Project: Stroop Effect - Statistical Analysis

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

Independent variable is the **task** performed – Congruent or Incongruent. Dependent variable is the **time** taken to perform each task.

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 null hypothesis would be $\mathbf{H_0: \mu_c = \mu_I}$ (or) $\mathbf{\mu_I - \mu_c = 0}$
and the alternate hypothesis would be, $\mathbf{H_A: \mu_c < \mu_I}$ (or) $\mathbf{\mu_I - \mu_c > 0}$

The null hypothesis always states that the status-quo is true, hence we can say that the time taken for both tasks is the same or in other words, the difference of mean times is zero.

Stroop effect states that the time taken for the incongruent task is more than that of the congruent task. It explains that interference by the automation of reading, where the mind automatically determines the semantic meaning of the word (it reads the word "red" and thinks of the color "red"), and then must intentionally check itself and identify instead the color of the word (the ink is a color other than red), a process that is not automated. [1]. Hence to validate this claim, our alternate hypothesis would be that the time taken for the incongruent task is more than that of the congruent task. Or the difference of mean times is more than zero.

Since we only have a sample and do not have any population parameters, a one-sample, one-directional t-test would be the appropriate choice.

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

Sample size, n = 24
Degrees of freedom, df = n-1 = 23

Mean congruent time, X_c = 14.05 sec
Mean incongruent time, X_I = 22.02 sec

Standard deviation of the sample (congruent), S_c = 3.56 sec
Standard deviation of the sample (incongruent), S_I = 4.80 sec

Standard error of the sample (congruent), SE_c = 0.73 sec
Standard error of the sample (incongruent), SE_I = 0.98 sec

Mean difference (of times), $X_D = X_I - X_c$ = 7.96 sec
Variance of difference, S_D = sum of squares of differences from mean difference / Sample size

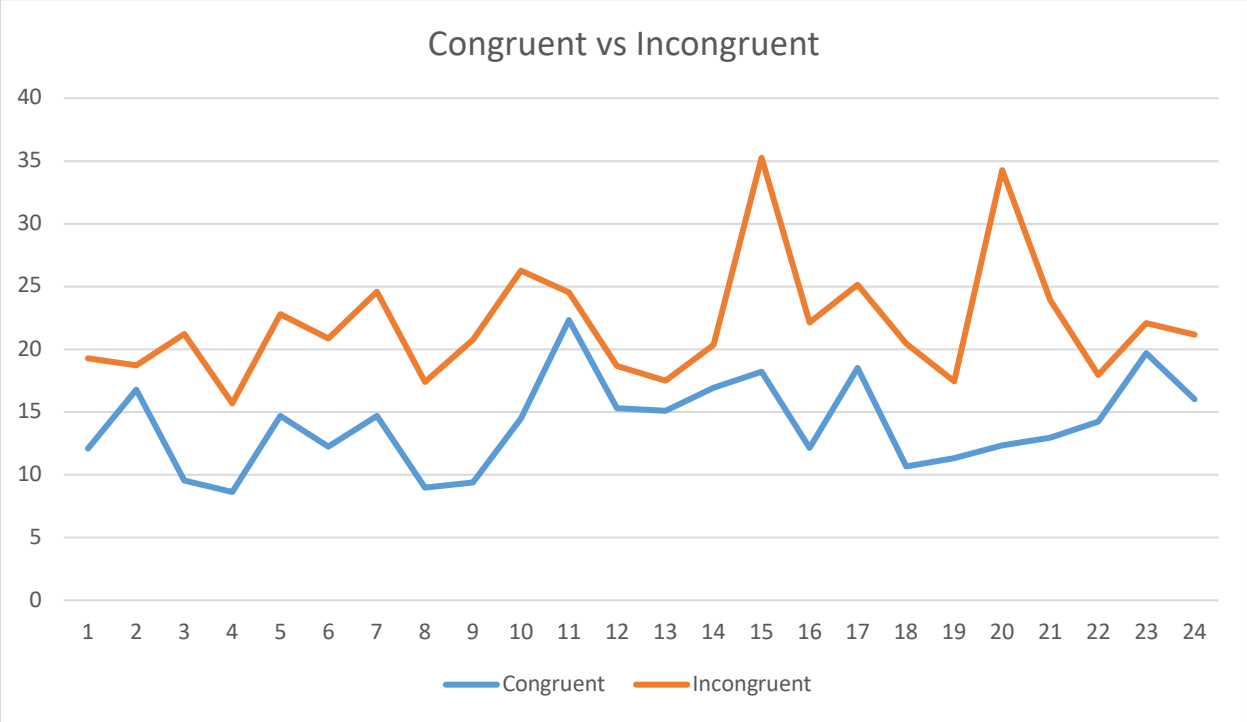
$$= \frac{\sum (X_D - X_d)^2}{(n-1)} = 23.67$$

We are using Bessel's correction (n-1 instead of n), as we are using sample statistic to estimate population parameter

Standard deviation of difference, S_D = √variance = 4.86

Standard error, $S.E_D$ = $\frac{\text{standard deviation of difference}}{\text{Sample size}} = \frac{S_D}{\sqrt{n}} = \frac{4.86}{\sqrt{24}} = 0.99$

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.



The plot shows that for every person in the sample, the time taken for performing an incongruent task is higher than the time taken for a congruent task.

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?

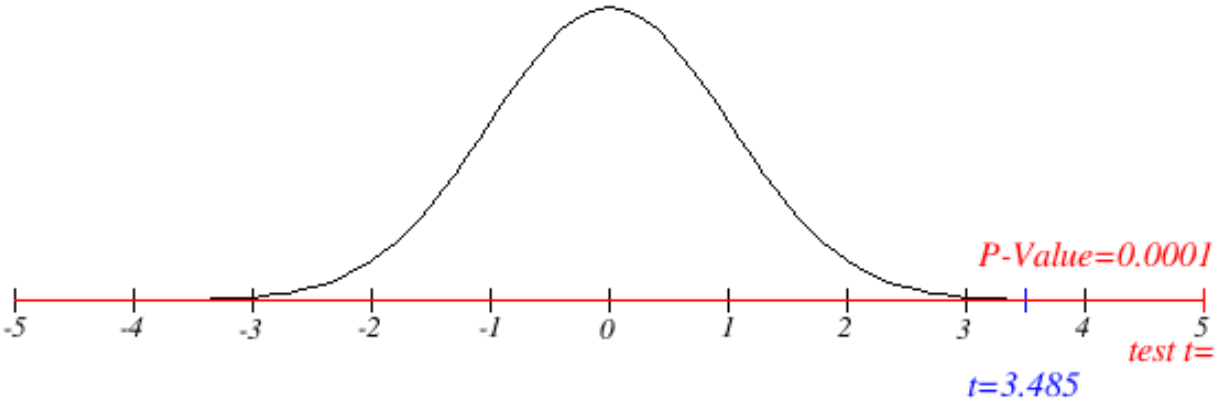
t-statistic = $\frac{\text{Mean difference (or) Difference of means}}{\text{Standard error of difference of sample means}} = \frac{7.96}{0.99} = 8.02$

Let's do the t-test for a 99.99% confidence level. This puts the significance level (alpha) at 0.001 (0.1%)

t* at significance level 0.001 (0.1%) for a one-directional t-test for 23 (n-1) degrees of freedom = 3.485

$CI = X_D \pm t^* \frac{S_D}{\sqrt{n}} = 7.96 \pm 3.485(0.99) = 7.96 \pm 3.45$

We can say with a 99.99% confidence level that the mean difference of the population ($\mu_I - \mu_C$) lies between [4.51,11.41]



The figure above shows that the t-statistic falls in the critical region. Hence we **reject the null hypothesis** since the results show that there is **statistically significant** evidence that the null hypothesis is not true.

The results matched my expectations since the difference at each data point ($X_I - X_C$) is greater than zero, as shown in the picture above.

6. Optional: 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? Some research about the problem will be helpful for thinking about these two questions!

As explained above one reason might be due to the automation of reading by our mind. It automatically determines the semantic meaning of the word (it reads the word "red" and thinks of the color "red"), and then must intentionally check itself and identify instead the color of the word (the ink is a color other than red), a process that is not automated. Also it could be due to the brain's inability to identify colors quicker than words.

The number stroop effect generates a similar effect where a same word is written a couple of times but the number of times it is written has to be read (the word "two" is written 3 times and we have to say the number of times, that is 3).

References:

1. Stroop, John Ridley (1935). "Studies of interference in serial verbal reactions". *Journal of Experimental Psychology*. **18** (6): 643–662. doi:10.1037/h0054651