P1: Test a Perceptual Phenomenon

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

As a general note, be sure to keep a record of any resources that you use or refer to in the creation of your project. You will need to report your sources as part of the project submission.

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

Answer:

Our independent variable is 'word color congruency in congruent and incongruent conditions', and the dependent variable is the time it takes to name the colors based on whether thetest is in a congruent condition or an incongruent one.

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 can be: There is no time difference between the two congruent and incongruent conditions; meaning the time it takes to say the ink colors are the same in both conditions.

The alternative hypothesis can be: There is a time difference between the two congruent and incongruent conditions. This means that the time it takes for the population to say the ink colors in the incongruent condition is more than the congruent one.

Null hypothesis:

H_0: $\mu_c = \mu_I$ (sub C is for congruent condition and sub I is for incongruent)

$\mu_c > \mu_I$

Alternative hypothesis:

H_a: $\mu_c < \mu_I$

Mathematical symbol definition:

H0: Null Hypothesis

Ha: Alternative hypothesis

μc: Population mean for the congruent condition

μI: Population mean for the incongruent condition

Sub 'C' is for congruent condition and sub 'I' is for incongruent condition

The type of statistical testing that I think would be suitable for this experiment is a **paired-sample 1-tailed t-test**[1].

- I chose a t-test since we are doing hypothesis testing, and we do not have the population standard deviation, and only can compute the sample standard deviation; then t-test would be the way to go.
- I chose a 1-tailed test[2] since we would be interested to see if the incongruent situation would make the timing longer than the congruent one, so one tail of a normal distribution with the positive t-critical would be of interest to analyze. In other words, the alternative hypothesis shows that we need a 1-tailed test.
- I will go with a paired-sample t-test because people who are playing the game in the congruent and incongruent conditions are the same. This means we have two samples that have the same participants.

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

Answer:

Measures of Central Tendency:

For this I have chosen to report **Mean, Median and Mode**. All calculations are done in the excel sheet attached to this project.

- Congruent dataset
  - Mean: 14.0511
  - Median: 14.3565
  - Mode: N/A – There are no modes in this dataset
- Incongruent dataset
  - Mean: 22.0159
  - Median: 21.0175
  - Mode: N/A – There are no modes in this dataset

Measure of Variability:

For this I have chosen to report the **Sample Standard Deviation**. All the calculations are done and visible in the excel sheet provided. Basically, I first counted the square variance for each sample, summed them all up, divided them by n-1 (i.e. 23), and took a square root of that.

- Congruent dataset
  - Sample SD: 3.5593
- Incongruent dataset
  - Sample SD: 4.7970

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.

Answer:

The visualizations have been done using the Interactive Histogram tool[3] for each of the conditions, and then an excel chart which compares both datasets.

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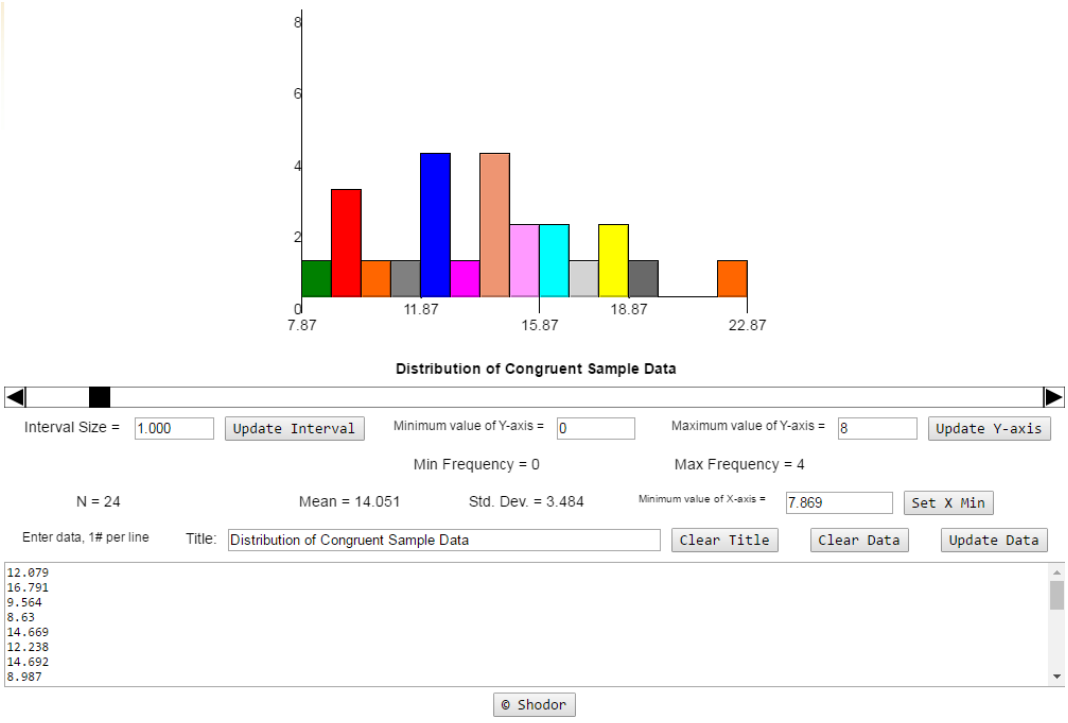
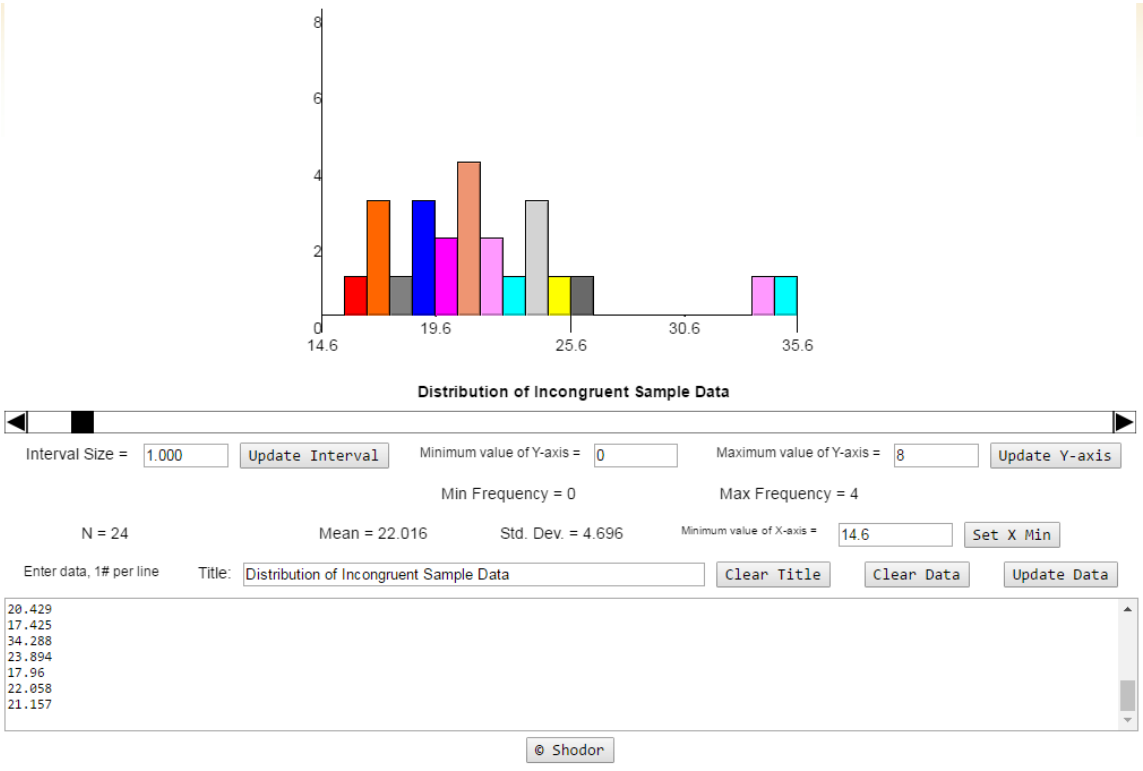
[1] The difference between t-score and z-score: http://www.statisticshowto.com/when-to-use-a-t-score-vs-z-score/ and Paired/Dependent t-test: https://rstudio-pubs-static.s3.amazonaws.com/34222_701124f9913b40c9ba318ef3b2b17e45.html

[2] For this question, I first went with a 2-tailed t-test, since I was on the assumption that in the incongruent condition we want to check whether the time it took to complete the game is less or more than the time it took to complete the game in the congruent condition. But after reading the forum: https://discussions.udacity.com/t/two-tailed-vs-one-tailed-when-to-use-which/34478/2 and the article that was suggested in the thread: http://psychclassics.yorku.ca/Stroop/ , I went for a 1-tailed t-test.

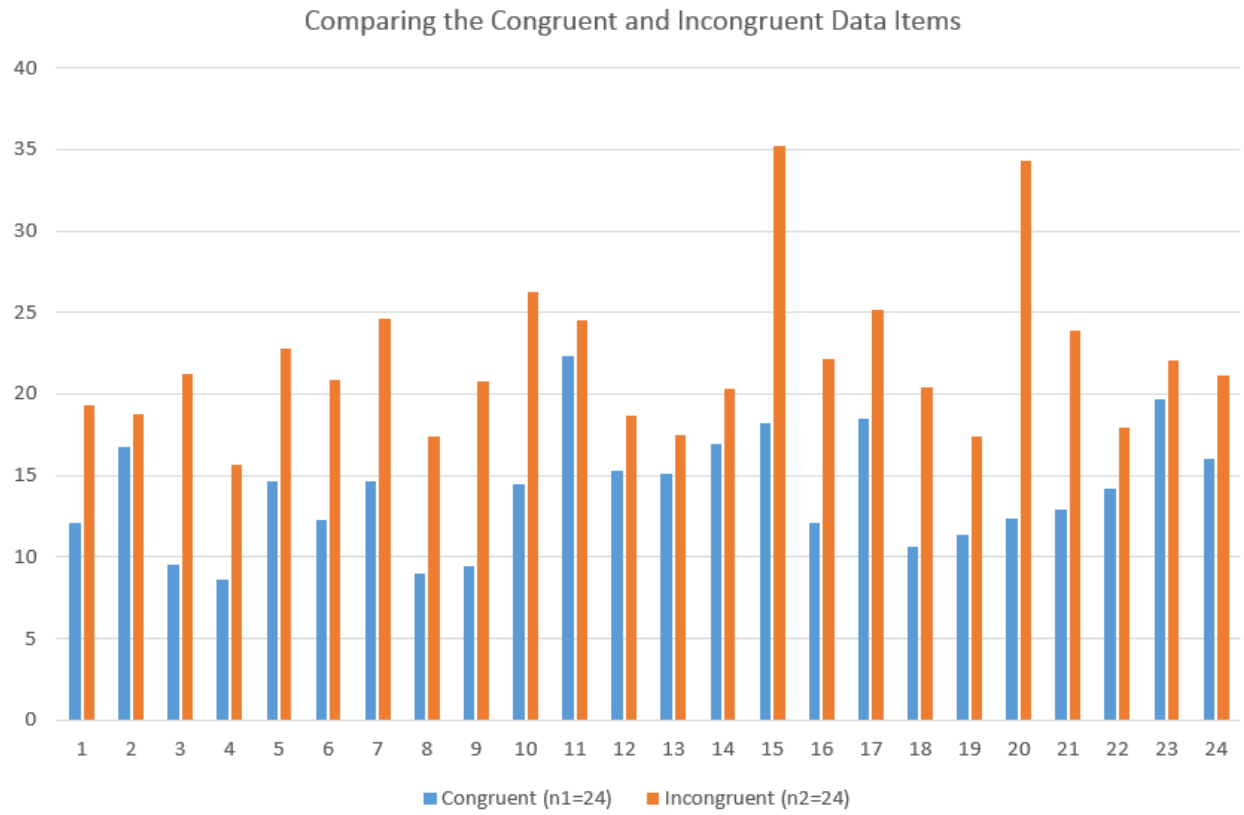
[3] Interactive histogram tool: http://www.shodor.org/interactivate/activities/Histogram/

From the interactive histogram diagrams, it is clearly visible that the highest time to say the name of an ink color has increased in the incongruent condition (i.e. 35.6), while in the congruent condition the longest time is 22.87.





In the below excel chart, when comparing the congruent to incongruent condition, it is clearly visible that everyone who did the test in congruent condition, took more time to complete the test in the incongruent condition.



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?

Answer:

- The table below (as well as the excel file attached for this exercise), shows the statistical test report. I chose alpha level of 0.05 since the question didn't mention anything specific, so I went with the typical alpha level.
- Based on the $T_{Statistic}$ and the $T_{Critical}$ values, I reject the null hypothesis and go with the alternative one in which the timing it takes for the incongruent condition is more than the congruent one. The difference between these two values are statistically significant.
- By playing the game before starting this exercise and then gotten out some visualization from the data (e.g. the excel chart), I was quite sure that I will reject the null hypothesis since the difference in the time between the congruent and incongruent conditions were significant when I extracted the excel chart.

Alpha Level	0.05
Degrees of Freedom	N=24 -> df=23
$T_{Critical}$	1.714
Mean Difference	7.97
Sample SD for the Mean Difference	4.86
Standard Error of the Mean Difference	0.99
$T_{Statistic}$	8.02
P-Value[4]	0.05 -> 5%
Confidence Interval (90%)	(6.27,9.66)

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!

Answer:

I think the main thing responsible is how the brain by default goes for comprehending what it sees as what is really represents, especially in games like this—there are already words that represent colors, and they are written in colored fonts as well.

For similar tasks, one example can be the Numerical Stroop Effect[5] which is about the relation between the numerical values and their physical size. For instance, in case of 3 and 5, if you write it like 5 3 (congruent condition in which the bigger number has a bigger size), and also like 3 5 (incongruent condition in which the smaller numberhas a bigger size), comparing these two numbers takes more time in the incongruent condition. 3 < 5 but since the size is bigger in the incongruent condition, a person needs more time to comprehend that.

[4] Did the calculations from this website: http://vassarstats.net/tabs.html

[5] Different examples of Stroop effect: https://en.wikipedia.org/wiki/Stroop_effect