Project P1: Test of Perceptual Phenomenon

Submitted by: Vivek Raj

Stroop Test:

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.

In psychology, the **Stroop effect** is a demonstration of interference in the reaction time of a task.

Results Section:

1. **What is our Dependent Variable? What is our Independent Variable?**

The **reaction time** taken to name ink colors in equally sized lists is the dependent variable in this case. The independent variable is the congruency between ink color and the word.

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

Research Question	Verbal Null Hypothesis (H_0)	Symbolic Null Hypothesis	Verbal Alternate Hypothesis (H_a)	Symbolic Alternate Hypothesis (H_a	No of Tails
Does Population Perform better (lesser reaction time) in Congruent task compared to Incongruent task or in other words does population take higher time to perform incongruent task compared to congruent task??	The Population Mean of time taken in performing Incongruent task and Population Mean of time taken in performing Congruent task don't differ.	**H_0: $\mu_{Incongruent} = \mu_{congruent}$ or H_0: $\mu_{Incongruent} - \mu_{congruent} = 0$ or H_0: $\mu_D = 0$ Where (D = incongruent – congruent)**	The Population Mean of time taken to perform Incongruent task is higher than Population Mean of time taken to perform Congruent task.	**H_a:$\mu_{Incongruent} - \mu_{congruent} > 0$**	**One tail Test in Positive Direction.**

Null hypothesis H_0 : $\mu_{incongruent} = \mu_{congruent}$ or $\mu_D = 0$

Alternative Hypothesis H_a : $\mu_{incongruent} > \mu_{congruent}$ or $\mu_D > 0$

The null hypothesis states that there is no significant difference in Population mean response time between congruent word condition & incongruent word condition.

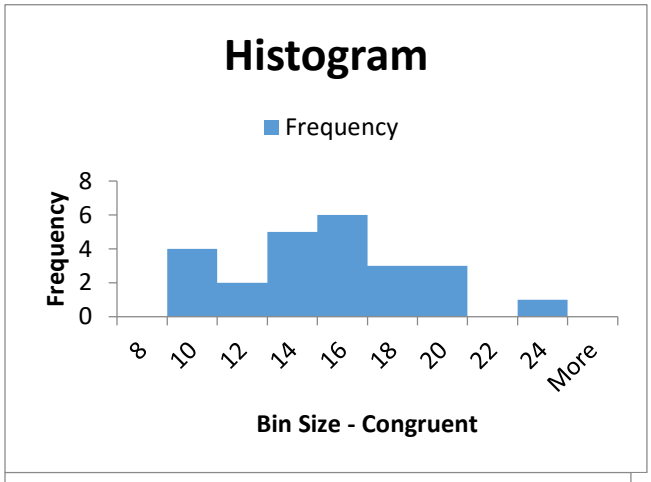
The alternate hypothesis states that there is significant **increase in Population mean response time** in case of incongruent word condition.

To access the statistical significance, we will do **dependent one-tail t-test** for paired samples in a **positive** direction with α=.05. We opted to perform a dependent t-test because the population parameters i.e. standard deviations & distribution mean is unknown and **sample size is less than 30**. The reason to perform a one tailed test in positive direction is that we have to predict only the **direction** of the treatment effect and when we compute the **t – test we expect a positive value** ($\mu_D > 0$).

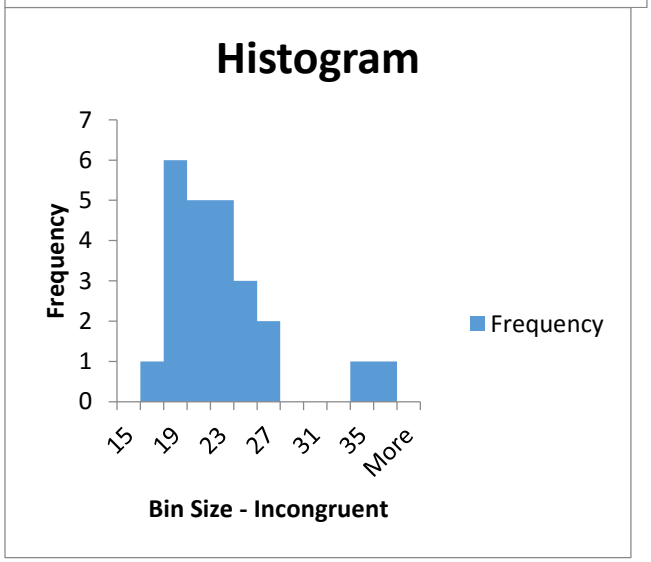
3. **Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.**

	Mean	Median	Variance	Standard Deviation
Incongruent	22.016	21.018	23.012	4.797
Congruent	14.051	14.357	12.669	3.559
Difference	7.965	7.667	23.667	4.865

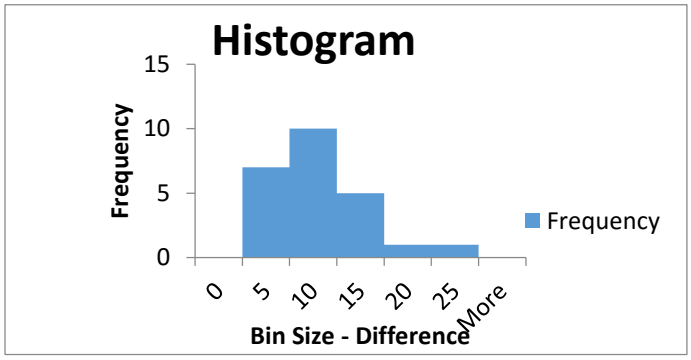
4. **Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.**



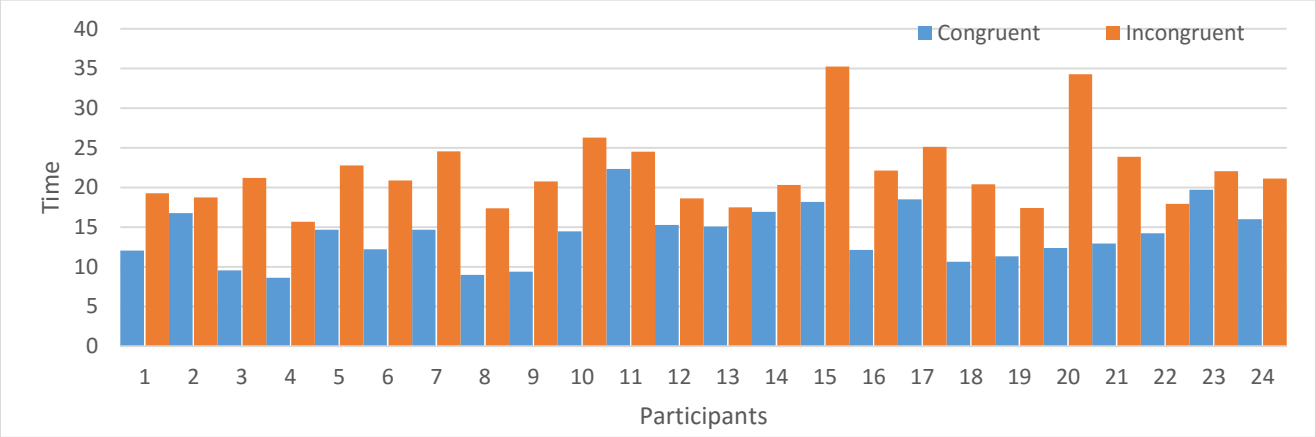
Bin Size - Congruent	*Frequency*
8	0
10	4
12	2
14	5
16	6
18	3
20	3
22	0
24	1
More	0



Bin Size - Incongruent	*Frequency*
15	0
17	1
19	6
21	5
23	5
25	3
27	2
29	0
31	0
33	0
35	1
37	1
More	0



Bin Size - Difference	*Frequency*
0	0
5	7
10	10
15	5
20	1
25	1
More	0



We can see that the histogram plot for **difference** shows a unimodal normal distribution with left skewness. As the skewness is not too big, a t-test can be applied to predict the statistical significance.

The last bar chart shows the time taken by individuals in the sample to perform congruent/incongruent word task. This chart is particularly helpful in determining the type of t-test (One tailed test in positive direction).

5. **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?**

   Point Estimate for ($\mu_{incongruent} - \mu_{congruent}$) = 7.965

   Degree of Freedoms = 24-1= 23.

   t-Critical Values for one tail Statistic at (α = .05) $t_{critical}$ = 1.714

   t = $\frac{(\mu_{incongruent} - \mu_{congruent})}{SEM}$ => $(\mu_D - 0)/_{SEM}$

   SEM = $\frac{S}{\sqrt{n}}$ = 0.993 where n = 24

   Sample Statistics t = 7.965/0.993 = 8.02

   Margin of Error = 1.714 x 0.993 = 1.702

   Confidence Interval = (6.263, 9.667)

The t-statistic for the two samples is 8.02 with alpha =.05 and 23 degrees of freedom, the t-critical value for a one-tailed test in the positive direction is 1.714, margin of error is 1.702 and confidence interval of (6.263, 9.667). The p-value calculated from the t-statistic and 23 degrees of freedom gives a p-value that is less than 0.0001(p=2.0515E-08).

As the p-value is less than the alpha level (.05) and sample t-statistics is significantly larger than the t-critical values, we reject the null hypothesis. This shows that the use of incongruent word condition significantly increases the reaction time i.e. there is statistically significant evidence that the time taken to read the incongruent list is greater than the time taken to read the congruent list for the population.

The results agree with my expectations.

In APA Style for (α = .05)

t (23) = 8.02, p < .00001, positive one tail test

95% CI = (6.263, 9.667)

Effect Size Measure

Cohen's d = 1.64

r^2 = .74

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?

There are various theories used to explain the Stroop effect and are commonly known as 'race models'. This is based on the underlying notion that both relevant and irrelevant information are processed in parallel, but "race" to enter the single central processor during response selection. They are:

i) Processing speed

This theory suggests there is a lag in the brain's ability to recognize the color of the word since the brain reads words faster than it recognizes colors.This is based on the idea that word processing is significantly faster than color processing. In a condition where there is a test regarding words and colors (e.g. Stroop test), if the task is to report the color, the word information arrives at the decision-making stage before the color information which presents processing confusion. Conversely, if the task is to report the word, because color information lags after word information, a decision can be made ahead of the conflicting information.[14]

ii) Selective attention

The Selective Attention Theory suggests that color recognition as opposed to reading a word, requires more attention, the brain needs to use more attention to recognize a color than to word encoding, so it takes a

little longer. The responses lend much to the interference noted in the Stroop task. This may be a result of either an allocation of attention to the responses or to a greater inhibition of distractors that are not appropriate responses.

iii) Automaticity

This theory is the most common theory of the Stroop effect. It suggests that since recognizing colors is not an "automatic process" there is hesitancy to respond; whereas, the brain automatically understands the meaning of words as a result of habitual reading. This idea is based on the premise that automatic reading does not need controlled attention, but still uses enough attentional resources to reduce the amount of attention accessible for color information processing. Stirling (1979) introduced the concept of response automaticity. He demonstrated that changing the responses from colored words to letters that were not part of the colored words increased reaction time while reducing Stroop interference.

iv) Parallel distributed processing

This theory suggests that as the brain analyzes information, different and specific pathways are developed for different tasks. Some pathways, such as reading, are stronger than others; therefore, it is the strength of the pathway and not the speed of the pathway that is important. In addition, automaticity is a function of the strength of each pathway, hence, when two pathways are activated simultaneously in the Stroop effect, interference occurs between the stronger (word reading) path and the weaker (color naming) path, more specifically when the pathway that leads to the response is the weaker pathway.

An alternative to the Stroop Color-Word Test (SCWT), denominated the **Colored Numbers Test (CNT),** was developed to evaluate the selective attention of illiterate individuals. A total of 30 volunteers with basic education (control group) and 30 illiterate volunteers (experimental group) performed the SCWT and the CNT. Volunteers had to name the color of the rectangles in the CNT neutral condition, and in the critical condition they had to either name the color of the numbers or, when the numbers were black, read the numbers. An interference index (II) was calculated for both tests by subtracting the time taken to complete the task in the neutral condition from the time taken to complete the task in the critical condition. The control group showed an II of 14.9 s in the SCWT and of 19.1 s in the CNT, and the experimental group, which practically presented no interference in the SCWT (II = 0.2 s), showed an II of 18.7 s in the CNT. These findings suggest that the CNT can be used to evaluate selective attention. Further work should confirm its validity. Its advantage over the SCWT is that it does not depend on the ability to read words, being then suitable for illiterate individuals.

References:

- Udacity Statistics Course Material.
- Wikipedia Information on Stroop Effect (https://en.wikipedia.org/wiki/Stroop_effect)
- Alternative to the Stroop Color-Word Test for illiterate individuals (http://www.ncbi.nlm.nih.gov/pubmed/17853139)
- http://www.graphpad.com/quickcalcs