Test a perceptual phenomenon

By Mrityunjay Kumar

Project Problem Statement

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.

Response to Questions of Investigation

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

In the Stroop Task experiment we are measuring response / reaction time for two different conditions (Congruent words condition and Incongruent words condition) for a group of people. We are trying to measure the significant difference between **response time or reaction time** in both conditions.

Our **independent variable** is the name of colors and their print colors. Name of colors can be same or different than their print color. When both are same it is Congruent words condition whereas when they are different it is incongruent words condition. Subject has to provide name of ink color. These two conditions impacts our dependent variable in this experiment.

Our **dependent variable** is **response time,** in which subject provides the name of the ink in which color name is printed.

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

Appropriate set of Hypotheses for this task

Null Hypothesis - Mean response time for Congruent and Incongruent set of colors are same.

$$H_0 : \mu_{con} = \mu_{incon}$$

Alternate Hypothesis - Mean response time for Congruent and Incongruent set of colors are not same.

$$H_A : \mu_{con} \neq \mu_{incon}$$

Where

μ_{con} Population mean of congruent response time. *con* stands for congruent.

μ_{incon} Population mean of incongruent response time. *incon* stands for incongruent.

Expected Statistical Test to performed

We have two samples of size 24, one for congruent response time and another for incongruent response time. Sample size is very small.

We will carry out **Two tailed dependent t-test for paired samples at α=0.01.**

Population parameters (μ or σ) are not available for our experiment. Hence we have to use t *Distribution* rather than $\mathbb{Z}$ distribution. t Distribution is more prone to error in compare to $\mathbb{Z}$ distribution, however it is useful in absence of population parameters.

We have used *Paired Samples t Test* because, in Stroop Effect test, we can compares two means that are from the same individual but for two different conditions. We will look for significant difference between both of the condition.

We choose two tailed test here as we interested in knowing significant change in mean response time of congruent or incongruent test in both of the direction.

(Note: We can do one tail test to and there is no problem there.)

Now it's your chance to try out the Stroop task for yourself. Go to this link, which has a Java-based applet for performing the Stroop task. Record the times that you received on the task (you do not need to submit your times to the site.) Now, download this dataset which contains results from a number of participants in the task. 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.

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

Data Set

Congruent	Incongruent	Difference (Congruent - Incongruent)
12.079	19.278	-7.199
16.791	18.741	-1.95
9.564	21.214	-11.65
8.63	15.687	-7.057
14.669	22.803	-8.134
12.238	20.878	-8.64
14.692	24.572	-9.88
8.987	17.394	-8.407
9.401	20.762	-11.361
14.48	26.282	-11.802

22.328	24.524	-2.196
15.298	18.644	-3.346
15.073	17.51	-2.437
16.929	20.33	-3.401
18.2	35.255	-17.055
12.13	22.158	-10.028
18.495	25.139	-6.644
10.639	20.429	-9.79
11.344	17.425	-6.081
12.369	34.288	-21.919
12.944	23.894	-10.95
14.233	17.96	-3.727
19.71	22.058	-2.348
16.004	21.157	-5.153

We have added a new column with values which are difference of Congruent and Incongruent values. We can also use absolute value of these and do Single Sample t Test.

Descriptive Statistics For Data Set

Stat	Congruent	Incongruent	Difference (Congruent - Incongruent)
Size (n)	24	24	24
Mean ($\bar{x}$)	14.051	22.016	-7.965
Median	14.357	21.018	-7.667
Min	8.63	15.687	-21.919
Max	22.328	35.255	-1.95
Sum	337.227	528.382	-191.155
Variance (S^2)	12.669	23.012	23.667
Standard Deviation (S)	3.559	4.797	4.865

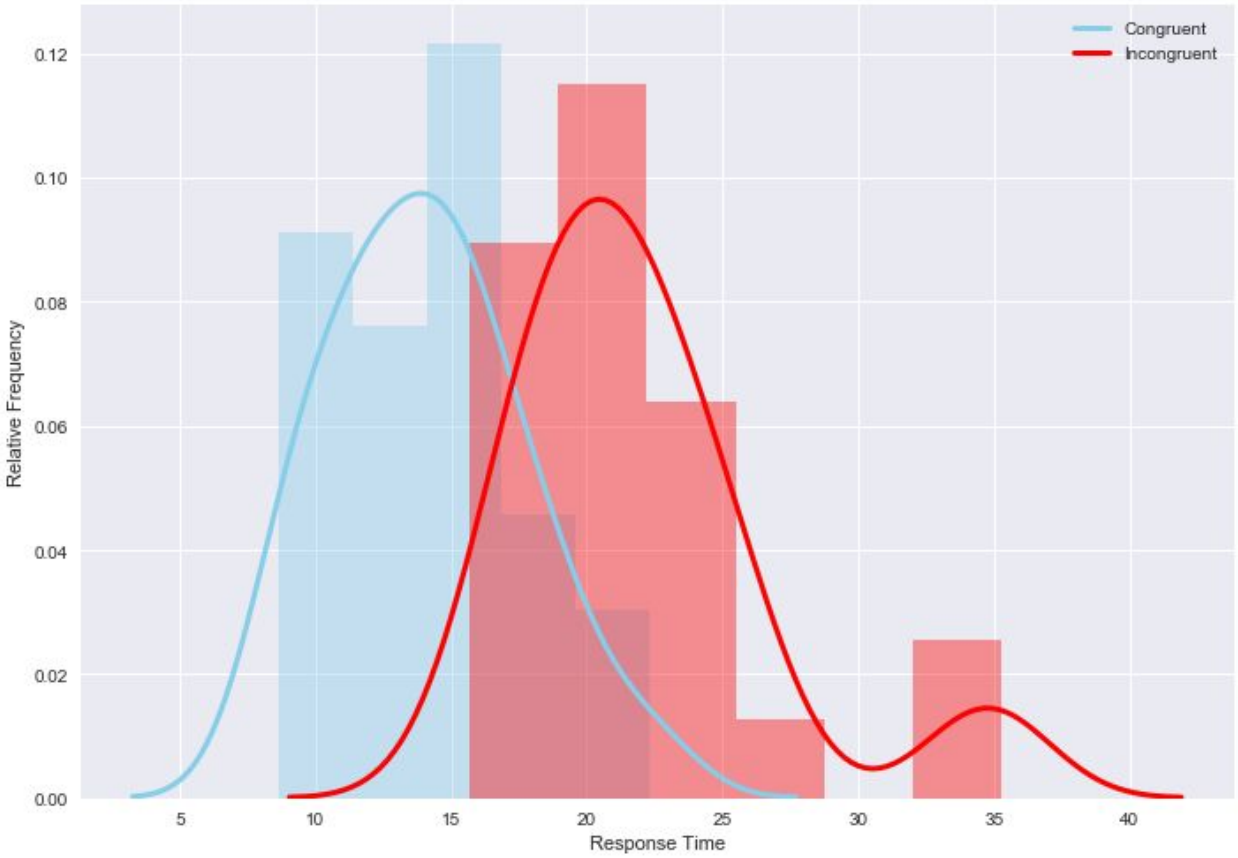
Standard Error (SE) of Mean	0.726	0.979	0.993

Few important findings from these data:

1. We can easily see that average time taken by subject to do Incongruent activity is more than congruent activity.
2. Total time taken in Incongruent activity is more than congruent activity.
3. It seems incongruent activity takes more time in compare to congruent activity.
4. Standard Deviation is higher in incongruent activity, so we can say it has higher variability.

Link to calculation google spreadsheet.

Q.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.



Above visualization is the histogram of Congruent and Incongruent sample distributions. On the x axis we have Response time while on the y axis we have relative frequency. We can find out following information from the visualization:

1. Minimum (~8) & Maximum (~22) response time for Congruent Distribution is less than the Minimum (~16) & Maximum (~35) response of Incongruent Distribution.
2. Both Congruent and Incongruent is normally distributed.
3. In Congruent test most frequently occurring response time (Mode) is between 14 to 17.
4. In Incongruent test most frequently occurring response time (Mode) is between 19 to 22.

Q.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?

We have:

Mean of Congruent Sample: $\overline{x_{con}}$ = 14.051

Mean of Incongruent Sample: $\overline{x_{incon}}$ = 22.016

Point Estimate: $\mu_{con} - \mu_{incon} = \overline{x_{con}} - \overline{x_{incon}}$ = 14.051 - 22.016 = **-7.965**

Population Standard Deviation from sample (S) : $\sqrt{\frac{\sum(X_i - \bar{X})^2}{n-1}}$

S: **4.865**

t value = Point estimate / (Standard Deviation from sample (S) / square root of sample size) = -7.965 / (4.865 / $\sqrt{24}$) = -8.020631367427755 ~ **-8.02**

t critical value at alpha 0.01 , for 23 degree of freedom for two tailed test is ± 2.8073.

t value -8.02 is in critical region far beyond the negative side t critical value of -2.8073.

Hence **we will reject the null Hypothesis** H_0**:** $\mu_{con} = \mu_{incon}$ and **accept the alternate hypothesis** H_A**:** $\mu_{con} \neq \mu_{incon}$.

At the 99% confidence level (α = .01) and 23 degrees of freedom

We can say both the population mean is significantly different ath 99% confidence level with 23 degree of freedom.

Negative t value signifies subject has exhibited significantly less response time while working on Congruent task in compare to incongruent task.

This result have significantly match up with my expectation.

Q.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!

The human brain is practiced to interpret word and its meaning, while stroop test force the brain to do something which they have not practiced for, hence it takes more time in incongruent task.

We can think of many experiments based on similar principal, for e.g.

1. Asking subjects to tell the name of animal appearing in the picture, while different name of animal is showing.
2. Asking subjects to use alphabetical keyboard and qwerty keyboard. Subjects are use to Qwerty keyboard, hence we will observe they are typing slow while using alphabetical keyboard.

References

1. https://en.wikipedia.org/wiki/Stroop_effect
2. https://www.graphpad.com/quickcalcs/statRatio2/
3. https://www.psytoolkit.org/lessons/stroop.html
4. https://libguides.library.kent.edu/SPSS/PairedSamplestTest