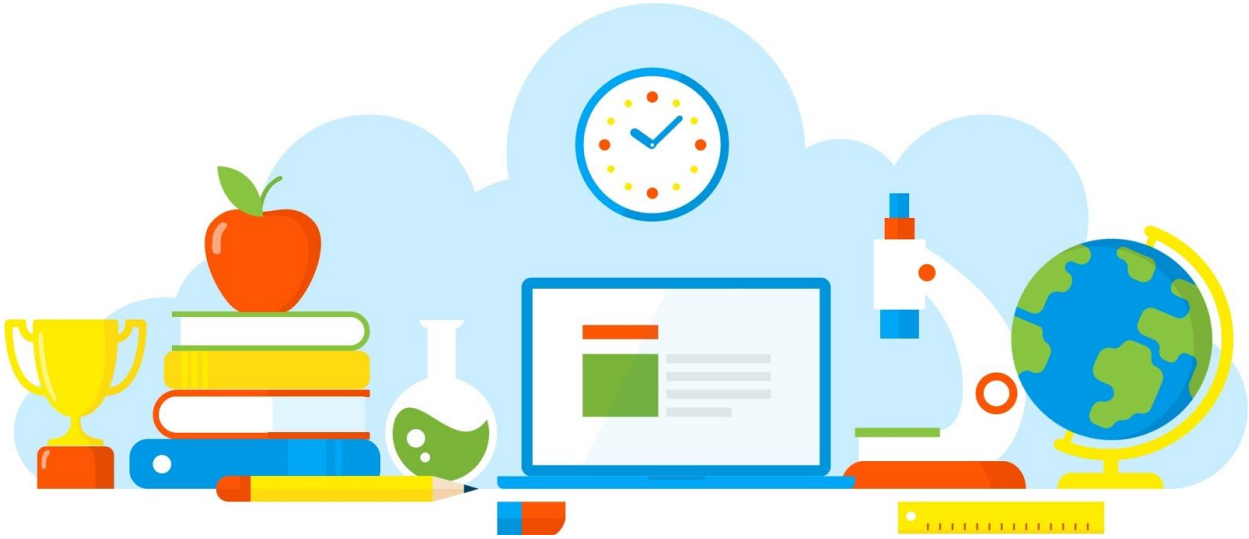

The Stroop Effect

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29/01/2018

Introduction

The Stroop effect is named after John Ridley Stroop. In basic terms, the Stroop Effect is where the subject is made to read out aloud the colour of the ink as opposed to the actual text. For example, red would be blue and blue would be red. The experiment is split into two conditions. One condition is where the colour of the text font is the same as in the text e.g red. This is known as being a congruent condition. The second condition is the incongruent condition where the colour of the text doesn't match the word e.g red. What John Stroop showed in his experiments was that subjects took a longer time to process incongruent text as opposed to congruent text. The time taken to read incongruent text was generally longer than congruent text. This difference in time is what's measured and as such is the measure of interference.

Project Questions

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

In both stimuli, the dependent variable is the time taken to interpret the colour of the text. The independent variable is the congruency of the text ie if the text is congruent or incongruent.

What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform?

The outcome of this experiment is to measure the effect interference when stating the colour of the text in an incongruent condition to that of stating the colour of the text in an incongruent condition. The experiment is conducted in a controlled manner where the results don't occur by chance. As a result it would be safe to say that the results could be used as inferences about the population.

The following symbols will be used:

- μ_c - Denotes the mean value of time taken to read each congruent text for the population.
- μ_i - Denotes the mean value of time taken to read each incongruent text for the population.

So the Hypothesis would be the following:

H_0: The null Hypothesis states that the time taken to state the colour of the text in a congruent condition is greater than or there is no significant difference to the time taken to state the colour of the text in an incongruent condition for the population.

Which is mathematically equivalent to:

H_0: $\mu_i - \mu_c \leq 0$

H_A: The alternate Hypothesis is that, the time taken to state the colour of the text in an incongruent condition is significantly greater than the time taken to state the colour of the text in a congruent condition for the population.

Which is mathematically equivalent to:

H_A: $\mu_i - \mu_c > 0$

As can be seen from this particular experiment, both the population mean or the standard deviation of the population is not known. From the sample chosen, we can only calculate and use the sample standard deviation. The sample size is less than 30 and so it can be said that the sample size of 24 is small:

$n = 24$

Using the Central Limit Theorem, we could say that the mean of the sample means is the same as the population mean. The sampling distribution of means would also be normal.

For this reason, we are using a t-test as opposed to a z-test.

In this experiment, the sample size of 24 people are subjected to two conditions within the same test. As a result, this would be treated as a dependant t-test. This will be treated as a “Repeated measures design” test.

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

The dataset used was the following:

Congruent	
12.079	3.889277016
16.791	7.506915016

9.564	20.13429077
8.63	29.38859627
14.669	0.3817695156
12.238	3.287422266
14.692	0.4107207656
8.987	25.64536202
9.401	21.62366252
14.48	0.1839337656
22.328	68.50665977
15.298	1.554697266
15.073	1.044228516
16.929	8.282164516
18.2	17.21316377
12.13	3.690721266
18.495	19.74802502
10.639	11.64259702
11.344	7.328525766
12.369	2.829544516
12.944	1.225725766
14.233	0.03307851562
19.71	32.02286627
16.004	3.813720766

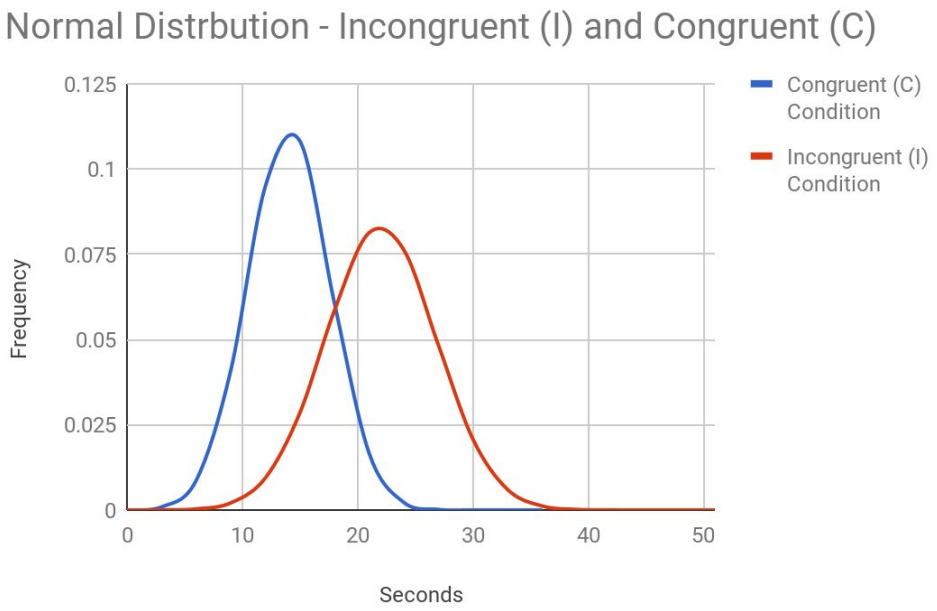
Based on the above dataset, the following descriptive statistics were calculated:

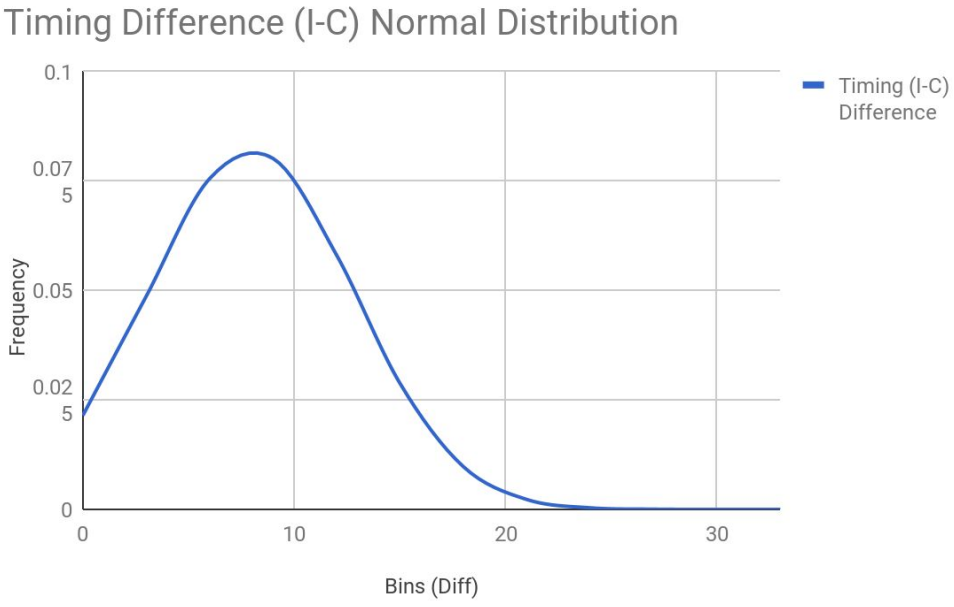
Descriptive Stats	Incongruent Condition (I) (secs)	Congruent Condition (C) (secs)	Difference (I-C) (secs)
Max	35.255	22.328	21.919
Min	15.687	8.63	1.95
Median	21.0175	14.3565	7.6665
Mean	22.0159	14.0511	7.9648

Standard Deviation (s)	4.7971	3.5594	4.8648
Q1	18.7168	11.8953	3.6455
Q3	24.0515	16.2008	10.2585
IQR (Inter Quartile Range)	5.3348	4.3055	6.613

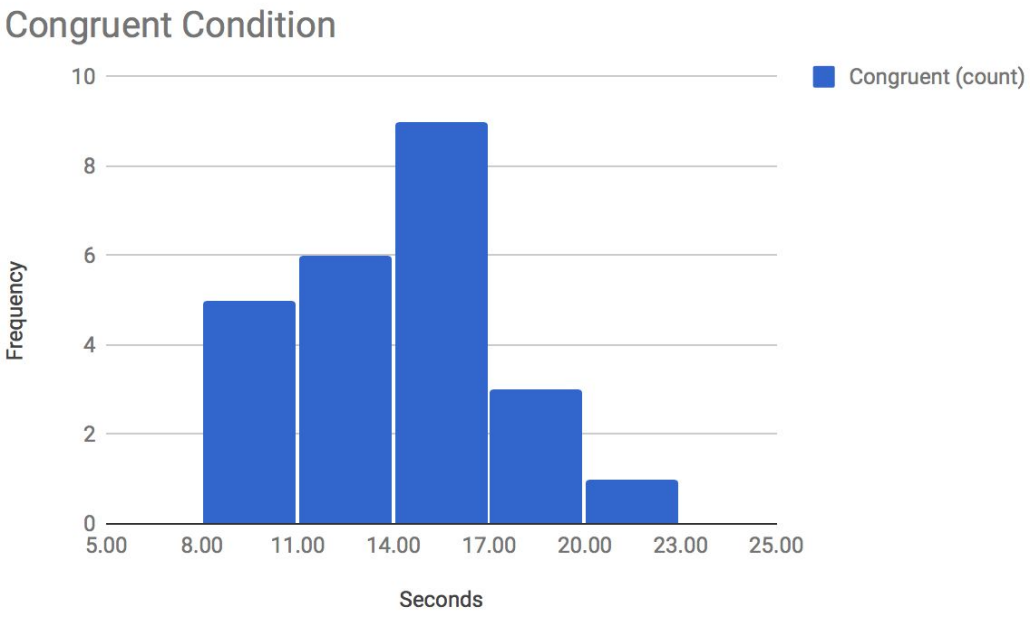
Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

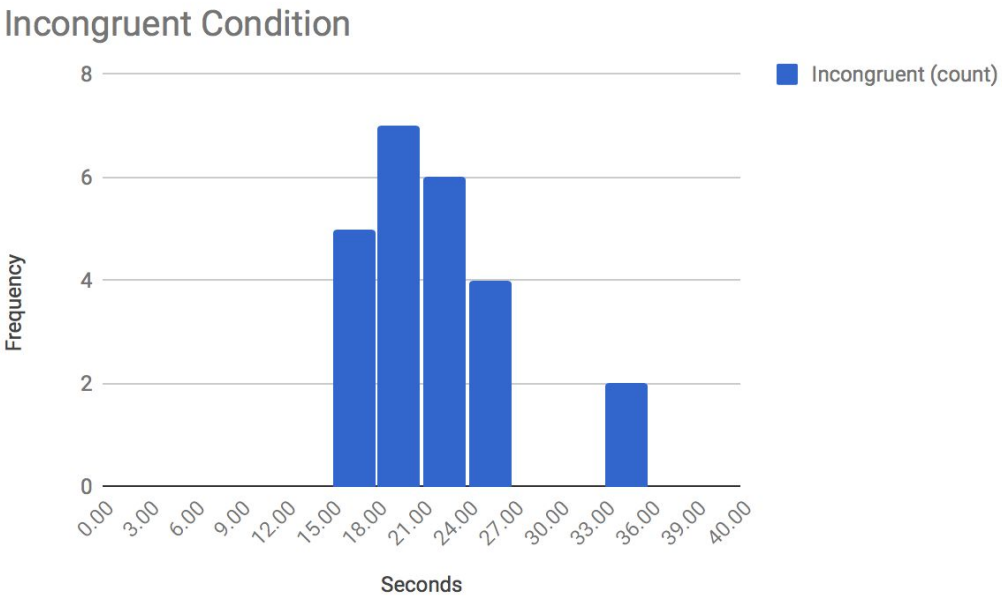
Normal Distribution for each condition





Histograms


Congruent Condition
Congruent (count)
10
8
6
4
2
0
Frequency
5.00
8.00
11.00
14.00
17.00
20.00
23.00
25.00
Seconds


Incongruent Condition
Incongruent (count)
8
6
4
2
0
Frequency
0.00
3.00
6.00
9.00
12.00
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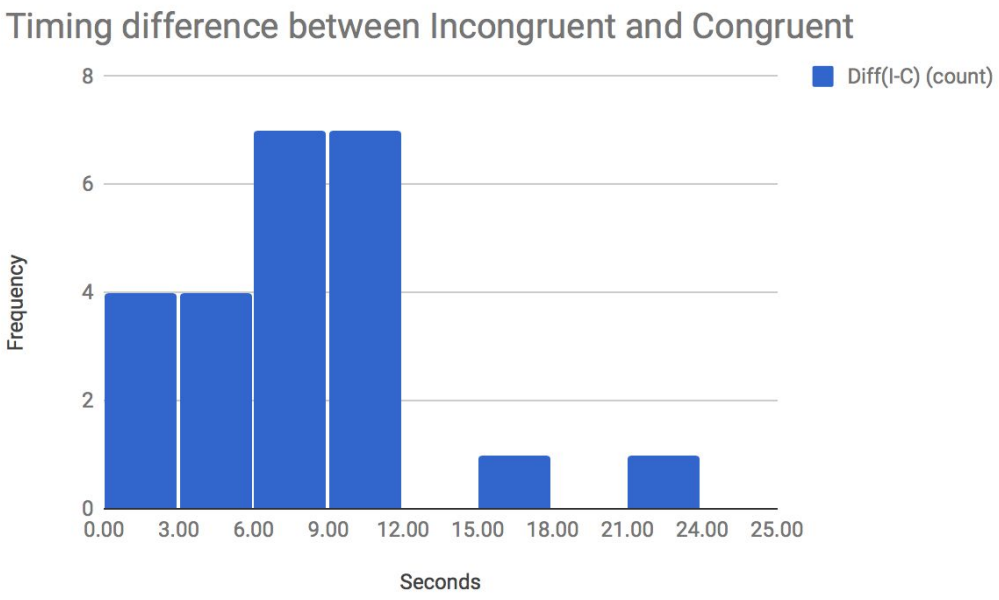
24.00
27.00
30.00
33.00
36.00
39.00
40.00
Seconds



Brief Explanation

It was interesting note in the normal distribution plots, the incongruent condition is a flatter and wider curve as opposed to that of the congruent condition. It was interesting to note where the incongruent condition when taken as a treatment is a more flatter and wider curve. It's shifted to the right and follows the higher mean and bigger standard deviation when compared to the congruent condition. Also when looking at the histogram and the normal distribution plots, they seem to have the same shape.

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?

Using the hypothesis from a previous question:

H_0: $\mu_i - \mu_c \leq 0$

H_A: $\mu_i - \mu_c > 0$

$\rho < .05$

It was also mentioned that this would a one-tailed t-test in the positive direction. The type of test is the “Repeated Measures Design” test.

Using the following alpha value:

$\alpha = 0.05$

The degrees of freedom:

$df = 23$

The critical t-value for this one-tailed test would be:

$t_{critical} = 1.714$

The t-value for this test is (using values from table):

$$t(23) = \frac{(\bar{x}_i - \bar{x}_c) - (\mu_i - \mu_c)}{(S_d/\sqrt{n})} = \frac{7.965}{(4.685/\sqrt{24})} = 8.021$$

Using the above t-value the p-value was calculated to be:

$\rho < 0.0001$

A 95% Confidence Interval (CI) for this test would be:

$$95\%\ CI\ = (\mu_{\ d} - t_{\ critical} * (\frac{S_{\ d}}{\sqrt{n}}),\ \mu_d\ +\ t_{\ critical} * (\frac{S_{\ d}}{\sqrt{n}}))$$
$$= (7.965 - 2.069 * (\frac{4.685}{\sqrt{24}}),\ 7.965 + 2.069 * (\frac{4.685}{\sqrt{24}}))$$

$$= (5.91, 10.019)$$

Cohen's d for this test would be:

$$Cohen's\ d\ = \frac{\mu_{\ d}}{S_{\ d}} = \frac{7.965}{4.685} = 1.637$$

The correlation measure for $r^{\ 2}$ would be:

$$r^{\ 2} = \frac{t^{\ 2}}{t^{\ 2}+df} = \frac{8.021^{\ 2}}{8.021^{\ 2}+23} = 0.737$$

Conclusion:

As above, the t-value of this test was found to be significantly higher than the t-critical value for 23 degrees of freedom. Additionally, the p-value was calculated to be $\rho < .05$. As a result, we can reject the null hypothesis.

As seen in this experiment, there is a significant difference in timing in reading, between the incongruent and congruent texts. When reading texts that are congruent, ie the text and the colour are the same, we get into a more automatic mode when reading the text. It's an easier task to perform. However, when incongruent text is introduced i.e. when the colour of the text doesn't match the text, a form of interference is introduced. That people took a longer time to interpret the colour of the text as opposed to reading just the text.

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!

This effect shows that we as humans automatically tend to process the text as opposed to processing the colour of the text. Our brain automatically tends to interpret the text automatically. However, in a lessor known experiment that Stroop conducted, we can also train ourselves to control this effect and reduce the interference time i.e.

the time difference between congruent and incongruent text. So in other words, we can train our brain and try to control the effect.

There have been a number of variations developed along in the same manner in which John Ridley Stroop conducted his own experiment. As highlighted by this website, there is an “Emotional Stroop Test”. The variation being, that emotional words like “pain” and “joy” are introduced in amongst the coloured texts. Then the reaction to interpret such texts took even longer. Another variant is the “Numerical Stroop Effect” where the size of the number is denoted by number itself e.g. the size of the number 2 is smaller than the size of the number 7 etc. So where the original Stroop effect used colours, in the same manner, the “Numerical Stroop Effect” uses numbers.

References:

- MacLeod, C. M. (1991). Half a century of research on the Stroop: An integrative review. (Obtained through the link: Half a Century of Research on the Stroop Effect: An Integrative Review) - Ignore highlighted sections, that's not mine.
- Stroop effect - Link: http://www.psytoolkit.org/lessons/stroop.html
- http://psychclassics.yorku.ca/Stroop/
- http://www.whatispsychology.biz/the-stroop-effect-experiment-00048
- https://imotions.com/blog/the-stroop-effect/