

Stroop Effect

Test a Perceptual Phenomenon

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Background

In psychology, the Stroop effect is the delay in reaction time between congruent and incongruent stimuli [2]. The Stroop effect is a phenomenon that occurs when you must say the color of a word but not the name of the word. For example, **blue** might be printed in red and you must say the color rather than the word. [1]

While it might sound simple, the Stroop effect refers to the delayed reaction times when the color of the word doesn't match the name of the word (Incongruent condition). It's easier to say the color of a word if it matches the semantic meaning of the word (Congruent condition). For example, if someone asked you to say the color of the word "**black**" that was also printed in black ink, it would be much easier to say the correct color than if it were printed in green ink.[1]

The task demonstrates the effect that interference can have when it comes to reaction time. It was first described during the 1930s by American psychologist John Ridley Stroop for whom the phenomenon is named. His original paper describing the effect has become one of the most famous, as well as one of the most frequently cited, in the history of psychology.[1]

How does Stroop effect work?

The words themselves interfere with your ability to quickly say the correct color of the word. Two different theories have been proposed to explain this phenomenon:

1. **Selective attention theory:** According to this theory, naming the actual color of the words requires much more attention than simply reading the text.
2. **Speed of processing theory:** This theory states that people can read words much faster than they can name colors. The speed at which we read makes it much more difficult to name the color of the word after we've read the word.
3. **Automaticity:** This theory proposes that automatic reading doesn't require focused attention. Instead, the brain simply engages in it automatically. Recognizing colors, on the other hand, may be less of an automated process. While the brain registers written meaning automatically, it does require a certain amount of attentional resources

to process color, making it more difficult to process color information and therefore slowing down reaction times.[1]

Question 1

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

Answer 1

Independent Variable: The independent variable is the variable the experimenter changes or controls and is assumed to have a direct effect on the dependent variable. For the Stroop Effect, **Congruent** and **Incongruent** Word condition are independent variables.

Dependent Variable: The dependent variable is the variable being tested and measured in an experiment, and is 'dependent' on the independent variable. For the Stroop Effect case, the response time of the participants is the dependent variable.

Question 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 2

From my experience after taking the test and after studying literature on **Stroop Phenomenon**, it is stated that **Incongruent** stimuli requires more response time compared to **Congruent** stimuli. I would like to test this hypothesis.

Null Hypothesis (H_0): No difference or negative difference between the response time of **Incongruent** and **Congruent** time.

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

Alternate Hypothesis (H_1) : Positive difference between the response time of **Incongruent and Congruent time**.

$$H_1 = \mu_i - \mu_c > 0$$

μ_i : Sample mean of response time for Incongruent stimuli.

μ_c : Sample mean of response time for congruent stimuli.

Since the population parameters (mean and standard deviation) are not available and as the number of samples (n) are less than 30, we cannot perform **z-test**.

I would like to perform **paired (Dependent) one tailed t-test**. Since the same group of people participates in the test for determining the response time to different stimuli , the groups **are related or dependent** . When using a one-tailed test, the analyst is testing for the possibility of the relationship in one direction of interest, and completely disregarding the possibility of a relationship in another direction [3]. Here we are doing the same, we want to know whether Incongruent response time is higher than Congruent response time or not , hence we will be using **One tail t test**.

Some Assumptions:

- The assumption for a t-test is that the scale of measurement applied to the data collected follows a continuous or ordinal scale.
- The second assumption made is that of a simple random sample, that the data is collected from a representative, randomly selected portion of the total population.
- The third assumption is the data, when plotted, results in a normal distribution, bell-shaped distribution curve. When a normal distribution is assumed, one can specify a level of probability (alpha level, level of significance, p) as a criterion for acceptance.
- The final assumption is homogeneity of variance. Homogeneous, or equal, variance exists when the standard deviations of samples are approximately equal.

Question 3

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

Answer 3

I have used Google Sheets to calculate the below parameters.

Descriptive parameters	Incongruent Sample	Congruent Sample
Samples Size	24	24
Degree of freedom	23	23
Mean	22.01	14.05
Variance	23.01175704	12.66902907
Median	21.0175	14.3565
Standard deviation	4.797057122	3.559357958

Question 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.

Answers 4

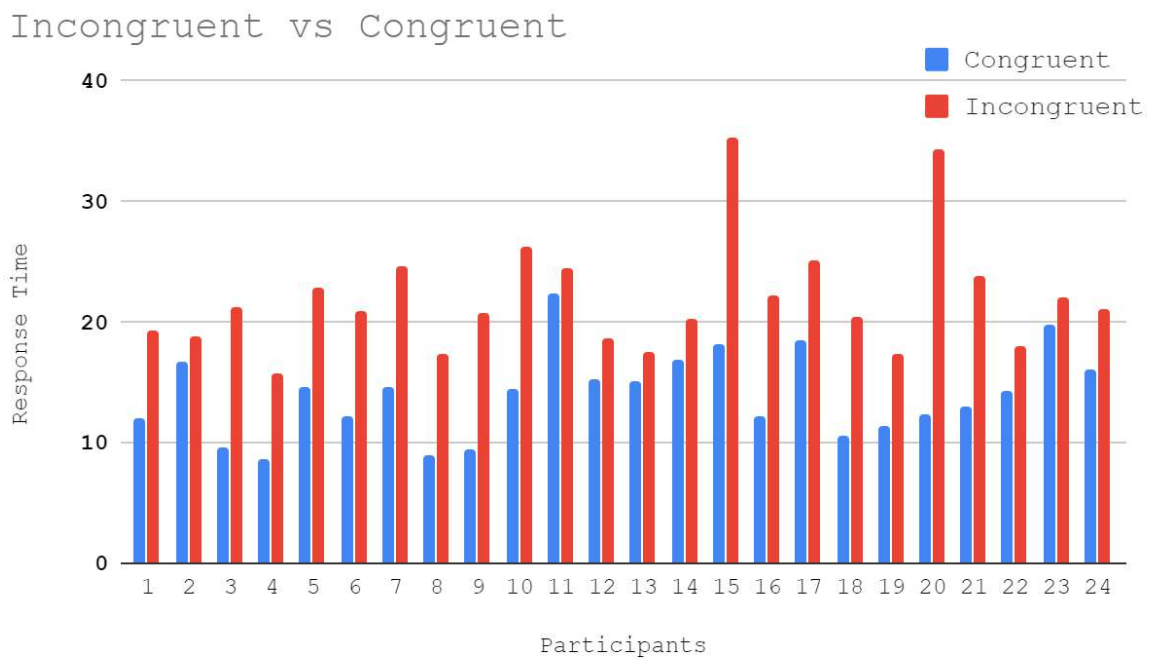


Figure 1: Participants response time to Incongruent and Congruent Stimuli

The above figure is generated using google sheets. It is evident from the figure that response time for **Incongruent stimuli** is significantly higher for all the participants than response time to **Congruent stimuli**.

We can see the same with individual plots. I tried fitting a normal distribution using norm.fit in python using scipy.stats. We can see that the distribution is little skewed to the left with most observations between 14-16 bins. (See figure 2). Note the **frequency is normalised**, since pdf are between 0 and 1.

For incongruent stimuli the response is again relatively higher. As most number of responses lie between 20-22.5.

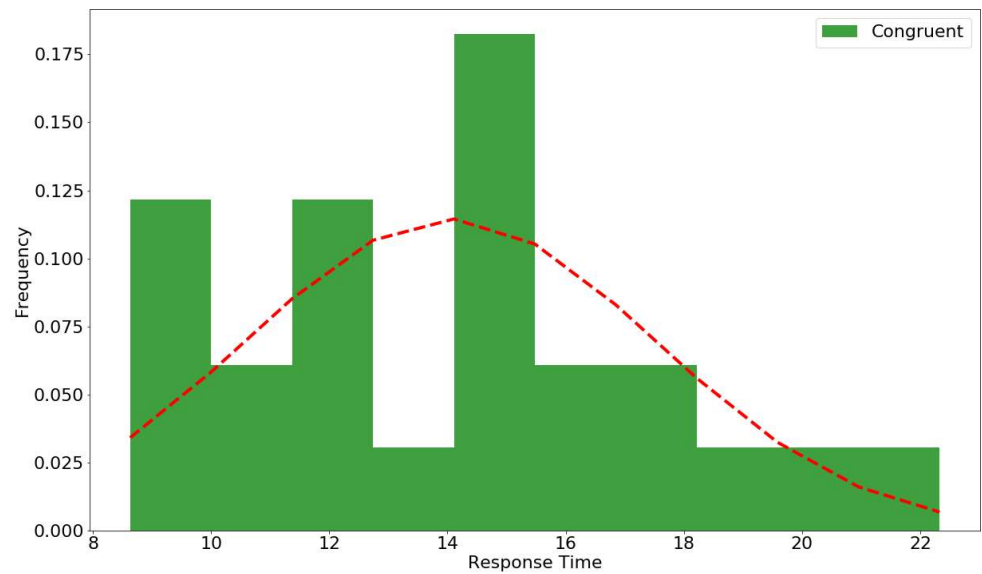


Figure 2: Congruent Stimuli Histogram fit

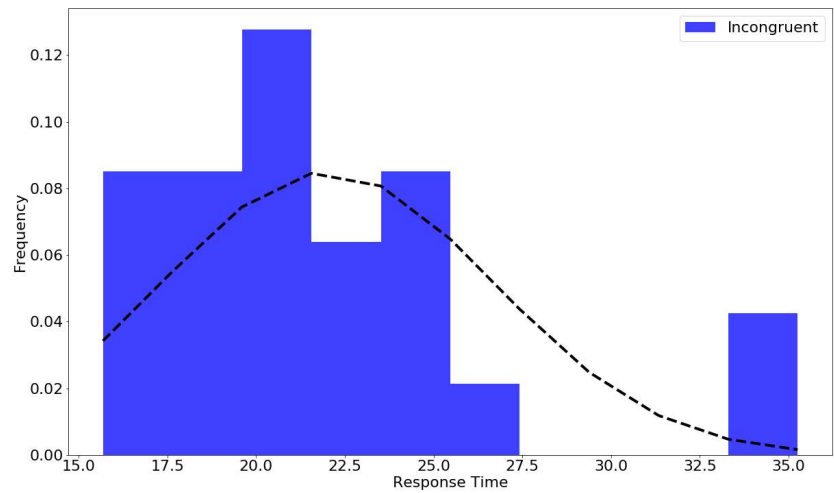


Figure 2: Congruent Stimuli Histogram fit

Question 5

Now, perform the statistical test and report your results. What is your confidence level and your critical statistical 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 5

I will be using the **one-tailed t test** as mentioned earlier in Question 2. I will use a **99% Confidence interval** for the test.

Degree of freedom= $n-1=23$ (n =number of samples)

Using the t-table chart the t -value(t_v) is **2.500** for One-tail test.

Difference of the mean between the two samples

$$\mu_i - \mu_c = 7.964$$

Standard deviation of the difference in response time (S_d)= **4.864**

$$t = (7.964 / 4.864) \times \sqrt{24} = 8.02$$

Using the google sheet ttest formula $t(23) = 8.02$ gives a probability (p value) of 0.00000002051500293 which is very small and is less than 0.01.

Since the $t(8.02) > t_v(2.500)$ at 99% Confidence interval, the null hypothesis (H_0) is rejected and Alternate Hypothesis (H_1) is accepted. Which means there is a positive difference in response time between incongruent and congruent stimuli.

Conclusion

The alternate hypothesis was accepted after performing the one-tailed paired t test which states that there is a positive difference between the response time of Incongruent and Congruent word conditions. This is consistent with the literature and also from my own personal experience while performing the test. The same can be seen from the histogram plots shown in Question 4.

Reference

1. <https://www.verywellmind.com/what-is-the-stroop-effect-2795832#:~:text=The%20Stroop%20effect%20is%20a,color%20rather%20than%20the%20word.>
2. https://en.wikipedia.org/wiki/Stroop_effect
3. <https://www.investopedia.com/terms/o/one-tailed-test.asp#:~:text=hypothesis%20testing%20tools.-,When%20using%20a%20one%20tailed%20test%2C%20the%20analyst%20is%20testing,is%20greater%20than%20the%20market's.>