Stroop Effect Significance Test

Background

The Stroop Effect is the concept that when psychological interference is encountered, our response times slow. The version of the Stroop Effect test that will be analyzed is the classic color-match/no-color match version. Participants are shown words *of* colors, each printed in a particular ink. Sometimes the ink of a word will match the color the word represents. Other times not.

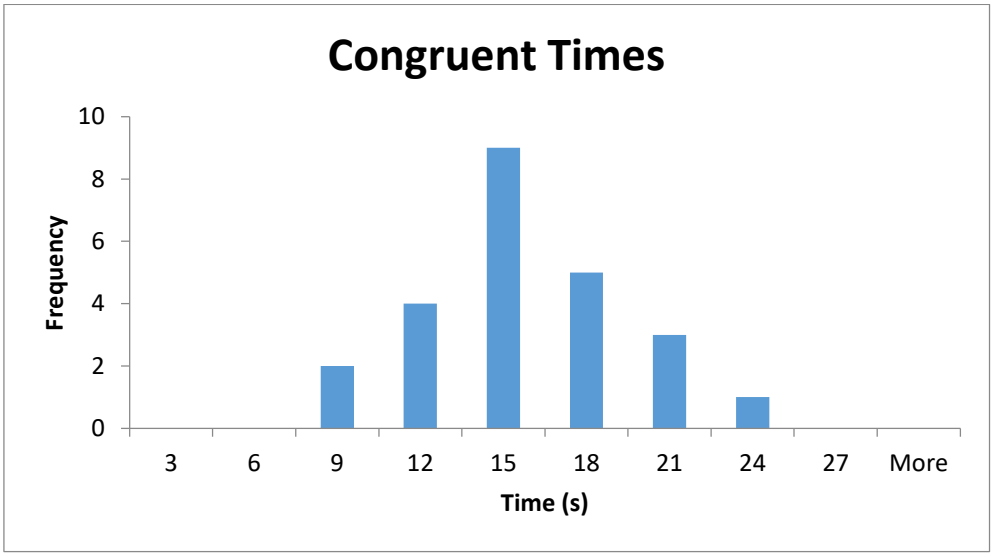
Variables

There are two variables worth considering for the purpose of statistical analysis. The independent variable is the congruency of the ink and the word. The dependent variable is the time it takes to complete the test.

Data Observations

Congruent Times

Plotting the congruent times on a histogram, we find a normally distributed set of data centered around ~15 seconds.

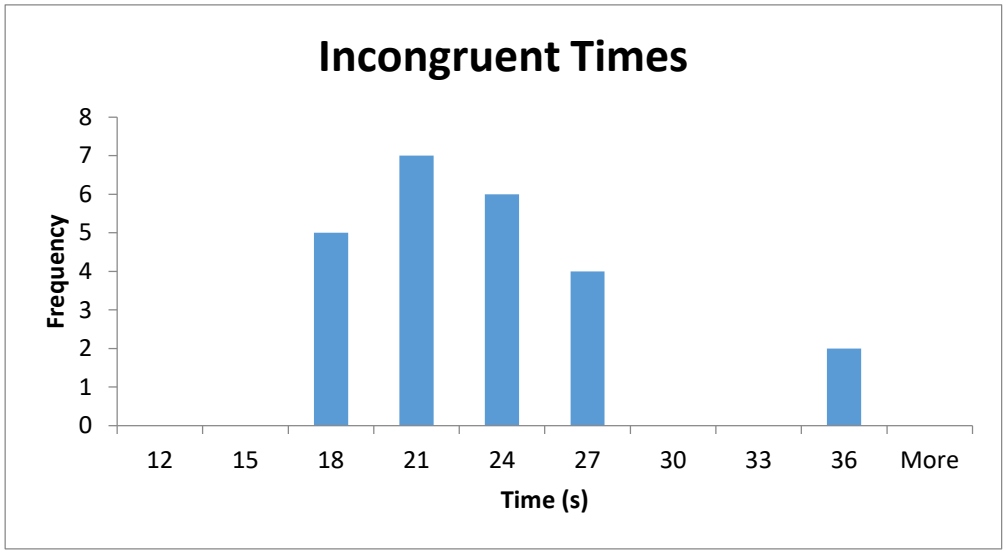


To determine if we have any outliers, we can calculate the inter-quartile range (IQR). The median value occurs at 14.4 when we put the times in order. Thus, our first quartile lies at t = 11.5, and our third quartile lies at t = 16.6. Finding the difference of these, our IQR is 5.1 seconds. Subtracting 1.5 times the IQR from the 1st quartile, and adding 1.5 times the IQR to the upper quartile, we can see if there are

any outliers; our lower fence lies at 3.9s and our upper fence lies at 24.2s. With no observations less than the lower fence, or greater than the upper fence, we observe there are no outliers.

Incongruent Times

Interestingly, we find incongruent times show a positively (or right) skewed distribution centered around ~24 seconds.



Applying the same procedure as before to test for outliers, we find our incongruent IQR is 5.7 seconds, not much different from the first test. Our lower fence lies at 10.1 seconds and our upper fence lies at 32.9 seconds. We see there are two values that qualify as outliers, the observations at 34.3 and 35.3 seconds.

Calculation

Choosing a Test

Since we are given samples of the data (each sample being less than 30), and population parameters are not available, we will use a Student's T-test. We will use this test to compare the means of the two tests to see if they are significantly different (a two sample T-test). Note this test assumes the distributions of the test times of each are normal.

Hypotheses

Null Hypothesis (H_0): There is no difference between the time it takes to complete the test with congruent ink and colors, and the test with incongruent ink and colors:

$$Where\ \mu_C\ is\ the\ mean\ of\ the\ test\ time\ with\ congruent\ ink\ and\ color\ names,$$

$$and\ \mu_I is\ the\ mean\ of\ the\ test\ time\ with\ incongruent\ ink\ and\ color\ names$$

$$\mu_C = \mu_I$$

Alternative Hypothesis (H_A): There is a difference between the time it takes to complete the test with congruent ink and colors, and the test with incongruent ink and colors:

$$\mu_C \neq \mu_I$$

Confidence Interval

To create a confidence interval, we will first select a significance level, α. A common significance level is α = 0.05, which will be useful for our purposes. Another could be chosen, but this is a good place to start.

From this critical level, we must determine the t-critical values. Both of our samples have 24 observations, so we have 24 + 24 - 2 = 46 degrees of freedom.

Consulting a t-table, the closest available degrees of freedom is 50, thus at the 5% alpha level we find a t-critical value of 2.009.

Calculating the standard deviations of the congruent and incongruent tests (using Bessel's correction, because we are taking from samples), they are 3.559 and 4.797, respectively.

With this information, we can calculate the standard error:

$$SE = \sqrt{\frac{3.559^2}{24} + \frac{4.797^2}{24}}$$

$$SE \approx 1.219$$

$$\mu_I - \mu_C = 22.016 - 14.051 = 7.965$$

$$t = \frac{\mu_I - \mu_C}{SE} = \frac{7.965}{0.993} = 8.021$$

Interpretation

Because our calculated t value is greater than our t-critical value, our p value is *less* than the critical p-value and we can reject the null hypothesis; we believe the mean time on the incongruent test is not the same as the time on the congruent test at the α = 0.05 level. In fact, consulting our t table, we can see that this result is significant even at the α = 0.0005 level. Our result is compelling.

Further Study

Our statistical test has definitively shown there is a difference between the two tests. But it has not shown the cause of the difference. Further research is necessary to show why it takes longer to complete the incongruent test than the congruent test.