23/5/2012

CHEW ON THIS:

Gum's Effect on Our Ability to Memorize

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I. Question of Interest:

Does chewing gum help high school students focus in an academic environment?

In this experiment, we hope to see if there is an association between chewing gum and a high school student's mental agility with regards to memorization. We chose this topic because gum chewing is a controversial topic in many high schools across the country. Some high schools allow students to chew gum during class, while others ban it. Does the use, or lack thereof, of chewing gum play a role in a student's ability to perform well academically? This is the question we hope to answer in performing this experiment.

II. Research Design

Our experiment included many steps in order to overcome various obstacles that affected our data collection. In theory, we had hoped to have an unbiased experiment with a systematic random sample. As shown below, however, this was, unfortunately, not the case.

In order to conduct an unbiased survey, we decided to conduct an experiment with matched pairs. Therefore, each subject that we tested would be compared only to him or herself in varying circumstances. In our school of about 1100 students, we randomly chose 80 students to be a part of our survey, meaning that our sample population was less than ten percent of our total population of students. We chose these students from the online student directory using a systematic random sample. There are pictures of 12 students arranged alphabetically on each of the eighty pages, and, using a random digit table, we selected each student who was occupying the second position on each page to be a part of the sample population.

The students we chose varied in multiple ways—from grade level (freshman to senior), age, gender, and ethnicity. However, because we were conducting a matched pairs experiment, these factors did not confound our data.

With our subjects chosen, we continued to design our experiment. In order to test how much chewing gum helps or hurts a student, we decided to pick one specific brand of gum: Stride Spark. We chose the Stride Spark gum for no particular reason; we merely wanted a consistent brand for each test of the experiment. Then, we bought the Stride Spark gum in two flavors: Kinetic Mint and Kinetic Fruit. We wanted to see if certain flavors of gum changed a person's memorization ability.

With our gum chosen, we designed the rest of the experiment. First, we created a short survey to get to know more about our subjects. We asked each his or her age, grade level, gender, ethnicity, how many languages he or she spoke fluently, how often he or she chews gum per week, and how many pieces of gum he or she has per day when they do chew gum. We hoped to use this data about race, gender, and fluency in languages to determine if any confounding variables existed. Then, after the experiment, we asked each participant which flavor of gum he or she preferred: fruit, mint, both or neither. The survey that we used in our experiment is shown below. Each survey also included lines on which the subjects wrote down as many numbers and letters as they remembered.

Survey:

1. How old are you? (Only in years)
2. What grade are you in?

   Freshman Sophomore Junior Senior Post-Graduate

3. What is your gender?

   Male Female

4. What is your race? (Circle One)

   White (Including Middle Eastern) Black/African American

   Asian/Pacific Islander Native American

   Mixed Other

5. Are you Hispanic or Latino?

   Yes No

6. How many languages do you speak fluently?

   1 2 3 4 or more

7. How many days do you chew gum per week?

   0 1 2 3 4 5 6 7

8. On days where you do chew gum, how many pieces of gum do you chew?

   1-2 3-4 5-6 7 or more

1. Fruit Mint No Gum _____
2. Fruit Mint No Gum _____
3. Fruit Mint No Gum _____

9. Which flavor of gum did you like the most?

   Fruit Mint I liked both the same I did not like either

After the survey was taken, we conducted the experiment. We created the experiment to have as few variables as possible. The experiment consisted of taking a short test of memorization while either chewing or not chewing gum. First, using a random number generator, we assigned each subject a number from 1 to 3, which determined if a subject would begin by chewing mint gum, chewing fruit gum or chewing no gum at all. (This process of randomly assigning a flavor to each subject would be repeated for each of the three trials until each subject had memorized once with mint gum, once with fruit gum and once without gum). Then, gum was distributed to those who were to chew during the first trial and they were asked to chew the gum for one minute before beginning the test. In the meantime, each subject was also given a list of random letters and numbers, exactly 30 numbers and letters in total. After the minute had passed, each subject was given another minute and was asked to memorize as many of the numbers and letters as possible. Immediately after this minute, each subject wrote down as many letters and numbers from the pattern. The score was then calculated by counting the amount of numbers and letters that were correctly written. A correct answer was defined as a number or letter that was written in the original order in which it had appeared on the strip of paper. The grading of each test ended at the first incorrectly placed number or letter and the number of correct answers written up to that point was then recorded.

We chose this type of test because it measures only one's ability to memorize, and not one's verbal and math skills, two skills that are the foci of tests of anagrams or multiplication problems. We created the lists of random letters and numbers using the website http://www.random.org/strings . In terms of the order of the tests, everyone was randomly assigned to a list by choosing a number: one, two, or three. Each number corresponded to a particular string of numbers and letters. We did this so as to randomize the pairings of strings and gum flavors). The random lists are shown below.

Three Lists:

```
bpvx6iezrw8nusvbm8ng2xa2z27x1s

u55zp5uyc866t3mfbwubrb46l4wbi3

8ycbwkhsl8lliral9ud8j2xpw37hma
```

This test involved a matched pairs design, because we tested how well each student did against him or herself depending on the flavor or use of gum.

We also drafted a script for us (as the administrators of the test) to use during the experiment, so that we would not introduce any bias into the experiment. We made sure that our experiment had as few confounding variables as possible. For example, after each trial, the

students would eat two saltine crackers and drink a small amount of water so that the taste of the gum previously chewed would not remain in their mouths during the next trial. We judged the correctness of our participants' answers by how many letters and numbers a student could remember in the correct order. This means that once a subject wrote an incorrect letter or number in the sequence, we stopped counting and recorded the last correct character in the sequence as their "score" for the data collected. The score could range from 0 to 30, because there were 30 random letters and numbers in our three lists.

ORDER OF EXPERIMENT:

1. Subjects take the survey.
2. Administrators explain the testing procedure with the pre-written script.
3. Administrators hand out pieces of gum.
4. Have participants chew gum (if assigned) for one minute.
5. Conduct memory test with random strings: one minute to memorize, one minute to write.
6. Give each subject two saltine crackers and a small amount of water to cleanse their mouths if they have just chewed gum.
7. Repeat twice, with a different flavor of gum or no gum at all.

A copy of the script is provided on the following page.

Unfortunately, we did not have as successful of a turnout as we had hoped with our systematic random sample. Although we attempted to entice our participants with a raffle of free homemade banana bread or cookies, we had only 15 people from our original set of participants show up to partake in the experiment. Because of this, we had to ask friends to participate in our experiment to bolster our numbers, which introduced bias due to the lack of response and the convenience sampling.

Script:

Hello, thank you for coming. At your table, you will find two pieces of gum, three strips of paper and a survey. Please do not touch the strips of paper until instructed to do so, but answer the questions on the survey.

(Wait for them to finish answering)

You will have one minute to memorize as much of this string as you can.

Now, if you are supposed to chew gum, start chewing. If you are not supposed to chew gum, just wait.

(Make sure everyone is ready)

Now, turn one of the strips of paper over and begin memorizing.

(Stop them after one minute)

Stop. Now, write down as many numbers and letters as you can remember.

(Stop when they have finished writing, but do not give them more than one minute to write.)

Now, if you are supposed to chew another piece of gum, begin chewing. If not, just wait.

Okay, turn another one of the strips of paper over and begin memorizing.

(Stop them after one minute)

Stop. Now, write down as many numbers and letters as you can remember.

(Stop when they have finished writing, but do not give them more than one minute to write.)

Now, if you are supposed to chew another piece of gum, begin chewing. If not, just wait.

Okay, turn another one of the strips of paper over and begin memorizing.

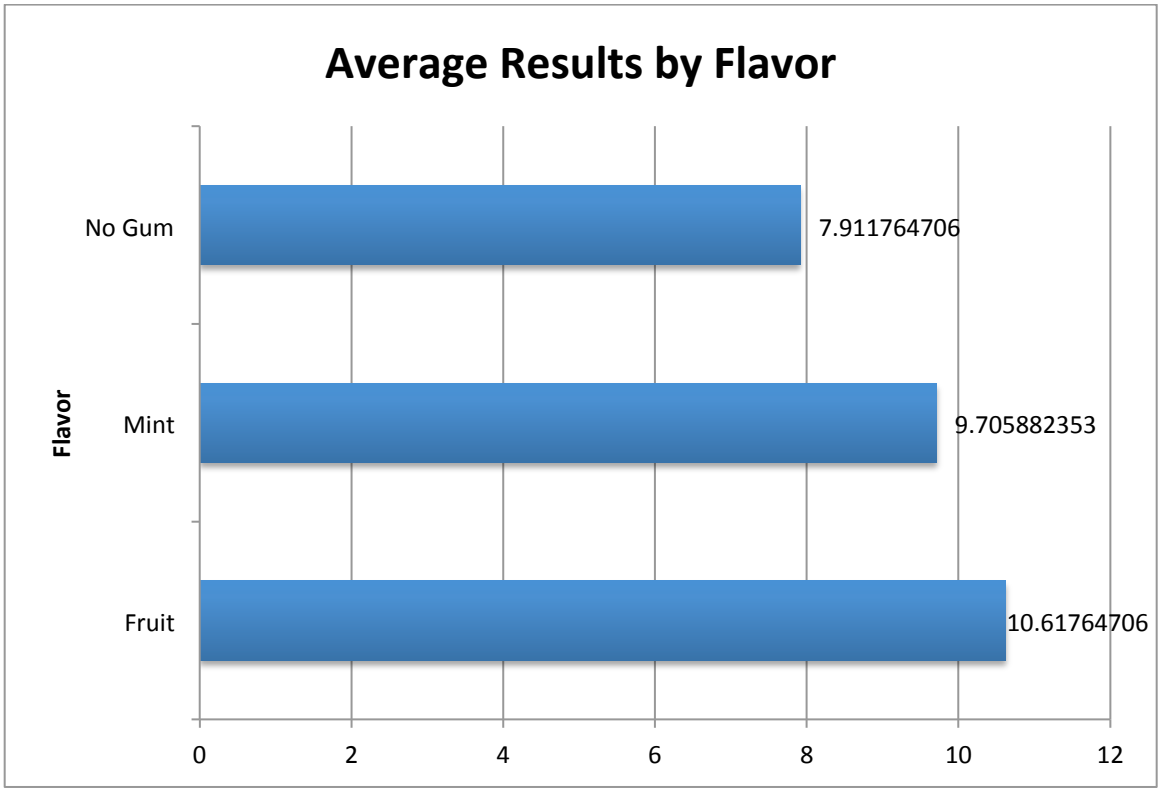
(Stop them after one minute)

Stop. Now, write down as many numbers and letters as you can remember.

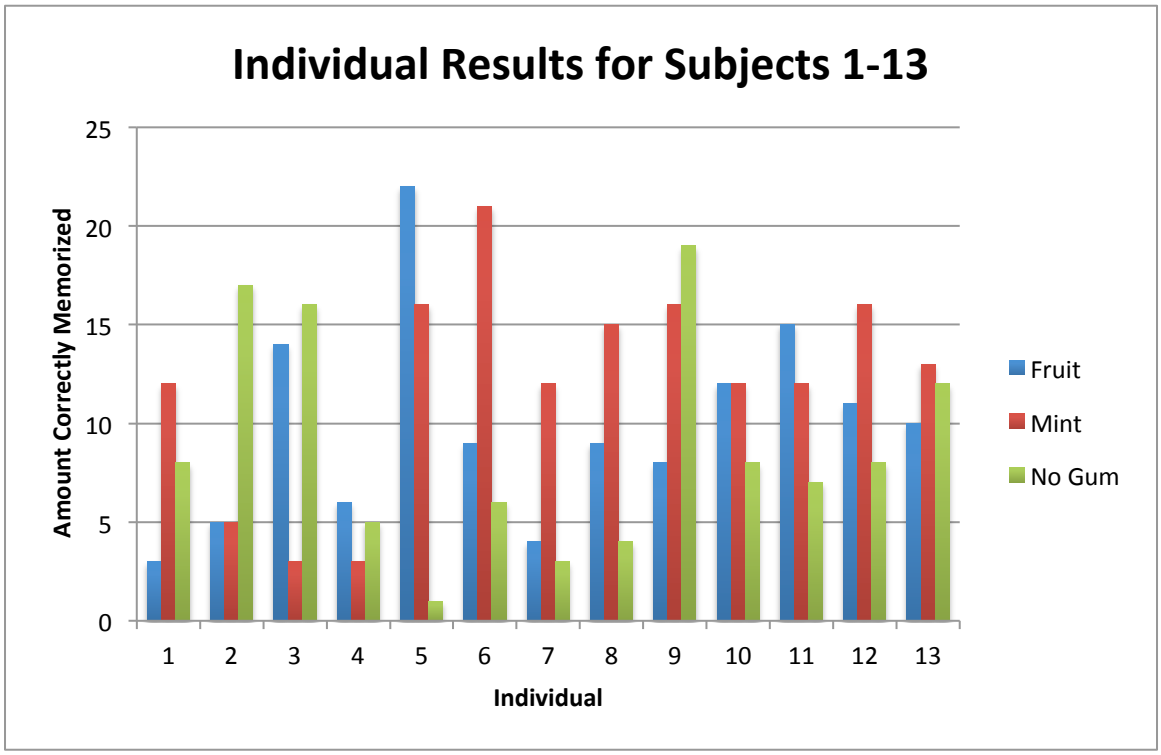
(Stop when they have finished writing, but do not give them more than one minute to write.)

Thank you for coming! Please write down your name on a piece of paper to be entered in the raffle.

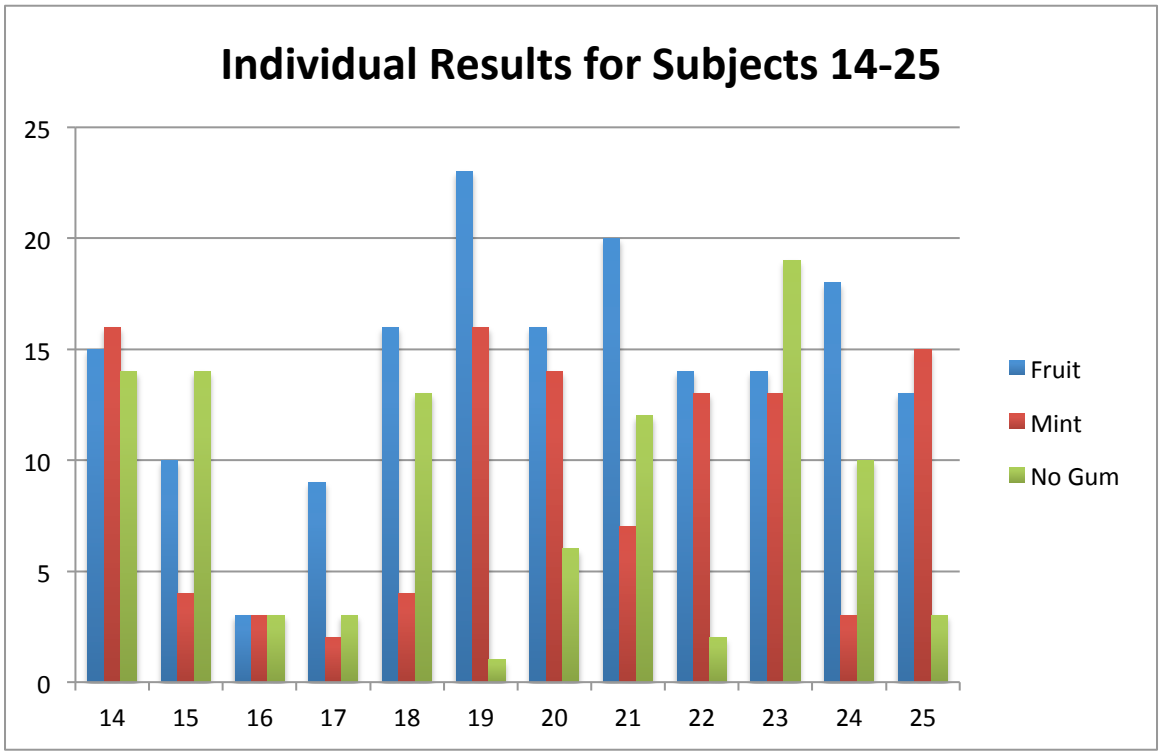
IV. ANALYSIS OF DATA



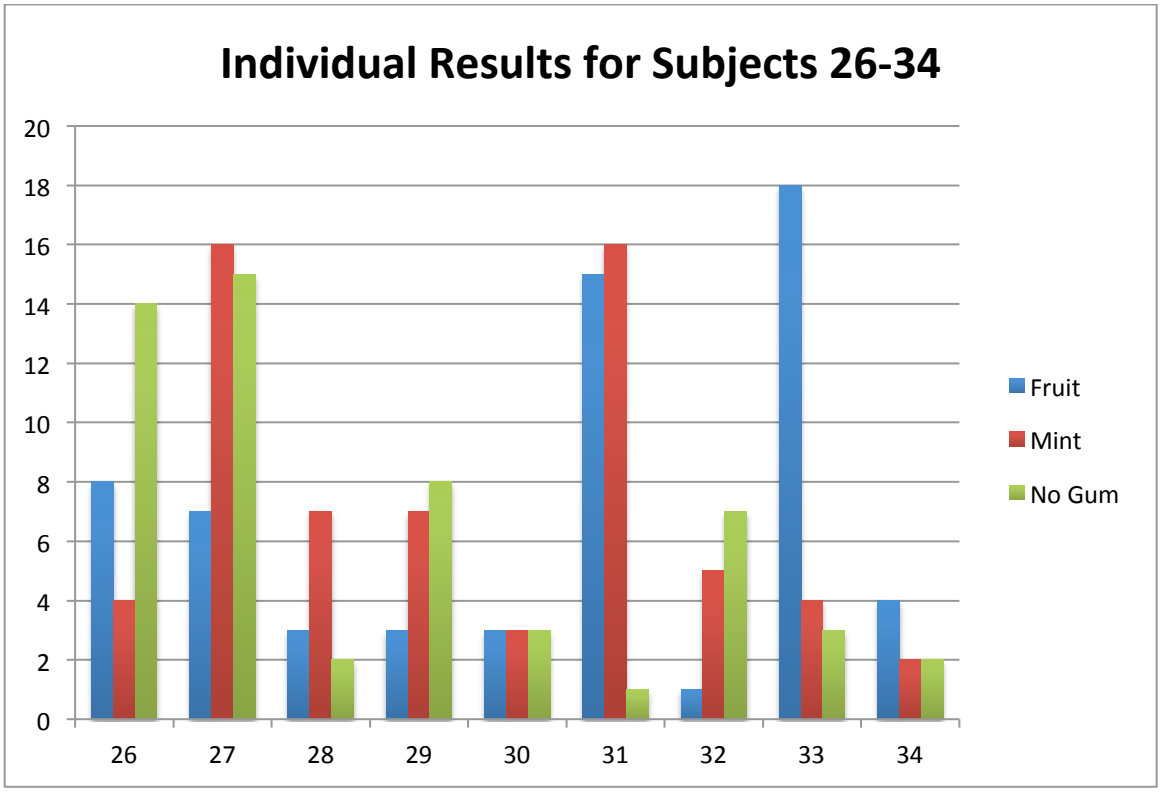
The fruit-flavored gum resulted in the highest average score. Both gums, however, yielded average scores higher than the one achieved without gum.



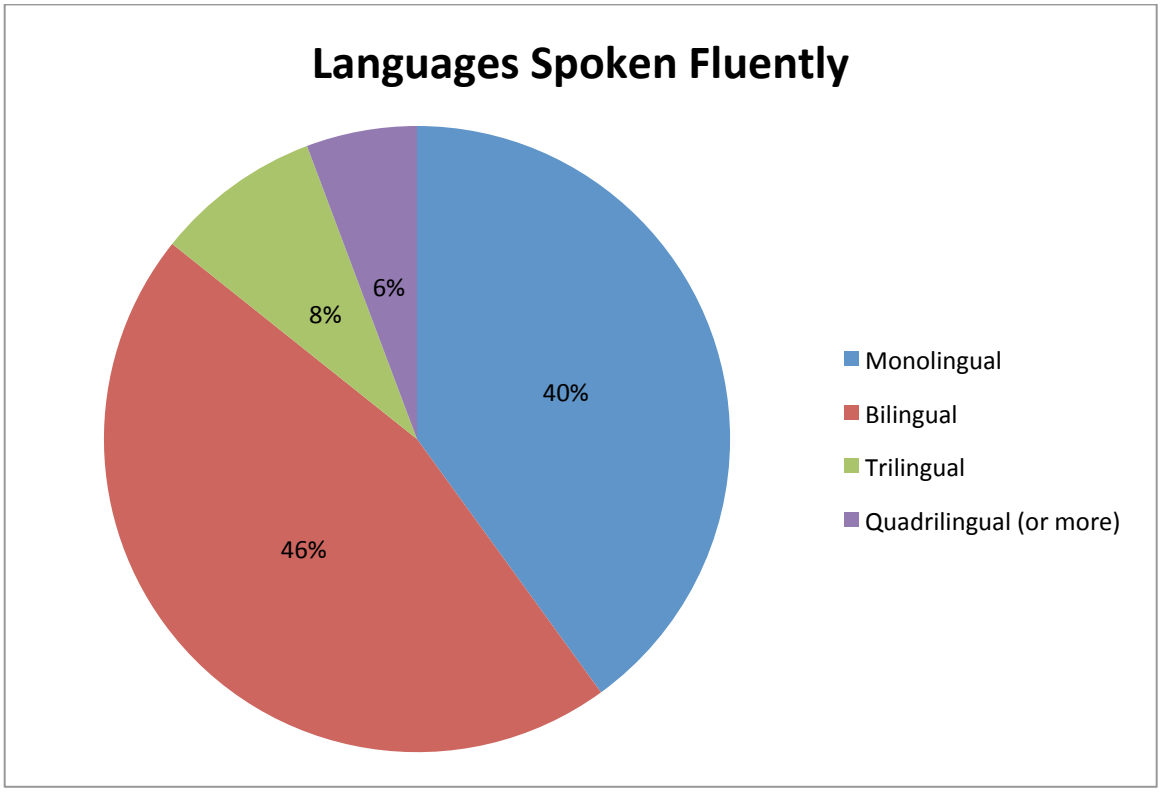
The results of the 34 subjects were distributed amongst three different graphs in order to preserve clarity. Subject 5 achieved the highest score on this first plot with the fruit gum. This sample subject, however, also featured the lowest score when not chewing either gum.



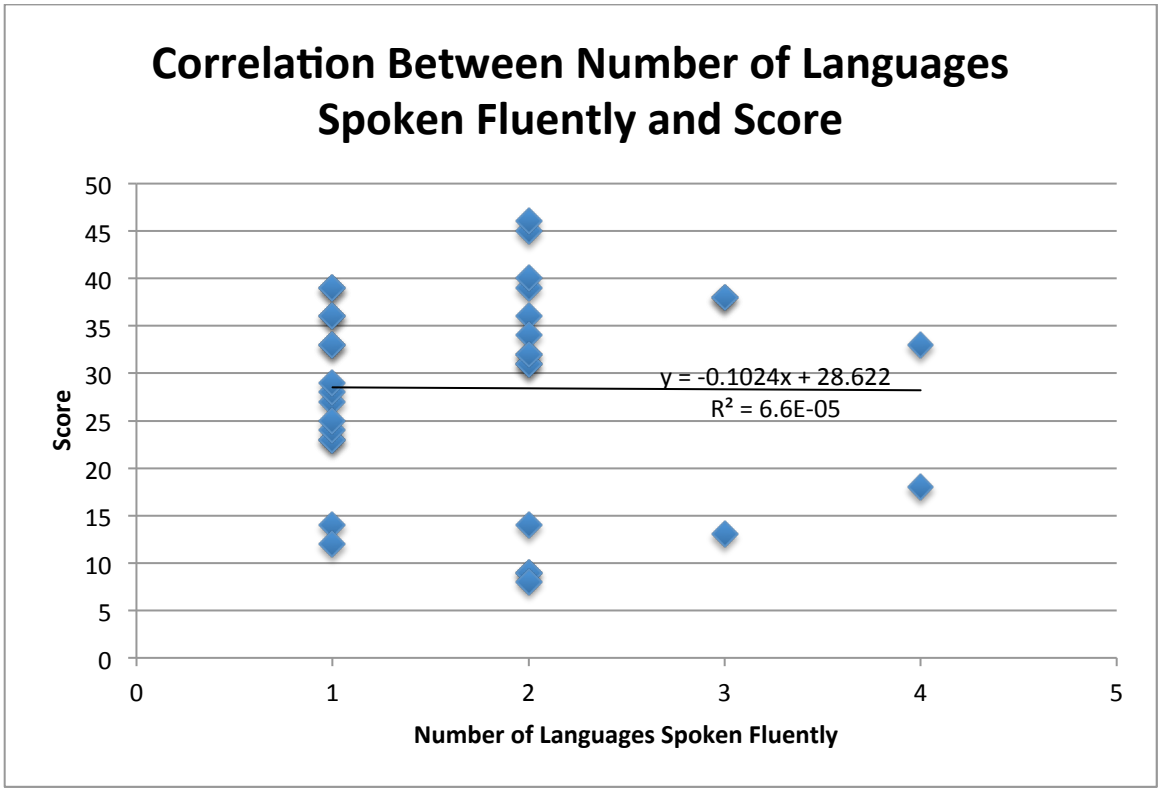
Subject 16 achieved the same score of 3 each time, but the lowest score was achieved by Subject 19, who earned a score of 1 when chewing no gum.



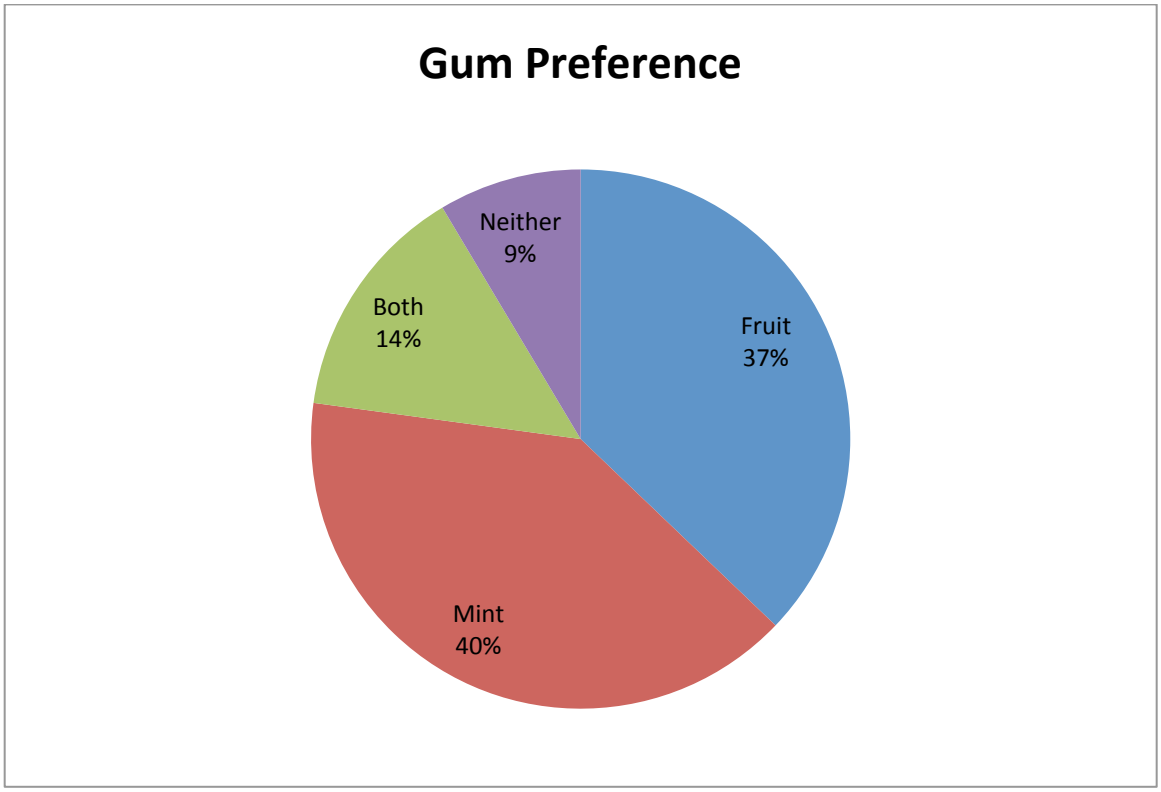
The highest score out of all of the subjects was a score of 30, achieved by subject 32 while chewing mint gum.



The majority of our subjects were bilingual. We expected that the number of languages a person speaks should help improve his or her memory. However, as shown below, there was no correlation between the amount of languages spoken and the score of each participant.



One hypothesis we had was that students who were fluent in multiple languages would be better at memorizing than those who spoke only one language. Hence, a bilingual student would more easily memorize the string than a monolingual student and a trilingual student would be even better at memorizing than a bilingual student. We expected multilingualism to be a confounding variable on our data. After plotting the number of languages each student spoke fluently against each student's score, however, we found that the correlation was very low at r=. 00387. Therefore, because only $1.5x10^{-5}$% of the change in score can be explained by the linear regression of score on number of languages spoken fluently, we conclude that there is no correlation between a student's score and the number of languages he or she speaks fluently.



Out of the choices of mint, fruit, both, or neither flavors of gum, 40% of our subjects claimed to prefer mint gum. After mint, 37% of the participants showed preference to fruit-flavored gum. We would expect to see a correlation between one's favorite flavor of chewing gum and how well one does while chewing that gum compared to while chewing the other gum or not chewing gum at all. If we could, we would hope to study this potential correlation in another experiment.

Tests of Significance

We conducted two one-sample tests of significance for the population mean difference between the test scores regarding the use of gum. Our first test compared the mean difference between the average scores with the use of gum (using both the fruit and mint gum data) and with no gum. Our second test compares the mean difference between the use of fruit gum and the use of mint gum. We decided to conduct a test of significance at the alpha level of .05. We decided to conduct two one-sample tests of significance for the sample mean difference in order to stay constant with our matched pairs design.

Test One

Our population is all high school students in the United States. Our parameter is the difference in scores when chewing and not chewing gum. Our procedure is a 1-sample test of significance for the population mean difference in the test scores of participants regarding each flavor of gum. Naturally, we used a t statistic to conduct our test of significance.

Conditions:

A Simple Random Sample: Though the data were meant to be collected as a systematic random sample, due to lack of response, we were forced to resort to a convenience sample, which may introduce bias. Therefore, we will proceed with caution.

Normality: Because our sample size is greater than 30, we can proceed.

Independence: The population of our school, which is roughly 1100 students, is greater than 10 times our sample size of 34 students.

Hypothesis:

$H_o: \mu = 0$

The null hypothesis states that there is no difference between scores achieved while chewing gum and while not chewing gum

$H_A: \mu > 0$

The alternative hypothesis is that chewing gum improves a student's score.

Data: $\bar{x} = 2.426470588$ $n = 34$

$S = 7.40099538$ $\mu_o = 0$

Formulas: $t^* = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$ $df = n - 1$

Calculations:

$$t^* = \frac{2.426470588 - 0}{\frac{7.40099538}{\sqrt{34}}} = 1.01720322 \qquad df = 34 - 1 = 33$$

$$P(t^* \geq 1.01720322) = 0.0323139949$$

Conclusion: As shown by our P-value of .0323139949, we can reject the null hypothesis that the average scores between the use of gum and the lack of gum are the same. Our P-value states that there is roughly a three percent chance that we would receive these sample scores if the null hypothesis were true. That means that students taking our test did perform better while they were chewing gum.

Test Two

Our population is all high school students in the United States. Our parameter is the mean difference of test scores when chewing fruit gum and chewing mint gum. Our procedure is a 1-sample test of significance for the population mean difference in the test scores of participants regarding each flavor of gum. Again, we used a t statistic to conduct our test of significance. In this case, each flavor means either the use of fruit gum or the use of mint gum.

Conditions:

A Simple Random Sample: Though the data were meant to be collected as a systematic random sample, due to lack of response, we were forced to resort to a convenience sample, which may introduce bias. Therefore, we will proceed with caution.

Normality: Because our sample size is greater than 30, we can proceed.

Independence: The population of our school, which is roughly 1100 students, is greater than 10 times our sample size of 34 students.

Hypothesis:

H_o: $\mu = 0$

The null hypothesis is that there is no difference between scores achieved while chewing fruit gum and while chewing mint gum.

$H_A: \mu > 0$

The alternative hypothesis is that chewing fruit gum will improve your score more than chewing mint gum will.

Data: $\bar{x} = .911763706 \qquad n = 34$

$S = 6.960353731 \qquad \mu_o = 0$

Formulas: $t^* = \frac{\bar{x} - \mu}{\frac{S}{\sqrt{n}}} \qquad df = n - 1$

Calculations:

$$t^* = \frac{.911763706 - 0}{\frac{6.960353731}{\sqrt{34}}} = .7638198209 \qquad df = 34 - 1 = 33$$

$$P(t^* \geq .7638198209) = .2252007799$$

Conclusion: As shown by our P-value of .2252007799, we have failed to reject the null hypothesis that there is no difference between scores achieved while chewing fruit gum and while chewing mint gum. Our P-value states that there is roughly a 22.5 percent chance that we would receive these sample scores if the null hypothesis were true. That means that the flavor of gum used during our tests of memorization did not matter and fruit gum did not improve a student's score more than mint gum did.

V. Conclusion:

Overall, we determined that the use of gum does help a student's memorization. The first test showed us that the difference in scores when a student chewed and did not chew gum was, in fact, significant at a p-value of .0323139949. In addition, we discovered that the flavor of gum does not affect a participant's test results because, as the second test proved, the differences in scores achieved while chewing fruit gum and mint gum were not statistically significant at a p-value of .2252007799. Although our data were biased, we believe that our results remained significant. If possible, we would repeat this experiment again using unbiased data. This experiment could be used to help high schools determine their school rules regarding chewing gum.

Vi. Reflection

Looking back at our experiment, we pinpointed one major issue: lack of response. Although we tried to entice our participants with food, we had a very low response rate. In a future experiment, we would try to combat this conflict by inviting even more people to participate in the test and by using similar measures of enticement. We could also send follow-up emails after the initial invitation reminding them of the location and the time of the experiment so that they will be more likely to remember to participate. In theory, our experiment design worked well. It is always difficult, however, to predict how high school students will act in regards to a statistical survey.

If we could repeat this experiment, our group would like to further the experimental study by measuring how well habitual gum chewers scored on the memorization test versus how well infrequent gum chewers performed. We hypothesized that habitual gum chewers would perform better on the test than non-habitual gum chewers, when they had their preferred flavor of gum. Also, we would like to explore if a certain flavor of gum affects habitual gum chewers or non-habitual gum chewers more in regards to their test scores.

VII. Appendix

Because there are so many columns, our data is presented across three pages with the "Number" column always appearing as the first column.

Number	Fruit	Mint	No Gum	Language	Race	Days/Week	Pieces/Day
1	3	12	8	1	W	7	1 or 2
2	5	5	17	1	W	2	1 or 2
3	14	3	16	1	W	4	1 or 2
4	6	3	5	1	W	5	1 or 2
5	22	16	1	2	A	3	1 or 2
6	9	21	6	2	A	7	1 or 2
7	4	12	3	1	W	1	1 or 2
8	9	15	4	2	W	7	1 or 2
9	8	16	19	4	A	2	1 or 2
10	12	12	8	2	B	3	3 or 4
11	15	12	7	3	A	3	1 or 2
12	11	16	8	1	W	5	1 or 2
13	10	13	12	1	W	1	1 or 2
14	15	16	14	2	A	0	NA
15	10	4	14	1	A	0	NA
16	3	3	3	2	A	2	1 or 2
17	9	2	3	2	A	0	1 or 2
18	16	4	13	1	W	5	1 or 2
19	23	16	1	2	W	3	1 or 2
20	16	14	6	1	W	4	1 or 2
21	20	7	12	1	W	1	1 or 2
22	14	13	2	1	W	6	1 or 2
23	14	13	19	2	A	1	1 or 2
24	18	3	10	2	W-H	0	5 or 6
25	13	15	3	2	B	3	1 or 2
26	8	4	14	1	W	6	1 or 2
27	7	16	15	3	A	0	NA
28	3	7	2	1	W	5	1 or 2
29	3	7	8	4	W	0	3 or 4
30	3	3	3	2	A	0	1 or 2
31	15	16	1	2	A	7	1 or 2
32	1	5	7	3	W	6	1 or 2
33	18	4	3	1	W	0	1 or 2
34	4	2	2	2	W-H	6	3 or 4
Average	10.61764706	9.705882353	7.911764706				
Sum	361	330	269				
St. Dev.	6.020242147	5.702362146	5.626601574				

Number	Gender	Age	Grade Level	Favorite	Total Correct
1	F	17	12	N	23
2	F	18	12	M	27
3	M	17	12	M	33
4	F	18	12	F	14
5	F	17	11	F	39
6	M	18	11	F	36
7	F	17	12	M	23
8	M	19	12	M	32
9	M	18	12	F	33
10	M	16	10	M	34
11	M	18	12	B	38
12	F	19	12	M	39
13	M	16	10	M	36
14	F	18	12	M	45
15	F	18	12	M	28
16	F	17	11	B	9
17	F	18	12	B	14
18	F	16	11	F	33
19	F	16	10	F	40
20	F	17	11	M	36
21	F	17	12	F	39
22	M	18	12	M	29
23	F	17	12	F	46
24	F	18	12	M	31
25	F	18	12	F	31
26	F	16	10	F	24
27	F	16	10	B	38
28	F	17	11	B	12
29	M	17	12	F	18
30	M	18	12	N	9
31	M	17	12	M	32
32	F	18	12	F	13
33	F	17	12	F	25
34	F	17	11	M	8

Number	Average Gum Score	Matched Pairs Gum-No Gum	Matched Pairs Fruit-Mint
1	7.5	-0.5	-9
2	5	-12	0
3	8.5	-7.5	11
4	4.5	-0.5	3
5	19	18	6
6	15	9	-12
7	8	5	-8
8	12	8	-6
9	12	-7	-8
10	12	4	0
11	13.5	6.5	3
12	13.5	5.5	-5
13	12.5	4.5	-3
14	15.5	1.5	-1
15	7	-7	6
16	3	0	0
17	5.5	2.5	7
18	10	-3	12
19	19.5	18.5	7
20	15	9	2
21	13.5	1.5	13
22	13.5	11.5	1
23	13.5	-5.5	1
24	10.5	0.5	15
25	14	11	-2
26	6	-8	4
27	12.5	-2.5	-9
28	5	3	-4
29	5	-3	-4
30	3	0	0
31	15.5	14.5	-1
32	3	-4	-4
33	11	8	14
34	3	1	2
St. Dev.	4.742124534	7.40099538	6.960353731
Average	10.22058824	2.426470588	0.911764706

Table 1. Each subject was assigned a number from 1 to 35. The charts represent the data collected on each subject through the experiment and the survey. We have broken the chart up into three segments in order to make the data easier to read.

For some of the categories, we used abbreviations. In the race column, A = Asian, B = Black or African-American, W = White and H = Hispanic (thus W-H means a White Hispanic). Under the gender column, M = male and F = female. Under the favorite column, F = fruit gum, M = mint gum, B = the subject liked both gums equally and N = the subject did not like either gum.

VIII. Bibliography

Bubble Gum. PhotoPostBlog. Web. 23 May 2012. <http://photopostsblog.com/wp-content/uploads/2008/11/top-chewing-gum-bubbles5.jpg