Visual and Auditory Learning

I. Introduction

There are many ways to learn something new. In fact, according to Vanderbilt University Center for Teaching, there are more than 70 different learning styles. Two common ones include auditory (learning through sound) and visual (learning through images or pictures).

A recent study in NCBI concluded that the most effective and preferred method of teaching was not one singular method, but actually a combination of multiple methods. However, after looking at each singular method, there does not seem to be one that is strongly preferred. Thus, our group decided to launch an investigative, experimental exploration into the question of whether there is, in fact, a significant difference between learning styles for the population of CCA students as a whole.

II. Statistical Question: Is there a significant difference in the number of words that the subject correctly remembers between a visual exposure and an auditory exposure?

Hypotheses	Definitions
H_o: $\mu_D = 0$	$\mu_D = \mu_A - \mu_V$
H_A: $\mu_D \neq 0$	μ_V: true mean number of words correctly memorized when the words are displayed on the projector screen for CCA students
	μ_A: true mean number of words correctly memorized when the words are played in an auditory recording for CCA students

III. Data Collection Procedure

We assigned each homeroom teacher a unique integer from 1 to 92. Then, using technology (online random generator), we randomly generated two integers from 1 to 92, with no skips or repeats. The two corresponding teachers were chosen for the sample. Our sample consisted of Mr. Ancona's and Mr. Quinn's homeroom classes. A cluster random sample was performed, as all students are assigned a homeroom class at Canyon Crest Academy, so each person has an equal chance of being selected to be a part of the sample. An advantage of using a cluster random sample is that this method maximizes time and efficiency; rather than going to multiple classrooms, we only had to visit two homerooms to obtain our data. In addition, each homeroom matches the ideal cluster (*"different within, but similar between"*). Every homeroom consists of students of different grade levels, different genders, different ethnicities, etc. Thus, each cluster is representative of the entire school population and our scope of inference is all students at CCA.

Using an online random word generator, we randomly generated a list of 6 three-lettered words, 12 four-lettered words, 12 five-lettered words, 12 six-lettered words, 12 seven-lettered words, and 6 eight-lettered words (with no skips or repeats), for a total of 60 words. Then, based on the order of the words with the same number of letters, we separated the words into two separate lists: Visual and Auditory. For instance, the first 3 three-lettered words went to Visual; the first 6 four-lettered words went to Visual; and so on. After we obtained our two separate lists of random words, we randomized the order of the words within each list using a random number generator. Based on the initial order of the words, we assigned each word a unique integer from 1 to 30. Then, using a random number generator, we generated the 30 distinct integers from 1

and 30, such that each integer from 1 to 30 came up once and in a randomized order. Finally, using the assignment of words to integers, we randomized the order of the words within each list.

After obtaining the two lists of random words, we created a video for the Visual list, in which each of the thirty words appeared in Arial font, black color, large font, against a white background. The words appeared on the screen one-at-a-time for three seconds each, in the randomized order (as explained above). The YouTube link of the video was then sent out to the selected teachers. The link to the video can be found here, and the list of the Visual words can be found here. The video for the auditory treatment wasn't shown to the studios; the photos are fillers for audio.

Similarly, we also created an audio recording for the Auditory list. Using an online platform, we inserted the random words and then downloaded the audio recording, which was then sent out to the selected teachers. The list of the Auditory words can be found here.

While conducting the experiment, we first passed out half sheets of paper for the students to write on. Then, we flipped a coin to determine the order of treatments, where heads indicated Visual first, and tails indicated Auditory first. We will only describe the procedure for *Visual, Auditory* below, since the procedures for *Visual, Auditory* and for *Auditory, Visual* are identical, with the exception of the order of the treatments. Thus, one can obtain the *Auditory, Visual* procedure by switching the words "video" and "recording".

Visual, Auditory Procedure: First, we explained to the subjects that their goal was to correctly memorize and write down as many words as they possibly can. When the video is playing on the screen, the subjects are not permitted to write anything down. When the video is finished, the subjects will have three minutes to write down as many words as they remember,

without looking at another student's paper or talking with one another. Spelling and the order of the words does not matter. After answering any potential questions, we played the video and then set a timer of three minutes. After the Visual treatment, we explained their goal (again), played the audio recording, and set a timer of three minutes. Once the experiment was entirely complete, we collected the papers and then scored them on our own time.

We had both groups perform both tests to minimize any variation of scores between different people in order to provide an accurate comparison of the two tests. A random order of treatments was performed, as the confounding effects of a difference in behavior due to taking one test before the other is lessened. We attempted to control as many extraneous variables by creating videos, so everyone has the same experimentation process for an accurate comparison between the two tests. Having 50 subjects partake in our experiment ensures that the results of our experiment is not due to chance variation from the random assignment of the order of treatments.

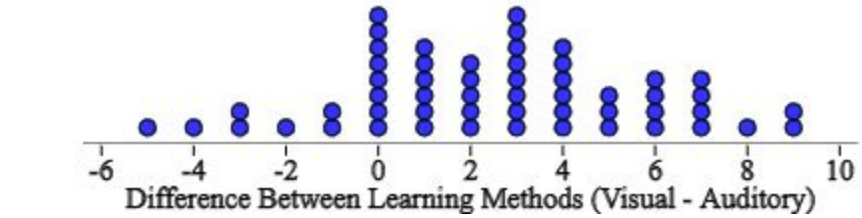
Data Display

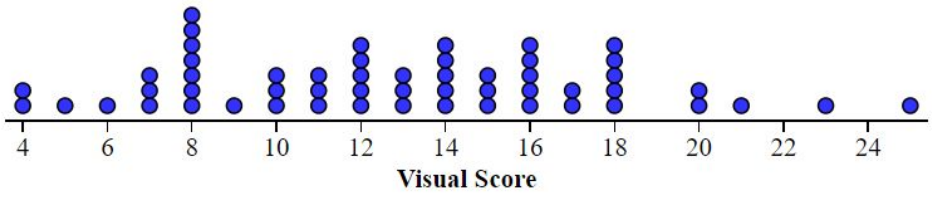
Raw Data							
Subject	Visual	Auditory	Visual - Auditory	**Subject**	Visual	Auditory	Visual - Auditory
1	11	10	1	**28**	12	5	7
2	8	5	3	**29**	17	14	3
3	7	7	0	**30**	23	19	4
4	4	4	0	**31**	6	7	-1
5	12	12	0	**32**	18	12	6
6	16	13	3	**33**	7	4	3
7	14	10	4	**34**	14	11	3
8	13	10	3	**35**	8	7	1
9	8	2	6	**36**	15	6	9
10	4	6	-2	**37**	18	13	5
11	20	11	9	**38**	16	21	-5
12	8	8	0	**39**	15	11	4
13	8	1	7	**40**	12	12	0
14	18	17	-1	**41**	12	5	7
15	14	10	4	**42**	10	10	0
16	14	8	6	**43**	25	17	8
17	10	5	5	**44**	13	13	0
18	11	12	-1	**45**	21	14	7
19	14	13	1	**46**	5	8	-3
20	12	12	0	**47**	7	6	1
21	11	10	1	**48**	9	7	2

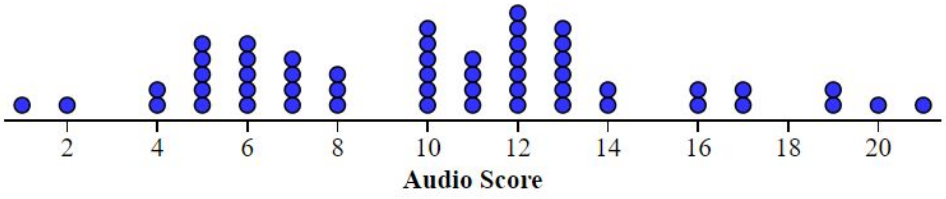
22	10	6	4	**49**	18	12	6
23	18	16	2	**50**	8	6	2
24	17	12	5	**51**	20	16	4
25	16	19	-3	**52**	16	13	3
26	16	20	-4	**53**	8	5	3
27	15	13	2	**54**	13	11	2

Summary Statistics for the Difference in Scores between Learning Methods		
$n = 54$	$\bar{x}_D = 2.556$	$s_D = 3.214$

Dotplot Distributions







IV. Data Analysis

The sample distribution for the amount of words memorized of the audio test is approximately normal, while the sample distribution for the amount of words memorized during the visual test is slightly skewed right. There appears to be no outliers in either distribution. The center is larger for the visual distribution, where the median is 13 words, compared to the median for the audio distribution at 10.5 words. The visual test data has a slightly greater spread, where the IQR is 8 words, while the IQR for the auditory test is 7 words.

The sample distribution of the difference in scores between learning methods follows an approximately normal distribution. Any outliers are either below Q1-1.5*IQR or above Q3+1.5*IQR. The IQR is 5 (Q3=5, Q1=0, IQR=Q3-Q1=5-0=5).The boundaries for outliers are (-6.5, 12.5). Because there are no values greater than 12.5 or less than -6.5, there are no outliers in the data set. The data is centered at a difference of 3 words (the median) between treatments and has a spread of 5 words (IQR).

Conditions for Test of Inference:

1. **Random**: A random sample of two homerooms was taken. In addition, for each subject, there was random assignment of treatments since the flip of a fair coin determined the order of the treatments: heads indicated visual first, then auditory; tails indicated auditory first, then visual.
2. **Normal**: We do not know if the population distribution of μ_D is Normal. However, since $n = 54 \geq 30$, by the Central Limit Theorem, we can assume normality in the sampling distribution of the difference in means.

3. **Independent / 10%**: When sampling without replacement, we check the 10% condition to assume independence. There are more than $10 \cdot 54 = 540$ students at Canyon Crest Academy, so the 10% condition is satisfied.

Calculations for Paired t-Test:

$\text{df} = n - 1 = 54 - 1 = 53$ $\quad t = 5.844$ $\quad P = 3.21 \cdot 10^{-7}$

$t = \frac{\bar{x} - 0}{\frac{s_D}{\sqrt{n}}}$ $\quad t = \frac{2.566 - 0}{\frac{3.214}{\sqrt{54}}}$ $\quad \alpha = 0.05$

V. Conclusion

Because $P = 3.21 \cdot 10^{-7} < 0.05 = \alpha$, we reject H_0. We have convincing statistical evidence that there is a significant difference between the mean number of words that Canyon Crest Academy students can correctly remember after a visual exposure and the mean number of words that Canyon Crest Academy students can correctly remember after an auditory exposure.

VI. Reflection

Overall, the project went well, and the experiment process was mostly successful. We were able to get multiple classes for our sample to increase our sample size, satisfying the Large Counts Condition as well as lowering variability. However, one difficulty that we encountered was making sure that everyone was using equal effort for both tests. The majority of the subjects tried their best to remember the words for both tests. However, during the experiment, there were a few people who became bored after the first test and gave up. This may have skewed the results as there would be a much larger difference in words remembered. Thus, the amount of effort put into each test could confound the results. While we did randomize the order of treatments, the experimental design was matched-pairs, so the difference between the two methods would not be truly reflective of the student's capability. For instance, if the student

received Visual first, then Auditory, and if (s)he stopped trying during Auditory, then the difference Visual - Auditory would be much greater than the difference had the subject put in equal effort. Additionally, the audio recordings of a few words were unclear and could be mistaken for other similar sounding words. Some subjects commented that the audio recording was difficult to hear. While our group did our best to accept all close answers while grading (such as homophones), it still may have potentially skewed our data. It becomes a confounding variable because we do not know whether the mean difference in words remembered was because of the different learning methods or because the subjects did not entirely understand what the recording had said. While using the audio recording may have confused a few people, having pre recorded videos for the audio and visual learning was actually an effective way to implement controls. By using the same videos for the audio and visual learning methods for each class we tested, we eliminate the chance of having any confounding variables that may have resulted from differences in the auditory and visual teaching between classes, making our results more valid and reliable. For future experiments, we would like to test combinations of teaching methods to find the most effective method and to see if there is a significant difference between one method and multiple. Another application could be to perform the test in a more realistic school environment by repeating the words once per day over the span of a week. This experiment lacks realism, as students are rarely tested on content immediately after they learn it. Performing it over the course of a week would take into account the spacing effect, where retention increases by distributing study time over a longer period of time.

VII. Works Cited

Kharb, Poonam, et al. “The Learning Styles and the Preferred Teaching-Learning Strategies of First Year Medical Students.” *Journal of Clinical and Diagnostic Research : JCDR*, JCDR Research and Publications (P) Limited, June 2013, www.ncbi.nlm.nih.gov/pmc/articles/PMC3708205/.

Mcdaniel, Rhett. “Learning Styles.” *Vanderbilt University*, Vanderbilt University, 6 Nov. 2019, cft.vanderbilt.edu/guides-sub-pages/learning-styles-preferences/.