P1: Test a Perceptual Phenomenon

In this project, we investigate a classical phenomenon from experimental psychology, called Stroop Effect. The Stroop effect is a demonstration of interference in the reaction time of a task. When the name of a color (e.g., "blue", "green", or "red") is printed in a color that is not denoted by the name (e.g., the word "red" printed in blue ink instead of red ink), naming the color of the word takes longer and is more prone to errors than when the color of the ink matches the name of the color. When the color of the ink is same as the printed name, it's a "congruent words" condition, while when the color of the ink differs from the printed name, it's an "incongruent words" condition.

Following questions are investigated as part of the project:

1. **What is our independent variable? What is our dependent variable?**
   Independent variable: List of congruent and incongruent ink colored words.
   Dependent variable: Time taken to name the ink color of words in each list.

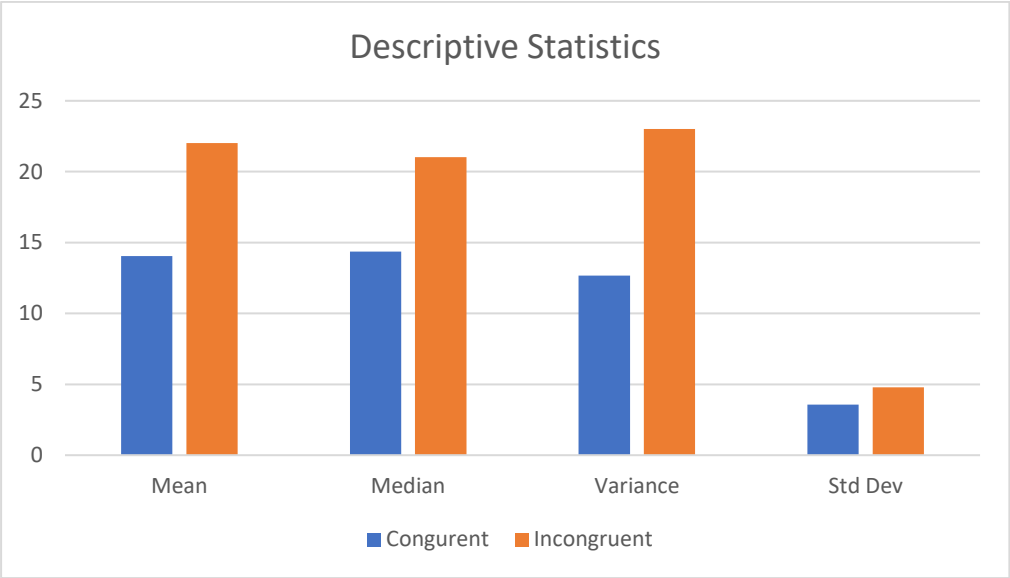
2. **What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform?**
   Following is the set of hypotheses I intend to use for this task:
   Null Hypothesis:
   $\mu_c - \mu_i = 0$, where μ_c is the amount of time that it takes to read list of congruent words, and μ_i is the amount of time to read the list of incongruent words. So, Null hypothesis says that there is no significant difference between both time measurements. Notice that zero does not mean that the time should be same. It only means that the difference does not have any significance.
   Alternative Hypothesis:
   $\mu_c \neq \mu_i$, i.e., there is a significant difference between both measurements and functioning of human brain may be responsible for it.

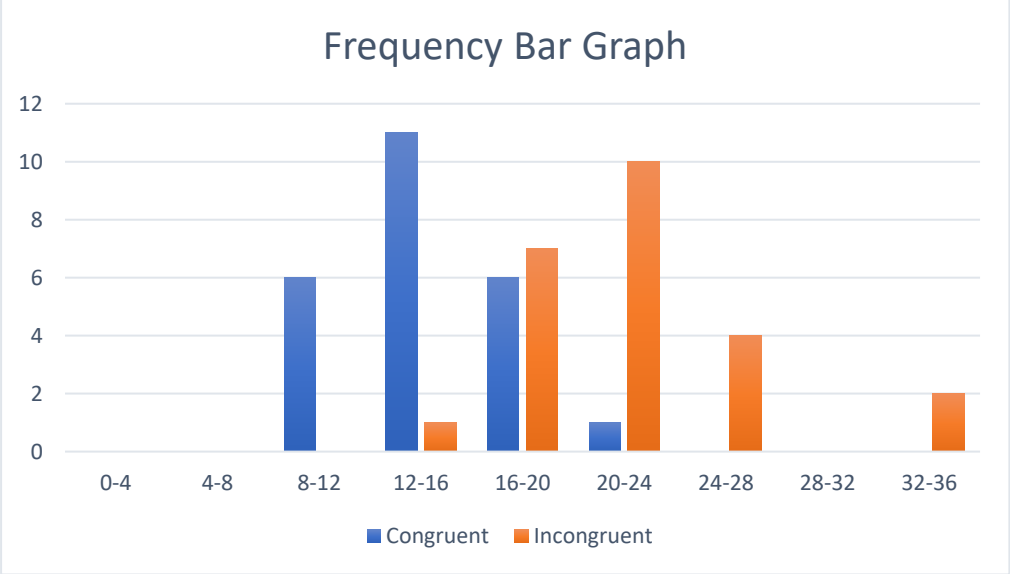
   The statistical test I would like to perform is dependent sample two-tailed t-test for following reasons:
   1. The population parameters are not known to us, so we cannot perform z-tests.
   2. Since, same subjects take the test twice, we perform dependent sample t-test.
   3. Since the alternative hypothesis considers the difference between two measurements, we perform a two-tailed t-test. We are interested in the difference between two samples and not which one is greater or lesser.

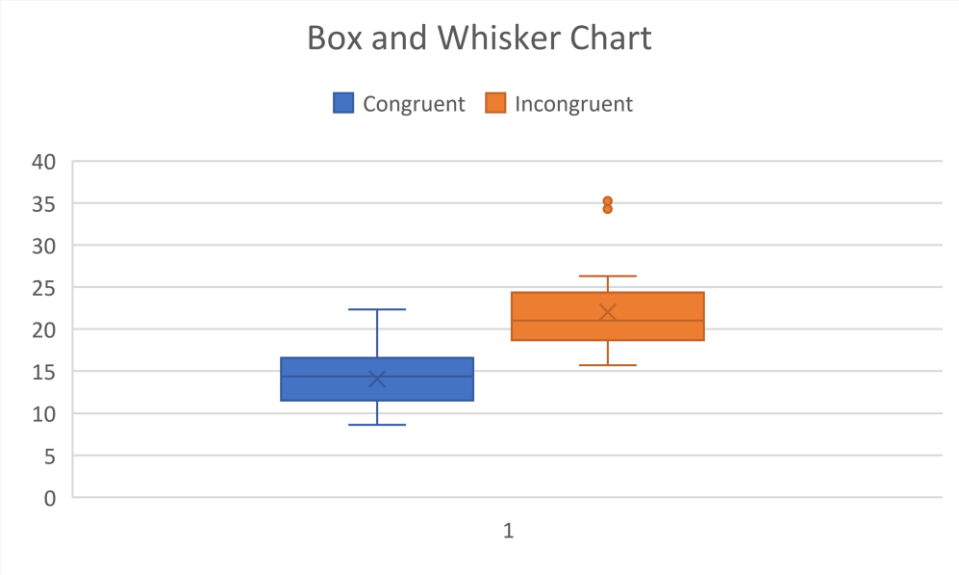
3. **Report some descriptive statistics regarding the dataset. Include at least one measure of central tendency and at least one measure of variability.**
   Following descriptive statistics are measured regarding the dataset given for both congruent and incongruent lists:

	Congruent Words	Incongruent Words
Mean	14.051	22.016
Median	14.357	21.018
Variance	12.669	23.012
Standard Deviation	3.559	4.797

4. **Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.**







Following observations are made based on the above visualizations:

a. Descriptive statistics like mean and variance of Incongruent words condition is more than that of congruent word condition.
b. Most of the data points for congruent words lie in the range of 8 – 20 secs, while for incongruent words, most of the data lies between 16-28 secs.
c. For the incongruent words, we also have two outliers with values at around 35 secs.
d. While 75% of the people read congruent words in less than 17 secs, similar number of people read incongruent words in 25 secs or less.
e. So, we say that people take significantly more time to read incongruent words in comparison to congruent words.

5. **Perform the statistical test and report your results. What is your confidence level and your critical statistic value? Do you reject the null hypothesis or fail to reject it? Come to a conclusion in terms of the experiment task. Did the results match up with your expectations?**

We perform the following steps to calculate our two-tailed t-test for dependent samples.

a. Calculate the point estimate $\mu_i - \mu_c$.
    a. $\mu_D = \mu_i - \mu_c = 22.016 - 14.051 = 7.965$

b. Calculate the Standard Deviation for each difference.
    a. Using spread-sheet, the standard deviation, $S_D = 4.865$

c. Calculate t-statistic as, $t = \frac{\mu_D}{S_D/\sqrt{n}}$.
    a. $t = \frac{7.965}{(\frac{4.865}{\sqrt{24}})}$ = 8.021 So, the t-statistic, t = 8.021.

d. For 95% confidence level and 23 degrees of freedom, we calculate the t-critical value from t-table. Since it's a two-tailed test, we look for value under 0.025, which comes out to be 2.069. So, *t-critical* = 2.069.

e. Now that we have our *t-statistic* and *t-critical*, we see that *t-statistic* is more than the *t-critical* and lies in the critical region, we will reject the null hypothesis. This means that participants took significantly more time for recognizing the ink-color of incongruent words than recognizing congruent words. Hence, we conclude that our brain is able to recognize congruent words faster than incongruent words. This meets my expectations.

6. What do you think is responsible for the effects observed? Can you think of an alternative or similar task that would result in a similar effect? Some research about the problem will be helpful for thinking about these two questions!

Following theories are provided to support the Stroop effect:

1. One reason for Stroop effect may be that there is a lag in brain's ability to recognize the color of the words, as it tends to read words faster than recognize colors. Therefore, where the task is to identify the color of the word than to read it, the word information arrives earlier and creates confusion.
2. Second reason may be the selective attention theory which suggests that brain needs more attention to recognize color than to understand word encoding.
3. Automaticity is another common theory which suggests that recognizing colors is not an automatic process, whereas brain stores character-set to word mappings due to our habitual reading, and majority of reading process is automated.
4. Another plausible theory of parallel distributed processing suggests that brain develops different pathways for analyzing different tasks. Some pathways, like reading, are stronger than others. So, when two pathways are simultaneously activated, like in Stroop effect, interference occurs, and response is delayed.

Another task that would result in an effect similar to Stroop effect is the "Number Strop effect" experiment. In this experiment setting, for the first case, there are displayed some boxes each of which contains a word printed numerous times. One should count the number of times a word appears in each box, and note the total time he/she takes. For the second case, the experiment is similar except that the word that is printed in each box should be the word representation of numbers. So "one" may be printed thrice, and in that case the person should report three.

References:

1. en.wikipedia.org/wiki/Stroop_effect. Wikipedia link of Stroop effect
2. imbs.uci.edu/~kjameson/ECST/MacLeod_TheStroopEffect.pdf. Colin M. MacLeod, Department of Psychology, University of Waterloo, Canada
3. https://faculty.washington.edu/chudler/java/readyn.html. An interactive demonstration of "Number Stroop effect"