10 | 8 |
| 6 (10-12) | 10 | 8 |
| 8 (12-14) | 11 | 8 |
| 10 (14-16) | 11 | 8 |
| 12 (15-18) | 12 | 9 |

*: Results are rounded to full numbers as half words or pictures cannot be remembered. See Appendix 5 for raw average results.

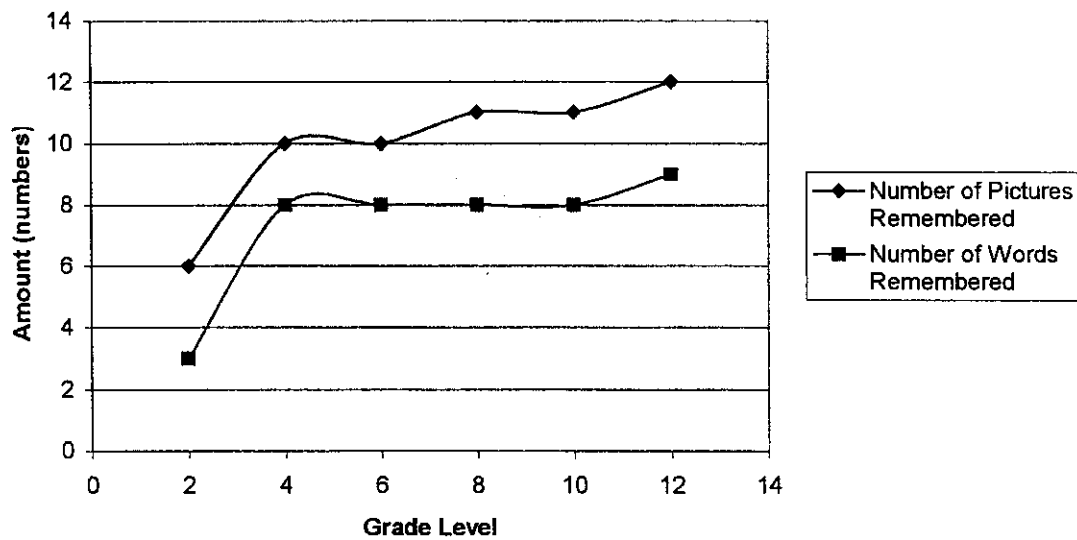
Results in Table 1 were converted to percentages to derive Table 2, which indicates the number of pictures and words remembered.

Table 2: Percentage Pictures and Words Remembered out of 20

| Grade | Picture | Word |
|-------|---------|------|
| 2 | 30 | 15 |
| 4 | 50 | 40 |
| 6 | 50 | 40 |
| 8 | 55 | 40 |
| 10 | 55 | 40 |
| 12 | 60 | 45 |

| Grade | Grade |
|-------|-------|
| 2 | 6-8 |
| 4 | 8-10 |
| 6 | 10-12 |
| 8 | 12-14 |
| 10 | 14-16 |
| 12 | 15-18 |

Graph Number 1 Showing Average Raw Results for the Number of Words and Numbers Remembered by Students



The next table indicates at what percentage the students' memory capacity has increased from the previous grade. It shows the rapid increases and when there were no changes occurring from grade to grade.

Table 3 Showing % Increase in Number of Objects Remembered from Previous Grade

| 2 | 0 | 0 |
|-----------|------|-------|
| 4 | 66.7 | 166.7 |
| 6 | 0 | 0 |
| 8 | 10.0 | 0 |
| 10 | 0 | 0 |
| 12 | 9.1 | 12.5 |

The following table indicates the percentage increase in the number of words and pictures remembered in a developmental range. It shows the total percentage increase of each grade from the youngest grade tested, 2nd grade. It correlates directly to graph number 1.

Table 4 Showing % Increase in Number of Objects Remembered from Second Grade

| 2 | 0 | 0 |
|-----------|------|-------|
| 4 | 66.7 | 166.7 |
| 6 | 66.7 | 166.7 |
| 8 | 83.3 | 166.7 |
| 10 | 83.3 | 166.7 |
| 12 | 100 | 200 |

Analysis:

From these results it can be observed that as age increases so does the brain's capacity to remember pictures and words. From the results it is visible that from grade two to grade four there is the largest change in the ability of the brain to recall objects. In grade two students were capable of remembering approximately six pictures whilst they can only remember three words on average. However in grade four students were able to remember ten pictures and eight words. That is an increase in picture remembrance of 66.7% and an increase in words of 166.7%. Next the process stayed the same; grade six students were able to remember the exact same amount of pictures and words as those students of grade four. After this is seen that the students from grade eight were able to remember eleven pictures (a 10% increase) however still only remembering eight words as the previous grade had.

Then there is another similar result with grade ten as there was with the similarity of results from grade four and six. Grade ten was able to memorise the same amount of words and pictures as the previous grade; grade eight, remembering eleven pictures and eight words. Lastly, we can see that grade twelve students were capable of memorising approximately twelve pictures and nine words indicating a very large increase, a 100% increase for words and a 200% increase in words, from students in grade two but also showing us that as age increases the brain's ability to retain and recall information does indeed increase considerably notably by six more words and also six more pictures.

The graph indicates that there is an exponential phase of increasing in memory's abilities from grades two to four, then a slow but steady increase with the grades that follow, sometimes resulting in periods of lag phases as there are between grades four and six and grades eight and ten.

What we are also shown from the results is that there is a large difference in the average amount of pictures and the average amount of words that individuals are able to memorise. Pictures seem to be by far a lot easier for the subjects to remember than the words are. This is due to the fact that with a picture, the individuals are already given a clear and visible image that

the mind is able to recall. Therefore when trying to remember them, the student can recall not only the word but also the picture associated with it. However with words, and especially with abstract words, it is harder to associate a picture in the mind's eye with the word shown on the paper in a very short amount of time.

The trends shown on the graphs for both picture recollection and word recollection are, however, considerably similar. They both develop in the same manner with an exponential growth phase for the memory of second grade students to fourth grade students and then they both proceed in rising slowly but steadily till they reach the final results for twelfth grade. The main difference though is that, as it can be seen on the graph and from the results, the capability for students to remember words does however increase less quickly than that of their memory's ability to remember pictures. The graph for word recollection goes through a considerably longer lag phase (than the picture recollection graph does) from grade four to grade ten where all students remembered an average of approximately eight words.

Also from the final result it can be seen that the difference between both picture and word recollection equally increases by six objects for each. This could be a coincidence however it could also indicate that a child's ability to retain and recall information conforms to a certain pattern and increases according to exact values. The latter would be a more acceptable view as the brain does develop as the age of the child in question increases, thus allowing for more information to be able to be stored as the child progresses through an education that requires memorising skills.

The fact that most students, particularly in those from grades eight to twelve were able to memorise more than two pictures than the generically accepted 7 ± 2 amount of objects the short-term memory part of the brain is said to be able to remember (as investigated by George A Miller)¹ indicates that throughout the period of thirty seconds when they were looking at the pictures some of the pictures must have slipped out of the short-term memory part of the brain and into the long-term memory section. This can be seen because the short-term memory of an

¹ "Memory." *Wikipedia, The Free Encyclopedia*.

individual's brain generally has "a strictly limited capacity and duration, which means that information is available for a certain period of time, but is not retained indefinitely"¹.

The picture or word could be moved from short-term memory to long-term memory through repetition of its name several times. If one of the subjects were to have focused on the first two rows of pictures and repeated those objects over and over again in their head these objects could then have been moved from the short-term memory area of the brain to long-term memory, thus allowing for it to be remembered more exactly². However as there are twelve more pictures on the page past those first two rows, the brain cannot focus on just those single eight and, as is in human nature, feels compelled to regard all other objects. Therefore less can be remembered more exactly due to the lack of time that the subject has. "A major reason for forgetting is simply the failure to learn"³. As subjects skimmed over both the words and pictures, they only viewed them, and did not learn them.

This is one part to the explanation but to it could be added that the individuals split the information into categories or groups which also increases a person's ability to remember pictures or words. As they group certain objects into certain categories connections and associations are made between two objects. For example, one of the pictures in the survey was of an elephant whilst another picture was of a butterfly. The two could be connected through the similar category of animal kingdom or of the fact that they are the two pictured that are of the most animated things on the page. Furthermore when a connection between two objects is made, thus a distinction can be placed with another group of objects that can subsequently be remembered as a counterpart to the previous category.

Thus through this experiment, primarily short-term memory was used and tested. As mentioned previously, short-term memory is capable of storing 7 ± 2 objects for a duration of approximately twenty seconds. The subjects were not really allowed enough time to move

¹ "Memory." *Wikipedia, The Free Encyclopedia*.

² Hall, E. (1973). *Why We Do What We Do*. Houghton Mifflin Company Boston.

³ *Ibid.*

objects into their long-term memory and hence it was ensured that what was being tested was short-term memory.

One exception that is indicated through the experiment and that must therefore be looked into is the radical change in the capabilities of memorising things for children in the second grade to those students in the fourth grade. It has been investigated and said “that the short-term memory span increases as children mature”¹ which would therefore support the results of the experiment done. However, this does not account for the sudden change between the results of children in grades two and four. Learning ability in children is said to reach its’ maximum between the ages of three and ten, where the child’s brain can absorb the most amount of information and where teaching the children new things is the easiest and is they are able to learn the fastest².

When a child is in the second grade they are around the age of seven. Though up till then they have been able to, as previously mentioned, absorb information quickly, the information they have been taking in is not such that will allow them to complete a memory test perfectly. They have been learning about their environment, about how to interact socially and how to remember say names, faces and information about people, yet are only just starting to deal with the concept of reading and writing and really speaking in coherent sentences and using proper language. Therefore it can be assumed that such a memory test as provided in this experiment would be quite a challenge for minds that are still so young. Also, their reading capabilities and abilities to understand some of the more complex words would also have helped in causing for a significant difference in the amount of words they were able to memorise.

However, by the age of nine and ten, which were the average ages of children in the fourth grades tested, students will be better able to read at a faster pace and to take in the words without looking at them for too lengthy a period of time.

¹ Neu, J. “In Short-Term Memory, Faster Is Not Better, MU Study Shows.”

² DeBord, K. (1997). *Brain development* [Extension Publication].

From the results produced we also see that after the fourth grade there is not much more of a radical change in the abilities of the children to remember pictures and words though there is a range of ages from eight to eighteen years of age. This is due to the fact that around the ages of eleven and twelve, children start to reach the same performance levels as adults, therefore eighteen years or older, in simple cognitive tests as the brain has reached round about its fully developed stage. This is because it is believed and has been researched on “that in adolescence, there is a shift toward integrating what one knows rather than learning new basic skills”¹. So once children reach a point of adolescence, the brain stops developing rapidly, thus no longer increasing the amount of objects that can be stored in an individual’s brain greatly.

Sources of Error/ Improvements:

In this experiment several sources of error were encountered. Firstly and the main source of error, was the fact that the students were tested in a classroom surrounded by their peers. This allowed not only for conversation to occur, though they were asked to be silent, but it was also highly likely and easy for students to be able to look at one another’s papers. Though they were asked to be honest, it was an inevitable occurrence that some of the students would be prone to cheat. To improve this error ideally each student should be tested one by one in order to get the most optimal results. This would require quite a lot of time for the examiner (and was not possible within the framework of the extended essay), yet if it could be done would be the optimal solution.

Secondly, one problem was that not all the students that were tested were anglophone students. Primarily in the lower grades as well a lot of the students spoke and wrote very little English making it a lot harder for them to read the words, let alone write them. This could be improved either by doing tests in various languages or testing only children with English as their first language.

¹ Waber DP *et al.* "The NIH MRI Study of Normal Brain Development: Performance of a Population Based Sample of Healthy Children Aged 6 to 18 Years on a Neuropsychological Battery."

Another error encountered was that not the same amount of students were tested in each grade. This did not make too much of a difference, however it could have affected the final averages by a couple of tenths. This would be an easy improvement that could be solved by not only testing the same amount of students in each grade but also by testing even more students from each grade to get the most accurate results.

One error that increased the difficulty of the test was the amount of words and pictures on the papers that students were expected to remember. Twenty of each is quite a large amount, therefore to alter the experiment to make it more effective would be to decrease the number of objects on each page to fifteen and see if the outcome would alter.

Lastly, it was inevitable that the students in each grade wouldn't all be of the same ages. Therefore grouping the students by grade isn't the fairest test as there were as much as two years of age difference between some of the students tested that were, however, in the same grade. To get the most accurate experiment it should, optimally, not be undertaken by grade but more so by age group. Therefore every grade would have to be tested and the results could reflect all age categories. However, improving it in this sense would not show all the students' development as they learn to read by grade and not by age.

Conclusion:

From this experiment it can be derived that, as a child's brain develops, and as he or she increases in age and maturity, the brain's ability to store, memorise and then recall information increases. However, in contrast to the hypothesis established at the beginning of the experiment assuming that the brain's ability to memorise pictures and words would increase at a constant and steady pace till the age of eighteen, a child's ability to remember things actually slows down once the child has reached adolescence or even pre-adolescence. The brain reaches a fully developed stage at the age of around eleven and twelve and then may still slightly increase in ability of memorising certain things but not by any type of significant amount.

Also can be concluded that, for all ages, pictures with a clear-cut visual reference are easier to memorise and recall than a word that has an abstract nature or that doesn't provide a visual attachment to the individual taking the experiment.

The experiment could also be investigated further and expanded upon. A group of students taking the tests could be followed from second grade till twelfth grade, the study thus being a long-term one, however showing us the exact changes occurring in the brain that could be monitored.

Another extension of this experiment would be to cross reference age with grade of some of the particular older or younger students in grades. A student in grade two that is 8 years old could be compared to a student in grade four that is 8 years old as well. Thus could be seen whether the increase in a child's brain depends on the amount of past learning and experience or if short-term memory does increase according to age.

Bibliography

"Brain," Microsoft® Encarta® Online Encyclopedia 2007

<<http://uk.encarta.msn.com>>

Clegg, J. (2000). *Advanced Biology Principles and Application*. John Murray Ltd.

DeBord, K. (1997). *Brain development* [Extension Publication]. Raleigh, NC: North Carolina Cooperative Extension Service.

Hall, E. (1973). *Why We Do What We Do*. Houghton Mifflin Company Boston.

"Memory." *Wikipedia, The Free Encyclopedia*. 5 Aug 2007. Wikimedia Foundation, Inc. 6 Aug 2007. <<http://en.wikipedia.org/w/index.php?title=Memory&oldid=155661033>>.

Murray, B. "Understanding Brain Development And Early Learning." 10 Mar 2003.

<www.facsnet.org>

Neu, J. "In Short-Term Memory, Faster Is Not Better, MU Study Shows." 3 Nov 2005. Association for Psychological Science. 15 Aug 2007 <<http://www.psychologicalscience.org>>

"Short-term memory." *Wikipedia, The Free Encyclopedia*. 26 Jul 2007. Wikimedia Foundation, Inc. 6 Aug 2007 <http://en.wikipedia.org/w/index.php?title=Short-term_memory&oldid=153569893>.

Waber DP *et al.* "The NIH MRI Study of Normal Brain Development: Performance of a Population Based Sample of Healthy Children Aged 6 to 18 Years on a Neuropsychological Battery." *Journal of the International Neuropsychological Society*, 2007, Vol. 13, pp. 1-18.

Appendix 1 : Survey Used on Subjects

Extended Essay Survey

This survey is completely anonymous and all the results are used for experimental purposes as part of an extended essay. This survey is to test the abilities of short-term memory and whether it changes with age. The surveys will not be shown to any other persons, therefore I would highly appreciate it if it could be done in full honesty and to the best of everyone's capabilities.

Age: _____

Grade: _____

Gender: Male Female

Nationality (or multiple): _____

First Language: _____

Other Languages Spoken: _____

Have you ever had to re-do a year of school?: Yes No

If so, which one: _____

Have you ever skipped a year of school?: Yes No

If so, which one: _____

DO NOT TURN OVER THE PAGE. Further instructions will be given.

Appendix 2

Pictures used for test one.
Test 1



Test 1 Answer Sheet

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix 3
Words used for test two.

Test 2

CASTLE

WINE

BIKE

TABLE

PLANT

ROCK

MIND

CORN

HAMMER

WINDOW

PIZZA

EYE

BIRD

SHOE

PLATE

CLUE

GRAPH

COLOUR

IDEA

SEA

Appendix 4

Raw results from all the experiments undertaken on the students displayed by grade.
This data was used to calculate the average results in Appendix 5.

2nd Grade

| <u>Subject #</u> | <u>Gender</u> | <u>Age</u> | <u>Number of Pictures Remembered</u> | <u>Number of Words Remembered</u> |
|------------------|---------------|------------|--------------------------------------|-----------------------------------|
| 1 | F | 6 | 7 | 4 |
| 2 | M | 7 | 7 | 6 |
| 3 | M | 7 | 5 | 5 |
| 4 | F | 8 | 4 | 1 |
| 5 | F | 7 | 3 | 2 |
| 6 | F | 7 | 8 | 4 |
| 7 | M | 7 | 4 | 2 |
| 8 | F | 7 | 7 | 3 |
| 9 | M | 7 | 7 | 6 |
| 10 | M | 7 | 8 | 6 |
| 11 | F | 7 | 4 | 1 |
| 12 | F | 6 | 8 | 4 |
| 13 | F | 7 | 9 | 2 |
| 14 | M | 7 | 9 | 6 |
| 15 | F | 7 | 7 | 5 |
| 16 | M | 8 | 5 | 3 |
| 17 | M | 6 | 8 | 4 |
| 18 | F | 7 | 4 | 2 |
| 19 | F | 7 | 5 | 4 |
| 20 | F | 7 | 8 | 1 |
| 21 | M | 7 | 7 | 4 |
| 22 | F | 8 | 6 | 3 |
| 23 | M | 6 | 3 | 2 |
| 24 | M | 7 | 4 | 2 |
| 25 | M | 7 | 8 | 5 |
| 26 | F | 7 | 5 | 1 |
| 27 | F | 7 | 4 | 1 |
| 28 | M | 7 | 6 | 4 |
| 29 | F | 7 | 4 | 2 |
| 30 | M | 6 | 8 | 6 |
| 31 | M | 6 | 3 | 3 |

4th Grade

| Subject # | Gender | Age | Number of Pictures Remembered | Number of Words Remembered |
|------------------|---------------|------------|--------------------------------------|-----------------------------------|
| 1 | M | 9 | 7 | 4 |
| 2 | M | 9 | 12 | 9 |
| 3 | M | 10 | 15 | 10 |
| 4 | M | 9 | 12 | 12 |
| 5 | M | 9 | 13 | 12 |
| 6 | M | 9 | 12 | 10 |
| 7 | M | 9 | 12 | 5 |
| 8 | M | 9 | 12 | 6 |
| 9 | M | 9 | 13 | 9 |
| 10 | M | 9 | 10 | 7 |
| 11 | M | 8 | 8 | 7 |
| 12 | M | 9 | 11 | 9 |
| 13 | F | 10 | 11 | 9 |
| 14 | F | 9 | 14 | 7 |
| 15 | F | 9 | 11 | 7 |
| 16 | F | 8 | 9 | 2 |
| 17 | F | 9 | 13 | 10 |
| 18 | F | 9 | 6 | 6 |
| 19 | F | 9 | 7 | 8 |
| 20 | F | 9 | 12 | 11 |
| 21 | F | 9 | 11 | 11 |
| 22 | F | 9 | 7 | 3 |
| 23 | M | 8 | 10 | 7 |
| 24 | M | 8 | 7 | 3 |
| 25 | M | 10 | 9 | 8 |
| 26 | F | 9 | 10 | 8 |
| 27 | F | 9 | 13 | 11 |
| 28 | F | 9 | 12 | 9 |
| 29 | F | 9 | 9 | 6 |
| 30 | F | 9 | 8 | 7 |
| 31 | F | 9 | 11 | 9 |
| 32 | M | 8 | 13 | 12 |
| 33 | M | 9 | 9 | 8 |
| 34 | M | 9 | 8 | 6 |
| 35 | M | 9 | 9 | 9 |
| 36 | M | 10 | 6 | 4 |
| 37 | F | 9 | 11 | 10 |
| 38 | F | 8 | 14 | 9 |
| 39 | F | 9 | 8 | 8 |

6th Grade

| Subject # | Gender | Age | Number of Pictures Remembered | Number of Words Remembered |
|------------------|---------------|------------|--------------------------------------|-----------------------------------|
| 1 | M | 11 | 9 | 7 |
| 2 | F | 11 | 13 | 11 |
| 3 | F | 11 | 10 | 8 |
| 4 | F | 12 | 8 | 4 |
| 5 | F | 10 | 13 | 6 |
| 6 | F | 11 | 8 | 6 |
| 7 | F | 12 | 5 | 2 |
| 8 | M | 11 | 11 | 6 |
| 9 | F | 11 | 11 | 9 |
| 10 | M | 11 | 10 | 9 |
| 11 | M | 11 | 12 | 7 |
| 12 | F | 11 | 12 | 9 |
| 13 | F | 11 | 10 | 8 |
| 14 | F | 12 | 10 | 9 |
| 15 | F | 11 | 9 | 7 |
| 16 | F | 11 | 8 | 7 |
| 17 | F | 11 | 12 | 12 |
| 18 | M | 11 | 12 | 9 |
| 19 | F | 11 | 10 | 8 |
| 20 | M | 12 | 8 | 5 |
| 21 | M | 11 | 14 | 11 |
| 22 | F | 11 | 12 | 12 |
| 23 | F | 10 | 8 | 8 |
| 24 | F | 11 | 15 | 11 |
| 25 | M | 10 | 6 | 3 |
| 26 | M | 10 | 13 | 12 |
| 27 | F | 11 | 14 | 12 |
| 28 | F | 11 | 8 | 11 |
| 29 | M | 12 | 7 | 7 |
| 30 | M | 11 | 10 | 6 |
| 31 | F | 11 | 12 | 11 |
| 32 | M | 11 | 8 | 8 |
| 33 | F | 11 | 8 | 6 |
| 34 | F | 11 | 8 | 7 |
| 35 | F | 11 | 11 | 10 |
| 36 | M | 11 | 10 | 7 |
| 37 | F | 12 | 15 | 7 |
| 38 | F | 12 | 8 | 8 |
| 39 | M | 11 | 10 | 8 |
| 40 | M | 12 | 15 | 12 |

8th Grade

| Subject # | Gender | Age | Number of Pictures Remembered | Number of Words Remembered |
|------------------|---------------|------------|--------------------------------------|-----------------------------------|
| 1 | F | 12 | 9 | 7 |
| 2 | M | 13 | 7 | 6 |
| 3 | F | 13 | 14 | 11 |
| 4 | M | 13 | 17 | 8 |
| 5 | F | 12 | 13 | 10 |
| 6 | M | 12 | 13 | 9 |
| 7 | F | 13 | 12 | 7 |
| 8 | M | 14 | 10 | 5 |
| 9 | M | 13 | 9 | 6 |
| 10 | F | 13 | 14 | 7 |
| 11 | F | 12 | 14 | 7 |
| 12 | M | 12 | 12 | 11 |
| 13 | M | 13 | 12 | 10 |
| 14 | F | 13 | 13 | 8 |
| 15 | F | 13 | 9 | 7 |
| 16 | M | 13 | 14 | 8 |
| 17 | M | 13 | 12 | 7 |
| 18 | M | 12 | 12 | 11 |
| 19 | M | 14 | 10 | 7 |
| 20 | F | 14 | 12 | 6 |
| 21 | M | 12 | 7 | 9 |
| 22 | F | 13 | 7 | 8 |
| 23 | F | 13 | 17 | 11 |
| 24 | F | 13 | 9 | 10 |
| 25 | M | 12 | 12 | 11 |
| 26 | F | 14 | 10 | 9 |
| 27 | M | 13 | 12 | 13 |
| 28 | F | 13 | 10 | 7 |
| 29 | M | 13 | 14 | 11 |
| 30 | M | 12 | 12 | 7 |
| 31 | M | 14 | 5 | 6 |
| 32 | M | 13 | 10 | 6 |
| 33 | M | 13 | 8 | 8 |
| 34 | M | 12 | 13 | 10 |
| 35 | F | 13 | 13 | 9 |
| 36 | F | 12 | 13 | 11 |
| 37 | M | 12 | 12 | 7 |
| 38 | F | 13 | 10 | 9 |
| 39 | M | 13 | 8 | 8 |
| 40 | F | 13 | 10 | 11 |
| 41 | M | 13 | 8 | 7 |
| 42 | M | 13 | 8 | 5 |
| 43 | M | 12 | 8 | 7 |

10th Grade

| Subject # | Gender | Age | Number of Pictures Remembered | Number of Words Remembered |
|------------------|---------------|------------|--------------------------------------|-----------------------------------|
| 1 | F | 15 | 11 | 9 |
| 2 | F | 15 | 15 | 9 |
| 3 | M | 16 | 13 | 11 |
| 4 | F | 15 | 9 | 5 |
| 5 | M | 16 | 14 | 8 |
| 6 | M | 15 | 11 | 8 |
| 7 | M | 15 | 7 | 3 |
| 8 | F | 14 | 10 | 7 |
| 9 | F | 15 | 11 | 11 |
| 10 | F | 15 | 13 | 12 |
| 11 | F | 15 | 12 | 10 |
| 12 | F | 15 | 12 | 7 |
| 13 | M | 15 | 9 | 7 |
| 14 | F | 14 | 8 | 5 |
| 15 | M | 15 | 7 | 9 |
| 16 | M | 15 | 13 | 9 |
| 17 | F | 15 | 17 | 11 |
| 18 | F | 14 | 15 | 10 |
| 19 | M | 14 | 16 | 10 |
| 20 | M | 16 | 12 | 8 |
| 21 | M | 15 | 7 | 5 |
| 22 | F | 15 | 10 | 9 |
| 23 | M | 15 | 8 | 8 |
| 24 | F | 15 | 11 | 10 |
| 25 | F | 16 | 11 | 7 |
| 26 | M | 15 | 13 | 7 |
| 27 | M | 15 | 11 | 7 |
| 28 | M | 15 | 14 | 12 |
| 29 | F | 15 | 8 | 6 |
| 30 | F | 14 | 12 | 12 |
| 31 | F | 15 | 12 | 9 |
| 32 | M | 15 | 10 | 7 |
| 33 | F | 15 | 11 | 10 |
| 34 | F | 14 | 7 | 9 |
| 35 | M | 15 | 13 | 6 |
| 36 | F | 15 | 9 | 8 |
| 37 | M | 14 | 10 | 8 |
| 38 | M | 15 | 14 | 12 |

12th Grade

| <u>Subject #</u> | <u>Gender</u> | <u>Age</u> | <u>Number of Pictures Remembered</u> | <u>Number of Words Remembered</u> |
|-------------------------|----------------------|-------------------|---|--|
| 1 | M | 17 | 14 | 6 |
| 2 | F | 17 | 15 | 10 |
| 3 | F | 17 | 9 | 5 |
| 4 | M | 17 | 11 | 8 |
| 5 | F | 16 | 12 | 10 |
| 6 | F | 17 | 11 | 6 |
| 7 | F | 17 | 14 | 8 |
| 8 | M | 17 | 11 | 7 |
| 9 | M | 16 | 12 | 13 |
| 10 | M | 17 | 16 | 15 |
| 11 | F | 17 | 8 | 8 |
| 12 | F | 17 | 12 | 10 |
| 13 | F | 17 | 10 | 6 |
| 14 | F | 16 | 12 | 8 |
| 15 | M | 16 | 11 | 9 |
| 16 | M | 15 | 14 | 10 |
| 17 | M | 16 | 14 | 9 |
| 18 | M | 17 | 12 | 6 |
| 19 | M | 17 | 13 | 7 |
| 20 | F | 16 | 10 | 6 |
| 21 | F | 16 | 9 | 5 |
| 22 | M | 18 | 13 | 10 |
| 23 | F | 17 | 12 | 12 |
| 24 | M | 16 | 11 | 9 |
| 25 | F | 17 | 12 | 11 |
| 26 | F | 17 | 15 | 13 |
| 27 | F | 17 | 16 | 10 |
| 28 | M | 17 | 11 | 11 |
| 29 | M | 17 | 13 | 9 |
| 30 | F | 17 | 14 | 10 |
| 31 | M | 17 | 11 | 7 |
| 32 | F | 16 | 14 | 8 |
| 33 | M | 17 | 15 | 11 |
| 34 | M | 16 | 10 | 6 |
| 35 | F | 16 | 11 | 10 |

Appendix 5

Raw average results calculated through use of the raw data.

| Grade | Number of Pictures Remembered | Number of Words Remembered |
|--------------|--------------------------------------|-----------------------------------|
| 2 | 5.9 | 3.4 |
| 4 | 10.4 | 7.9 |
| 6 | 10.3 | 8.1 |
| 8 | 11.0 | 8.3 |
| 10 | 11.2 | 8.4 |
| 12 | 12.2 | 8.8 |