Test_a_Perceptual_Phenomenon

April 27, 2021

1 Test a perceptual phenomenon

1.1 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 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: 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.

1.2 Analysis

1.2.1 Q1.

What is our independent variable? What is our dependent variable?

1.2.2 A1.

The independent variable is the variable that is changed or controlled in a scientific experiment to test the effects on the dependent variable. If the independent variable is changed, then an effect on the dependent variable can be observed.

In this case the independent variable has two conditions, either the congruent words condition or the incongruent words condition. The dependent variable is the response time for each participant to name the color.

1.2.3 Q2.

a) What is an appropriate set of hypotheses for this task? b) What kind of statistical test do you expect to perform? Justify your choices.

1.2.4 A2.

a) Null Hypothesis, H_0 - No change in time between two reading tasks (congruent or incongruent) Alternate Hypothesis, H_a - incongruent task takes more time than congruent.

Null Hypothesis (H_0): A null hypothesis claims that no significant difference exists between the set of variables. It is the original or default statement, with no effect. In this experiment the null hypothesis is the hypothesis that there is no significant difference between the time taken to say the congruent words and incongruent words. I.e. the mean of the reaction time for the congruent sample ($\bar{x_c}$) will be equal to the mean of the reaction time for the incongruent sample ($\bar{x_i}$).

Alternative Hypothesis (H_a): An alternative hypothesis claims that there is a significant difference between the set of variables. In this experiment the alternative hypothesis is that there is a significant difference between the time taken to say the congruent words and incongruent words. I.e. the mean of the reaction time for the congruent sample ($\bar{x_c}$) will **not** be equal to the mean of the reaction time for the incongruent sample ($\bar{x_i}$).

H_0 (Null Hypothesis) : $\mu_i = \mu_c$

H_a (Alternative Hypothesis) : $\mu_i \quad \mu_c$

μ_i = Mean time to name the ink color for incongruent words. μ_c = Mean time to name the ink color for congruent words.

If we get a significant result, we can reject the null hypothesis and accept the alternative hypothesis that there are statistically significant differences between the mean time taken to name ink color between two test conditions.

b) Option 1: Hypotheses Test - A hypothesis test is used to test a claim that someone has about how an observation may be different from the known population parameter

Option 2: Dependent T-Test - The dependent t-test (also called the paired t-test or paired-samples t-test) compares the means of two related groups to determine whether there is a statistically significant difference between these means - The t-Test is best to use when we do not know the population standard deviation

I will chose the t-Test because: - we do not know the population standard deviation - t-test is best used to compare two dependent samples(paired samples). They are dependent when the same subject takes the test twice. This is a Within-subject design. For example when each subject is assigned two conditions, like we do in our case.

1.2.5 Q3.

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

[98]:
```
import math
import seaborn as sns
import numpy as np
import pandas as pd
from scipy.stats import t as pt
import matplotlib.pyplot as plt
%matplotlib inline
```

[99]:
```
data = pd.read_csv("stroopdata.csv")
data
```

[99]:

	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
5	12.238	20.878
6	14.692	24.572
7	8.987	17.394
8	9.401	20.762
9	14.480	26.282
10	22.328	24.524
11	15.298	18.644
12	15.073	17.510
13	16.929	20.330
14	18.200	35.255
15	12.130	22.158
16	18.495	25.139
17	10.639	20.429
18	11.344	17.425
19	12.369	34.288
20	12.944	23.894
21	14.233	17.960
22	19.710	22.058
23	16.004	21.157

[100]:
```
data.describe()
```

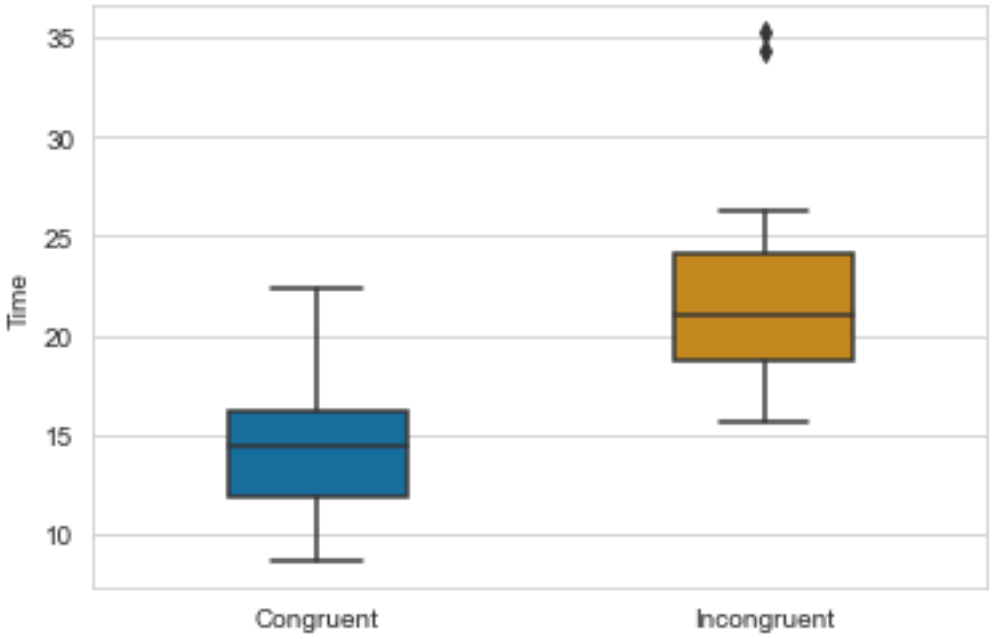
[100]:

	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

1.2.6 Q4.

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.

[101]:
```
#Boxplot for both samples
sns.set_style("whitegrid")
sns.boxplot(data=data[['Congruent', 'Incongruent']], orient="v",width=0.4,␣
 ↪palette="colorblind");
plt.ylabel("Time");
```



Above boxplots show the interquartile range of the two datasets. One can see that the average incongruent times are higher. The incongruent data set even contains two outliers at around 35 seconds.

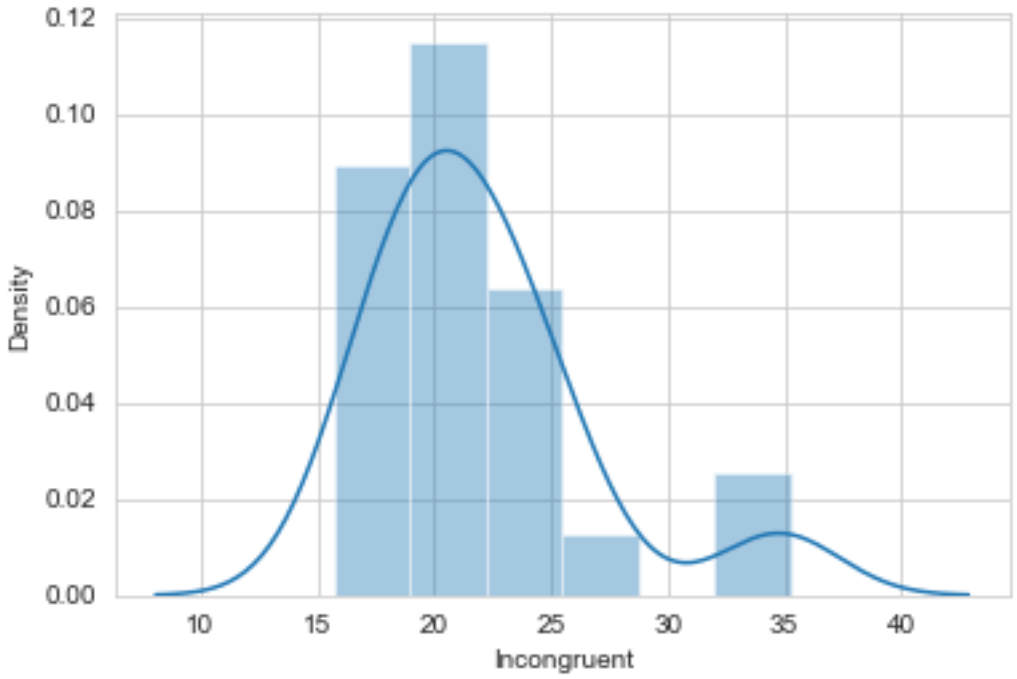
[102]:
```
#Plot a Graph for congruent dataset
sns.distplot(data['Congruent'])
plt.xlabel("Time");
plt.ylabel("Frequency");
plt.title("Response Time for Congruent Words");
```

```
C:\Users\Rapha\anaconda3\lib\site-packages\seaborn\distributions.py:2551:
FutureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-level
function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

[103]:
```
sns.distplot(data['Incongruent'])
```

```
C:\Users\Rapha\anaconda3\lib\site-packages\seaborn\distributions.py:2551:
FutureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-level
function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

[103]:
```
<AxesSubplot:xlabel='Incongruent', ylabel='Density'>
```



[104]:
```
#Compare Both the datasets and make a graph
sns.distplot(data['Congruent'],label = "Congruent")
sns.distplot(data['Incongruent'],label = "Incongruent")
plt.xlabel("Time");
plt.ylabel("Frequency");
plt.title("Response Time For Congruent and Incongruent");
plt.legend();
```

```
C:\Users\Rapha\anaconda3\lib\site-packages\seaborn\distributions.py:2551:
FutureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-level
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function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

Both datasets are quite close to normal distribution with clearly different means. Only the two outliers disturb the picture.

1.2.7 Q5.

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?

1.2.8 A5.

I will use a two tailed t-Test to test my two samples against my Null-Hypotheses that both groups are not significantly different.

$t = \frac{\mu_c - \mu_i}{\frac{S}{\sqrt{n}}} = \frac{\bar{x}_c - \bar{x}_i}{\frac{S}{\sqrt{n}}} = \frac{\bar{x}_D}{\frac{S}{\sqrt{n}}}$

$\bar{x}$ (=point estimate of the population mean μ_0), here $\bar{x_c}$ = sample mean congruent, $\bar{x_i}$ = sample mean incongruent

D = Sample differences (= $\bar{x_c}$ - $\bar{x_i}$)

$\bar{x}_D$ = Mean of the sample differences

S (= Standard Deviation), here S_D = Standard Deviation of the differences = $\sqrt{\frac{\sum(D-\bar{x_D})^2}{n-1}}$

t = t-Statistic, or difference between sample means in standard errors

$\frac{S}{\sqrt{n}}$ = standard error (SE)

$t \times \frac{S}{\sqrt{n}}$ = Margin of error

[105]:
```
#standard deviation of the differences (as per L10a - 34.)

from statistics import mean

D = data['Congruent'] - data['Incongruent']
x_D = mean(D)
sqrd_devs_from_mean = (D-x_D)**2
n = len(D)
```

[106]:
```
x_D
```

[106]:
```
-7.964791666666667
```

[107]:
```
S_D = math.sqrt(sum(sqrd_devs_from_mean)/(n-1))
S_D
```

[107]:
```
4.864826910359056
```

[108]:
```
#Alternatively using python std function

S_D = D.std()
S_D
```

[108]:
```
4.864826910359056
```

Let's find the critical value of t at 95% confidence level Link to t-table: https://s3.amazonaws.com/udacity-hosted-downloads/t-table.jpg

-level: 0.05 t-critical values = ± 2.069

For the dependent t-Test S corresponds to the Standard deviation of the differences S_D

t-Statistic:

[109]:
```
t = x_D/(S_D/math.sqrt(n))
t
```

[109]:
```
-8.020706944109957
```

Null hypothesis rejected: Since our t-statistic is well past our t-critical values we reject H_0. At = 0.05, the time to name colours is significantly different between congruent and incongruent tasks. Participants do not name colours at the same speed when the word's meaning and its colout match compared to when they do not match. The result confirms my expectations.

Confidence Interval: $CI = \bar{x}_D \pm t_{critical} \times (\frac{S}{\sqrt{n}})$

[110]:
```
t_crit = 2.069

CI_lower = x_D - t_crit*(S_D/math.sqrt(n))
```

```
CI_upper = x_D + t_crit*(S_D/math.sqrt(n))

print(CI_lower, CI_upper)
```

```
-10.019367912023053 -5.91021542131028
```

As per confidence intervals we can expect that on average the congruent group is between 5.9 and 10.0 seconds faster than the incogruent group.

1.2.9 Q6. (optional)

Hypotheses regarding the reasons for the effect observed are presented. An extension or related experiment to the performed Stroop task is provided, that may produce similar effects.

1.2.10 A5.

Our brain is trained from the beginning to make connections and predictions based on experience and probably even through evolution it developed in a way that it automatically draws connections and conclusions. That is why the human brain is so capable. This is being done all the time unconciously because this helps the brain to focus only on what is relevant and tune out other stuff. Otherwise it would always run on full capacity trying to analyse everything. That is what some autistic people do. But that is only my guess, no research.

One idea of a test that would be comparable is if we give people used to a QWERTY keyboard any other keyboard. Then it is not the color that is connected to a letter but a location.