

## Aarthy C Vallur – Test a perceptual phenomenon

**Analysing the Stroop effect** - 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.

**Goal-** The goal of this project is simple and standard analysis reviewing the basic concepts of statistics of a dataset, including

How to identify components of an experiment

How to use descriptive statistics to describe qualities of a sample

How to set up a hypothesis test, make inferences from a sample, and draw conclusions based on the results

**Dataset-** Data from 24 participants is given below:

### Time taken to identify colors (minutes)

Congruent	Incongruent
12.079	19.278
16.791	18.741
9.564	21.214
8.63	15.687
14.669	22.803
12.238	20.878
14.692	24.572
8.987	17.394
9.401	20.762
14.48	26.282
22.328	24.524
15.298	18.644
15.073	17.51
16.929	20.33
18.2	35.255
12.13	22.158
18.495	25.139
10.639	20.429
11.344	17.425
12.369	34.288

12.944	23.894
14.233	17.96
19.71	22.058
16.004	21.157

### Variables and hypotheses-

**Independent variable-** Ink color of the words displayed

**Dependent variable-** Time taken to identify the ink colors

The appropriate hypotheses for this task are

Assuming  $u_1$  is the mean of the Congruent group (where the color of the words and the words match, such as in blue and purple) and  $u_2$  is the mean of the Incongruent group (where the color of the words and the words do not match, such as in blue and green)

Question	Verbal null hypothesis	Symbolic null hypothesis	Verbal alternate hypothesis	Verbal alternate hypothesis
When the color of the ink does not match the color word, the observer takes longer to correctly identify the color of the ink.	The time taken to identify ink color of congruent and incongruent words are the same	$H_0 = u_1 = u_2$	The time taken to identify ink color of incongruent words will be more than the time taken to identify congruent words	$H_1 = u_1 < u_2$

The alternate hypothesis is chosen to be one- sided due to the expectation that the incongruent words will be harder to identify based on my experience taking the Stroop test at <https://faculty.washington.edu/chudler/java/ready.html>. Following which the null hypothesis assumes no difficulty in identifying the color of the words in both groups.

**The appropriate statistical test for this activity is a paired, one- tailed t- test.** This is a small sample size and the samples here are derived from a population that can be considered Gaussian. Also, the samples here represent a “before” and “after” experimental design, the same person taking the test before and after incongruence in the ink color. One- tailed test is appropriate because, the alternate hypothesis states that that  $u_1 < u_2$

### Descriptive statistics-

Mean and median are measures of central tendency while standard deviation, variance and sample range are measures of variation

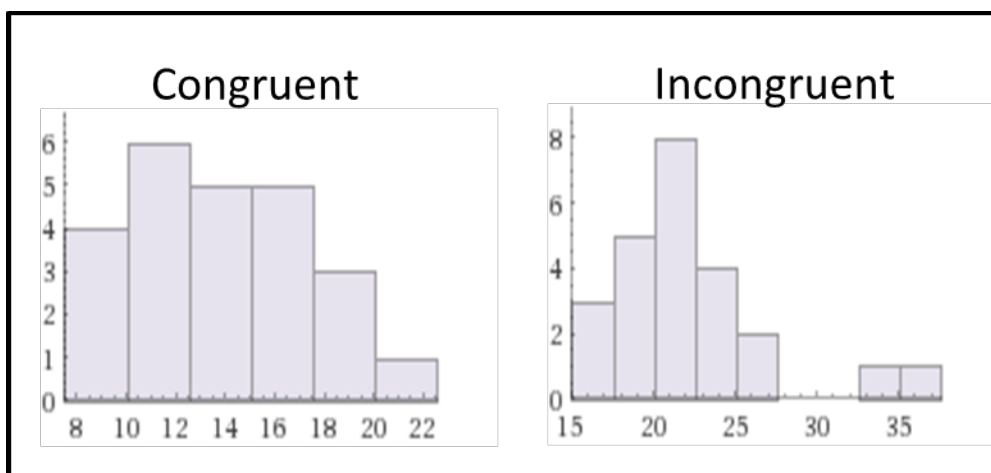
### For congruent words

		sample standard deviation	3.559
mean	14.05	sample variance	12.67
first quartile	11.71	interquartile range	4.686
median	14.36	sample range	13.7
third quartile	16.4	coefficient of variation	0.2533

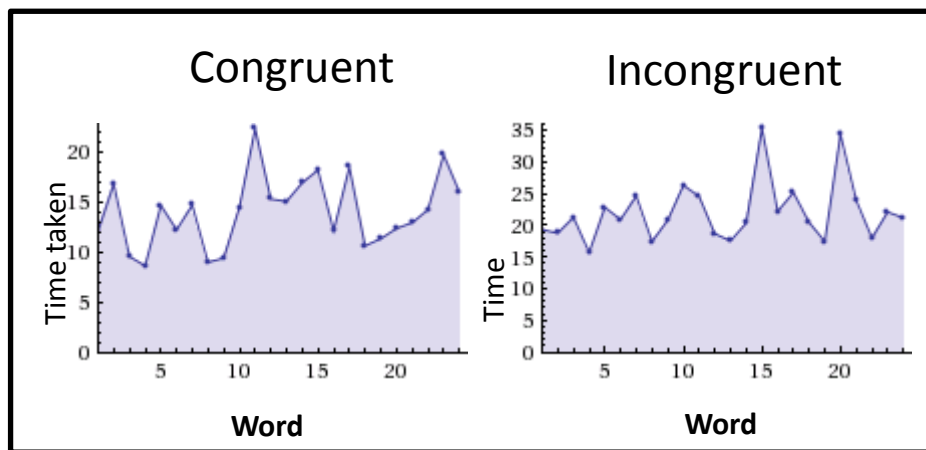
### For incongruent words

		sample standard deviation	4.797
mean	22.02	sample variance	23.01
first quartile	18.69	interquartile range	5.517
median	21.02	sample range	19.57
third quartile	24.21	coefficient of variation	0.2179

**Visualisation of data-** Histogram showing the distribution of time taken to identify ink color (x-axis) over number of occurrences (y-axis). The x-axis has been binned to intervals of 2 for the congruent group and 2.5 for the incongruent group. Histogram was generated using Wolfram alpha and Tableau 8.2. Histogram shows a normal distribution for both groups with the upper and lower limits of the y-axis (time taken) being higher for the incongruent group. Hence the mean will be higher for the incongruent group.



Distribution line plot of time taken (y- axis) for every word (x- axis) read by the participant in both groups. Line plot generated using Wolfram alpha. Line plot shows the time taken being higher for the words (x- axis) being higher for the incongruent group highlighting a trend difference between the groups.



### Inferential statistics

Upon performing a paired, one- tailed t- test, the  
Mean difference = 7.97  
SEM = 0.99  
The df (degrees of freedom) for this test was 23.

$$t \text{ statistic} = \text{Mean difference} / \text{SEM} = 7.97 / 0.99 = 8.02.$$

$$t_{\text{critical}} \text{ at } \alpha = 0.05 = 1.684.$$

Based on these parameters, the 95% CI was between 5.51-10.42.

The calculated p value < 0.0001, much less than the critical  $\alpha = 0.05$ . Hence the difference in means between the 2 groups is statistically significant. All this makes the alternate hypothesis true. We can discard the null hypothesis and conclude that the difference in means between the 2 groups is not by chance and  $\mu_1 < \mu_2$

My expectations from taking the Stroop test and observing the difference in means came true and indeed, time taken to identify ink color is affected by whether the words and the ink color were congruent or incongruent.

### Reflection-

The “Stroop effect” is a neurological effect first noticed and reported by the psychologist J. Ridley Stroop in 1935. It is a demonstration of the interference of an aspect of the printed word such as its color in identifying it. Though many theories, including speed of processing words and color as well as the use of different lobes of the brain are put forward to explain the phenomenon, I favor the selective attention theory. I think that reading simple words such as the ones used in this task requires much less attention than identification of the color. This could be a purely neurobiological effect or an effect of practice- reading is a frequent activity in which every average person is trained for speed and accuracy. No wonder it is accomplished faster than a secondary activity such as identifying color. I don’t think the same will hold for other senses like taste or smell, the physiology of vision and processing by the brain is different and independent of the other senses. This is not the same for senses like taste and smell, which are inter related and affected by one another.

### **References-**

1. <http://www.scientificamerican.com/article/seeing-science-exploring-color-perception-with-the-stroop-effect/>
2. <https://faculty.washington.edu/chudler/words.html>
3. “Intuitive Biostatistics” by Harvey Motulsky
4. <http://rpsychologist.com/d3/cohend/>
5. Wikipedia
6. Wolfram alpha
7. Graph Pad Prizm software