Udacity – Stroop Effect Statistical Analysis

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Introduction

A Stroop task is when the subject must say out loud the color of a word despite what the word is itself. When the word and the color of the word are the same, ie RED the word is considered congruent. Words like BLUE, are incongruent because the word mismatches the color of the word. In this statistical analysis, I will look at the effect incongruence has on time it takes for a subject to finish the test. The subject first reads out loud 25 congruent words and their time is recorded. Second they read out loud 25 incongruent words and their time is again recorded.

Hypothesis Test

For the Stroop Effect study, we will compare the average times of the two tests, the congruent test, which will be denoted with a subscript C, and the incongruent test which will be denoted with the subscript I. The independent variable in the Stroop Effect Test is whether the words are congruent or incongruent, the dependent variable is the time taken to finish a test in seconds. For this test, the null hypothesis will be that the incongruent test took the same or less amount of time in seconds as the congruent test and the alternative hypothesis is that the incongruent test took more time than the congruent test. This hypothesis test is outlined below:

$$H_0: \mu_I - \mu_C \leq 0 \quad (1)$$

$$H_A: \mu_I - \mu_C > 0 \quad (2)$$

μ_I represents the average time of subjects in the incongruent test and μ_C represents the average time of subjects taking the congruent test. This test will be a one-tailed test, in the positive direction, with an $\alpha = 0.05$. The test is assumed to be a dependent same test, with the same subject being tested twice with two different conditions. Some advantages of this type of test includes being able to control for individual differences, it is however disadvantageous as the first test may affect the subject's results in the second test administered. I will be using a t-test to analyze the time it takes to finish either test. This is the most appropriate test because we have less than 30 samples, we have no information on the population mean or standard deviation, which is why a t-test is preferential to a z-test. Additionally, this will be a paired t-test, because we are finding the difference between two different tests for the same person. We also should assume that the distributions for these tests are near normal. For this test, I will assume that the order of the tests was randomized so the lurking variable of test order will have a negligible effect on the results.

Descriptive Statistics

For both samples the average and the standard deviation of the difference change of result. n_C and n_I represent the sample size of each sample set. The mean difference is notated by $M_D$and the standard deviation of the difference is given by s_{diff}

$$\mu_C = \frac{\sum_{i=1}^{n} x_{Ci}}{n_C} = 14.05\ s \tag{3}$$

$$\mu_I = \frac{\sum_{i=1}^{n} x_{Ii}}{n_I} = 22.02\ s \tag{4}$$

$$M_D = \mu_I - \mu_C = 7.96\ s \tag{5}$$

$$s_{diff} = \sqrt{\frac{\sum_{i=1}^{n}[(x_{Ii} - x_{Ci}) - \mu_{I-C}]^2}{n-1}} = 4.86 \tag{6}$$

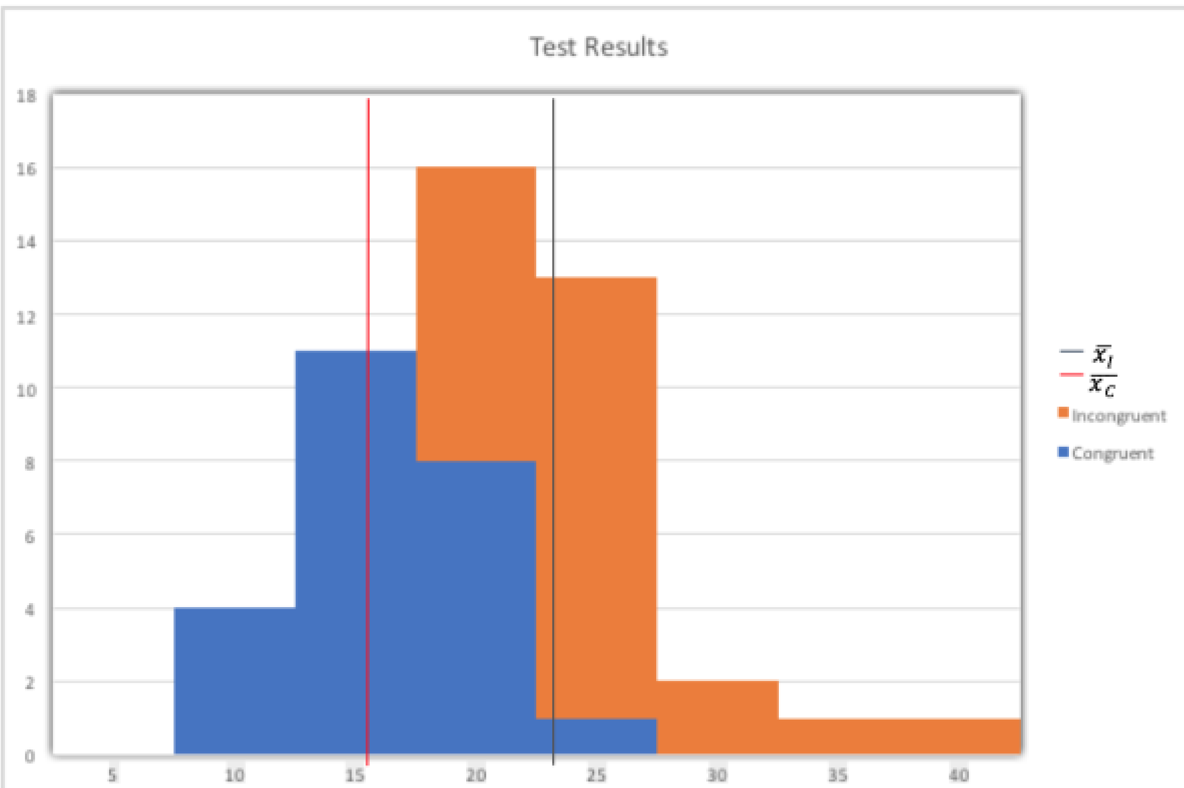

Figure 1:Histogram showing the distribution of Congruent and Incongruent test results.

In Figure 1 a histogram showing the distribution of test results for both the Congruent and Incongruent tests is charted, along with the averages for each test displayed as a vertical line at the approximate average. The largest bin for the Incongruent test in the bin from 15-20, while the largest bin for the congruent test is the bin from 10-15. (The number below the bar represents the high end of that bin). The average for the congruent test is shown to be approximately 8 seconds less than the incongruent test.

Statistical Test

For these results, a t-test makes the most sense. The hypothesis test compares averages of two sample sets. The the t_{stat} is calculated using equation (7).

$$t_{stat} = \frac{mean\ difference}{s/\sqrt{n}} = \frac{\mu_I - \mu_C}{s/\sqrt{n}} = \frac{22.02 - 14.05}{0.99} = 8.02 \quad (7)$$

Using the t-table with an $\alpha = 0.05$ and the degree of freedom = 23, the $t_{critical} = +\ 1.71$. The $t_{stat} > t_{critical}$, which means $p < 0.05$. Meaning that the incongruent results are less than 5% likely to be due to chance.

Cohen's D

$$Cohen's\ D = \frac{mean\ difference}{standard\ deviation\ of\ the\ differences} = \frac{\mu_I - \mu_C}{s_D} = 1.64 \quad (8)$$

Equation 8 tells us that the mean difference of the incongruent test is 1.64 standard deviations larger than the mean difference of the congruent test.

r^2

$$r^2 = \frac{t_{stat}^2}{t_{stat}^2 + df} = \frac{8.02^2}{8.02^2 + 23} = .73 \quad (9)$$

In equation 9, the results of the mean difference for these two tests is 73% attributable to the change of the tests administered (incongruent vs congruent)

CI

$$\left(M_D - t_{critical}\left(s/\sqrt{n}\right), M_D + t_{critical}\left(s/\sqrt{n}\right)\right)$$
$$(6.30\ , 9.63) \quad (10)$$

95% of the differences will fall in the above range of values.

Conclusion

Using a t-test the data the null hypothesis is rejected, given the t_{stat} is greater than the $t_{critical}$. Which means that the incongruent test does take longer than the congruent test. Additionally, the r^2 = .73 which indicates that 73% of the time difference between the two tests is attributable to the test administered. These results indicate that the incongruent test is substantially harder to perform than the congruent test, and the mind is not as fast to process color of the word that miss matches the word itself.