Project 1: Test a Perceptual Phenomenon Stroop Task

Question 1

Independent variable: Congruency (of the name and color of the word)
Dependent variable: Time (it takes to name the ink color)

Question 2

Null hypothesis H$_0$: The mean of the differences between the congruent-test's population and incongruent-
-test's population is greater than or equal to zero.

$$\mu_D \geq 0$$

Where μ_D is the mean of the differences between the two tests (μ_c - μ_i)
μ_c is the mean of the congruent test
μ_i is the mean of the incongruent test

Alternative hypothesis H$_A$: The mean of the differences between the congruent test's population and the
incongruent test's population is negative.

$$\mu_D < 0$$

http://medical-dictionary.thefreedictionary.com/Stroop+effect
https://en.wikipedia.org/wiki/Stroop_effect

Types of Statistical Tests to Perform: One tailed T-test[1].
Reasons:
  - We do not know the population's mean and standard deviation
  - The sample size is less than 30
  - Dependent samples, with repeated measures.
  - Non-skewed, Gaussian distribution is assumed
  - The reason one tailed was chosen over the two-tailed test lies in the definition of the Stroop effect itself,
that it increases the reaction time.
http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/hypothesis-tests/tests-of-means/types-of-t-tests/

We will compute the T-Statistic for the differences, and assume an alpha level = 0.025. If the p-value is less
than the alpha-level (And hence the T-value will lie inside the critical region), we would reject the null
hypothesis.

1: *I am aware that in the lectures (Lesson 9), it was mentioned that generally we should favor two-tailed tests because they are more conservative; but I could not ignore that
in the phenomenon's definition, it is explicitly defined that it will increase the reaction time.*

Link for spreadsheet where the calculations are: https://docs.google.com/spreadsheets/d/1-87GeLFkwdNFnDdVLE92WrZ9jpI3XFvBbEu7jg9AkUc/edit?usp=sharing

Question 3

Descriptive Statistics:

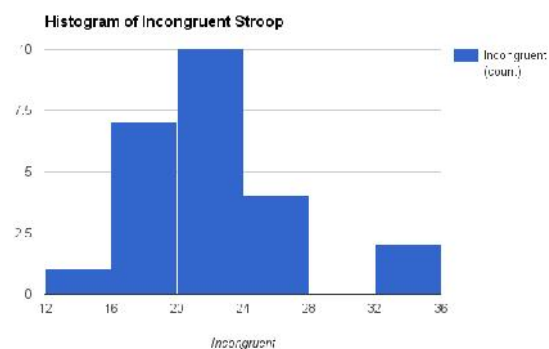|	Congruent		Incongruent
Sample Size	24		
Maximum	22.328		35.255
Outlier Upper Bound	18.9671		28.6025
Q3	16.2008		24.0515
Median	14.3565		21.0175
Mean	14.0511		22.0159
Q2	14.3565		21.0175
Outlier Lower Bound	11.5901		16.4665
Minimum	8.630		15.687
Range	13.698		19.568
Inter-Quartile Range	1.8443		3.034
Variance	12.6690		23.0118
Sample Standard Deviation	3.5594		4.7971

Question 4

Two visualizations: Histogram and bar plot
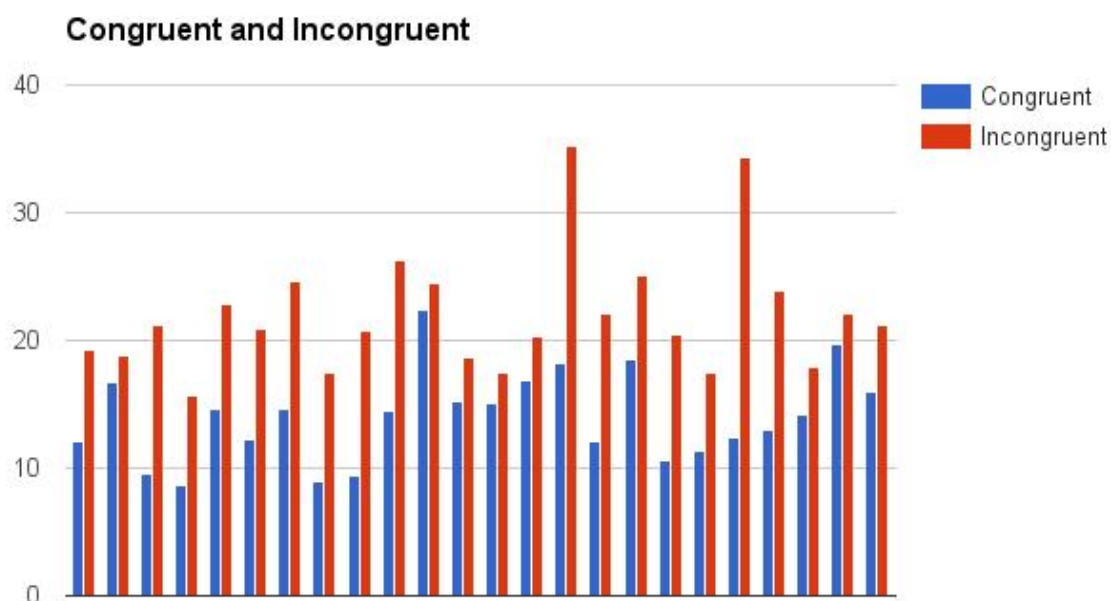
Histogram:
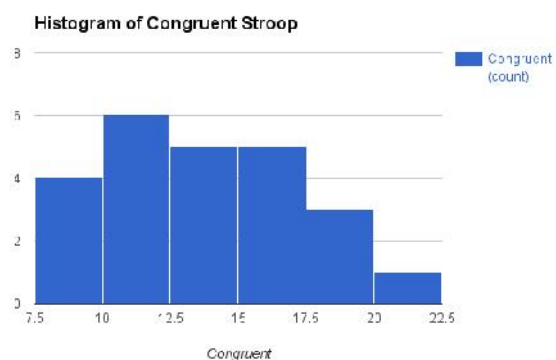
Congruent Histogram

Incongruent Histogram

Bar-plot:

From the histogram, we can see that the "Congruent" data is more uniform and less spread than the "Incongruent" data. From the bar plot, what has caught my eyes is that the "Incongruent" data is always greater than the "congruent" one.

Question 5

Inferential Statistics:

Statistic	Symbol	Value
Sample Size	n	24
T Critical Value	$T_{Critical}$	-2.069
Alpha Level	α	0.025
Degrees of Freedom	df	23
Median, Congruent	μ_c	14.0511
Median, Incongruent	μ_i	22.0159
Median of Differences, Point Estimate	μ_D	-7.9648
Variance of Differences	S_D^2	23.6665
Standard Deviation of Differences	S_D	4.8648
Standard Error	SEN	0.993

Link for spreadsheet where the calculations are: https://docs.google.com/spreadsheets/d/1-87GeLFkwdNFnDdVLE92WrZ9jpI3XFvBbEu7jg9AkUc/edit?usp=sharing

T-Value	T	-8.0207
Cohen's d	d	1.6372
Confidence Interval	CI	(-5.9102 , -10.0194)
Coefficient of Determination	r^2	0.7366

$$p < \alpha$$

$$T < T_{Critical}$$

Conclusion:

$T_{(23)}$ = -8.02, **p** < .01, Negative one-tailed

Confidence interval on the mean difference; 95% **CI** = (-5.9102, -10.0194)

Effect Size Measures
 d = 1.64
 r^2 = .74

 - Since the T-Score is past the T-Critical value (T < $T_{Critical}$, p < α), we have to reject the null hypothesis H_0.
 - It is very comfortable to say that our numbers are statistically significant, with a probability less than 0.0001 to have these numbers by pure chance.
 - Also, the coefficient of determination is high; 74% of the timing difference is due to (in)congruency.
 - On average, a person takes 5.9102 to 10.0194 seconds less during the test setting when the text and its color are congruent.

Did it match my expectations?
Yes, the results matched up my expectations that were formed after seeing the bar chart above. The red (incongruent) bars were always (And sometimes significantly, over the double) higher than the blue (congruent) bars. That was a hint for significance.

Question 6

Possible Causes:
1- Speed of Processing Theory
2- Selective Attention Theory
3- Automacity Theory
4- Parallel Distributed Processing Theory

According to Wikipedia, Automacity is the most common theory for the Stroop effect.

Link for spreadsheet where the calculations are: https://docs.google.com/spreadsheets/d/1-87GeLFkwdNFnDdVLE92WrZ9jpI3XFvBbEu7jg9AkUc/edit?usp=sharing

My Opinion:

In my opinion, the **"Selective Attention"** theory is very plausible too: I have already encountered this phenomenon (But I did not know its name until this project) when I played with the Lumosity app.

It is hard to explain; but when I played this game, I used to keep my eyes fixed on the meaning part and all my mental focus is over my peripheral vision towards the "text color" section. With the peripheral vision, I cannot read the section of the text color, but I can cleanly distinguish the color, thus eliminating the interference coming from the second word. So that was how I performed best, when I selectively chose to put most of my attention to the text color section.

As a clarification for what I meant, focus over the 'e' in "red" in the screenshot below, and do not move your eyes at all. Mentally try to focus over the color that is coming from the right cell (text color box). You will find that it is clearly yellow, even if you cannot read the text itself. That way, answering if it matches or not is much faster, after separating the color and reading processes into distinct tasks. I hope that this clarifies my opinion about it.
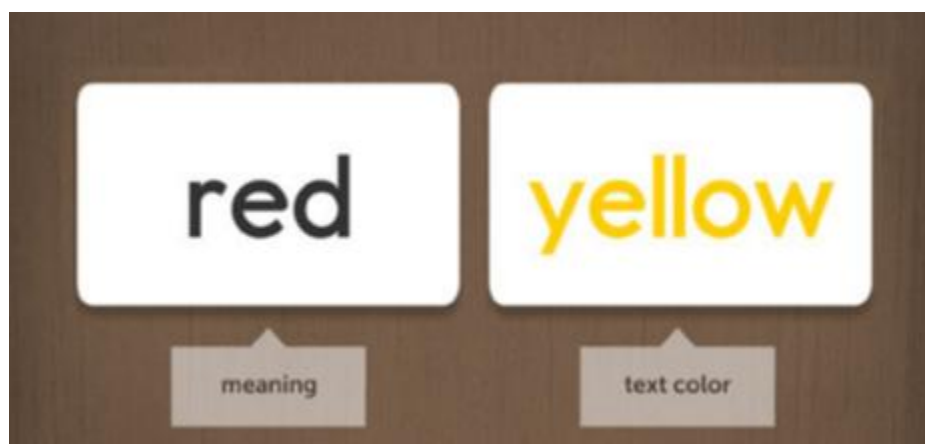
Screenshot of Lumosity's Stroop game

I also think that with enough training this phenomenon can be neutralized. A similar task I have experiences was when I had my piano lessons: reading the notes while simultaneously playing with both hands takes a considerably longer time than either reading alone or playing alone. After a long time of training (months), people can perfect this task perfectly.

Similar Task

Playing piano from a musical sheet (reading and kinetic)