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 fprinted. 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

1. **What is our independent variable? What is our dependent variable?**
   - The independent variable is the color of the ink in which the color words are printed.
   - The dependent variable is the time it takes to name the ink colors in equally sized lists.

2. **What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.**
   - In this task we want to understand if the difference between the mean of the sampling distribution for the incongruent condition and the mean of the sampling distribution for the congruent condition is significant.
   - To gain this understanding I will perform a dependent t-test for paired samples. This will be a two-tailed test ($\alpha = .05$):
     i. A t-test is appropriate – as opposed to a Z-test – because our sample size is smaller than 30, and we do not know the population mean.
     ii. Each subject in this example will respond both to the treatment and the control. This design calls for a dependent t-test for paired samples. This type of test is also called a "within-subject" or "repeated measures" design.
     iii. The test will be a two-tailed test because we are not concerned with the direction of the difference but rather knowing whether or not there is a difference.
     iv. I chose an alpha level of .05 because that is typically accepted as a sufficient level of significance but alpha levels of .01 or .001 are other options that if met would indicate a lower probability that a randomly chosen sample would have that particular mean.

- Null hypothesis: H_0: $u_c = u_i$
    i. u_c = The mean of the population of participants who were exposed to the *congruent* condition, as measured in seconds.
    ii. u_i = The mean of the population of participants who were exposed to the *incongruent* condition, as measured in seconds.

- Alternative hypothesis: H_a: $u_c \neq u_i$

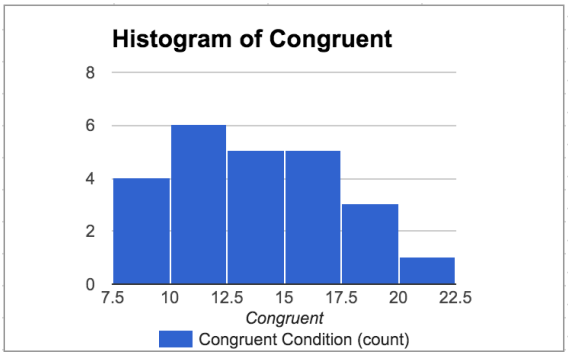
- The hypotheses above are appropriate for a two-tailed test of the type we're conducting. In this case, we are not concerned with the direction of the difference (i.e. larger or smaller) but instead we're concerned with whether there is a difference of some type.

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

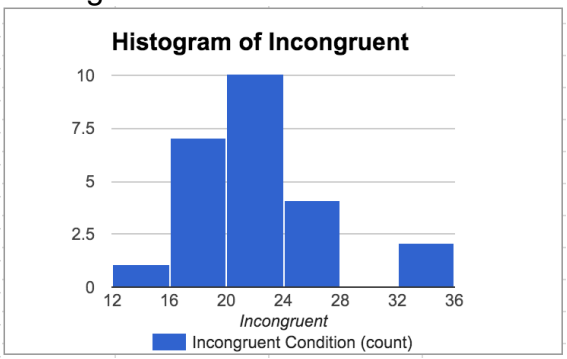
- Congruent words condition:
    i. n = 24
    ii. mean (X_c) = 14.05 seconds
    iii. median = 14.36 seconds
    iv. sample standard deviation / standard error = 3.56 seconds
- Incongruent words condition:
    i. n = 24
    ii. mean (X_i)= 22.02 seconds
    iii. median = 21.02 seconds
    iv. sample standard deviation / standard error = 4.80 seconds

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.

Histogram #1



Histogram #2



- These histograms plot the independent variable (Congruent or Incongruent condition) on the x-axis and the dependent variable (time, in seconds to read the color words) on the y-axis.
- The chart depicts the number of observations within each subset of the data or bin.
- For Histogram #1 the bin size is 2.5 seconds. For Histogram #2 the bin size is 4 seconds.
- The Histogram of the Incongruent dataset has a larger range than that of the Histogram for the Congruent dataset.
- Both of the histograms are somewhat normal-shaped.

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?**
   - Point estimate for X_c - X_i = 14.05 – 22.02 = -7.97
   - Standard Error, S = 4.86
   - t-value = t(23) = $u_c - u_i$ / (S / $\sqrt{24}$) = -7.97 / (4.86/4.90) = -8.05
   - critical values of the t-statistic ($\alpha = .05$) = +2.069 and -2.069

   - Conclusions:
     i. The null hypothesis is rejected because the t-value is well inside the critical region.
     ii. The confidence interval = -7.97 +/- 2.069(4.86 / $\sqrt{24}$)) = -7.97 +/- 2.05 = (-10.02,-5.92)
     iii. p value = less than .0001 (extremely statistically significant). (Calculated via GraphPad.)
     iv. r^2 = .74
     v. The experiment shows it is very unlikely that random chance caused the difference between the mean results of the congruent sample and incongruent sample. The experiment does not prove causality, however. It does allow us to reject the null hypothesis that that two means are equal.
     vi. These results align with intuition and experience. By taking the stroop test myself I can say it takes more time to process the incongruent condition than the congruent condition.

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!**

Based on my limited knowledge of cognitive neuroscience and on my readings from the web on the Stroop Effect -- specifically a faculty website at the University of Washington (url) -- I think the effects observed could be caused by a variety of factors. Generally speaking it could be due to an increased cognitive load when reviewing the incongruent condition. Specifically, the Speed of Processing Theory and the Selective Attention Theory could respectively or in tandem account for the increased amount of time on average it takes participants to complete the incongruent condition.

As noted in the University of Washington website, an interesting take on this study would be to try it with young children who know their colors but don't yet know how to read. Young childrens' lack of prior knowledge would perhaps allow them to process the color information more quickly. While this study is limited to colors it definitely prompts thinking on the impact of preconceived notions on how we evaluate the world.

Another related study, although perhaps difficult to carry out in an appropriately sensitive manner, could be to show pictures of peoples' faces but, for example, show the facial features of someone with a white, Northern European ethnicity/race but have the color of the skin be brown or black. Have the name of the race/ethnicity printed on the picture and ask the participants to read the words out loud. To be sure, it would hard to pull off this study in a sensitive way but the results could be interesting.