Project 1: Test a Perceptual Phenomenon

Jim Sulit

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.

Questions For Investigation

1. **What is our independent variable? What is our dependent variable?**

   The independent variable is whether the color words whose names match the colors in which they are printed (i.e. whether the names of the colors match the ink colors; i.e. whether it is congruent words condition or incongruent words condition). The dependent variable is the reaction time – the time each participant takes to name the ink color.

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

   One hypotheses here is that there is a difference in reaction time between congruent words condition and incongruent words condition, for all potential subjects in the world, means Stroop effect is existed. Therefore, we are comparing average time each group required to say the color of the words - population mean of congruent words group and population mean of incongruent words group.

   However, it is not possible to perform the test with all population in the world. Therefore, we use the sample to make inference about the population means. In our case, we will use the sample difference to estimate the population difference.

   Here is the hypotheses testing and explanation of the symbols I used:
   H_0 (null hypotheses)
   H_A (alternative hypotheses)

μ_{con} (population mean of congruent words group)

μ_{in} (population mean of incongruent words group)

$H_0 : \mu_{con} - \mu_{in} = 0$

The null hypotheses is that there is no difference in reaction time on average between congruent words condition and incongruent words condition (i.e. the average time required to say the colors of the words between the two conditions are equal).

$H_A : \mu_{con} - \mu_{in} \neq 0$

The alternative hypotheses is that there is difference in reaction time between these two conditions (i.e. the average time required to say the colors of the words between the two conditions are not the same).

I expect to perform two-tailed dependent t-test for paired samples.

The reason for two-tailed test: We want to test whether two means were significantly different from one another.

The reasons for using t-test:

The population standard deviation is unknown.
The sample size is less than 30 (i.e. our n=24).

The reasons for using dependent t-test for paired samples:

We are comparing the means of two related groups to determine whether there is a significant difference between these means.
Our test is an example of "repeated-measures" statistical test. This means the same participants are tested more than once. Thus, each participant has been measured on two occasions (i.e. congruent words condition and incongruent words condition) for the same dependent variable (i.e. reaction time).

In addition, we need to consider the test assumptions for t-test for dependent means:

1). The dependent variable is measured on an interval or ratio scale (i.e. reaction time is measure by seconds).

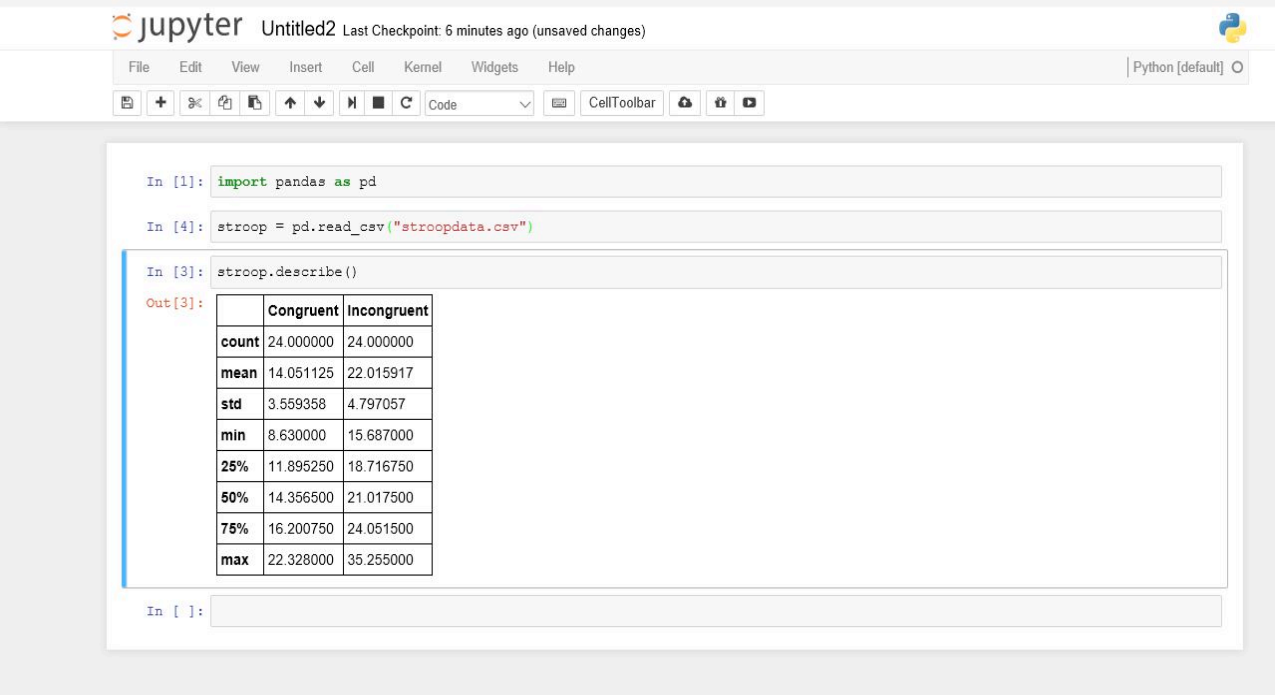
2). Random sampling from a defined population.

3). Samples used to produce the different scores are linked in the population through repeated measurement (i.e. the differences in reaction time are linked in the population through congruent words measurement and incongruent words measurement).

4). Scores are normally distributed in the population; difference scores are normally distributed. However, the t-test for dependent means is considered typically "robust" for violations of normal distribution. This means although our sample time difference

distribution is not normal, in most circumstance we can still use t-test for dependent means especially for a two-tailed t-test.

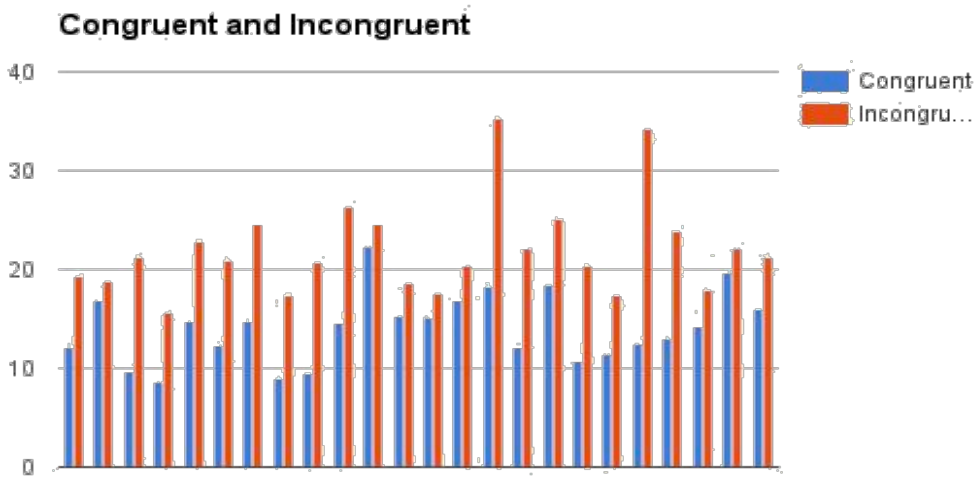
3. **Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.**



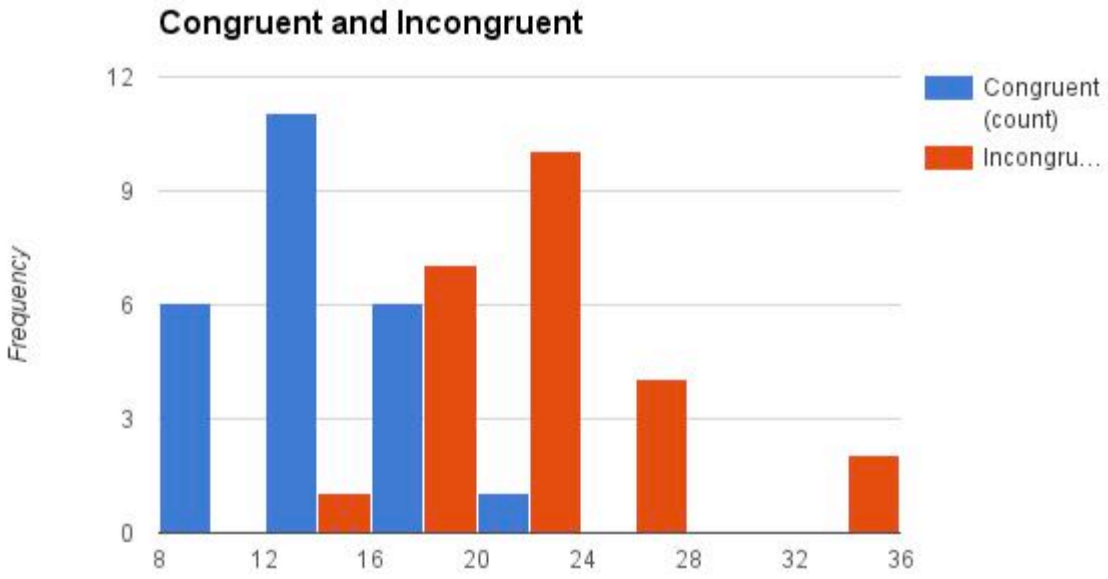
	Congruent	Incongruent
count	24.000000	24.000000
mean	14.051125	22.015917
std	3.559358	4.797057
min	8.630000	15.687000
25%	11.895250	18.716750
50%	14.356500	21.017500
75%	16.200750	24.051500
max	22.328000	35.255000

In [ ]:

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.**



The above bar chart indicates that the time required to say the word color in the incongruent group is always more than the congruent group.



The above histogram shows that the two groups have the significant difference in the mode, median and the mean. The incongruent group needs a lot more time no matter what the measurement is.

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: $\mu_{con} - \mu_{in} = 0$

H_A: $\mu_{con} - \mu_{in} \neq 0$

n = 24

df = n-1 =23

S = 4.865

$\mu_{con} - \mu_{in} = -7.965$

for $\alpha = 0.05$, $t_{critical} = \pm 2.069$

$t = (\mu_{con} - \mu_{in}) / (S/\sqrt{}) = -8.021$

t (23) = -8.021 P < .0001, two-tailed

Since our t statistics fall in to the critical region, the result is statistical significant at α level 0.05 (P<.05), we reject the null. This means that participants require significantly less time in congruent words condition than in incongruent word condition. Since this was an experimental design, we can make casual statement that the type of test had a causal effect on the time spent to respond the color of the words. This result is in line with my expectation.

Cohen's d = -1.637

These two means are 1.637 standard deviation apart.

$r^2 = .74$

The differences in reaction time for the sample of 24 participants, approximately 74% of those differences are due to the Stroop effect.

Confidence interval on the mean difference; 95% CI = (-10.02, -5.91)

If we give all population the Stroop task, the time difference between congruent words condition and incongruent words condition is on average -10.02 and -5.91.

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!**

   Anyone who has tried Stroop task knows that the interference caused by an incongruent word in naming the word ink color is powerful. Although we think of colors at ease. The existence of Stroop effect indicates that there is a computational process in our brain, and this process can be interfered.

   There are several new variations of Stroop task such as directional Stroop effect, number Stroop effect and animal Stroop effect.

References

https://statistics.laerd.com/statistical-guides/dependent-t-test-statistical-guide.php
http://imbs.uci.edu/~kjameson/ECST/MacLeod_TheStroopEffect.pdf
https://faculty.washington.edu/chudler/words.html
https://www.youtube.com/watch?v=_x6j-rH33Og
http://www.psychology.emory.edu/clinical/bliwise/Tutorials/TOM/meanstests/assump.htm
http://50.30.47.15/ebook/IPE/Probability&Statistics_for_Engineers&Scientists(9th_Edition)_Walpole.pdf (p 248)
http://www.chem.utoronto.ca/coursenotes/analsci/stats/12tailed.html