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 colour of ink. The participant's task is to say out loud the *colour 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 colour words whose names match the colours in which they are printed: for example RED, BLUE. In the *incongruent words* condition, the words displayed are colour words whose names do not match the colours in which they are printed: for example PURPLE, ORANGE. In each case, we measure the time it takes to name the ink colours 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: Independent variable is the condition of words presented i.e. a congruent words condition, and an incongruent words condition.

Dependent variable is time taken to name the ink colours in the equally-sized lists.

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:

Null Hypotheses: $H_0 \rightarrow \mu_{\text{congruent condition}} = \mu_{\text{incongruent condition}}$

That is: there is no difference between the mean of time taken under congruent conditions and incongruent conditions.

Alternative Hypotheses: $H_A \rightarrow \mu_{\text{congruent condition}} \neq \mu_{\text{incongruent condition}}$

That is: The mean of time taken under congruent conditions and incongruent conditions are not equal.

Where $\mu_{\text{congruent condition}}$ is mean of time taken to read out the words in congruent conditions

And $\mu_{\text{incongruent condition}}$ is mean of time taken to read out the words in incongruent conditions

Since we don't have access to the population parameters, we must conduct a dependent sample t-test.

A two tailed dependent sample t-test will be suitable for the above mentioned hypotheses as we are not drawing out any conclusions as to which one takes lesser or greater time. All we need to do is prove that there is a difference in both the conditions.

This might be termed as a t-test under two conditions as we are recording time taken by an individual when subjected to two different types of letter and colour combinations.

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

Answer: STROOP DATA

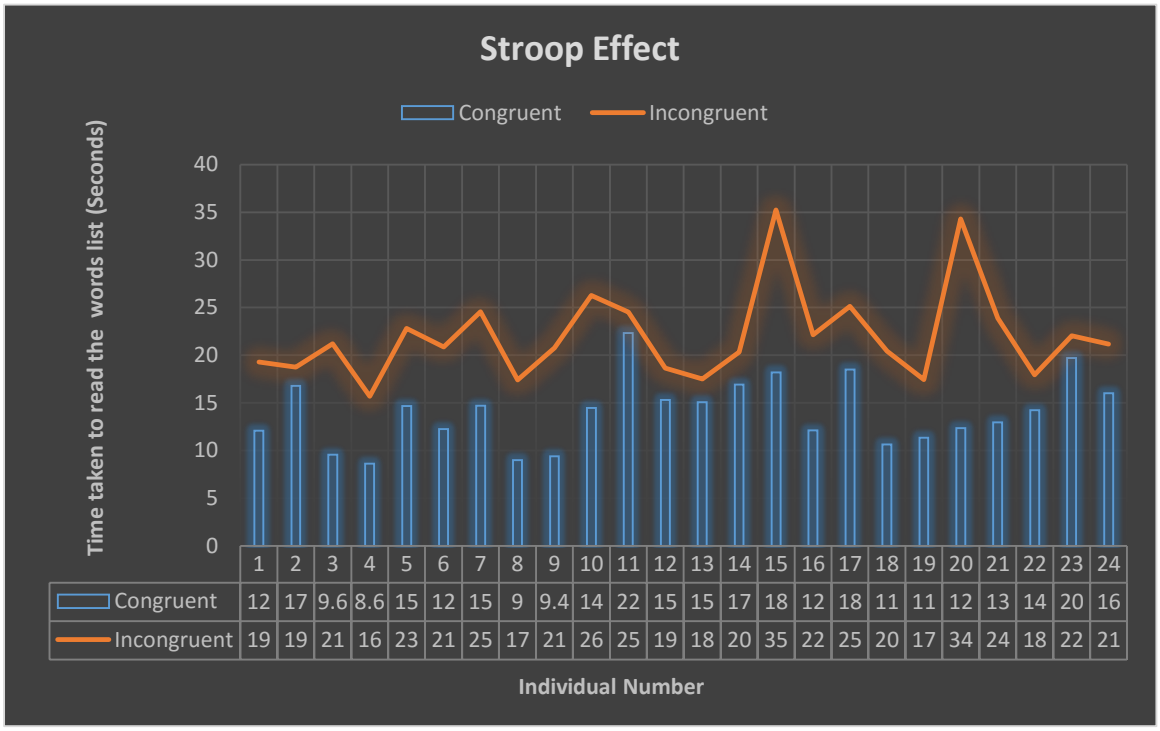
	Congruent	*Incongruent*
1	12.079	19.278
2	16.791	18.741
3	9.564	21.214
4	8.63	15.687
5	14.669	22.803
6	12.238	20.878
7	14.692	24.572
8	8.987	17.394
9	9.401	20.762
10	14.48	26.282
11	22.328	24.524
12	15.298	18.644
13	15.073	17.51
14	16.929	20.33
15	18.2	35.255
16	12.13	22.158
17	18.495	25.139
18	10.639	20.429
19	11.344	17.425
20	12.369	34.288
21	12.944	23.894
22	14.233	17.96
23	19.71	22.058
24	16.004	21.157
Mean	14.05113	22.01592
Median	14.3565	21.0175
Standard Deviation	3.559358	4.797057

Link to actual Spread Sheet:

https://docs.google.com/spreadsheets/d/1WNDPJ2tacmaYzYdhbcgcfH2zdyBJEOuTxyUyiJiOgIA/edit?usp=sharing

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:



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Congruent	12	17	9.6	8.6	15	12	15	9	9.4	14	22	15	15	17	18	12	18	11	11	12	13	14	20	16
Incongruent	19	19	21	16	23	21	25	17	21	26	25	19	18	20	35	22	25	20	17	34	24	18	22	21

This visualisation depicts a trend that the time taken under incongruent conditions is usually higher than that under congruent conditions. There are a few outliers where the incongruent time is significantly higher and in some cases both are approximately same. A proper statistical test needs to be conducted to confirm the significance of this data.

Thus, we conduct a two tailed dependent sample t-test

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:

We are performing a two-tailed t-test with $\alpha = 0.05$ which correspond to a t-critical value of $t = +2.069, -2.069$ and the Degrees of Freedom $Df = 24 - 1 = 23$

$H_0: \mu_{congruent} = \mu_{incongruent}$

$H_A: \mu_{congruent} \neq \mu_{incongruent}$

We get a t-value of $t = 8.0207$

Result: The p-value is less than 0.00001
(Calculated using http://www.socscistatistics.com/pvalues/tdistribution.aspx)

The t-statistic (8.0207) is much higher than t-critical (2.069) thus our result falls in the critical region.
Thus we **reject the null hypotheses**.

Link to spread sheet:

https://docs.google.com/spreadsheets/d/1zmovihhCwUTFp3enhTBNE66h1kjHzhdOFm3OyKislS4/edit?usp=sharing

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:

The possible explanation of this phenomenon can be that since recognizing colours is not an “automatic process” there is hesitancy to respond; whereas, the brain automatically understands the meaning of words as a result of habitual reading

There are various other theories that suggest other reasons for the effect but in my opinion the theory mentioned above is the best possible explanation.

There are lots of other tests that can cause a similar effect, including five variations of the Stroop test (Wrapped Words, Emotional, Spatial, Numerical and reverse).

Details of Various Stroop Tests: (Source: Wikipedia)

Warped words

For example, the warped words Stroop effect produces the same findings similar to the original Stroop effect. Much like the Stroop task, the printed word's colour is different from the ink colour of the word; however, the words are printed in such a way that it is more difficult to read (typically curved-shaped). The idea here is the way the words are printed slows down both the brain's reaction and processing time, making it harder to complete the task.

Emotional

The emotional Stroop effect serves as an information processing approach to emotions. In an emotional Stroop task, an individual is given negative emotional words like "grief," "violence," and "pain" mixed in with more neutral words like "clock," "door," and "shoe".[34] Just like in the original Stroop task, the words are coloured and the individual is supposed to name the colour. Research has revealed that individuals that are depressed are more likely to say the colour of a negative word slower than the colour of a neutral word.[35] While both the emotional Stroop and the classic Stroop involve the need to suppress irrelevant or distracting information, there are differences between the two. The emotional Stroop effect emphasizes the conflict between the emotional relevance to the individual and the word; whereas, the classic Stroop effect examines the conflict between the incongruent colour and word.

Spatial

The spatial Stroop effect demonstrates interference between the stimulus location with the location information in the stimuli. In one version of the spatial Stroop task, an up or down-pointing arrow appears randomly above or below a central point. Despite being asked to discriminate the direction of the arrow while ignoring its location, individuals typically make faster and more accurate responses to congruent stimuli (i.e., an down-pointing arrow located below the fixation sign) than to incongruent ones (i.e., a up-pointing arrow located below the fixation sign). A similar effect, the Simon effect, uses non-spatial stimuli.

Numerical

The Numerical Stroop effect demonstrates the close relationship between numerical values and physical sizes. Digits symbolize numerical values but they also have physical sizes. A digit can be presented as big or small (e.g., 5 vs. 5), irrespective of its numerical value. Comparing digits in incongruent trials (e.g., 3 5) is slower than comparing digits in congruent trials (e.g., 5 3) and the difference in reaction time is termed the numerical Stroop effect. The effect of irrelevant numerical values on physical comparisons (similar to the effect of irrelevant colour words on responding to colours) suggests that numerical values are processed automatically (i.e., even when they are irrelevant to the task).

Reverse

Another variant of the classic Stroop effect is the reverse Stroop effect. It occurs during a pointing task. In a reverse Stroop task, individuals are shown a page with a black square with an incongruent coloured word in the middle — for instance, the word "red" written in the colour green — with four smaller coloured squares in the corners. One square would be coloured green, one square would be red, and the two remaining squares would be other colours. Studies show that if the individual is asked to point to the colour square of the written colour (in this case, red) they would present a delay. Thus, incongruently-coloured words significantly interfere with pointing to the appropriate square. However, some research has shown there is very little interference from incongruent colour words when the objective is to match the colour of the word.