Statistics: The Science of Decisions

Project - Stroop task

In this task, the dataset has results from a number of participants who have undertaken the Stroop test. The treatment involves presenting the participants with a list of words. The participant's task is to say out loud the colour of the ink in which the word is printed. Each row of the dataset contains the performance for one participant, with the first number their results on the congruent task (where the word-colour match) and the second number their performance on the incongruent task(where there is a word-colour mismatch). We are determining whether there is a difference in the average reaction times between the congruent condition and the incongruent condition.

Project resources:
Paper, pencils, calculator, t-table,graphpad(p-values) and PC spreadsheets.

Formulas required
Mean
Standard deviation
Degrees of freedom df
Standard Error SE
T-statistic
T-critical
Confidence Interval CI
P-value
webpages:-
http://libguides.library.kent.edu/SPSS/PairedSamplestTest
http://www.statisticssolutions.com/manova-analysis-paired-sample-t-test/

1. a What is our independent variable?

The condition is the independent variable. We have two conditions

- where the word-colour match
- where the word-colour do not match

1.b What is our dependent variable?

The time taken to complete the list of words also called reaction time is the dependent variable.

2.a What is an appropriate set of hypotheses for this task?

Ho, the null hypothesis is that the average reaction time for the word and colour match is the same as the average reaction time for word-colour mismatch (Ho: u1 - u2 = 0).

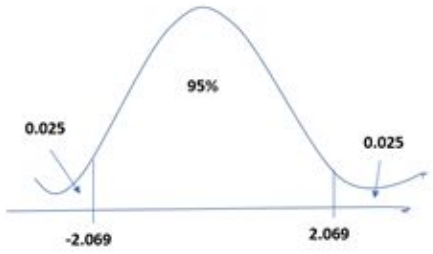
Ha, the alternate hypothesis is that there is a difference in the average reaction times between the two conditions, we are not choosing any direction this time so it will be a two tailed test (Ha: u1 - u2 ≠ 0).

Ho: u1 - u2 = 0
Ha: u1 - u2 ≠ 0

where

- μ_1 is the population mean of congruent,
- μ_2 is the population mean of incongruent.

Using an alpha level of .05 ie α = 0.05, for a two tailed test at 23 degrees of freedom, we find the t-critical level using the T-table



t-critical = -+ 2.069

Based on this test critical number, the test statistic is supposed to fall within -2.069 and 2.069 if we are to accept the Ho.

2.b What kind of statistical test do you expect to perform? Justify your choices.

We are dealing with paired data therefore a paired samples t-test will be performed. Such a test is used

- when the variables are numeric
- when a subject is used twice - here we have two conditions of treatment per subject.
- we are comparing two means from the same group at different times;

- a t-test will be used because we do not know the population parameters of this data and also because the sample size is a small one that is less than 30

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

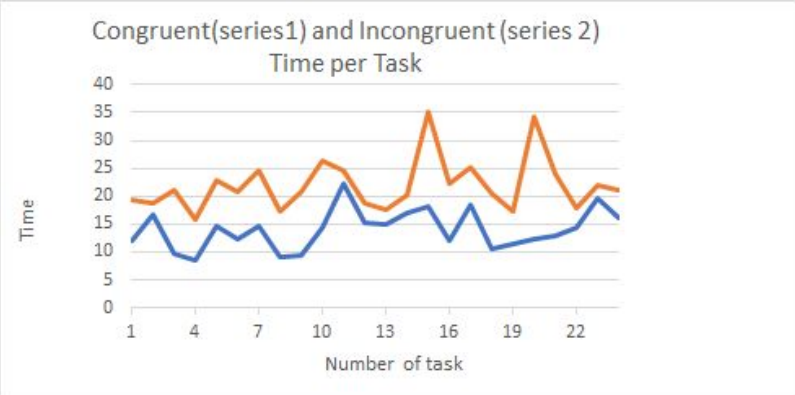
Measures of centre can be shown by the means of the two conditions Congruent and Incongruent having means of 14.05 and 22.06 respectively. This is already telling us that there is a difference in the average times between the two conditions. So our task is to establish how significant this difference is.

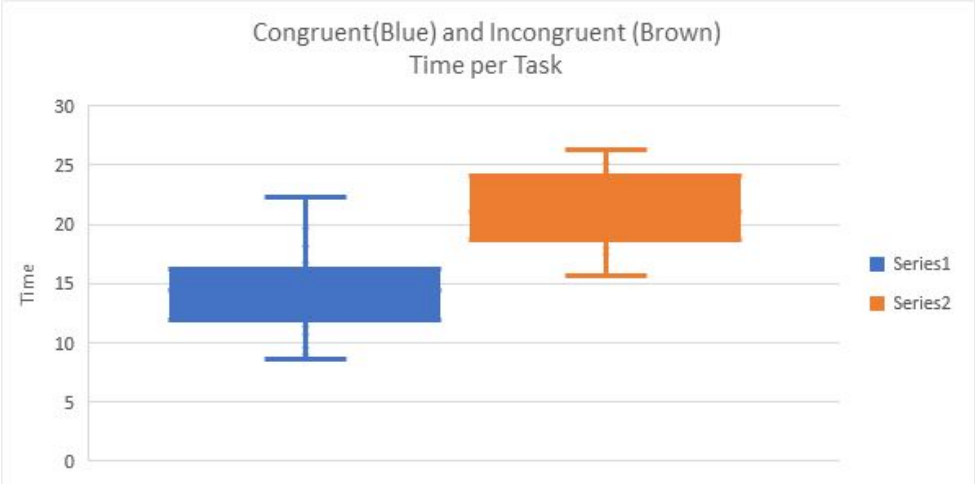
Measures of variability are shown by the mean difference of -7.96, the variance of 23.67 and a standard deviation of 4.864

	Congruent X	**Incongruent Y**
Mean	14.05	22.02
Variance	23.67	
Stdeviation	4.864	

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 scatter plot below shows the variation of the two conditions over time. The trend of the incongruent condition is higher than the congruent condition suggesting a difference in the means.





A boxplot shows us the distribution of the data, the variability and the center of a data set. In the plot the Incongruent data has a higher centre and a less spread. The longer line on the Congruent plot from 16 to 23 shows a bigger spread. Both situations pointing to the possibility of a difference in the means.

5. Now, 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

5.a The statistical test, t-Test

Before we can do the statistical test, we need to determine the sample statistics. For paired data we need the mean of the paired differences and the standard deviation of all the differences in the pairs in the sample. These sample statistics are then standardised using the formula below.

$$t\text{-statistic} = \frac{\text{Mean Difference MD}}{\text{SE}}$$

$$\text{SE} = \text{S} / \sqrt{n}$$

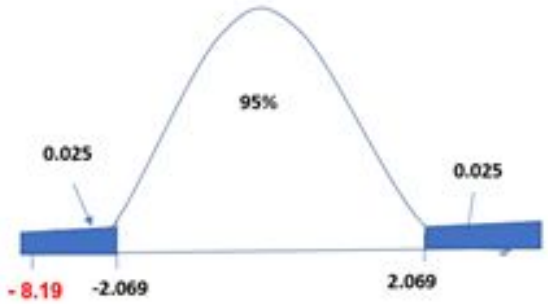
where
Mean difference = Sample mean of the differences
n = Sample size
SE = Standard Error
S= Sample standard deviation of the differences

= -7.965 / 0.99

= - 8.04 .

Results:

The test-statistic is -8.04.

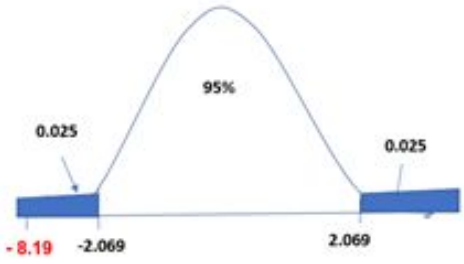


N.B The t-statistic is - 8.04 and not -8.19 as

The t-statistic is greater than the t-critical on the negative side. i.e.it lies in the critical region(0.025) at -8.04 units, we therefore reject the Ho.

This means the average difference for this sample is 8.04 standard errors below 0. However, because our sample size is below 30 - this information is not enough for us to say that the difference in the two conditions is significant as a population parameter. We therefore need to find -8.04 on the t-distribution with 23 degrees of freedom to calculate the P-value. Here we apply graphpad to find the P-value.

The two-tailed P value is less than 0.0001. The P-value is less alpha = 0.05, therefore we reject the Ho.



5.b. Confident Interval CI

A confidence interval allows us to add a measure of variability to our estimate.

Confidence interval at 95%

= MD - + t-critical x SE

where

MD = sample mean of the differences

n = sample size (i.e., number of observations)

S = sample standard deviation of the differences

SE = estimated standard error of the mean (sample standard deviation /sqrt(n))

= - 7.965 - 2.05 , - 7.965 + 2.05

Therefore **CI** = (-10, -5.91)

A CI of -10, -5.91 is the range of likely values for the parameter meaning it is the interval or area within which we are confident of finding our population mean.

5.c. Cohens d

Further to standardising the sample statistic, we calculate cohens d.

Cohen's d = $\frac{\text{mean difference}}{S}$

Where

Mean difference = Sample mean of the differences

S = Sample standard deviation of the differences

= -7.96 / 4.86

= -1.64

The mean differences are -1.64 standard deviation units apart.

Conclusion:

The sample data set already indicated that the sample means of the congruent condition is lower but we went ahead to do a hypothesis test in order to infer a broader conclusion about the population. In this case we are trying to prove that there is a difference between the two population means.

The P-value has shown that there is a highly statistically significant difference between congruent and incongruent conditions. The results are inline with our earlier expectations based on the sample means and the visualisations. Are the results meaningful - yes, based on what we set out to achieve. That was to verify whether there is a significant difference in the two experimental conditions.

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!

I think the effects are due to the added requirement/ burden placed on the brain. Personally I got muddled up in the beginning and kept getting confused. I then decided to do 3 samples for each word set to get a proper estimate. With the congruent condition the brain simply assess the print colour and the job is done. However, with a word-colour mismatch the brain has to do more sorting and detangling. It sorts through the word and ink to get the job done hence the need for more time.

This is can be compared to a postman delivering letters. In case A they the postman is required to simply drop off the letters in the letter box(es) on street York and the job is done. In case B, the postman takes the letters to the same street but this time the letters have to be received and signed for by the recipients before the job is done. The added requirement in Case B means that Postmen in B will take more time than than usual to accomplish their task. Any added responsibility calls for more time.