P1 : Test a perceptual phenomenon

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1. What is our independent variable? What is our dependent variable?

Dependent variable:
The time taken by the participants to read the words for each category of words

Independent variable:
The type of the words in the stroop effect, read by the participants (the congruent words and the incongruent words). The type of the word is the independent variable here

2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

So lets represent Incongruent as I and Congruent as C for the sake of definitions. Let the Population mean of Congruent set be μ_C and the population mean of Incongruent set be μ_I

The null hypothesis: The population means of the congruent word times and the population means of incongruent word times are not different from each other. That is, the condition of the word does not have any effect on the time taken.

$H_o : \mu_C = \mu_I$ (or) $\mu_C - \mu_I = 0$

The Alternate hypothesis: The population mean of times of both the conditions of words are significantly different.

$H_A : \mu_C \neq \mu_I$ (or) $\mu_C - \mu_I \neq 0$

The statistical test that is chosen to test the hypothesis in this case is a "Dependents T-sample test" with two tailed œ(alpha) values. This design is also called the repeated measures design.

The reason dependent samples T test is chosen is because, we have information enough to obtain the sample statistics from our given samples and we do not know any population statistics. We can draw conclusions about the statistical significance by computing the t-statistic and t-critical values.

Also, we only need to know that the difference between population means for both conditions is significantly present. We need not find out if the times were improved or deteriorated by the condition of the readable words. Hence a two tailed test where we show that $\mu_C - \mu_I \neq 0$ is enough.

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

Sample mean of Congruent X_C= 14.051125
Sample mean of incongruent mean X_I= 22.01591667

Sample standard deviation of the difference(D) S_D = 4.86482691, calculated using the stdev() function in excel that gives us the sample estimate as using SQRT((∑(xi-x)^2)/n-1)

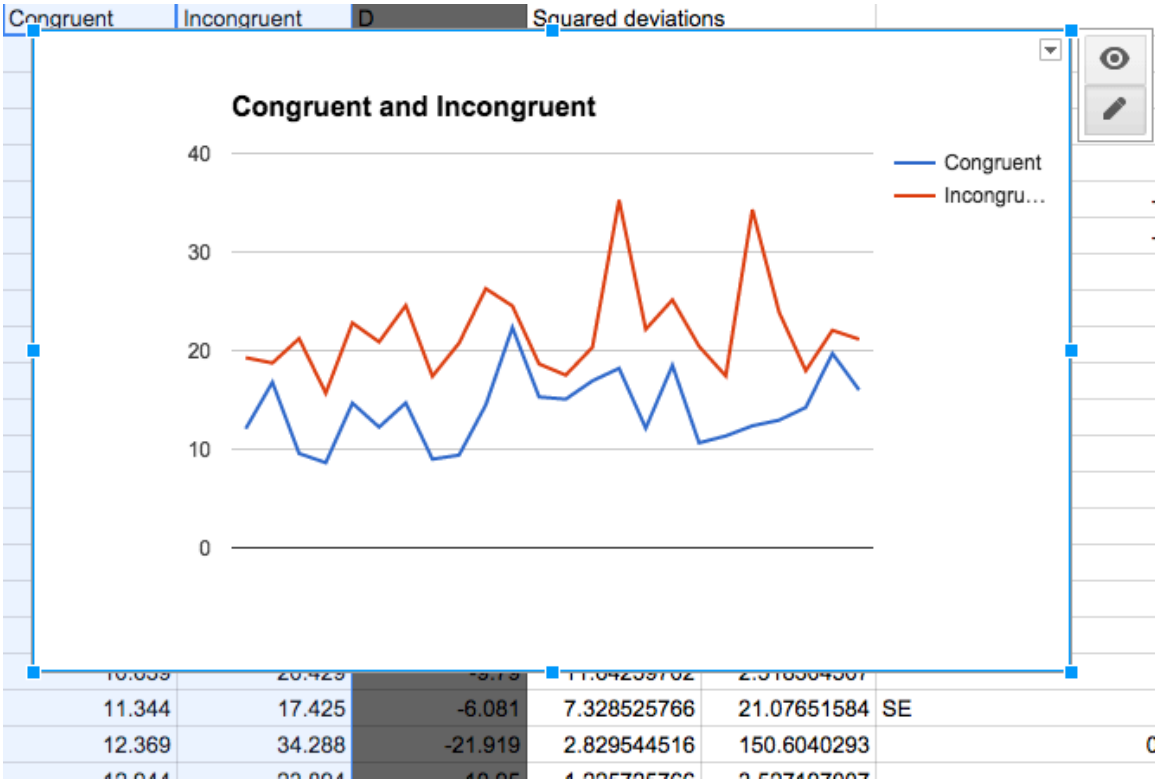
Congruent	Incongruent	D
12.079	19.278	-7.199
16.791	18.741	-1.95
9.564	21.214	-11.65
8.63	15.687	-7.057
14.669	22.803	-8.134
12.238	20.878	-8.64
14.692	24.572	-9.88
8.987	17.394	-8.407
9.401	20.762	-11.361
14.48	26.282	-11.802
22.328	24.524	-2.196
15.298	18.644	-3.346
15.073	17.51	-2.437
16.929	20.33	-3.401
18.2	35.255	-17.055
12.13	22.158	-10.028
18.495	25.139	-6.644
10.639	20.429	-9.79
11.344	17.425	-6.081
12.369	34.288	-21.919
12.944	23.894	-10.95
14.233	17.96	-3.727
19.71	22.058	-2.348
16.004	21.157	-5.153
		4.86482691

Standard Error of mean of difference = $S_D / \sqrt{n}$ where n is the size of the sample
Therefore $SE_D = 4.86482691/\sqrt{24} = 0.9930286348$

t-Statistic = $(X_C - X_I)$ / SE = -7.964791667/0.9930286348 = -8.020706944

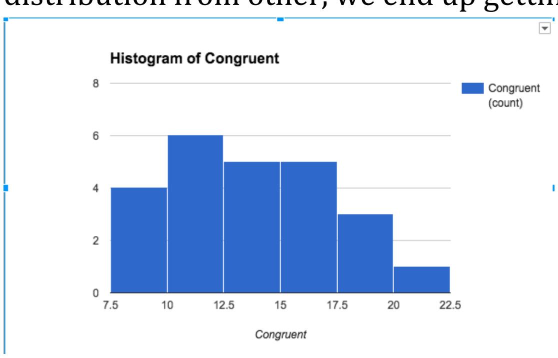
4. Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

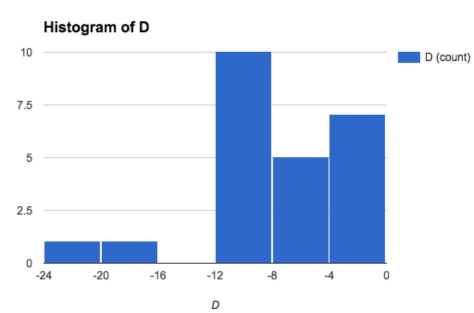
The plot between the sample of Congruent data and incongruent data is shown below:



From the above plot, it can be observed that the congruent condition times for every observation falls below the incongruent condition times.

Also if we look at the histograms of Congruent and incongruent separately, we can see that they are both normal distributions. And when we subtract the one normal distribution from other, we end up getting a normal distribution





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?

The t-statistic as calculated earlier is: -8.021
If we choose to analyze the result at 95% confidence interval in which case our alpha (œ) <0.05(or 5%), our t critical values from the t-table will be as follows for a two-tailed test:

Tail probability –0.025 and degrees of freedom df – 24-1 = 23

Table B *t* distribution critical value

	Tail probability *p*							
df	.25	.20	.15	.10	.05	.025	.02	.0
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.8
2	.816	1.061	1.386	1.886	2.920	4.303	4.849	6.9
3	.765	.978	1.250	1.638	2.353	3.182	3.482	4.5
4	.741	.941	1.190	1.533	2.132	2.776	2.999	3.7
5	.727	.920	1.156	1.476	2.015	2.571	2.757	3.3
6	.718	.906	1.134	1.440	1.943	2.447	2.612	3.1
7	.711	.896	1.119	1.415	1.895	2.365	2.517	2.9
8	.706	.889	1.108	1.397	1.860	2.306	2.449	2.8
9	.703	.883	1.100	1.383	1.833	2.262	2.398	2.8
10	.700	.879	1.093	1.372	1.812	2.228	2.359	2.7
11	.697	.876	1.088	1.363	1.796	2.201	2.328	2.7
12	.695	.873	1.083	1.356	1.782	2.179	2.303	2.6
13	.694	.870	1.079	1.350	1.771	2.160	2.282	2.6
14	.692	.868	1.076	1.345	1.761	2.145	2.264	2.6
15	.691	.866	1.074	1.341	1.753	2.131	2.249	2.6
16	.690	.865	1.071	1.337	1.746	2.120	2.235	2.5
17	.689	.863	1.069	1.333	1.740	2.110	2.224	2.5
18	.688	.862	1.067	1.330	1.734	2.101	2.214	2.5
19	.688	.861	1.066	1.328	1.729	2.093	2.205	2.5
20	.687	.860	1.064	1.325	1.725	2.086	2.197	2.5
21	.686	.859	1.063	1.323	1.721	2.080	2.189	2.5
22	.686	.858	1.061	1.321	1.717	2.074	2.183	2.5
23	.685	.858	1.060	1.319	1.714	2.069	2.177	2.5
24	.685	.857	1.059	1.318	1.711	2.064	2.172	2.4
25	.684	.856	1.058	1.316	1.708	2.060	2.167	2.4

Therefore t Critical = plus or minus 2.069

When we compare our t-statistic with our t-critical, we can evidently see that our t-statistic is definitely in the critical region with a probability way less than 0.05

So, we have evidence to reject the null hypothesis. Therefore, we reject the hypothesis that the condition of the word has no effect on the time to read the word. We can conclude that the condition of the word does have an impact on the time taken to read the word. (i.e $\mu_C - \mu_I \neq 0$)

To be clearer, because the t-statistic is a –ve value and lies in the lower tail of the critical region, we can say that the difference between population means of the two conditions is less than 0 and so $\mu_{C} << \mu_{I}$.

It also naturally matches with our expectations because, through the plots we saw that the incongruent words took more time to be read on an average than the congruent words.

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!

The Stroop effect describes that the two areas in brain that resolve two different aspects of a problem come in conflict while reading the Incongruent words and this conflict results in more time taken by the brain to resolve the problem. I think this is the reason, every single participant in the sample recorded a lesser time for congruent words and more time for incongruent words

Some examples of similar tasks that would result in a similar kind of effect are:

1. Reading sentences the way we normally read vs Reading sentences up side down (i.e, reading when the book is turned facing the opposite side)
2. Counting numbers from 1 to 50 in a straight forward way vs Counting numbers with every multiple of 3 replaced by the word "BUS"

Both the above tasks result in the same kind of effect as our case, where the second version of the task takes longer than the first simpler version of the task.

Web sources and links referred:

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1. https://s3.amazonaws.com/udacity-hosted-downloads/t-table.jpg
2. https://en.wikipedia.org/wiki/Stroop_effect
3. and Statistics course Lesson 10 and 11 in Udacity