Times Taken to Complete a Stroop Task and the Effect of Interference

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Abstract

Stroop Effect is the phenomenon which is a demonstration of interference in the reaction time of a task. Participants are subject to a Stroop task where they are shown a list of words printed in different colors and their task is to read out loud the color of the ink in which the word is written, and total time to read all the words is measured. When the interference of the incongruent words condition was introduced, the participants took significantly longer time to complete the test than when the test was taken with the congruent words condition. Hence the Stroop effect was demonstrated to exist and have an influence on reaction times.

Keywords: stroop effect, color words, congruent, incongruent

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It has been observed that when the name of a color (e.g., "blue", "green", or "red") is printed in a color which is not denoted by the name (i.e., the word "red" printed in blue ink instead of red ink), naming the color of the word takes longer and is more prone to errors than when the color of the ink matches the name of the color. These two conditions are the congruent words condition where the words displayed are color words whose colours match the color in which they are printed, and the incongruent words condition in which the words displayed are colors words whose colours do not match the color in which they are printed.

Method

Participants

24 participants on a voluntary basis were selected to take the test. They voluntarily submitted their test scores after taking the self-test.

Materials

A website was used which ran an applet that would randomly display a list of words. When the test starts, the applet would start a timer. The applet would also display a button which a participant could use to signal that they finished the test. Clicking this button stops the timer and displays the total elapsed time. The applet also allows the participant to run the test with congruent words as well as with incongruent words.

Procedure

The participants took the Stroop test under both conditions in sequence. Initially the test was conducted with congruent words condition. The applet being used presented to them a random list of words and they were asked to read out loud and correctly the colors of the displayed words. When they finished, they would click a button which would give them the time it took for them to read all the words. This time is then recorded by the participants. The participants were then asked to take the test again, but this time with an incongruent words condition. Again the applet presented the same number of randomly generated words which the participants had to read out loudly and correctly and click the finish button once completed. The time taken was presented to the participants which they then recorded.

Results

The times taken by each of the 24 participants are presented in the raw form in Table 1. The *independent variable* for this experiment is the condition used to perform the Stroop task which is this case is the congruent words condition in the first test and the incongruent words condition in the second test. The *dependent variable* for this test is then the time taken to complete the Stroop task under each condition. The sample subjects take the two tests with a treatment applied between the two tests and hence this experiment is a *dependent t-test for paired samples with a repeated measures design*.

On analysis of this data, the congruent test is described by the mean ($M_C = 14.05$), median ($Q2_C = 14.36$) and interquartile range ($IQR_C = 4.69$). The congruent test also shows the sample standard deviation ($SD_C = 3.56$) and variance ($VAR_c = 12.67$). The incongruent test is

described by the mean ($M_I = 22.02$), median ($Q2_I = 21.02$) and interquartile range ($IQR_I = 5.52$).

It also shows the sample standard deviation ($SD_I = 4.86$) and variance ($VAR_I = 23.67$). The

histogram of the two distributions are presented in Figure 1 and Figure 2.

From these results and data, we want to ascertain whether there is a significant statistical

difference between the mean response time in the congruent words condition (M_c) and the mean

response time in the incongruent words condition(M_I). The null hypothesis ($H_0 : M_I - M_C = 0$) is

that there is no difference between the means of the two times. The alternate hypothesis ($H_A : M_I$

$- M_C \neq 0$) will show that there is indeed a significant difference between the two mean response

times. As the direction of change is not of concern, we will conduct a *two-tailed t-test* to analyse

the results at a probability with ɑ = .05.

For the difference between the two tests as presented in Table 2, we find the point

estimate to be ($X_C - X_I = -7.96$) and the standard deviation of differences ($SD_{C-I} = 4.86$) with its

variance ($VAR_{C-I} = 23.67$). The number of samples (n = 24) and the degrees of freedom (df =

23). The histogram for this sample differences is presented in Figure 3.

We can determine that t-critical = ±2.069 with ɑ = .05 for a two-tailed test with .025 in

each tail. We can also determine the t-statistic for the difference as $t(23) = 8.04; p < .0005$. The

probability of occurrence of the t-statistic is significantly less than the probability at t-critical and

falls well within the critical region. Hence we reject the null and go with the alternate hypothesis

that there is a statistically significant difference in the times taken to complete the task due to

interference from the Stroop effect.

The confidence interval at 95% CI = (-10.01, -5.91) seconds We can say that the

participants will, on an average, take at between 10 seconds to 6 seconds more time to perform

the incongruent words test as compared to the time taken to complete the congruent words test

with a 95% confidence.

The standardized difference between the means is d = -1.64. The correlation coefficient r^2

= .74 which says that 74% of the difference between the two mean response times is caused due

to the change of treatment from congruent words test to the incongruent words test.

Discussion

The Stroop effect is quite obviously seen here. There seems to be a high likelihood that

the reason for the increased response times is due to the interference caused by the Stroop effect

as we were also able to see from that t-statistic that there was an extremely low chance of picking

such a sample data at random.

In this case however, the congruent test was always conducted first and the incongruent

test was conducted next. The test could better control for variance by randomizing which test is

taken first so that the participants are not primed to take the test in a particular way. It is also

possible that the times taken to complete the test was lesser for the congruent test as one did not

have to read out the colors of the text, but just read out the color names once it was established

that the color words and the colors were one and the same. Normal reading seems to then kick in

which I realized when I took the test myself.

Upon self-testing, the times taken by me were X_C = 13.299 and X_I = 20.344. This further

establishes the pattern and hence interference is replicable. My standardized scores for the two

tests would then be Z_C = -0.21 and Z_I = -0.35. These values are not statistically different from the

means of the sample.

References

Writing Guidelines from https://owl.purdue.edu/owl/

Course on Descriptive Statistics from https://classroom.udacity.com/nanodegrees/nd009-infn

Stroop Effect from https://en.wikipedia.org/wiki/Stroop_effect

Table 1

Times taken (in seconds) by Participants to Complete Stroop Task under Two Conditions

Congruent Words Task (time in seconds)	Incongruent Words Task (time in seconds)
12.079	19.278
16.791	18.741
9.564	21.214
8.63	15.687
14.669	22.803
12.238	20.878
14.692	24.572
8.987	17.394
9.401	20.762
14.48	26.282
22.328	24.524
15.298	18.644
15.073	17.51
16.929	20.33
18.2	35.255
12.13	22.158
18.495	25.139
10.639	20.429
11.344	17.425
12.369	34.288
12.944	23.894
14.233	17.96
19.71	22.058
16.004	21.157

Note: The mean time taken for the congruent test ($M_C = 14.05$) is smaller than the mean time taken for the incongruent test ($M_I = 22.02$).

Table 2

Difference of Times Taken to Complete the Congruent Task and the Incongruent Task

Diff Xc - Xi
-7.057
-8.407
-6.081
-2.437
-3.727
-3.346
-1.95
-7.199
-3.401
-9.79
-11.361
-8.64
-5.153
-11.65
-2.348
-10.028
-8.134
-10.95
-2.196
-9.88
-6.644
-11.802
-21.919
-17.055

Note: All the differences are negative showing that all participants took a longer time to complete the incongruent test as compared to the congruent test.
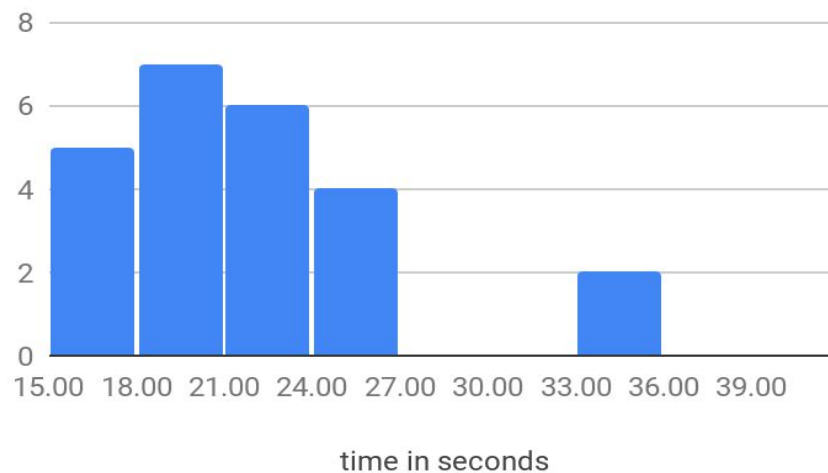
Figure Captions

Figure 1: Histogram of times taken for congruent words test

*Figure 2:* Histogram of times taken for incongruent words test

Figure 3: Histogram of difference in times taken between the two test conditions
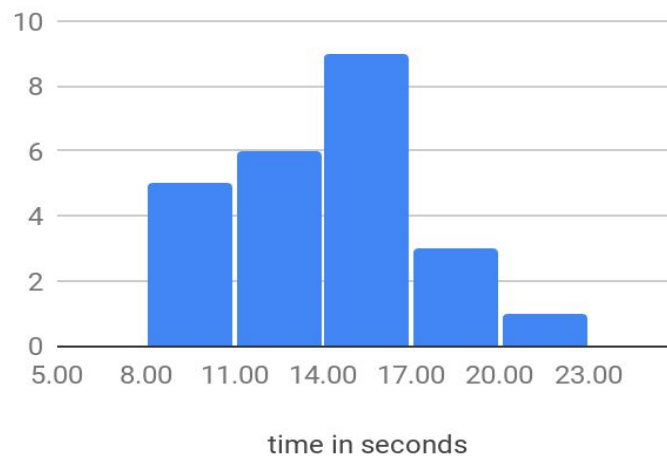
Figure 1: Histogram of times taken (in seconds) by 24 participants to complete the congruent words test. The distribution is mostly normal with a slight positive skew. The mode is between 14 - 17 seconds and there are no outliers.

Figure 2: Histogram of times taken (in seconds) by 24 participants to complete incongruent words test. The distribution is again mostly normal but there are outliers seen between the 33 - 36 seconds mark. The mode lies between 18 - 21 seconds.
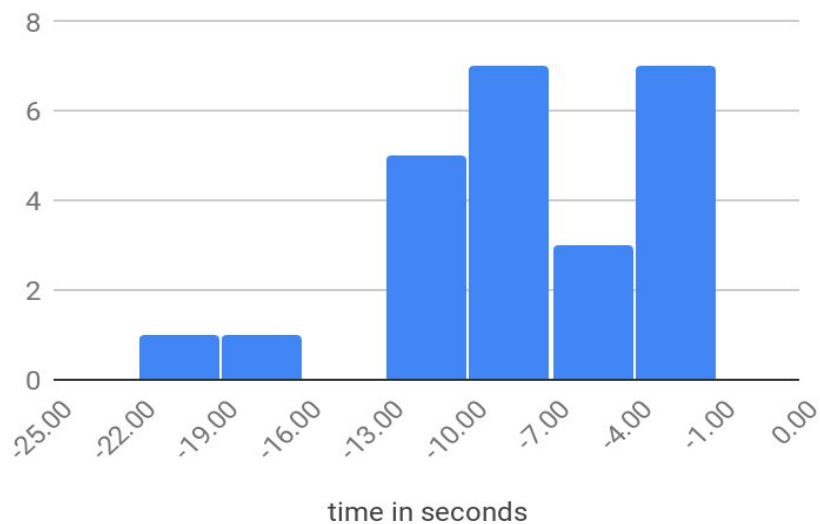
Figure 3: Histogram of the difference in time taken between the congruent test and the incongruent test. This shows a positively skewed distribution (negative axis) with a few outliers.