Project 1 - Stroop Effect Experiment Analysis
8/12/16

Experiment methodology:
In this experiment the participant is required to say the color of the word, not what the word says. For example, for the word, **RED**, you should say "Blue."
As soon as the words appear on your screen, read the list as fast as you can. When you have finished, click on the "Finish" button. The time it took you to read all of the words will be shown. If you want to try the same set of words, click on the "reload" button of your browser. If you want to continue with the experiment, click on "Continue Experiment."
In the first listing the ink color of the typed word is the same as the typed word color denotation; (eg 'Congruent', condition 1). In the second listing the ink color of the typed word is different from the typed word color denotation; (eg 'Incongruent', condition 2).

1. What is our independent variable? What is our dependent variable?
Independent Variable ---> the condition presented as being a congruent presentation or an incongruent presentation; specifically, the congruent or incongruent presentation between the color of the ink typed and the word for a particular color.
Dependent Variable ---> total response time; time it took you to speak out loud the ink color of a list of 25 words of various 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.
Null hypothesis ---> the difference in an average population response time to a congruent or an incongruent condition is zero
Alternative hypothesis ---> an Incongruent condition increases the average population response time

$$H_0 : \mu_{difference\ =\ 0}$$
$$H_A : \mu_{difference\ >\ 0}$$

$$\alpha = .01$$

A statistical 't test' would be expected in order to test the hypotheses since we have a sample but do not know the population parameters. Sample mean response time for the congruent condition provides a normal distribution which can be used to determine if the difference in congruent and incongruent response times is statistically significant.
The expected result is the Incongruent condition will show an increase in the average population response time.
Based on the alternative hypothesis, a one tailed in the positive direction t test is best suited to determine if there is a statistically significant increase in Incongruent condition response time. This is a within subject, two conditions experiment with a sample size of 24. The experiment results are presented as a paired, dependent sample. Thus, the sample size is statistically adequate given the dependent nature of the sample to state that t-test methodology is considered a statistically sound approach.

Justification for use of the t-test is as follows: It is reasonable to assert that the the underlying distribution of the population for the response time to the congruent condition for this experiment is symmetric, unimodal, and continuous. The 1-sample t-test is used to estimate the mean of an average population, in this case, for congruent condition response time and compare it to, in this case, a point estimate of the mean for the difference in response times between the congruent and incongruent conditions in this experiment. The t-test calculates the difference between the sample mean for the congruent condition and the hypothesized mean for the response time difference between the congruent and incongruent conditions relative to the variability of the sample. Usually, the larger the difference and the smaller the variability in the sample, the greater the chance that the population mean (eg average population response time to a congruent condition) differs significantly from the hypothesized mean (eg average population difference in response time to a congruent and incongruent condition).

3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.
Sample size ---> n = 24
Number of words in test set ---> 25
Mean response time Congruent set (condition 1): $\mu_{c = 14.05\ seconds}$
Mean response time Incongruent set (condition 2): $\mu_{i = 22.02\ seconds}$
Effect size ---> Mean of Difference; appropriate when experiment has a treatment variable and when meaning is easily understood. Indicative of the central tendency of the differences.
$\qquad \mu_D \ = \ 7.96$
Effect size ----> Standard Deviation of differences in response times for conditions 1 and 2 from sample: Indicative of variability of the differences.
$\qquad$ S = 4.87
Standardized measure ---> Cohen's d; the difference between the mean response times of the two individual conditions expressed in units of standard deviations of their differences..
$\qquad$ d = 1.64
Correlation measure ---> r^2; the proportion of increase in response time which can be explained by the Incongruent treatment.
$\qquad r^2 = .88$

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.
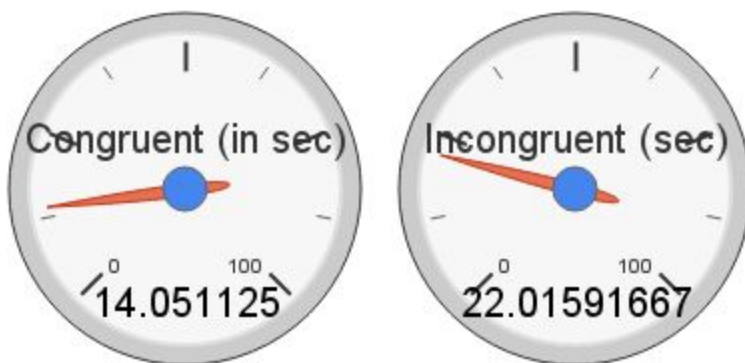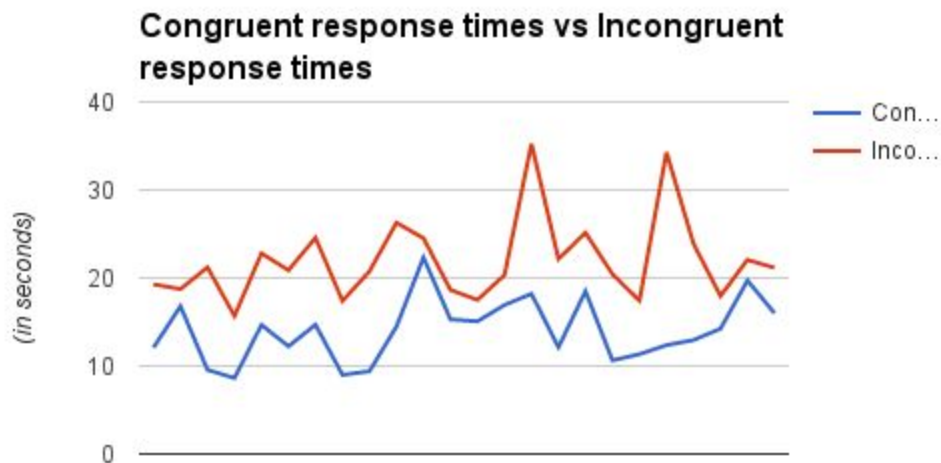
Mean response times in seconds

The top chart graph shows a consistent difference in response times across all participants. While there is not a sequential relationship between the participants the graphic is enhanced by inclusion of lines between the data points to focus on the consistentcy in response time differences and may be useful to highlight any potential outlier responses of additional samples. The lower chart visually shows the mean response time from each of the two conditions of the experiment.

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?

$H_0 = \mu_0 = 0$ $H_{A} = \mu_D > 0$ $\alpha = .01$ $t_{critical} = 2.500$

Results: t(23) = 8.02, p = .00001, one-tailed + direction

Conclusion: reject Null hypothesis; results match up with expectations.

The 99% Confidence Interval (CI) for the mean of the difference between the 'Incongruent' (condition 2) and 'Congruent' (condition 1) response times for the Stroop experiment is:
        CI (5.48, 10.45)

Effective Size measures: d = 1.64; r^2 = .88

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!

There are two theories that may explain the Stroop effect:
   1. Speed of Processing Theory: the interference occurs because words are read faster than colors are named.
   2. Selective Attention Theory: the interference occurs because naming colors requires more attention than reading words.

Similar tasks providing similar effects would be: 1) rotate the words upside down as opposed to changing the color of the word; 2) compare the use of short words to long words.

Two interesting observations based on my brief research of the Stroop Effect are:
   1) Young children may show a smaller differential response due to learning to identify colors earlier than learning spelling of words.
   2) Researchers use the Stroop test to determine a person's ability to multi-task and to test for disorders such as schizophrenia, ADHD, ADD.

References:
http://www.socscistatistics.com/pvalues/tdistribution.aspx; calculate probability
https://s3.amazonaws.com/udacity-hosted-downloads/t-table.jpg t-table reference
https://faculty.washington.edu/chudler/words.html understanding cause for Stroop effect
http://brainstormpsychology.blogspot.com/2013/08/the-stroop-effect.html
http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/hypothesis-tests/tests-of-means/why-use-1-sample-t