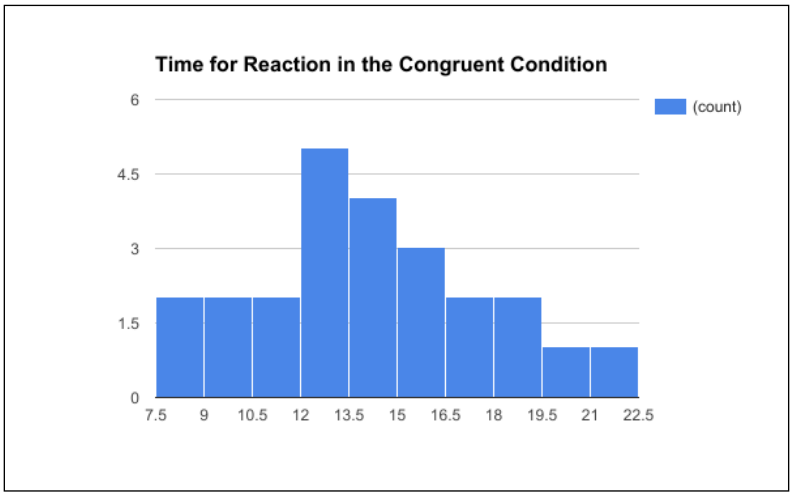
1. Introduction

The Stroop test exposes the same group of subjects to two different types of conditions and records the time for reaction in each case. The conditions include a congruent condition, where the color of the ink is the same as the text displayed and an incongruent one, where the color of the ink does not match the test displayed. The Stroop effect is a demonstration of interference in the reaction time of a task[1].

2. Graphical analysis of Data

The below measures of central tendency and variability were computed from analysis of the data provided in the project along with the individual distributions for reaction time from each condition.

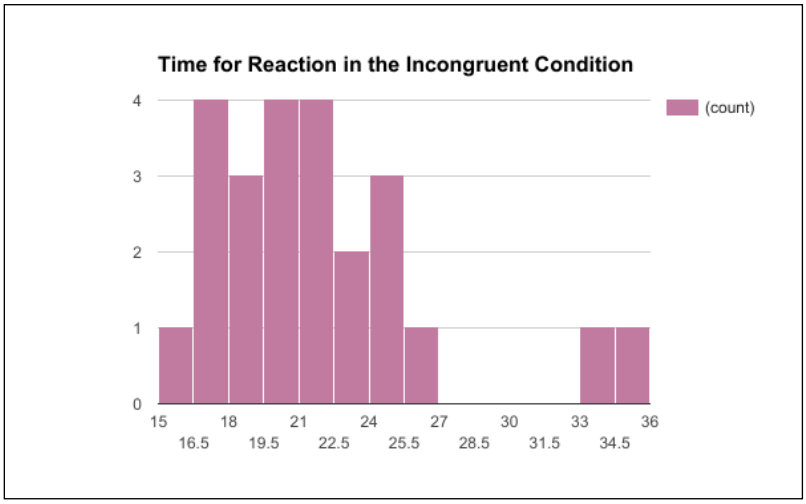
a. Time for Reaction in the congruent condition



Mean time for Reaction in the Congruent Condition, $\bar{x}_c$ = **14.05**

Sample standard deviation for time for Reaction in the Congruent Condition, $\bar{s}_c$ = **3.56**

b. Time for Reaction in the incongruent condition



[1] Source : https://en.wikipedia.org/wiki/Stroop_effect

Mean time for Reaction in the Incongruent condition, $\bar{x}_{IC}$ **= 22.01**

Sample standard deviation for time for Reaction in the Incongruent condition, $\bar{s}_{IC}$ **= 4.80**

It is interesting to note that the data set for the incongruent condition has two outliers. This can be computed as below

Q3 = 23.3485

IQR = 4.656

Therefore, Q3 + 1.5 * IQR = 30.3325

This means that the values 34.288 and 35.255 can be considered outliers.

The mean time for reaction in the incongruent condition is significantly more than that in the congruent condition.

3. Statistical Test

I will conduct a t-test due to the following reasons:

- The population parameters of population mean and standard deviation are not known.
- This is a comparison of means between a pair of dependent samples.
- The sample size is small (n <30).

a. Type

The type of test is a Dependent t test for paired samples, because the Stroop tests is a within subject analysis wherein the same group of subjects are made to take two different tests (congruent and incongruent). This is an example of a repeated measures design.

b. Variables

The Stroop test records the time taken by a subject to report the color of the ink in two different test conditions. Based on this, below are the types of variables in the test.

Independent Variable: Type of condition the subject is exposed to.

Dependent Variable: The time taken by the subject (reaction time) to report the color of the ink.

c. Hypotheses

Given the independent and dependent variables, the null and alternate hypotheses can be constructed as follows:

Null Hypothesis, H_o: The mean reaction time does not change between the congruent and incongruent conditions. The difference in mean reaction times is zero.

i.e. $\mu_C = \mu_{IC;} \rightarrow \mu_C - \mu_{IC} = 0$

Alternate Hypothesis, H_A: The mean reaction times for the congruent and incongruent conditions are different from each other.

i.e. $\mu_C > \mu_{IC;} \rightarrow \mu_C - \mu_{IC} > 0$

$\mu_C < \mu_{IC;} \rightarrow \mu_C - \mu_{IC} < 0$

$\mu_C \neq \mu_{IC}$

μ_C is the population mean reaction time in the congruent condition.

μ_{IC} is the population mean reaction time in the incongruent condition.

Here, extending the concept to the population not just the sample for the hypotheses.

d. Sample Size

The sample size here is **n = 24**

e. Point Estimate

The point estimate for the difference in time taken to report color of ink for the two tests is

$\mu_C - \mu_{IC} = -7.96$

f. Sample Standard deviation

The sample standard deviation of the differences in time is

S = 4.86

g. t-Statistic

Sample Size, **n =24**

Mean time for congruent test, $\bar{x}_C$ **= 14.05**

Mean time for incongruent test, $\bar{x}_{IC}$ **= 22.01**

Pont Estimate, $\mu_C - \mu_{IC} = -7.96$

Sample Standard Deviation, **S = 4.86**

The t- statistic can now be calculated using the formula

$$t = \frac{\mu C - \mu IC}{S/\sqrt{n}}$$

= -8.03

h. Type of t-test

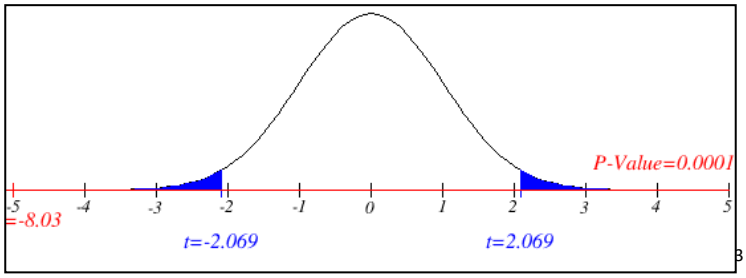
Since there is no explicit mention of the expected difference in time for the two tests in the question, I am therefore performing a two tailed test with an α level of **0.05.**

i. t-Critical Values

For an α level of 0.05 and 23 degrees of freedom, the t critical values are ±**2.069**

j. Decision

- Since the t- statistic lies within the t-critical region as shown below, I *reject the null hypothesis.*
- This means that the difference in times is not a chance event. With a p value of 0.0001 (<0.05), it is *statistically significant*.
- The results are also *meaningful* because they are indicative of an individual's cognitive control and processing speed.[2]



[3]

k. Measure of Effect Size

As a measure of effect size, Cohen's d is computed as below

Cohen's d = $\frac{\mu C - \mu IC}{S}$

= - 1.637

This means that the mean time taken to complete a congruent test is 1.637 standard deviations to the left of the mean time taken to complete an incongruent test.

l. Measure of Correlation

r^2 is computed as a measure of correlation between the two tests as below

$$r^2 = \frac{t^2}{t^2 + df}$$

= **.737**

This means that, among the differences in the time taken to complete a congruent test and incongruent test; ~74 % are because of the type of test.

m. Margin of Error

The margin of error for a 95% confidence interval for a two tailed test with level of 0.05 and 23 degrees of freedom is calculated as below

[2] Source: https://imotions.com/blog/the-stroop-effect/
[3] Source: http://www.imathas.com/stattools/norm.html

Margin = t $* \frac{S}{\sqrt{n}}$

= 2.05

n. Confidence Interval

The lower and upper limits of the confidence interval are as below

Lower Limit = Mean of differences – margin of error

= **-10.01**

Upper Limit = Mean of differences + margin of error

= **- 5.91**

Confidence Interval = **[-10.01, -5.91].** *This means that subjects will take approximately 10 to 6 units of time less to do the congruent test than to do the incongruent test.*

4. Conclusion

I conclude that the reaction time in the incongruent condition is much more than that in the congruent condition because the former requires more cognitive effort. This is intuitive, as the brain tends to read more easily than recognize and register the color of an object. This also matches my expectations as I myself took longer to react on the incongruent condition.

5. Additional Comments

Based on my research,[4] there are multiple theories that support the Stroop effect. Two popular theories are Speed of Processing Theory which says that the brain reads faster due to habit than it interprets color; and the Selective Attention Theory which says that the brain requires more attention to name a color than to read.

There is also a variation of the Stroop test called the Numerical Stroop Effect[5] which has similar effects as the above experiments. This experiment shows that presenting a subject with incongruent numerical data (numbers of different sizes) affects the cognitive processing and leads to longer comprehension time.

Numerical and graphical analysis for this project is available at:

https://docs.google.com/spreadsheets/d/1v0P9n_xfqKK5WhwXNjIwKxCtP6mXhgXutWst9NMQlYo/edit?usp=sharing

[4] Source: https://faculty.washington.edu/chudler/words.html
[5] Source: https://imotions.com/blog/the-stroop-effect/