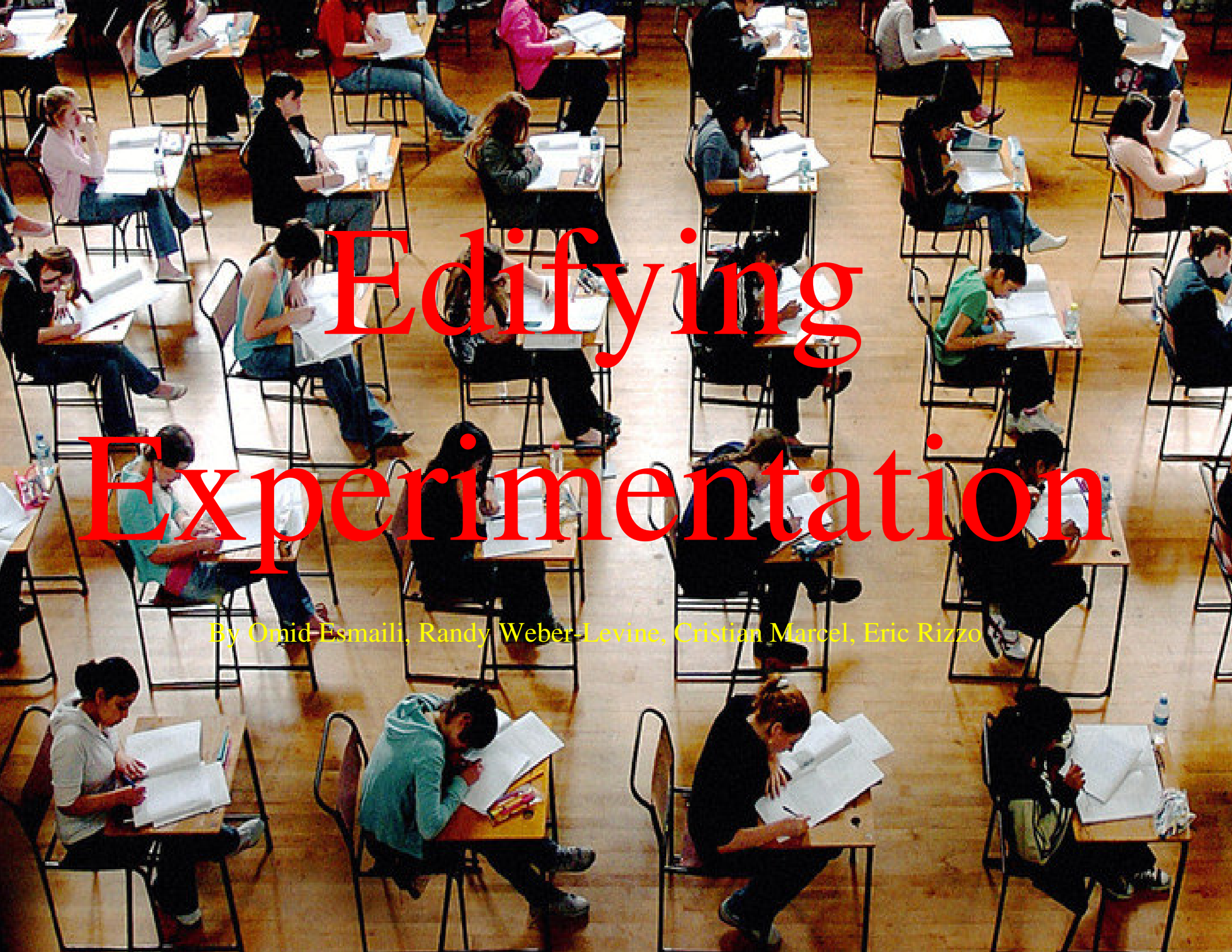


Edifying Experimentation

By Omid Esmaili, Randy Weber-Levine, Cristian Marcel, Eric Rizzo

Introduction

In an age of increasing competition for acceptance into top colleges and universities, it has become more and more pertinent for students to gain any step on the competition. One of the most essential ways to stand out from the rest of one's academic competitors is to have a higher grade point average (GPA). Besides usurping teacher attention from the rest of your classmates, the most direct way to increasing ones GPA is to study! It seems obvious, yet for many students studying can be a struggle. The bottom line is, studying is just memorization, yet what is the best way to memorize something?

Purpose

For our experiment we wanted to see how students can memorize best, visually or auditory. Additionally, we wanted to see if there is an association between GPA and memorization ability because students may only have higher GPA's than classmates due to their ability to memorize. After some research, we came to our first conjecture, that visual learning is much more beneficial than auditory learning. We also reached a second conjecture, that there is a linear association between GPA and memorization ability. In order to find the truth, we set out to gather data from a sufficient sample of high school students!

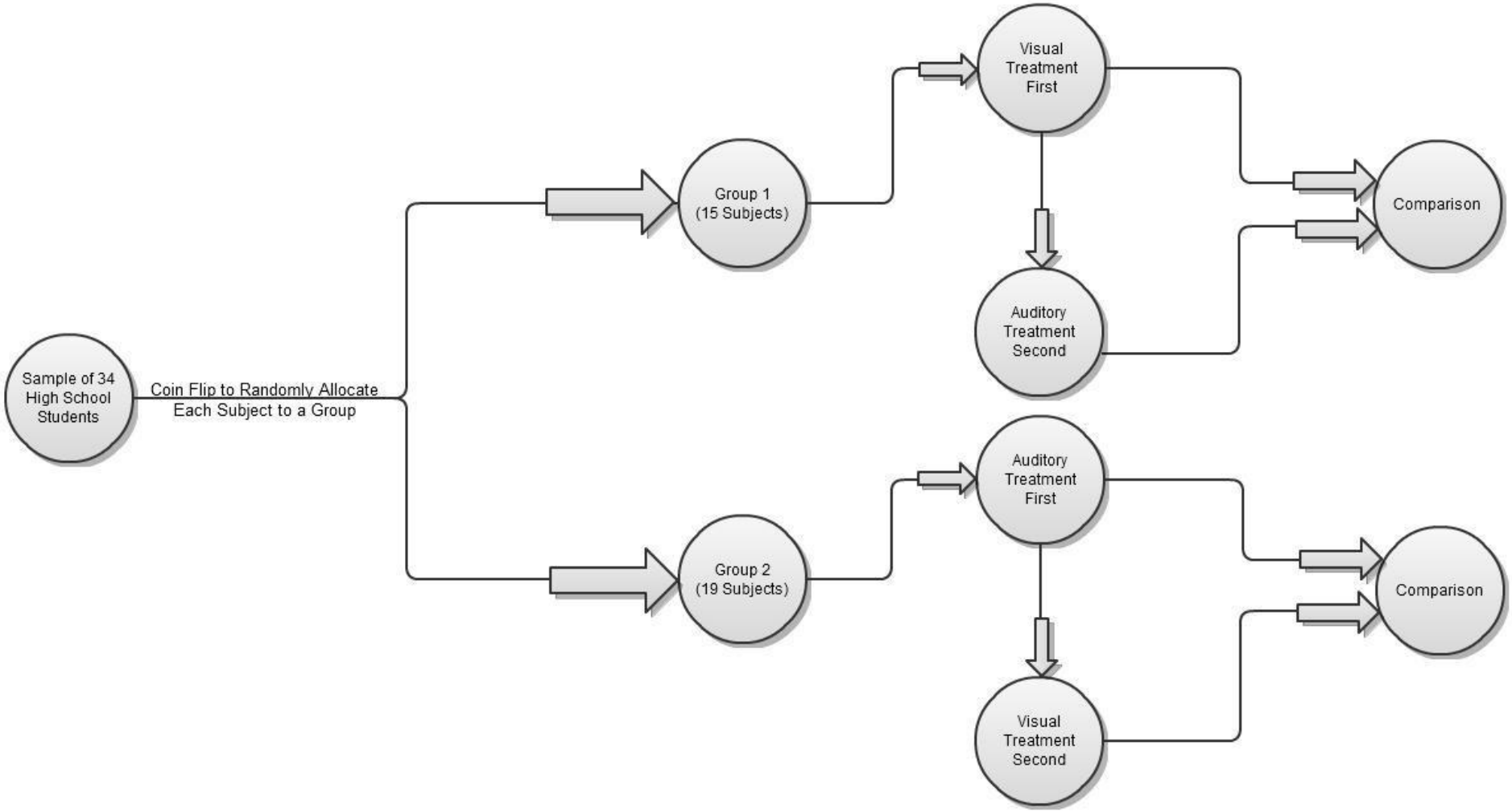
Procedure

To test this experiment, we first had all subjects flip a coin to determine if they would remember a ten-digit number through an auditory sample or by viewing a different ten-digit number first. This was simply a method to ensure randomization of treatments. If the coin landed on heads, the subject was given the visual treatment first. If the coin landed on tails, the auditory treatment was given first. The core of the experiment began when each subject was given exactly 30 seconds to memorize a ten-digit number to his or her full extent. They would then repeat the number back to us as we recorded the amount of numbers correct. After completing a treatment, the subject would repeat this for the other treatment. All subjects were given the same ten-digit number of 3741629538 for the visual treatment and the same ten-digit number of 6409572185 for the auditory treatment as a control. Both numbers were randomly generated through utilization of the TI-*n*spire CAS's random number generator function. As another control, the auditory treatment was given through a tape recording of the number so that the quality and length would be identical. The amount correct was calculated by accepting every number repeated aptly in order. The figure below shows how this would be done using the auditory treatment. All numbers with a line through them would be considered incorrect. The following subject would have received a score of 5.

Number that would be given: 6409572185

Number repeated by subject: 6~~5~~09~~317~~285

- Note the diagram on the following page.


Sample of 34 High School Students
Coin Flip to Randomly Allocate Each Subject to a Group
Group 1 (15 Subjects)
Visual Treatment First
Auditory Treatment Second
Comparison
Group 2 (19 Subjects)
Auditory Treatment First
Visual Treatment Second
Comparison

Student	GPA (out of 100)	AP Classes (Yes or No)	Gender	1st of 2nd: # of Numbers Remembered (Visual Out of 10)	1st of 2nd: # of Numbers Remembered (Auditory Out of 10)	Difference (Visual- Auditory)	Total (Visual + Auditory)
1	86	No	Female	1st : 10	2nd : 4	6	14
2	85	No	Female	1st: 9	2nd : 2	7	11
3	75	No	Male	2nd : 4	1st: 4	0	8
4	98	Yes	Male	1st : 10	2nd: 10	0	20
5	90	Yes	Female	2nd : 8	1st : 6	2	14
6	84	Yes	Male	1st : 6	2nd : 2	4	8
7	97	Yes	Female	2nd : 8	1st : 3	5	11
8	94	Yes	Female	2nd : 8	1st : 7	1	15
9	92	Yes	Female	1st : 10	2nd : 7	3	17
10	94	Yes	Male	2nd : 9	1st : 4	5	13
11	91	Yes	Male	2nd : 10	2nd : 1	9	11
12	104	Yes	Female	2nd : 10	1st : 4	6	14
13	88	Yes	Female	1st : 10	2nd : 3	7	13
14	82	No	Male	1st : 10	2nd : 3	7	13
15	92	Yes	Male	1st : 10	2nd : 5	5	15
16	90	Yes	Male	2nd : 10	1st : 7	3	17
17	95	Yes	Male	2nd : 7	1st : 6	1	13
18	94	Yes	Female	2nd : 5	1st : 7	-2	12
19	90	No	Male	1st : 10	2nd : 6	4	16
20	80	No	Male	2nd : 2	1st : 1	1	3
21	83	No	Male	1st : 9	2nd : 9	0	18
22	93	Yes	Male	2nd : 10	1st : 7	3	17
23	85	No	Male	1st : 10	2nd : 2	8	12
24	87	No	Female	1st : 8	2nd : 5	3	13
25	85	No	Male	2nd : 4	1st : 5	-1	9

Student	GPA (out of 100)	AP Classes (Yes or No)	Gender	1st of 2nd: # of Numbers Remembered (Visual Out of 10)	1st of 2nd: # of Numbers Remembered (Auditory Out of 10)	Difference (Visual- Auditory)	Total (Visual + Auditory)
26	84	No	Male	2nd : 5	1st : 5	0	10
27	85	No	Female	2nd : 7	1st : 2	5	9
28	75	No	Female	2nd : 3	1st : 3	0	6
29	96	No	Male	2nd : 7	1st : 6	1	13
30	85	No	Male	1st : 5	2nd : 8	-3	13
31	87	No	Female	2nd : 6	1st : 7	-1	13
32	90	No	Female	1st : 9	2nd : 3	6	12
33	89	No	Female	2nd : 5	1st : 3	2	8
34	80	No	Male	1st : 5	2nd : 3	2	8

Hypothesis Test:

H_o: $\mu_d = 0$ μ_d = Average Difference in Number of Numbers Memorized (Visual – Auditory)

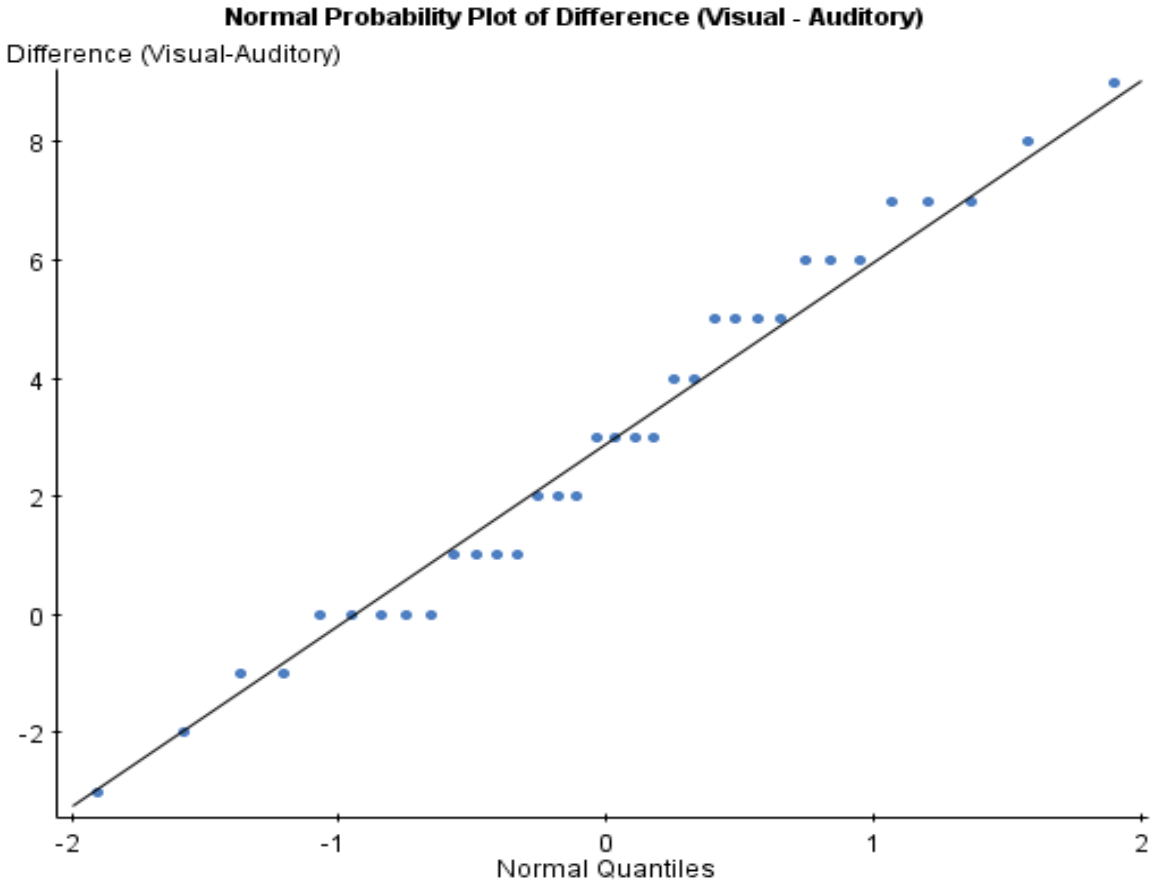
H_A: $\mu_d \geq 0$

R: Coin flipped to randomize the order of treatments given to each high school student.

P: Data paired by high school student.

T: 34 high school students is less than 10% of all high school students.

NN: The normal probability plot provided is very linear. It is plausible that our sample came from a normal population.



Matched Pair t-Test:

n = 34

Df = n – 1 = 34 – 1 = 33

$$t_{DF} = t_{33} = \frac{\bar{d} - 0}{SE(\bar{d})} = \frac{2.91176 - 0}{\frac{3.06859}{\sqrt{34}}} = 5.53296$$

P-Value = 0.000002

Since our P-Value is so low, we reject the null hypothesis. We have strong evidence that the average difference in number of numbers memorized (visual – auditory) is statistically significantly higher than zero. This provides support for the argument that visual memorization is more beneficial than auditory memorization.

Confidence Interval:

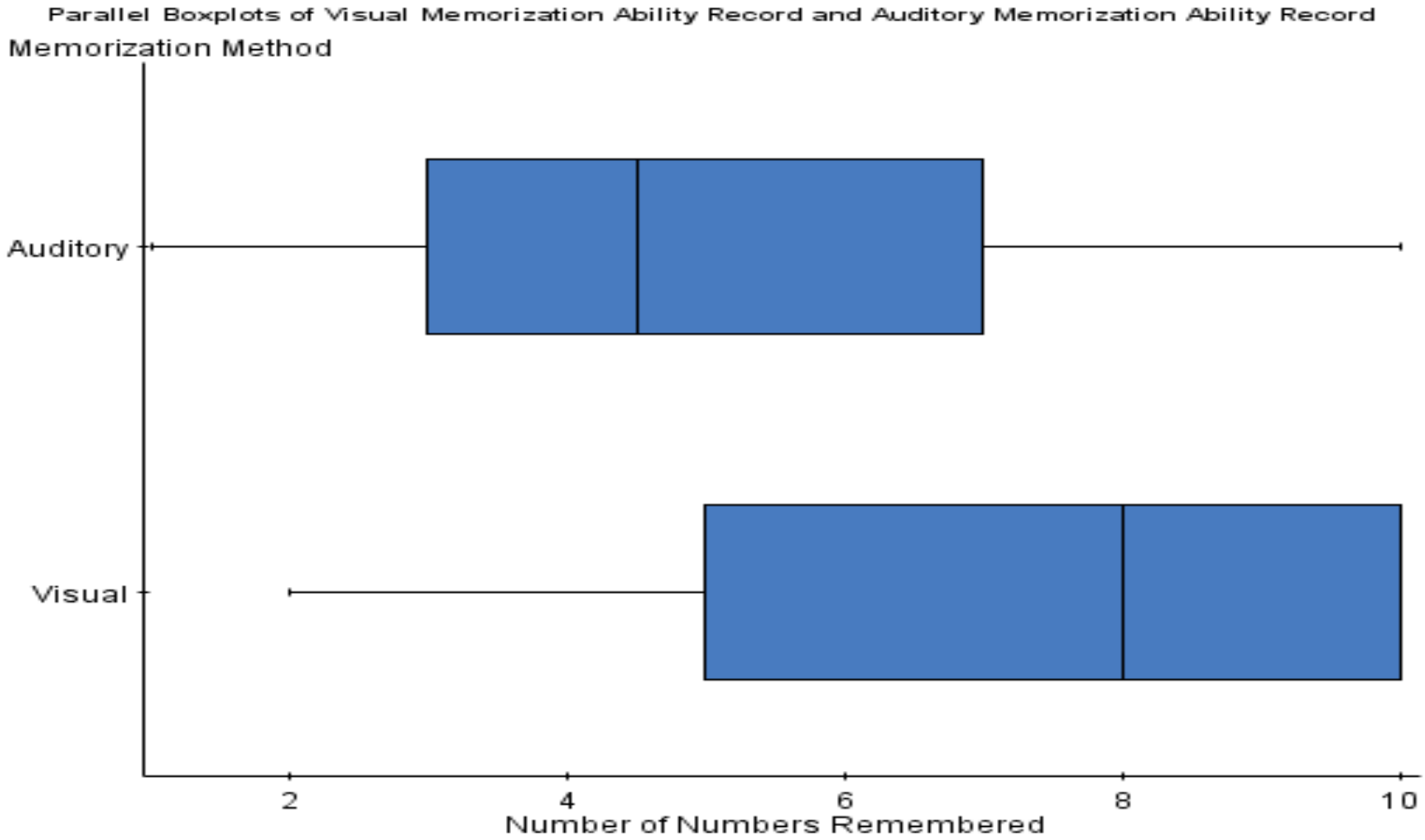
Matched Pair t-Confidence Interval:

$$\bar{d} \pm t_{DF}(SE(\bar{d}))$$

$$= 2.91176 \pm t_{33}\left(\frac{3.06859}{\sqrt{34}}\right)$$

$$= (1.84108, 3.98245)$$

We are 95% confident that the average difference between visual memorization ability record and auditory memorization ability record is in the interval (1.84108, 3.98245).



The distribution for the number of numbers remembered using the auditory memorization method as a treatment seems to be slightly skewed to the right. The distribution of the number of numbers remembered using the visual memorization method as a treatment is very different since it seems to be skewed to the left. Neither seems to have values that would be considered outliers. The median of the visual memorization method is much higher than the median of the auditory memorization method. There is less spread in the interquartile range (middle 50%) of the auditory memorization method than there is in the visual memorization method. It seems that the visual memorization method is more effective than the auditory memorization method.

Hypothesis Test:

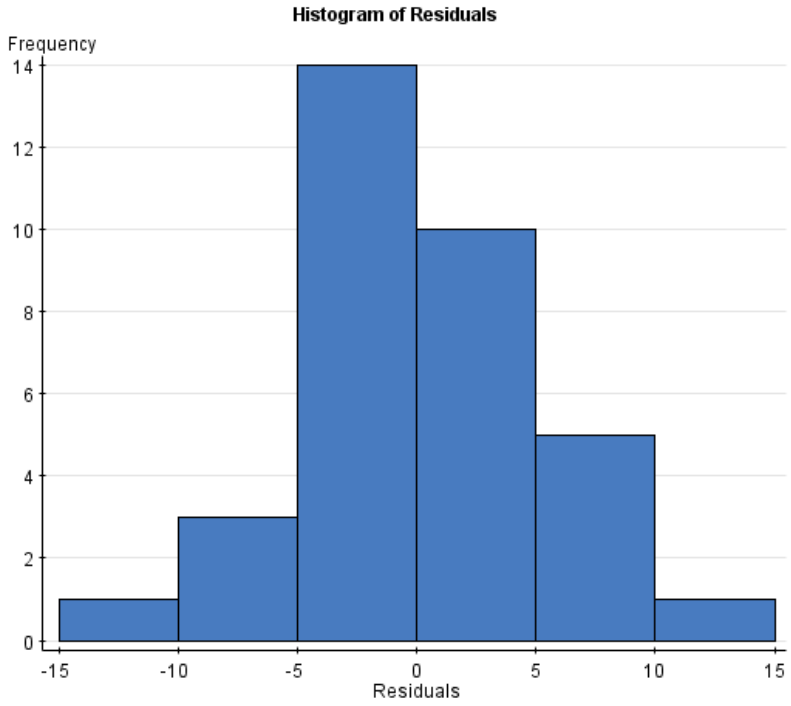
H_o: $\beta_1 = 0$ There is no linear association between GPA and memorization ability.

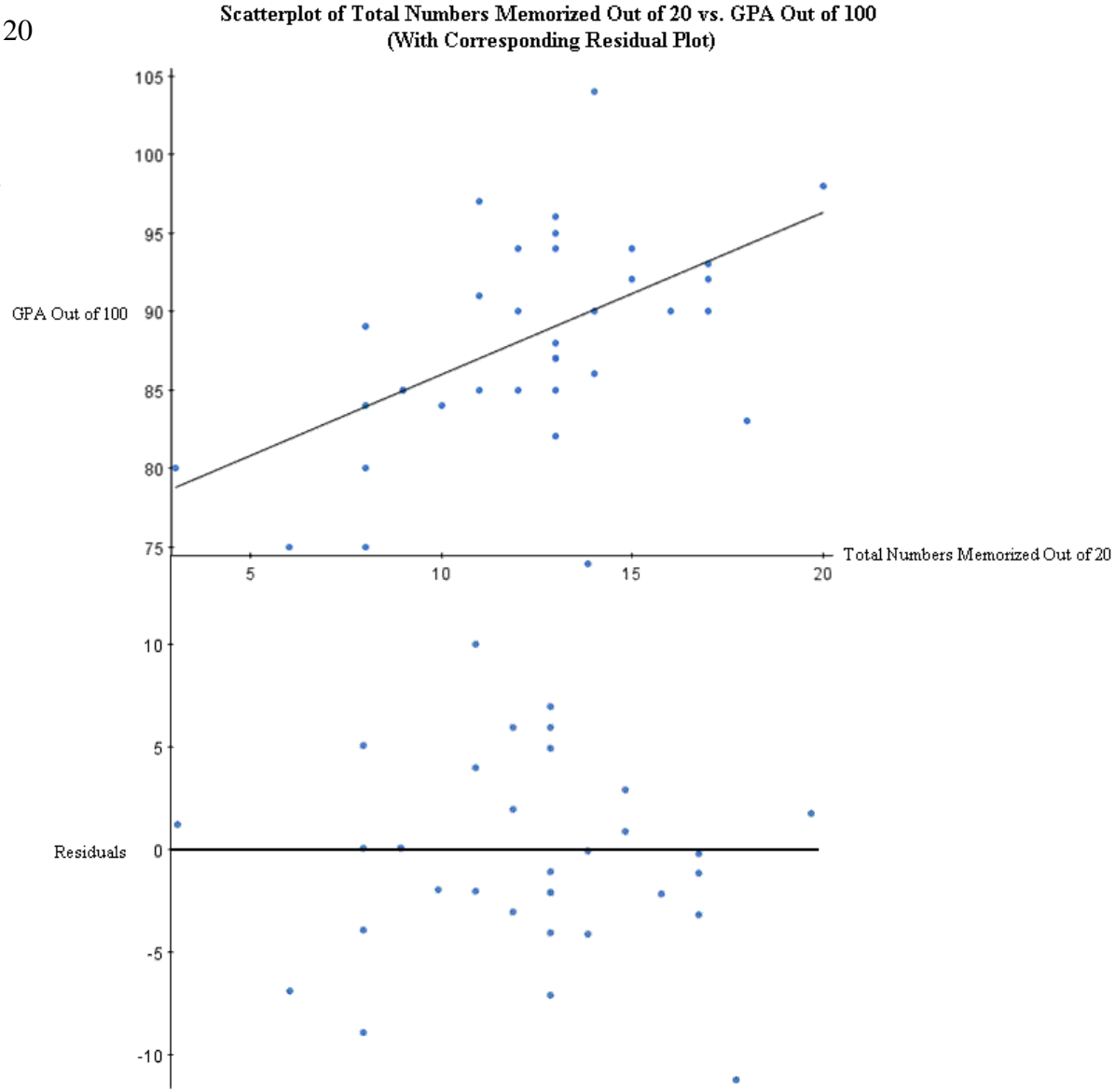
H_A: $\beta_1 \neq 0$ There is an association between GPA and memorization ability.

S: The scatter plot of total numbers memorized out of 20 vs. GPA out of 100 is straight enough.

R: The residuals do not show any specific patterns. Neither do they show any heteroscedastic behavior or clumps.

H: The histogram of residuals is unimodal and roughly symmetric.





Linear Regression t-Test:

Simple linear regression results:

Dependent Variable: GPA Out of 100
Independent Variable: Total of Numbers Memorized Out of 20
(GPA Out of 100) = 75.70598 + 1.0286318 (Total of Numbers Memorized Out of 20)
Sample size: 34
R (correlation coefficient) = 0.5824
R-sq = 0.3391462
Estimate of error standard deviation: 5.272359

Parameter estimates:

Parameter	Estimate	Std. Err.	DF	T-Stat	P-Value
Intercept	75.70598	3.2561529	32	23.250132	<0.0001
Slope	1.0286318	0.25383073	32	4.052432	0.000302

n = 34

Df = n – 2 = 34 – 2 = 32

$$t_{DF} = t_{32} = \frac{b^1 - 0}{SE(b^1)} = \frac{1.028631_8 - 0}{0.2538307_3} = 4.052432$$

P-Value = 0.000302

Since our P-Value is so low, we reject the null hypothesis. We have strong evidence that there is an association between GPA and memorization ability. This provides support for the argument that there is a linear association between GPA and memorization ability.

Confidence Interval:

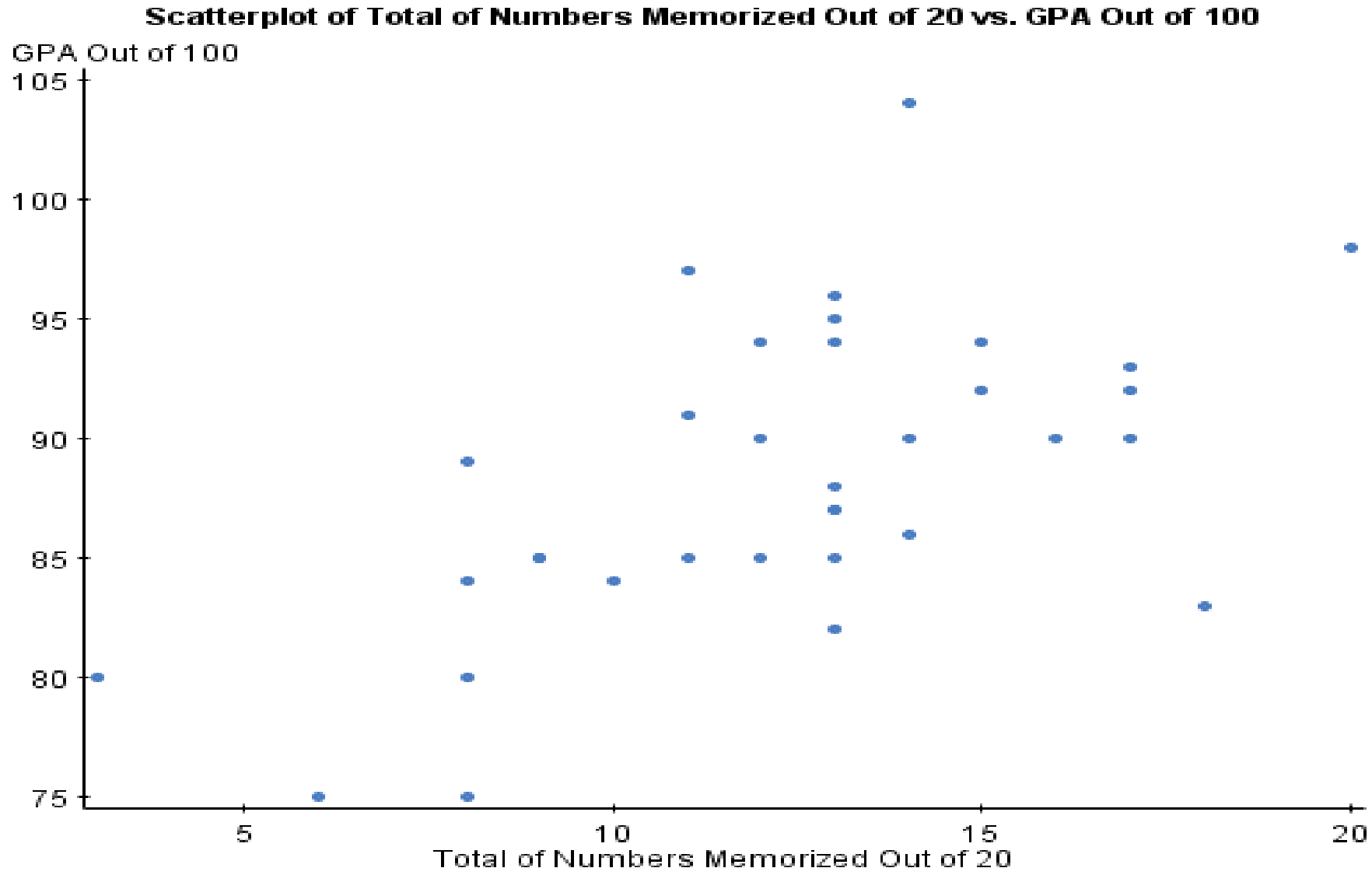
Linear Regression t-Confidence Interval:

$$b^1 \pm t_{DF}(SE(b^1))$$

$$= 1.028631_8 \pm t_{32}(0.2538307_3)$$

$$= (0.511596, 1.54567)$$

We are 95% confident that for each additional number memorized out of the total of 20, the average increase in GPA out of 100 is in the interval (0.511596, 1.54567).



The association between total of numbers memorized out of 20 and GPA out of 100 is moderate. It seems to be somewhat linear in form and has a positive direction, as can be verified by its positive correlation coefficient 0.5824. Some unusual findings include one subject with a total of 6 numbers memorized out of 20 and a GPA of 75 and another subject with a total of 8 numbers memorized out of 20 and a GPA of 75. Also, one subject had a total of 18 numbers memorized out of 20 and a GPA of 83. One last unusual finding included one subject that had a total of 14 numbers memorized out of 20 and a GPA of 104. This student's GPA stood out, being the highest one out of the whole sample, yet her total of numbers memorized out of 20 was very low in comparison to the predicted total. Despite the notable x-values or y-

values of these points, none of them or any other points seem to be influential points due to their negligible effect on the slope of the regression line.

Conclusions:

Since our P-Value for the matched pair t-test is so low, we reject the null hypothesis that the average difference in number of numbers memorized (visual – auditory) is equivalent to zero. Through this test, we have found strong evidence that the average difference in number of numbers memorized (visual – auditory) is statistically significantly higher than zero. Through a matched pair t-confidence interval, we became 95% confident that the average difference between visual memorization ability record and auditory memorization ability record is in the interval (1.84108, 3.98245). This information provides support for the argument that visual memorization is more beneficial than auditory memorization.

Since our P-Value for the linear regression t-test is so low, we reject the null hypothesis that there is no linear association between GPA and memorization ability. By the completion of this test, we have strong evidence that there is an association between GPA and memorization ability. This provides support for the argument that there is a linear association between GPA and memorization ability. Also, our linear regression t-confidence interval led us to become 95% confident that for each additional number memorized out of the total of 20, the average increase in GPA out of 100 is in the interval (0.511596, 1.54567).

We decided that like most experiments, ours was not perfect. We looked over our procedures and came to some agreements on how we would have done the experiment better. We realized that even though we used an honesty policy accompanied by the fact that the subjects were kept anonymous, some subjects may have not been the most truthful about their GPA. One way in which we would have been able to check their scores would be to receive a signature from them giving us consent to check their GPA through their high school.

Also, we noted that our sample was a good size, yet an increased sample size would have allowed us to detect the wrongness of the null hypotheses which we had more easily. Later on, during our work on the hypothesis tests and confidence intervals we completed, we recognized another factor, the size of our α-level (alpha level). A larger α-level would have given us more powerful tests and would have reduced the probability of any type I and/or type II error.

One main factor we ran into during our experiment was the actual numbers which we were using for each treatment. Despite their random generation, we noted that they had a few patterns which were not really notable but could be changed to make the memorization process more appropriate. For instance, the visual number we used, 6409572185, included the numbers 5 and 7 in a row. Some subjects may have noted that these are both odd numbers that succeed each other. This may have been one way in which subjects memorized the number more easily, by identifying with this pattern.

Despite the incomplete perfection of this experiment, this was a great experience. Through it, we learned a great deal about statistics and experimentation. This was one of few experienced where we have been able to be on the other side of statistics, where we conduct the experiment. It was very insightful and sparked more of an interest in statistics for us!