Test a Perceptual Phenomenon

January 30, 2019

0.1 Analyzing the Stroop Effect:

0.1.1 Background

Before We analyse the dataset lets see the background of Stroop Effect , 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: (e. RED wrotten in RED ink). In the incongruent words condition, the words displayed are color words whose names do not match the colors in which they are printed: (e. PURPLE wrotten in ORANGE ink). 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, and that's what we have as a dataset.

0.2 Overview

Now that we have seen the background of what is Stroop Effect is,now lets see the overview of this project First, we need to get to know our data, by printing some examples and the type of each variable. Then we clean and reorganize the variables before proceeding to the part of answering our question and making vizualisation. We will need to import pandas since we will be using our dataframes, and matplotlib to make some visualisations

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

The independent variable : The type of test (congruent / incogruent).
In this experiment it is whether the word name and font color were the same or different
The dependent variable : The response time in second,
in this experiment it is Response time(RT) of the participant to name the font color of the word.

```
In [1]: %matplotlib inline
        import pandas as pd
        import matplotlib.pyplot as plt
        import plotly.plotly as py
        import seaborn as sns
        import scipy.stats as stats
```

```
In [2]: stroop_data = pd.read_csv('stroopdata.csv')
```

```
In [3]: stroop_data.head()
```

```
Out[3]:    Congruent  Incongruent
        0     12.079       19.278
        1     16.791       18.741
        2      9.564       21.214
        3      8.630       15.687
        4     14.669       22.803
```

(2) What is an appropriate set of hypotheses for this task? Specify your null and alternative hypotheses, and clearly define any notation used. Justify your choices. We want to evaluate the effect on the performance of the participants and see whether the difference in our sample is because of the fact the congruent and incongruent test are significantly different.

- ţC : The congruent population's response time mean
- ţI : The incongruent population's response time mean An appropriate set of hypotheses :

H0 : The null hypothesis, that the congruent and incongruent populations are not significantly different (ţC ţI = 0)

- mathematically represented as ##### H0:ţC = ţI

HA : The alternative hypothesis, that the congruent and incongruent populations are significantly different (ţC ţI 0)

- mathematically represented as #### HA: ţI > ţC

In our case:
The sample size is below 30. (from stroop_data.info(1) (24 entries)) The same participant is measured at two time points. ###### Therefore, we will conduct a Dependent t-test for Paired Samples.

(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 'stroopdata.csv'.

```
In [4]: %matplotlib inline
        import pandas as pd
        import matplotlib.pyplot as plt
        import plotly.plotly as py
        import seaborn as sns
        import scipy.stats as stats
```

```
In [5]: stroop = pd.read_csv('stroopdata.csv')
```

```
In [6]: stroop.describe()
```

Out[6]:

	Congruent	Incongruent
count	24.000000	24.000000
mean	14.051125	22.015917
std	3.559358	4.797057
min	8.630000	15.687000
25%	11.895250	18.716750
50%	14.356500	21.017500
75%	16.200750	24.051500
max	22.328000	35.255000

In [7]:
```
congruent_data = stroop["Congruent"]
incongruent_data = stroop["Incongruent"]

# Create a Series for the difference between the conditions
stroop["Difference"] = stroop["Congruent"] - stroop["Incongruent"]

print("\n")
print ("Stroop Data Descriptive Statistics")
print("\n")
print (stroop.describe())
print("\n")
```

Stroop Data Descriptive Statistics

	Congruent	Incongruent	Difference
count	24.000000	24.000000	24.000000
mean	14.051125	22.015917	-7.964792
std	3.559358	4.797057	4.864827
min	8.630000	15.687000	-21.919000
25%	11.895250	18.716750	-10.258500
50%	14.356500	21.017500	-7.666500
75%	16.200750	24.051500	-3.645500
max	22.328000	35.255000	-1.950000

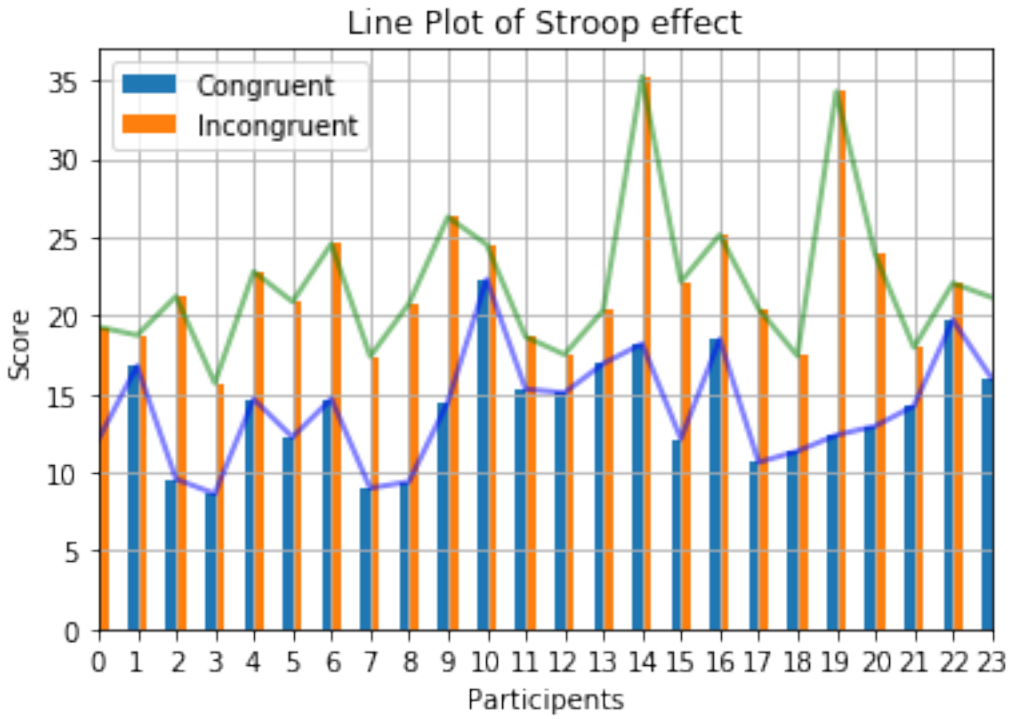
In [10]:
```
# Now we will Calculate for a sample t-value[7]
tvalueResults = stats.ttest_rel(incongruent_data, congruent_data)
tstat = tvalueResults[0]
pvalue = tvalueResults[1]
print ("t-value = " + '%.2f' % tstat)
print ("p-value = " + '%.8f' % pvalue)
```

```
t-value = 8.02
p-value = 0.00000004
```

(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.

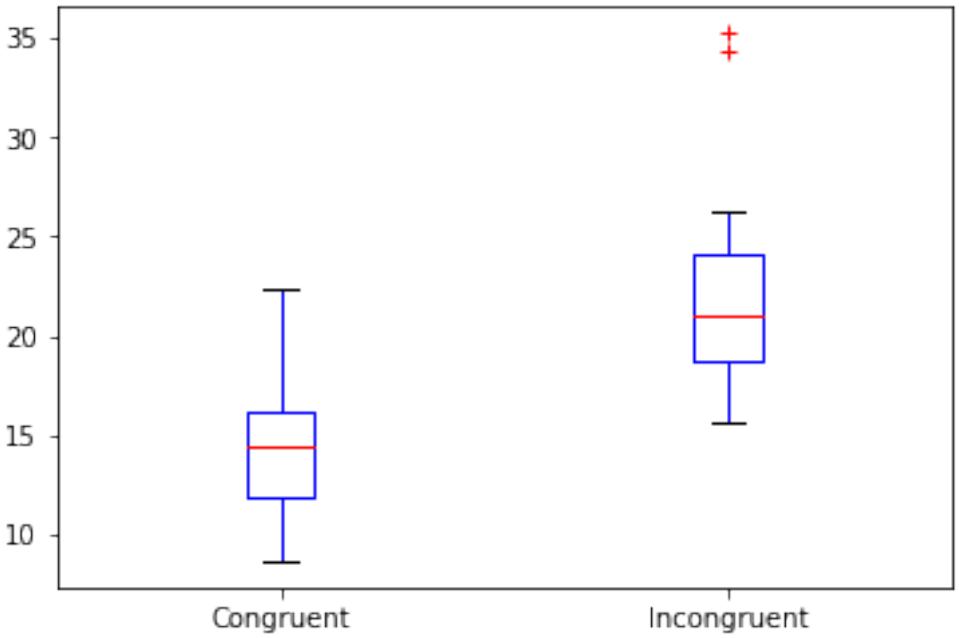
```
In [11]: stroop_data.plot(kind='bar')
         stroop_data.Congruent.plot(kind = 'line', color = 'b',label = 'Congruent',linewidth=2,a
         stroop_data.Incongruent.plot(color = 'g',label = 'Incongruent',linewidth=2, alpha = 0.5
         plt.xlabel('Participents')
         plt.ylabel('Score')
         plt.title('Line Plot of Stroop effect')
```

```
Out[11]: Text(0.5,1,'Line Plot of Stroop effect')
```



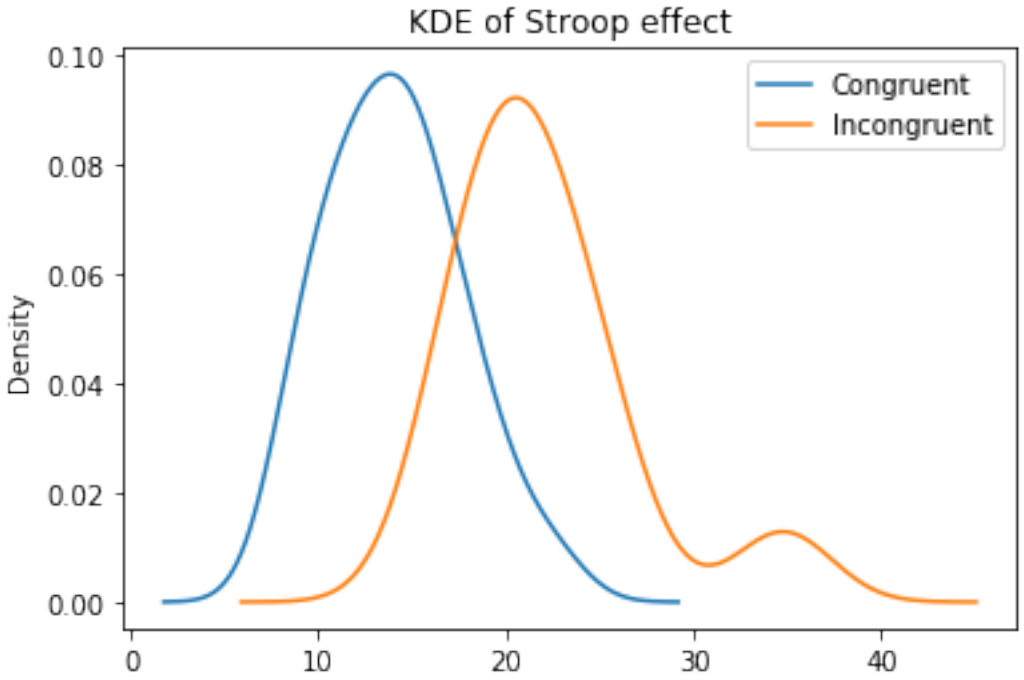

```
In [14]: color = dict(boxes='Blue', whiskers='Blue', medians='Red', caps='Black')
         stroop_data.plot.box(color = color, sym = 'r+')
```

```
Out[14]: <matplotlib.axes._subplots.AxesSubplot at 0x7f97dc5a1da0>
```




```
In [17]: stroop_data.plot.kde()
         plt.title('KDE of Stroop effect')

Out[17]: Text(0.5,1,'KDE of Stroop effect')
```



-both Sample look normally distributed with a similar variance

-The incongruent task distribution of performance times seems to have a small peak around 35 seconds

5. Now, perform the statistical test and report your results. What is your confidence level or Type I error associated with your test? What is your conclusion regarding the hypotheses you set up? Did the results match up with your expectations?

```
In [19]: # Calculte the mean of each test
         mean_congurent = stroop_data['Congruent'].mean()
         mean_incongurant = stroop_data['Incongruent'].mean()

         # Calculte a point estimate using (mean_congurent - mean_incongurant) / Average of diff
         estimate_point = mean_congurent - mean_incongurant

         # Calculate Square of Sums of difference of sample means
         ssd = sum( ( (stroop_data['Congruent'] - stroop_data['Incongruent']) - estimate_point )

         # Calculate the variance of difference
         vd = ssd / (24 -1)

         # Calculate Standard Deviation of Differences
         sdd = vd ** (1/2)
         ###########################################
         # We can get this result easily using pandas std()
         # but before we have to add a column this way
         # stroop_data['difference'] = stroop_data['Incongruent'] - stroop_data['Congruent']
         # sdt = stroop_data.std()
         # sdd = sdt['difference']
         ###########################################

         #  calculate the t-statistic for the difference
         tstatistic = estimate_point / ( sdd / ( 24 ** (1/2) ) )

         ###########################################
         # We could find t-statistic easily importing stats from scipy.stats
         # import scipy.stats as stats
         # stats.ttest_rel(a = stroop_data['Congruent'], b = stroop_data['Incongruent'])
         # Ttest_relResult(statistic=-8.020706944109957, pvalue=4.1030005857111781e-08)
         # then we get the tstatistic  and the p value
         ###########################################

         # Calculate the Degrees of Freedom (n -1)
         df = 23

         # Calculte the chances of seeing a result as extreme as the one we observed (known as t
```

```
        pvalue = stats.t.cdf(x = tstatistic, df = 23 ) * 2

        # Clacute t-critical for alpha level 0.005 (aiming to 99% confidence level)
        alpha = 0.005
        tcritical = stats.t.ppf(q=alpha, df=23)
```

```
In [20]: print("Degrees of Freedom : df =", df)
         print("Alpha- level : a =", alpha)
         print("t-critical values :  tc  =", -tcritical, tcritical)
         print("t-Statistic(df) : t(23) =", tstatistic)
         print("p-value : p =", pvalue)
```

```
Degrees of Freedom : df = 23
Alpha- level : a = 0.005
t-critical values :  tc  = 2.80733568377 -2.80733568377
t-Statistic(df) : t(23) = -8.02070694411
p-value : p = 4.10300058571e-08
```

If the calculated t-statistic is greater than the critical t-value, the test concludes that there is a statistically significant difference between the two populations. Therefore, you reject the null hypothesis that there is no statistically significant difference between the two populations.

We see that

- The t-statistic is clearly smaller than the negative t-critical value
- In the critical region with a p-value < 0.0001

Therefore we reject the Null Hypothesis with a 99% Confidence level and conclude that there is a significant difference in the scores for congruent and incongruent tasks

The results and our observation match up and expectations that there is a statistically difference in the response time to perform the incongruent test compared to the congruent test

(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!

The two main areas in the brain that are involved in the processing of the stroop task. One of them involves activating the area of the brain related to the color preception,the others focus on the word.

There are many theories that may explain the Stroop effect , two of them are:

- Speed of Processing Theory: the interference occurs because the brean reads faster than it recognizes colors
- Selective Attention Theory: the interference occurs because recognizing of colors requires more attention than reading words.

0.2.2 References

https://towardsdatascience.com/inferential-statistics-series-t-test-using-numpy-2718f8f9bf2f
https://en.wikipedia.org/wiki/Stroop_effect http://www.statisticshowto.com/probability-and-statistics/ http://hamelg.blogspot.com/2015/11/python-for-data-analysis-part-24.html
https://www.kaggle.com/anouarz/kernels/notebooks/new?forkParentScriptVersionId=1761024

In [ ]: