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Udacity Data Analyst Nanodegree – Test a Perceptual Phenomenon Project

The Stroop Effect

Background Information

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.

For this project, we are given a dataset, which contains results from 24 participants (given below). Each row of the dataset contains the performance for one participant; with the first number their results on the congruent task and the second number their performance on the incongruent task. We are asked to answer the given questions, using standard statistical analysis.

Congruent Incongruent

12.079	19.278
16.791	18.741
9.564	21.214
8.630	15.687
14.669	22.803
12.238	20.878
14.692	24.572
8.987	17.394
9.401	20.762

Dataset continued:

<u>Congruent</u>	<u>Incongruent</u>
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14.480	26.282
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22.328	24.524
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15.298	18.644
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15.073	17.510
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16.929	20.330
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18.200	35.255
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12.130	22.158
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18.495	25.139
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10.639	20.429
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11.344	17.425
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12.369	34.288
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12.944	23.894
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14.233	17.960
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19.710	22.058
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16.004	21.157
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Questions for Investigation

1. What is our independent variable? What is our dependent variable?

The independent variable is whether the words displayed are in the congruent words condition or the incongruent words condition (see definitions above).

The dependent variable is the time it takes to name the ink colors in equally-sized lists.

2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

The hypothesis being tested is whether the measurement times will be of a statistically significant amount longer for the incongruent samples, due to what Stroop called “interference or inhibition” (see reference).

For the statistical test:

Null Hypothesis: $H_0: \mu_{\text{congruent}} \geq \mu_{\text{incongruent}}$

Alternative Hypothesis: $H_A: \mu_{\text{congruent}} < \mu_{\text{incongruent}}$

To statistically analyze these hypotheses, a One-Tailed Dependent t-Test for Paired Samples will be performed.

The reason the t-Test chosen, is due to the fact that it is performed on a sample, as opposed to the population. It is One-Tailed is due to the fact that the null and alternative hypotheses are directional (include greater-than/less-than as opposed to only equals/not-equals). It is a Dependent Paired Samples test due to the fact that both the congruent and incongruent samples are taken from exactly the same sample sets of participants.

3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

The mean of the congruent times is 14.051 and the standard deviation of the congruent times is 3.559.

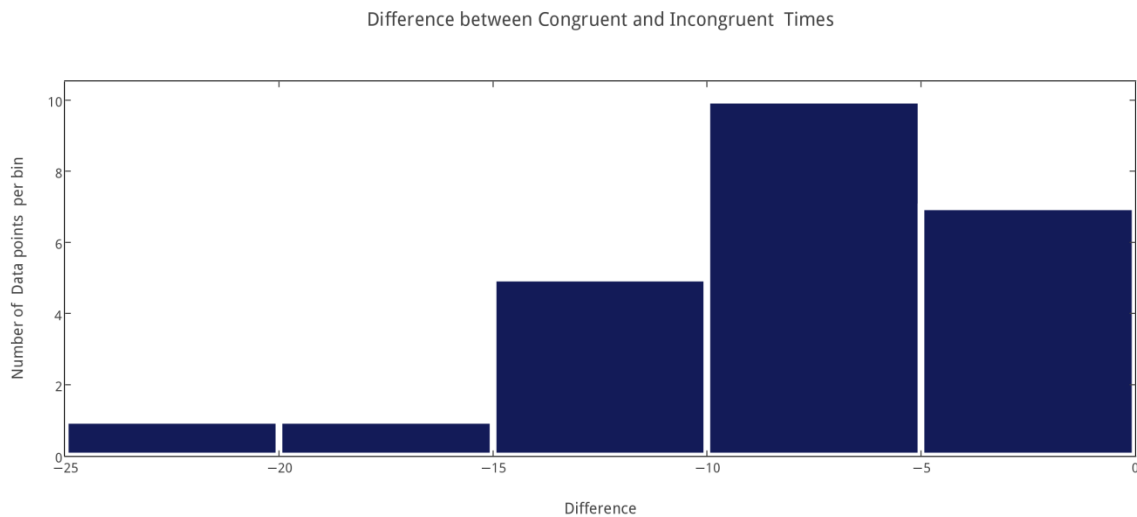
The mean of the incongruent times is 22.016 and the standard deviation of the incongruent times is 4.797.

The mean of the differences between congruent and incongruent times (congruent minus incongruent) is -7.965 and the standard deviation of the differences is 4.865.

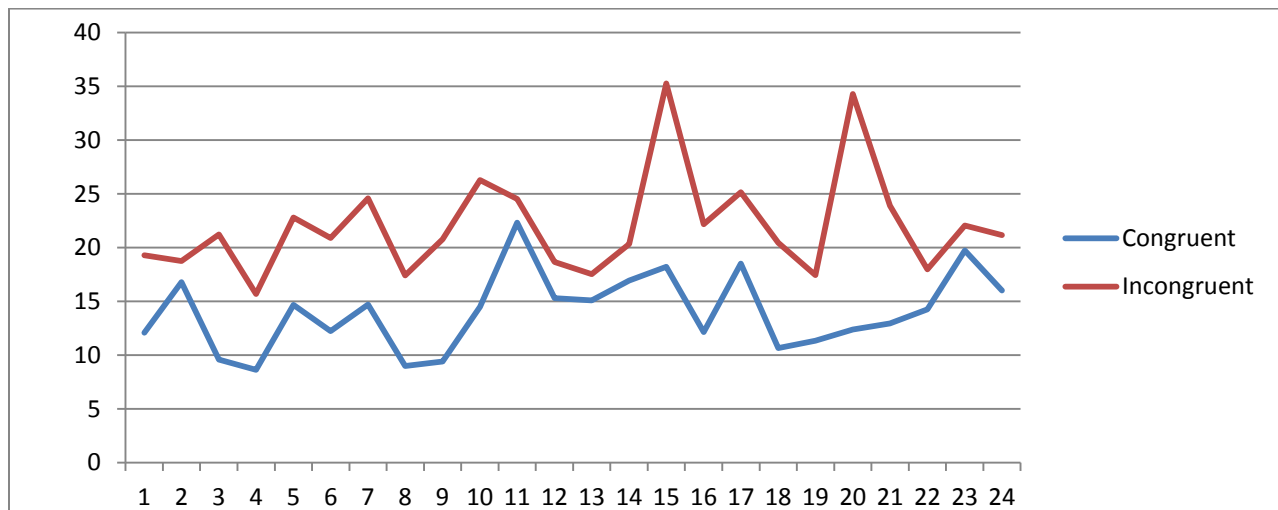
Note: due to the fact that this test was a performed on a sample, and not the population, the standard deviations were calculated with the degrees of freedom (23) as opposed to the sample size (24).

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.

Below is a histogram showing the differences between Congruent and Incongruent times with a bin size of 5 (in units of time). The histogram appears consistent with the reported mean value of -7.965.



Below is a line graph showing the congruent and incongruent times of each participant. In all cases the incongruent time is longer than the congruent time.



5. Now, 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?

This test will be applied with a 95% confidence level, $\alpha = 0.05$.

Our t-statistic is calculated as such:

$$t = (\mu_{\text{congruent}} - \mu_{\text{incongruent}}) / (s / \sqrt{n}) = (-7.965) / (4.865 / \sqrt{24}) = -8.021$$

The t-critical value from standard t-table, $p = 0.05$, $df = 23$ for one-tailed test is -1.714.

Cohen's d value:

$$d = (\mu_{\text{congruent}} - \mu_{\text{incongruent}}) / s = -7.965 / 4.865 = -1.637.$$

The 95% confidence interval:

$$CI = \mu_{\text{congruent}} - \mu_{\text{incongruent}} \pm (t\text{-critical} * (s / \sqrt{n})) = -7.965 \pm ((2.069) * (4.865 / \sqrt{24}))$$

$$CI = (-10.019, -5.910)$$

Our conclusion is to reject the null hypothesis due to the fact that our calculated t value lies in the t-critical region ($-8.021 < -1.714$).

This result matches up with the expectation that the interference due to incongruence would have an effect on lengthening response time. This is in agreement with the Stroop Effect as it has been tested and replicated numerous times in the past (see reference).

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?

From reading (see references) about the Stroop effect, the consensus is that the effect is due to "interference". According to Wikipedia on interference theory: "interference occurs in learning when there is an interaction between the new material and transfer effects of past learned behavior, memories or thoughts that have a negative influence in comprehending the new material". It would appear the participant's previous learning of the English words and their meanings and associations with colors is interfering with their recognition of the print color of the words presented. One would assume that a person with no knowledge of English would not exhibit this behavior when presented with the words in English. A similar task that might have a similar effect would be to do the same exact test, but instead of asking for the color of the print, ask them to read the word.

References consulted in preparation of project:

Udacity Statistics Class and accompanying notes

Udacity Forums

Websites:

<http://psychclassics.yorku.ca/Stroop/> (from link in Udacity forum)

<http://oak.ucc.nau.edu/rh232/courses/EP5525/Handouts/Understanding%20the%20Dependent%20t%20Test.pdf> (from link in Udacity forum)

https://en.wikipedia.org/wiki/Stroop_effect

https://en.wikipedia.org/wiki/Interference_theory#Iconic_research

Resources used in this project:

Calculations done with Microsoft Excel Spreadsheet