Statistics Project Report

P1: Test a Perceptual Phenomenon

1 Stroop Effect

In psychology, 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. The effect is named after John Ridley Stroop, who first published the effect in English in 1935 [1].

One can take the test following the link mentioned in [5]. This has a Java-based applet for performing the Stroop task.

2 Variables

- What is our independent variable?

Interference and no interference. The variable that is being changed to influence the outcome is the color of the words. Hence color of the words is the independent variable.

In this experiment we are taking control of the word color congruency condition and observe the time taken for each individual to name the ink color.

- What is our dependent variable?

Effect, i.e. time taken (seconds) per 100 words recognitions

3 Hypothesis

- What is an appropriate set of hypotheses for this task?

The cognitive recognition abilities depend on how the data is presented to the subject. The experiment is conducted to recognize that if the data is presented in an ‘incongruent’ manner, then it takes more time to recognize than if it is presented in a ‘congruent’ manner.

μ_c = Mean of the population tested with the congruent test

μ_i = Mean of the population tested with the incongruent test

H_0: $\mu_i - \mu_c = 0$ (There is no difference in the effect of congruent vs. incongruent tests)

H_a: $\mu_i - \mu_c > 0$ (Incongruent test results into more time than the congruent tests)

- What kind of statistical test can be performed? Justify the choices.

Dependent t-test for paired samples.

Here the population parameters are unknown. Hence a t-test is appropriate. The tests are conducted on the subjects of the same sample. Thus the two groups are related and hence a dependent t-test is the right choice.

Our hypothesis is directional. From the outcome of the tests on the sample, it appears that the time taken by the subjects for the incongruent test is more than that of the congruent test. Hence our alternative hypothesis is that the mean population time for the incongruent test is more than that of the congruent test. A one-tailed test on the provided samples will verify our alternative hypothesis.

For the purpose of the project submission, [2], [3], [4], [7] were also consulted for some elaboration on hypotheses/t-tests/distribution, besides the course material.

4 Working with the Stroop Effect experimental data

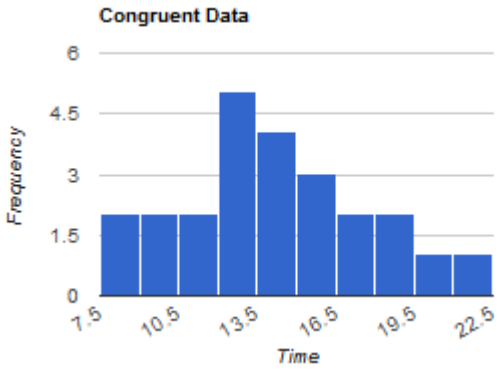
A set of data (experimental results from 24 participants) is provided [6]. Each row of the dataset contains the performance for one participant, with the first number as his/her result on the congruent task and the second number as his/her performance on the incongruent task.

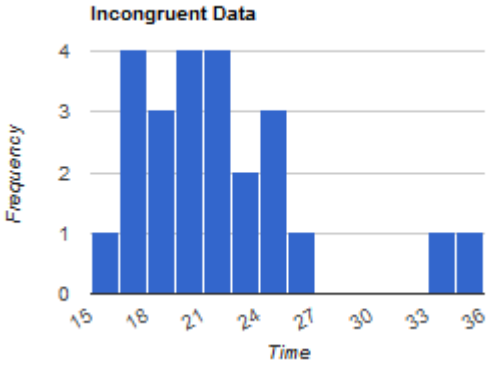
- Determine one measure of central tendency and at least one measure of variability.

Congruent: Sample mean (X_C) = 14.05, Variance SS_C = 17.07, Standard Deviation SD_C = 3.56

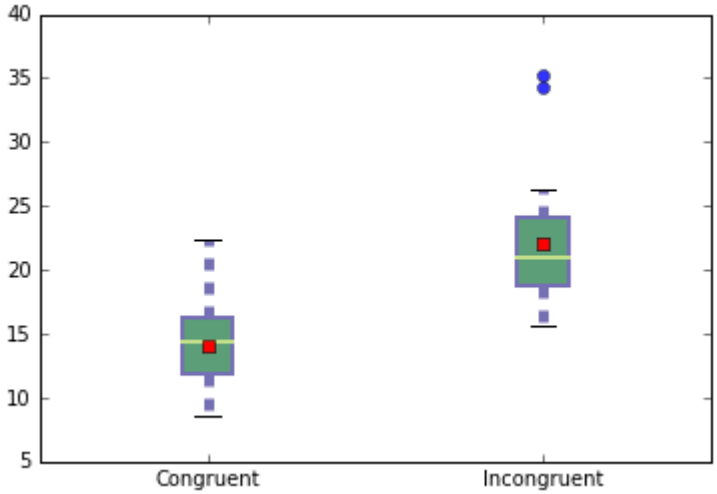
Incongruent: Sample mean (X_i) = 22.01, Variance SS_i = 23.00, Standard Deviation SD_i = 4.8

- Data visualization and observation

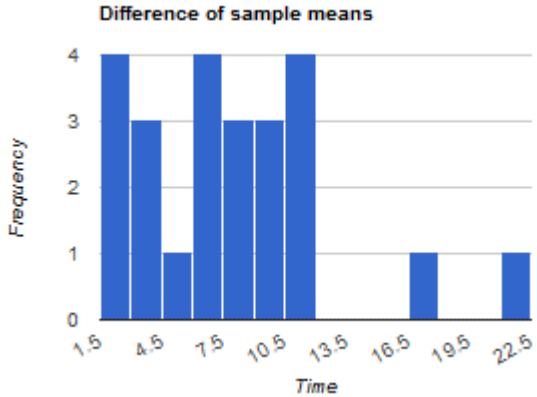




The same data can be visualized in box plot with median, mean and fliers information.



The distribution of the difference of the individual samples is shown below:



We can see that the sample mean for the congruent data is smaller than that of the incongruent data. The distribution for the congruent data approaches a normal distribution, whereas the distribution of the incongruent data is somewhat positively skewed.

The fourth plot shows the histogram for the difference of the individual sample data. It shows that the incongruent test time is always more than the congruent test time for this sample. The plot resembles more like the right half of a normal distribution. (It would be interesting to be able to plot the data for a larger sample!)

5 Statistical test

To restate the hypothesis:

H_0: $\mu_i - \mu_c = 0$

H_a: $\mu_i - \mu_c > 0$

About the sample means:

$X_c = 14.05$

$X_i = 22.01$

About the difference of the sample means:

Standard deviation of the difference of the sample means (σ) = 4.865
Standard error = $\sigma/\sqrt{24} = 0.993$
Degree of freedom (DF) = 23

Hence,

$t_{statistic}$ = (observed mean difference – expected mean difference) / Standard error

= ((22.01 – 14.05) – 0)/0.993

= 8.02

At significance level $\alpha = 0.01$, and DF = 23, we calculate $t_{critical} = 2.5$ (one-tailed test)

Since $t_{statistic}$ is more than $t_{critical}$, we conclude that the probability is too low to find this particular incongruent sample in any set of congruent samples. Statistically the difference of these two means is extremely significant. Hence we reject the null hypothesis and accept the alternative hypothesis. This observation matches with the expectation.

6 Possible causes and alternatives

- What do you think is responsible for the effects observed?

Researchers reasoned this effect by the following two theories [4]:

1. The read completes faster than the colors are perceived (Speed of processing theory)
2. The interference occurs since interpreting the color requires more attention than reading words (Selective attention theory)

In simpler terms the reason for the Stroop effect can be attributed to how our brain works. Processing of color and text happen at different parts of the brain. If there is a congruence between the activities then it results into shorter response time. The response time is more for activities that are not congruent.

- Can you think of an alternative or similar task that would result in a similar effect?

The effect indicates that the reader does not only read the words. There are some other traits like emotion, meaning, relevance, etc. involved in the process. E.g. the following variations of the test have been demonstrated by the researchers to result into the same effect [4]:

1. Emotion: Have the reader read the words like 'Happy', 'Pathetic', 'Fabulous', 'Bright'
2. Meaning: Have the reader read non-color words (besides the color words), like – house, zebra, mountain, paddy.
3. Relevance: Mix color words with meaningless words like 'kzdx', hjgt', '8j9j'

7 References:

1. https://en.wikipedia.org/wiki/Stroop_effect
2. www.sjsu.edu/faculty/gerstman/biostat-text/**Gerstman_PP09.ppt**
3. http://blog.minitab.com/blog/adventures-in-statistics/understanding-t-tests-t-values-and-t-distributions
4. https://statistics.laerd.com/statistical-guides/dependent-t-test-statistical-guide.php
5. https://faculty.washington.edu/chudler/words.html#seffect
6. https://drive.google.com/file/d/0B9Yf01UaIbUgQXpYb2NhZ29yX1U/view
7. http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/hypothesis-tests/basics/what-is-a-hypothesis-test/
8. http://matplotlib.org/api/pyplot_api.html?highlight=boxplot#matplotlib.pyplot.boxplot

Revision History

Revision	***Date***	***Description***	
1.0	12/4/2016	Initial project submission	AD
1.1	12/7/2016	Incorporated review feedback from v1.0	AD
1.2	12/10/2016	Incorporated review feedback from v1.1	AD