Statistics: The Science of Decisions Project Instructions

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?

Ans.

1.) Independent Variable:- The word conditions i.e. congruent words or incongruent words.

2.)Dependent Variable:- The amount of time it takes for the participant to indicate the color under each condition.

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

Ans.

H_0 : There would be a lower mean time for the incongruent tests than the congruent tests or no noticeable difference in time duration between the congruent and incongruent tests

H_A: There would be a noticeable increase in time duration between the congruent and incongruent tests.

The experiment should be a **one tailed type** scenario as there the question does mention “...does incongruence increase response times” as well as the incongruent times were predominantly larger than the congruent times.

- **μ1 =** the mean of time spent for the participant group of congruent test
- **μ2 =** the mean of time spent for the participant group of incongruent test

The null hypothesis (H_0): $\mu 1 - \mu 2 \geq 0$, the time duration difference of the congruent and incongruent tests would equal 0 or be greater than 0, meaning the incongruent times would be less or equal to the congruent times for the population.

The alternative hypothesis (H_A): $\mu 1 - \mu 2 < 0$, the time duration difference of the congruent and incongruent tests would be less than 0, meaning the incongruent times would be greater than the congruent test times for the population.

The statistical test that i’ll be using for the Stroop experiment is a T-test as we don’t know the mean of the total population however we have detailed data on a sampled group for both the congruent and incongruent tests. In addition, we only have a data set of 24 people in the sample

making it more better to use T-test to calculate our statistical test, the type of T-Test selected is:

• **Dependent:** I chose to go the dependent t-test route as even though we do two tests (congruent and incongruent) it is with the same group of people that was tested on the congruent words then tested on the incongruent words.

Now it's your chance to try out the Stroop task for yourself. Go to this link, which has a Java-based applet for performing the Stroop task. Record the times that you received on the task (you do not need to submit your times to the site.) Now, download this dataset which contains results from a number of participants in the task. Each row of the dataset contains the performance for one participant, with the first number their results on the congruent task and the second number their performance on the incongruent task.

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

Ans.

Central Tendency

Going into the dataset of the Stroop Experiment determining the:

Mean(Congruent($\bar{x}_c$) and Incongruent($\bar{x}_i$)**)**

$\bar{x}_c$ **= 14.051125**

$\bar{x}_i$ **= 22.01591667**

Median(Congruent(C_{med}) and Incongruent(I_{med})**)**

C_{med} = 14.3565

I_{med} = 21.0175

Mode

Considering all data on the congruent and incongruent test groups each have unique time, no time is same as the data is continuous there is no mode available on both test groups.

Measure of Variability

To get a better understanding of the general variability of the data sets we can find the **Standard Deviation** which will tell how a group is spread out of the average(mean).

Congruent**(** σ_c**)** and Incongruent**(** σ_i**)**

σ_c **= 3.559357958**

σ_i **= 4.797057122**

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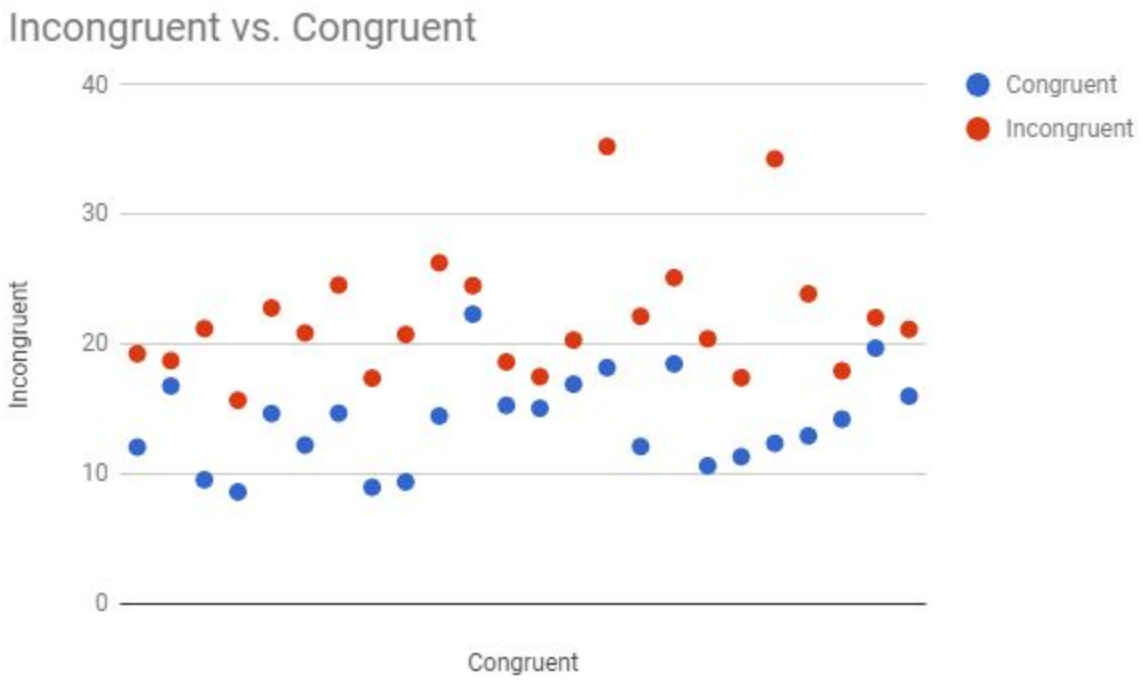
4. Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

Ans.



The above chart represents a scatter plot displaying the congruence conditions i.e. congruent words and incongruent words, we can visualize here that participants took more time during incongruent words as compared to the congruent words. We can also access that both the conditions have different ranges and medians and also we can see the outliers up there between 30 - 40 for incongruent words and below 10 for congruent words.

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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?

Ans.

As determined in question 2 we will calculate our data using the T-Test statistical test for the Stroop Effect experiment. Considering the group took both the congruent and incongruent tests this T-Test will be considered dependent.
Knowing the means of each test (congruent and incongruent, from question 3):

$\bar{x}_c$ **= 14.05(app.)** $\bar{x}_i$ **= 22.02(app.)**

We can calculate quickly a point estimate using: $\bar{x}_c$ **-** $\bar{x}_i$ **= -7.97(approx).**

A point estimate is handy to know as it gives us our “Best guess” on the difference of the population between the two tests (population difference estimate of congruent versus incongruent times).
Calculating the difference of the time points for each person (congruent minus incongruent) and averaging the differences should lead to the same value as the point estimate we calculated earlier. Using the average of the differences which should match the point estimate of -7.97 we subtract that value from the differences of each person and then square it:

(Difference of Congruent and Incongruent – Average of differences)^2

Having this set of squared deviations from the mean we can sum them up into Square of Sums Using:

$$\sum_{i=24}^{n} (x_i - \bar{x})^2$$

Square of Sums of difference of sample means = 544.3304

Given the SS (Square of Sums) we can use this to determine the variance of the difference. Since we are dealing with a sample we need to use the

equation with the denominator of n-1, n being the number of participants on the given tests (n = 24):
Variance of Difference = Square of Sums of Difference of Samples means / n − 1

Variance of difference = 23.667

Given we now know the Variance for the difference we can use that knowledge to get the **Standard Deviation of Differences**.

$$\sqrt{Variance\ of\ Difference}$$

SD of Differences = 4.865

If we designate SD of Differences as s (**SD of Differences = s**) we can now calculate the **t-statistic** for the difference using the equation:

T-statistic = $\bar{x}_c - \bar{x}_i / s / \sqrt{n}$

Given the numerator is the point estimate or average of the differences (both equal the same value), “s” was determined a step earlier and “n” is the number of participants in the Stroop experiment we can calculate the

T-Statistic: -7.97 / 4.865/ $\sqrt{24}$ **= -8.026**

Since we have the T-Statistic we can compare it to the **T-Critical value** to determine if the null hypothesis should be accepted or rejected, using what we know (24 participants, which means n=24 we can determine the Degrees of Freedom)
Knowing **n=24**, the degrees of freedom for this **t-test = n-1 = 23**. Since we are aiming to find with **99% Confidence level for a one tail our α = 0.005**

Given df = 23 and α = 0.005
@ 99% Confidence Level: need to be between +- 2.807

Given that the **T-Statistic found was - 8.026** it leads us to **reject the null hypothesis** due to T-Statistic being in the critical area of tested at 99% Confidence Level. The t-test confirms what was expected that incongruent tests would normally take longer than congruent tests as congruent test linked both visual colors with the correct printed name of the color while incongruent required to try to separate the visual color and the name of the color which required a bit more time to do.

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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!

Ans.

My hypothesis for the effects observed is that the brain dominantly focuses on reading the word rather than recognizing a colour when the eyes are presented with a coloured word. To recognize a colour, one has to override the brain's natural tendency of reading the word. This override takes time and is likely not always successful, which means re-analyzing a word after the error is recognized, which costs more time.

Numerical/Physical size Stroop tasks, where numerical values and physical size are the factors that contribute to congruence/incongruence, results in a similar effect. It takes longer to recognize the number and physical size (two separate tasks) of small numbers that have a large physical size and large numbers that have a small physical size.

Sources

1.) https://docs.google.com/spreadsheets/d/1_yTUeAfikgmXVf21hMnuCXY4_HHyRjivgV8uIPmP69w/edit#gid=0
2.) http://www.psychology.emory.edu/clinical/bliwise/Tutorials/TOM/meanstests/assump.htm
3.) https://statistics.laerd.com/statistical-guides/dependent-t-test-statistical-guide.php
4.) https://en.wikipedia.org/wiki/Stroop_effect