STATISTICAL ANALYSIS OF THE STROOP EFFECT

What is the Stroop effect?

The Stroop effect is a part of cognitive psychology. When the people do Stroop task, the Stroop effect can be seen. The Stroop effect is related to selective attention, which is the ability to respond to certain environmental stimuli while ignoring others.

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participant's task is to say out loud the color of the ink in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition.

In the congruent words condition, the words being displayed are color words whose names match the colors in which they are printed: for example RED, BLUE.

In the incongruent words condition, the words displayed are color words whose names do not match the colors in which they are printed: for example PURPLE, ORANGE. In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

Based on the above information,

Independent Variable:

The type of test - incongruent words test or congruent words test

Dependent Variable:

The time taken to name the ink colors in the tests.

Hypothesis:

We establish the **Null hypothesis** as 'The time taken to name the ink colors in a congruent test **is equal** to the time taken to name the ink colors in an incongruent test'.

We establish the **Alternate hypothesis** as 'The time taken to name the ink colors in a congruent test **is not equal** to the time taken to name the ink colors in an incongruent test'.

Let t_1 and t_2 denote the time taken to name the ink colors for congruent test and incongruent test respectively. Also, let μ_{t_1} and μ_{t_2} denote the population means of the times for congruent test and incongruent test. Then, symbolically, we represent Null and Alternate Hypothesis as –

$$\mathbf{H_0:}$$

$$\boldsymbol{\mu_{t_1} = \mu_{t_2}}$$

$$\mathbf{H_A:}$$

$$\boldsymbol{\mu_{t_1} \neq \mu_{t_2}.}$$

Now, we will be using the below dataset:

Congruent	Incongruent
12.079	19.278
16.791	18.741
9.564	21.214
8.63	15.687
14.669	22.803
12.238	20.878
14.692	24.572
8.987	17.394
9.401	20.762
14.48	26.282
22.328	24.524
15.298	18.644
15.073	17.51
16.929	20.33
18.2	35.255
12.13	22.158
18.495	25.139
10.639	20.429
11.344	17.425
12.369	34.288
12.944	23.894
14.233	17.96
19.71	22.058
16.004	21.157

It contains results from 24 participants in the Stroop task. Each row of the dataset contains the performance for one participant, with the first number as the time taken to name the colors on the congruent task (t_1) and the second number as the time taken to name the colors on the incongruent task (t_2).

A question now crops up in our mind:

Which kind of statistical test we should do to verify the Stroop effect on our sample dataset?

To answer this question, let us list out what data we have.

1. We have a sample dataset with 2 independent variables which are the 2 types of tests – Congruent words test and Incongruent words test – and a dependent variable which is the time taken.
2. We can calculate sample descriptive statistics from this data; specifically; means and standard deviations but cannot calculate population parameters.
3. The same participant took both the tests and each record in the sample dataset corresponds to their scores in each test.
4. In the alternate hypothesis, we don't know for sure if t_1 will be less than t_2 or t_1 will be greater than t_2.

Based on the above data, the most apt type of statistical test would be
A Within-subject design Dependent samples Two tailed t-test for Hypothesis testing.

Since it's a dependent samples t-test, we calculated the modulus of differences between t_1 and t_2 for each record. Let us denote it by D. Then, we'll calculate it's mean ($\bar{\mathbf{D}}$), it's sample standard deviation (**S**) and it's standard error of the mean (**SEM**).

Our Null and Alternative Hypothesis can now be rewritten as:

$$\mathbf{H_0:}$$

$$\boldsymbol{\mu_D = 0}$$

$$\mathbf{H_A:}$$

$$\boldsymbol{\mu_D \neq 0}$$

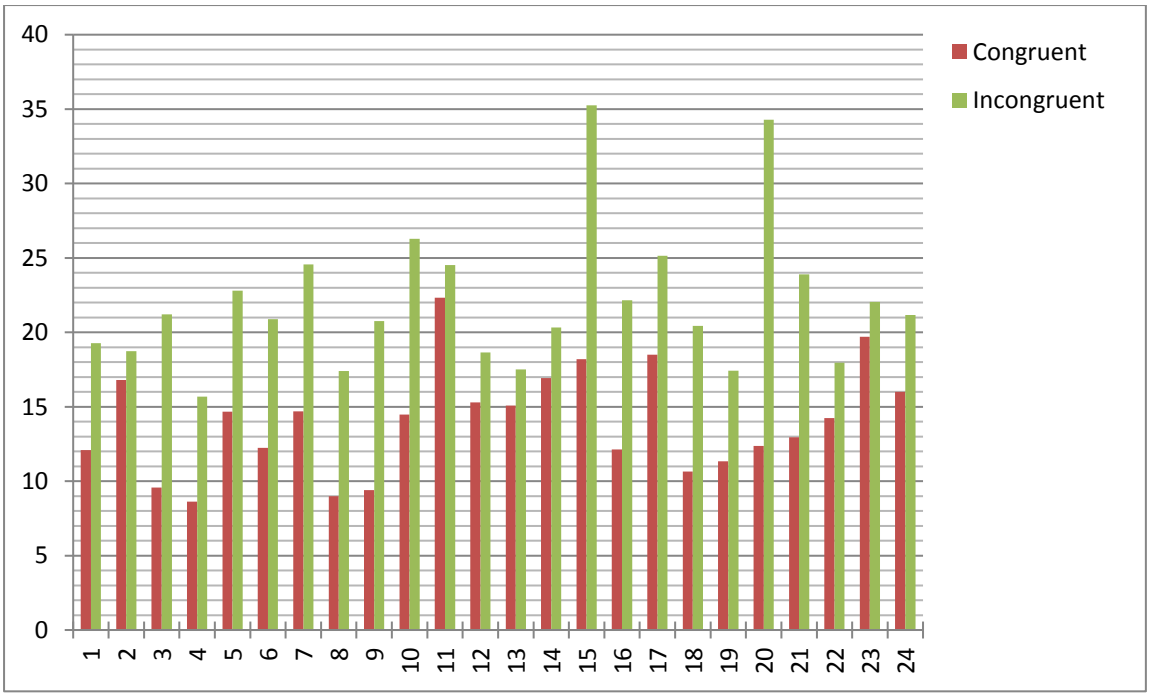
Where $\boldsymbol{\mu_D = \mu_{t_1} - \mu_{t_2}}$

Using Google spreadsheets, we found the **Descriptive Statistics** as:

Congruent	Incongruent	D	Sample Descriptive statistics
14.051125	22.01591667	7.964791667	**Means**
		4.86482691	**S**
		0.9930286348	**SEM**

[Note: We used Bessel's correction in calculating **S].**

Let us now visualize the data in the form of columns with each participant number on the x-axis and time in seconds on the y-axis.



Congruent vs Incongruent

Looking at the above chart, we observe that the time taken to name the ink color in the congruent test is lower than that in an incongruent test. This is in support of the Stroop effect.

Let us proceed with our Hypothesis testing on our dataset to confirm the Stroop effect.

$$t = \frac{\mu_c - \mu_i}{SEM}$$

where μ_c is the mean of time in seconds for congruent test and μ_i is mean of time in seconds for incongruent test. Therefore,

$$t = \frac{14.051 - 22.016}{0.99}$$

$$t = -8.021$$

We have 24 records in our dataset, therefore

$$n = 24$$

And therefore,

$$df = n - 1 = 23$$

Where df is degrees of freedom.

Assuming 95% Confidence Interval for Two Tailed t-test, and using the values of t and df, we can find the critical value of t

$$t_{crit} = 2.069$$

The two-tailed P value for our t statistic is less than 0.0001 and by conventional criteria; this difference is considered to be extremely statistically significant.

Therefore, we can safely **reject the Null hypothesis.**

Results of our t test in APA style

t (23) = -8.021, p < .05, two tailed

$p \ll 0.0001$

CONCLUSION:

The time taken to name the ink color in a congruent test is not equal to the time taken to name the ink color in an incongruent test.

Furthermore, since the value of our t statistic is negative, the time taken to name the ink color in a congruent test is much less than the time taken to name the ink color in an incongruent test.

Thus, we have verified the Stroop effect.

Hypothesis for the reason of the effect:

Humans have placed more importance on writing and reading text as compared to naming colors. Therefore, generally speaking, the parts of the human's brain related to reading skills is much more advanced than the parts of the brain related to color perception and naming them leading to a difference in turnaround time for both.

Due to this difference; in a Stroop task where text and color, both are involved incongruently, reading skill interfere with color perception and hence we take more time in naming the color of the ink.

References:

The Comprehensive LATEX Symbol List: http://tug.ctan.org/info/symbols/comprehensive/symbols-a4.pdf

LaTeX in MS word: https://superuser.com/questions/340650/type-math-formulas-in-microsoft-word-the-latex-way

For calculating critical value of t statistic: http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf

For calculating p value: http://www.graphpad.com/quickcalcs/pValue2/