Statistics: The Science of Decisions
Project Instructions

Background Information

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.

Questions For Investigation

As a general note, be sure to keep a record of any resources that you use or refer to in the creation of your project. You will need to report your sources as part of the project submission.

1. What is our independent variable? What is our dependent variable?
    a. Independent variable
        i. Word conditions (congruent or incongruent)
    b. Dependent variable
        i. Time it takes to name the ink colors
2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

There are two types of statistical hypotheses.

a. **Null hypothesis**. The null hypothesis, denoted by H_0, is usually the hypothesis that sample observations result purely from chance.

b. **Alternative hypothesis**. The alternative hypothesis, denoted by H_a, is the hypothesis that sample observations are influenced by some non-random cause.

c. Hypothesis for the stroop task :
    i. H_o (null hypothesis) : For the population, Congurent mean will be the same as incongruent population mean. The difference in the sample observations are purely from chance.

Congruent population mean (μ_c) = Incongruent population mean(μ_I)

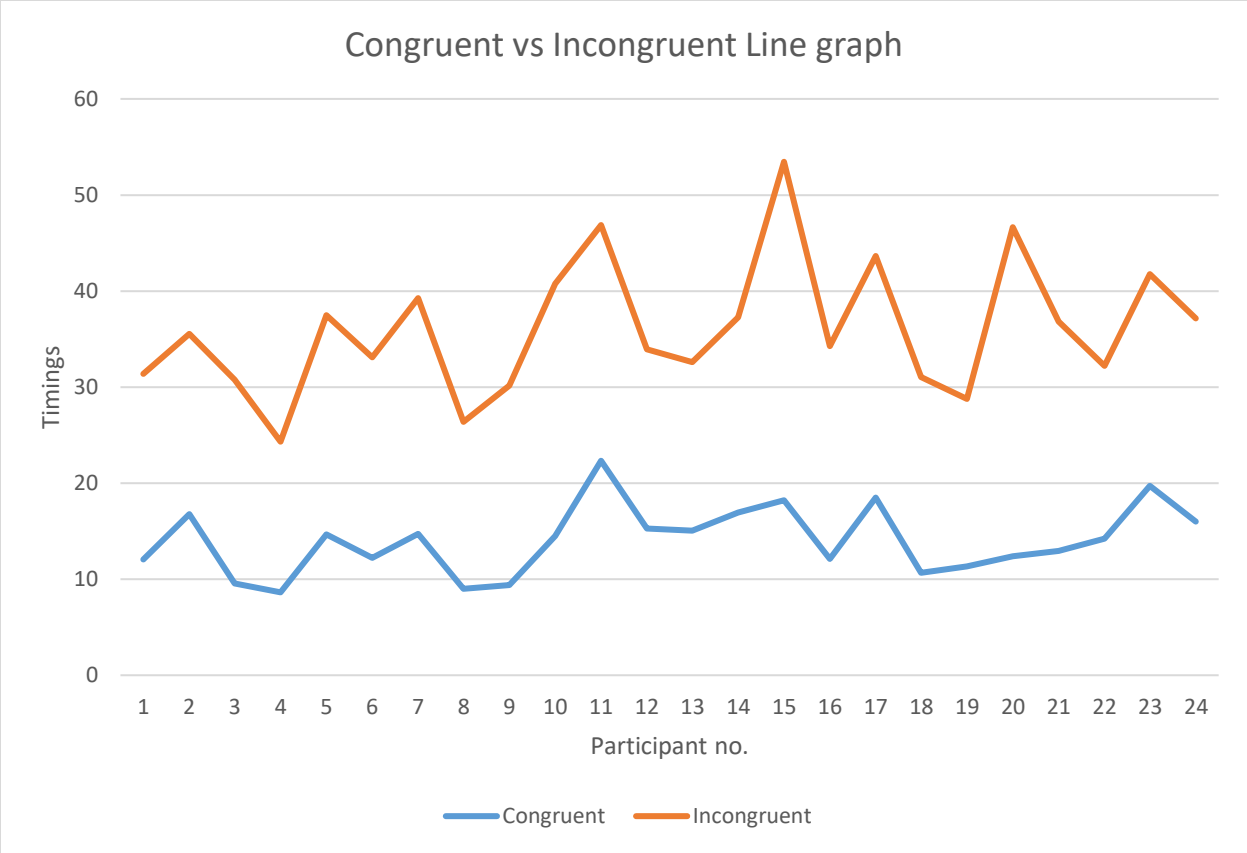
$\mu_c = \mu_I$

ii. H_a (alternative hypothesis) : For the population, Congurent mean will be less than the incongruent population mean. The difference in the sample observations are influenced by non-random cause.
Congruent population mean (μ_c) will be less than Incongruent population mean(μ_I)
$\mu_c < \mu_I$ --- chose a directional alternative

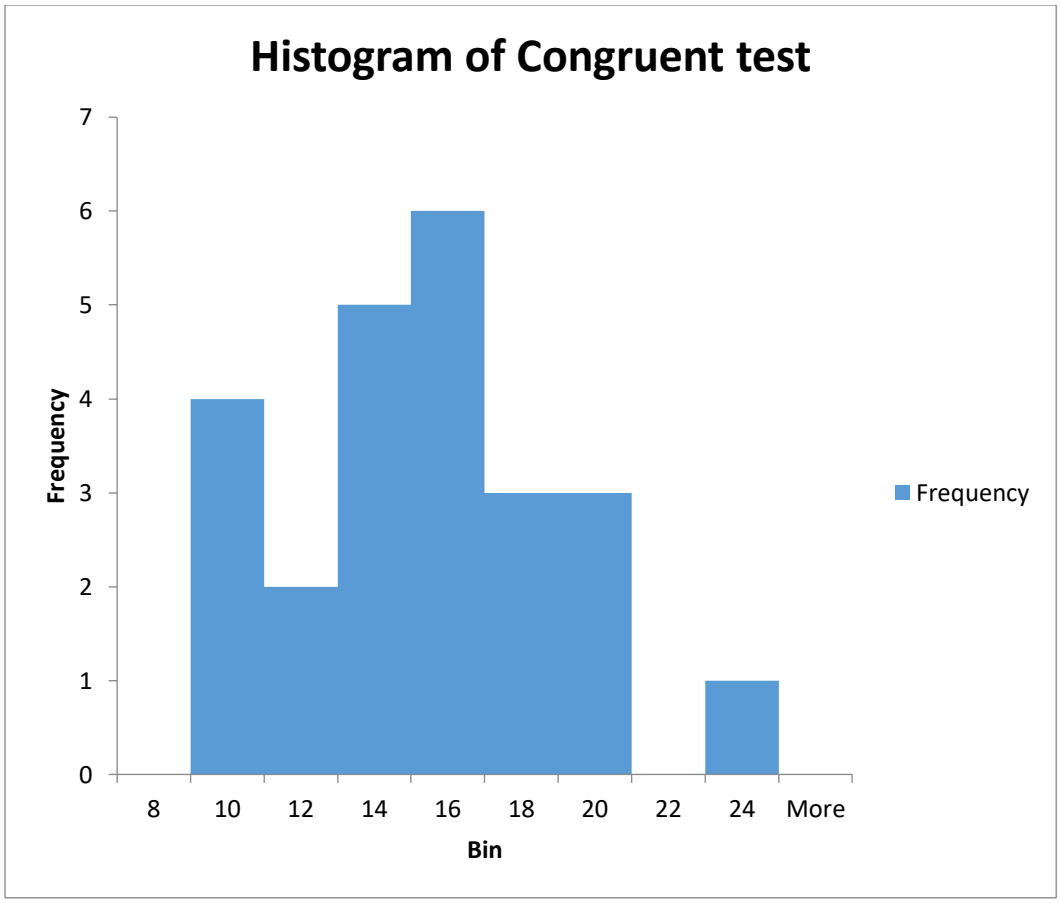
d. Types of test to perform:
   i. One-tailed t-test is chosen since the alternative hypothesis is directional, which is congruent population mean will be less than incongruent population mean.
      1. T-test is justified since we have results from a sample of participants. In this scenario z-test is not a good option since we don't have the population mean.
      2. In this scenario we have two dependent samples since the same subjects are taking the test twice with two different conditions.

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.

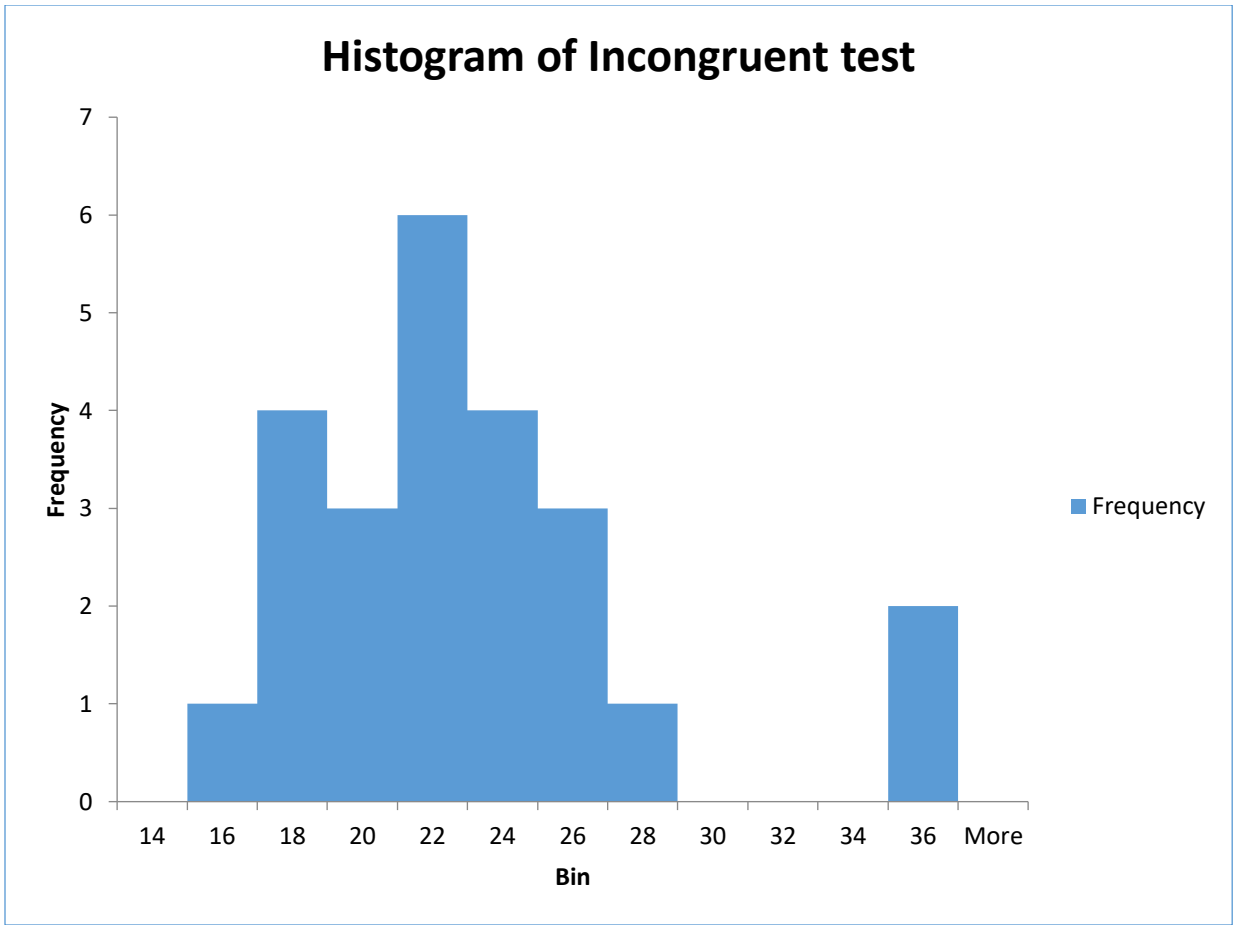
3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.
   a. Congruent average $\mu_c = 14.05$
   b. Incongruent average $\mu_I = 22.02$
   c. Difference average $\mu_d = \mu_I - \mu_c = 7.96$
   d. Sample size = n = 24
   e. Variance (using the differences between congruent and incongruent sample) = 544.33
   f. Sample standard deviation = $\sqrt{Variance \div (n-1)}$ = 4.86
   g. Degrees of freedom Df = n-1 = 23
   h. Standard Error = 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.



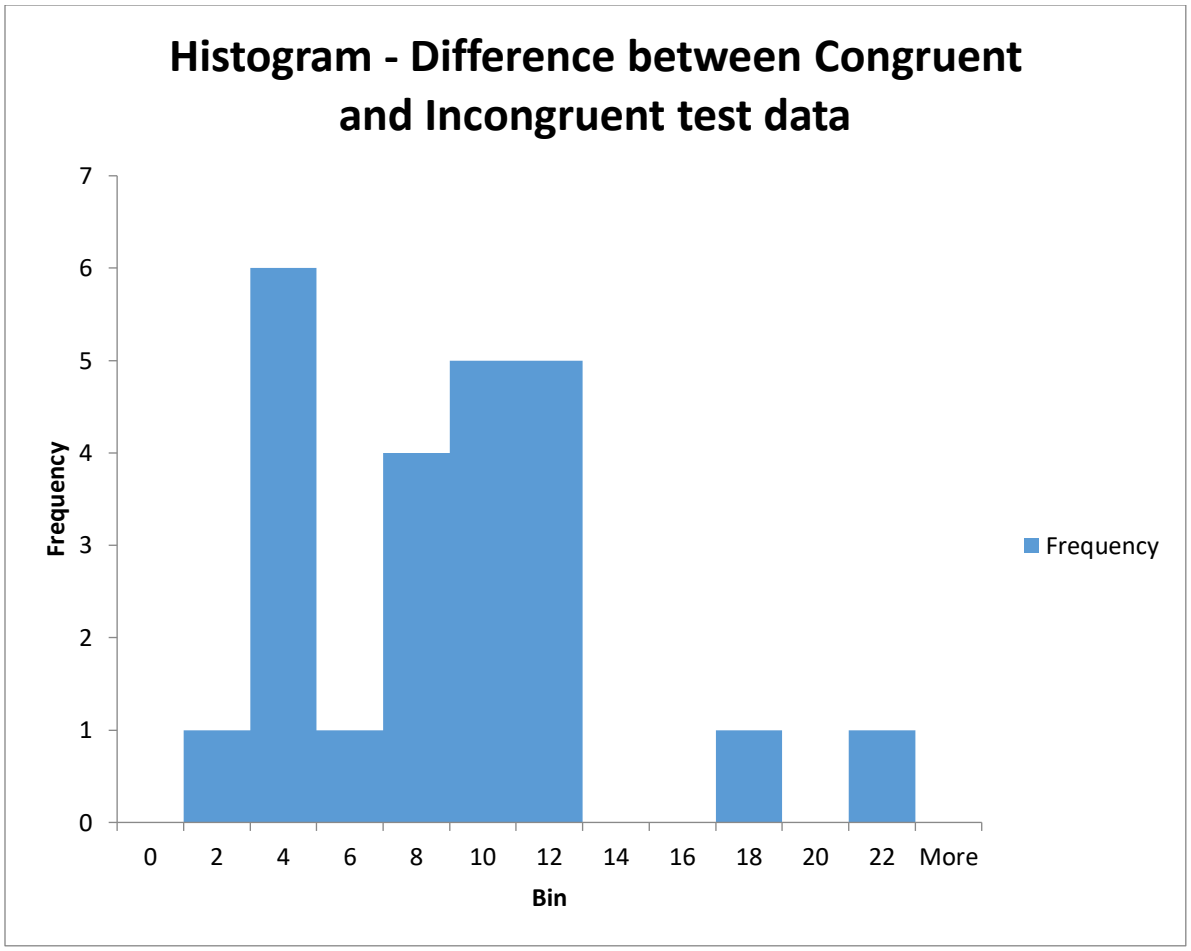
The above visualization is a line graph plotted with participants on x-axis and time taken for the test on Y-axis. From the visualization, it is clear that incongruent timings are consistently higher than the congruent timings for the sample participants.



The above Histogram represents the Congruent test data. The test results for most participants fall in the range between 13 and 17. It somewhat resembles normal distribution even though not a perfect one. We notice an outlier at 24 mins.



The above Histogram represents the Incongruent test data. The test results for most participants fall in the range between 17 and 27. It somewhat resembles normal distribution even though not a perfect one. We notice couple of outliers at 36 mins.



The above Histogram is plotted with timing difference between incongruent and congruent test results data. This distribution looks like a positively skewed distribution..

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?
   a. $t_{stat} = \frac{\text{Congruent aveage} - \text{Incongruent average}}{Standard\ Error}$ = -7.96/0.99 = -8.04
   b. $t_{critical}$ = -1.714 for $\alpha = 0.05$ with a single tail.
      i. t(23) = -8.04, p-value <0.00001 , one tailed
      ii. Since the t-statistic falls in the critical region based on the t-critical value, we reject null hypothesis. The result is significant at $p < 0.05$
      iii. 95% confidence interval of difference between congruent and incongruent means :

Upper limit = 7.96 + 1.714*0.99 = 9.66 and
Lower limit = 7.96 – 1.714*0.99 = 6.26
Confidence interval on the mean difference; 95% CI = (6.26, 9.66)

iv. Effect size measures:
    1. r^2 = 0.737 - it is very large which indicates the means of congruent and incongruent tests are likely very different
    2. Cohen's d =1.64 - the value indicates a very large effect that shows the congruent and incongruent means are going to be very different.

Conclusion: From our hypothesis testing and the results of the sample data, we can conclude for the population that there will be a significant difference in the mean task completion times between the congruent and incongruent tests. Incongruent tests will take much longer than the congruent tests.

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!
    a. There are couple of theories for stroop effect.
        i. **Speed of Processing Theory:** which says people are able to read words much quicker and to name the colour of the word is much more complex.
        ii. **Selective Attention Theory:** naming the actual colour of the words requires much more attention than reading the words.
    b. If participants are asked to identify the object in a picture, and presented with series of pictures and a title written on it, participants will do better if title matches the object in the picture. People tend to read titles faster than processing the picture.

References:
https://d2l.deakin.edu.au/d2l/eP/presentations/presentation_preview_popup.d2l?presId=67655

http://www.socscistatistics.com/pvalues/tdistribution.aspx - used this calculator for calculating p-value