Test a Perceptual Phenomenon

February 15, 2018

0.0.1 Analyzing the Stroop Effect

Perform the analysis in the space below. Remember to follow the instructions and review the project rubric before submitting. Once you've completed the analysis and write up, download this file as a PDF or HTML file and submit in the next section.

(1) What is the independent variable? What is the dependent variable?

```
In [3]: import pandas as pd
```

Answer:

The independent variable is the color of ink. The dependent variable is the 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.

Answer:

The null hypothesis (H0): the mean reaction time for color recognition for congruent words (C) is equal to or greater than the mean time for incongruent words (In), therefore implying a one-tailed test. H0: (c) >= (In)

The alternative hypothesis (H1): Mean of the congruent words is less than mean of the incongruent words. H1: (c) < (In)

Here is a population mean, the "C" represents the congruent words condition, and "In" represents the incongruent words condition.

A one-tailed, dependent samples t-test comparing the difference in means of reaction time should be performed. Using this test, we are going to determing whether there is enough evidence from the sample data to infer that the mean color reaction time of congruent words condition is shorter than the mean time of incongruent words condition for the whole population data.

A t-test is appropriate because the population variance is unknown and the sample size is less than 30. When the sample size is less than 30, the sample data no longer approximate a normal distribution, which makes the use of a Z-value inappropriate.

A one-tailed test is appropriate under the assumption that incongruent word conditions will not improve recognition times, which is intuitive. The one-tailed test allows for a more scrutinous examination of the negative impact of incongruent word conditions on recognition times.

Since the same subject is exposed to two conditions and tested for each, which are the defining criteria for "within-subjects" or "repeated-measures" statistical tests, the t-test should be of the dependent samples variety. "https://statistics.laerd.com/statistical-guides/dependent-t-test-statistical-guide.php"

(3) Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability. The name of the data file is 'stroop-data.csv'.

```
In [5]: df = pd.read_csv('stroopdata.csv')
        Congruent = df['Congruent']
        Incongruent = df['Incongruent']
        Difference = df['Congruent'] - df['Incongruent']

        # Calculate mean
        print('Mean: ', Congruent.mean(),
        Incongruent.mean(),
        Difference.mean())

        #Calculate median
        print('Median: ', Congruent.median(),
        Incongruent.median(),
        Difference.median())

        #Calculate STDV
        print('STDV: ', Congruent.std(),
        Incongruent.std(),
        Difference.std())
```

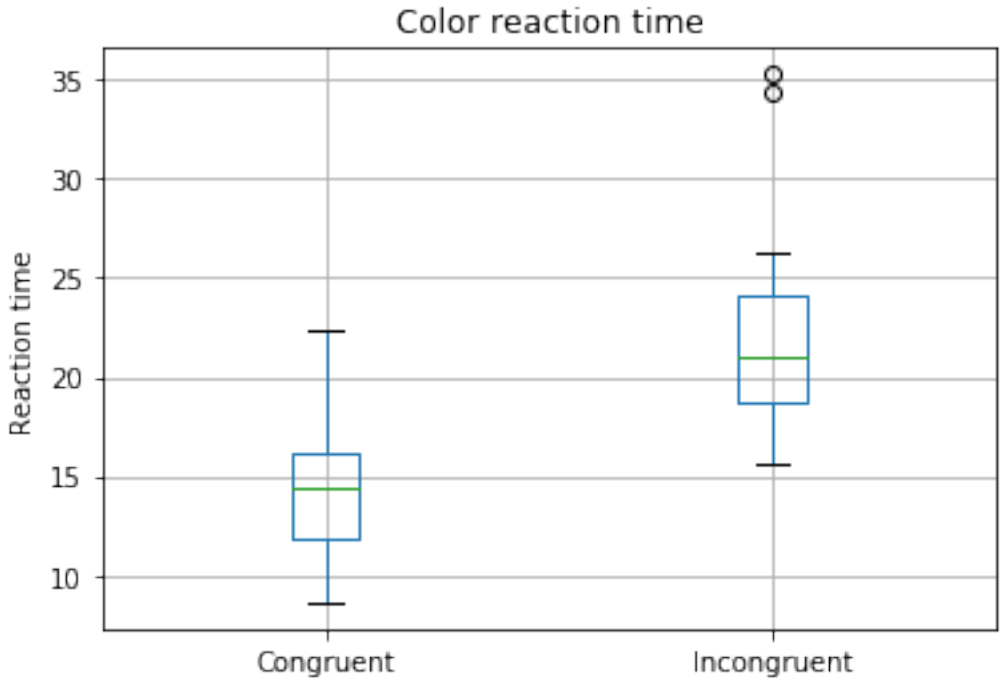
```
Mean:  14.051125 22.0159166667 -7.96479166667
Median:  14.3565 21.0175 -7.666499999999999
STDV:  3.55935795765 4.79705712247 4.86482691036
```

Answer:
Mean: Congruent(C): 14.0511 Incongruent(In): 22.0159 Difference(C-In):-7.9647
Median: Congruent(C): 14.3565
Incongruent(In): 21.0175 Difference(C-In): -7.6665
STDV: Congruent(C): 3.5593
Incongruent(In): 4.7970 Difference(C-In): 4.8648

(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.

```
In [7]: import matplotlib.pyplot as plt

        # Boxplot figure showing the distribution of the sample data
        # Reference https://matplotlib.org/examples/pylab_examples/boxplot_demo.html
        bp = df.boxplot()
        plt.xlabel(" ")
        plt.ylabel("Reaction time")
        plt.title("Color reaction time")
        plt.show()
```

```
# plots all columns against index
df.plot()
plt.xlabel(" ")
plt.ylabel("Reaction time")
plt.title("Color reaction time")
plt.show()
```



Answer:

Please check the two figures above which are showing the distribution of the sample data.

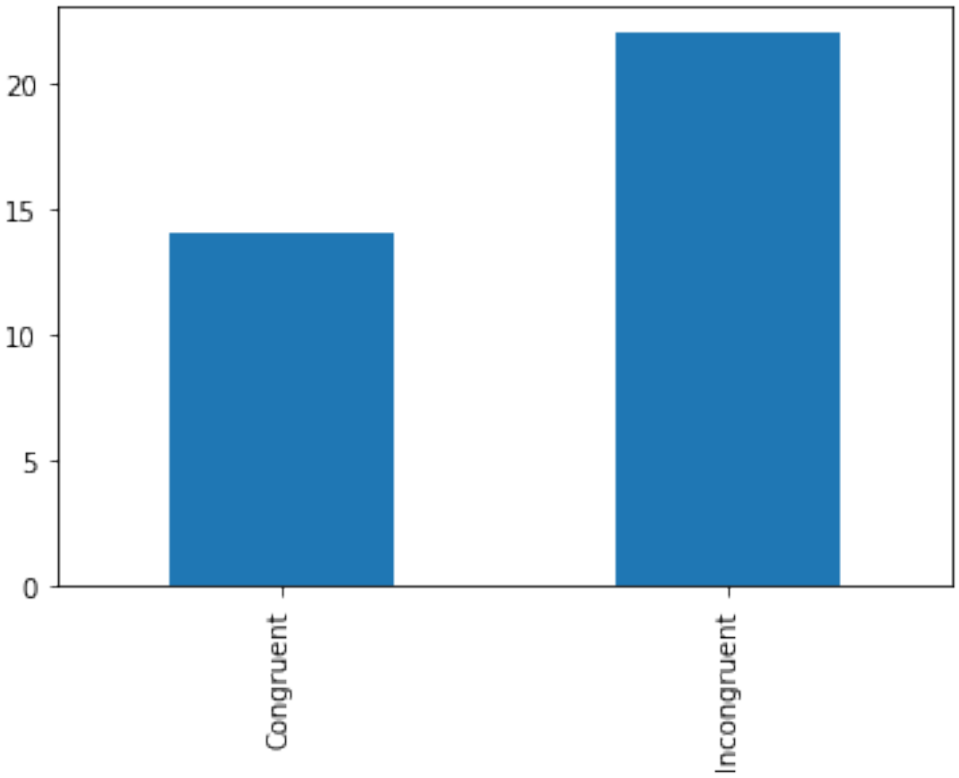
The range of reaction time of the congruent words is 8 seconds to 24 seconds. The range of reaction time of the incongruent words is 12 seconds to 36 seconds. Most of the congruent words reaction time are shorter than the incongruent words reaction time.

(5) Now, perform the statistical test and report the results. What is the 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?

```
In [12]: import plotly.plotly as py
         import plotly.graph_objs as go
         from plotly.tools import FigureFactory as FF

         import numpy as np
         import scipy.stats as stats
         Con = df['Congruent'].values.tolist()
         In = df['Incongruent'].values.tolist()

         # Plot the means (optional)
         df.mean().plot('bar')

         # Perform ttest
         twosample_results = stats.ttest_rel(Con,In)
         Statistic = twosample_results[0]
```

```
        #pValue for One-tailed t-test
        pValue = twosample_results[1]/2

        print ('Statistic: ', Statistic)
        print ('pValue: ', pValue)
```

```
Statistic:  -8.02070694411
pValue:  2.05150029286e-08
```



Answer:

At the 95% confidence level (= .05) and 23 degrees of freedom, the statistic for the difference in color reaction time means of the congruent and incongruent words data is -8.02070, the pValue of one-tailed t-test is 2.0515e-08 which is in the critical region, the null hypothesis is rejected.

According to the results showing above, the difference in mean reaction time for the congruent data vs the incongruent data is considered to be extremely statistically significant. Since we have used one-tailed paired t-test, the mean reaction time for the congruent data is considered to be statistically significantly shorter than the incongruent data. This results matched our hypothesis.

References:

Wikipedia: Numerical Stroop effect https://en.wikipedia.org/wiki/Numerical_Stroop_effect

Boxplot: https://matplotlib.org/examples/pylab_examples/boxplot_demo.html

One-tailed t-test in python: https://docs.scipy.org/doc/scipy-0.15.1/reference/generated/scipy.stats.ttest_1samp.html

Unpaired and paired t-test: https://en.wikipedia.org/wiki/Student%27s_t-test#Unpaired_and_paired_two-sample_t-tests