Quentin THOMAS

P1: Test a Perceptual Phenomenon

Stroop task project

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

The independent variable is the treatment here, namely the congruent/incongruent words condition.

The dependent variable is the participant performance: It is the time (in seconds) it takes to name the ink colors in equally-sized lists (25 colors).

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

We want to show that when the name of a color (e.g., "blue", "green", or "red") is different than the color ink, naming the color ink takes longer and is more prone to errors than when the color of the ink matches the name of the color.

μ_{Con} is the population mean time in seconds, to name the 25 ink colors of the Congruent test.

μ_{Incon} is the population mean time in seconds, to name the 25 ink colors of the Incongruent test.

$$H_0 = \mu_{Incon} - \mu_{Con} \leq 0$$

The null hypothesis (H_0):
The difference between the Incongruent test mean time and the Congruent test mean time is less or equal than 0. This means that for the population, the Incongruent word condition has no negative effect on the naming of the ink colors. It will not take more time to complete the test with the Incongruent word condition.

$$H_a = \mu_{Incon} - \mu_{Con} > 0$$

The alternative hypothesis (H_a):
The difference between the Incongruent test mean time and the Congruent test mean time is greater than 0. This means that for the population, the participants will take more time to name the incongruent words than the congruent ones.

We gave the same persons two different conditions and we have recorded how they have reacted each time. Because there are repeated measures (control and treatment test), we are speaking about dependent sample tests. To be more specific it is a **Paired t test**.

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

Congruent		Xi-Xbar	(Xi-Xbar)^2		Incongruent		Xi-Xbar	(Xi-Xbar)^2	
8,63	Mean:	-5,42	29,39	Sum:	15,687	Mean:	-6,33	40,06	Sum:
8,987	14,05	-5,06	25,65	291,39	17,394	22,02	-4,62	21,36	529,27
9,401	Median:	-4,65	21,62	n-1:	17,425	Median:	-4,59	21,08	n-1:
9,564	14,36	-4,49	20,13	23	17,51	21,02	-4,51	20,30	23
10,639		-3,41	11,64	Variance:	17,96		-4,06	16,45	Variance:
11,344		-2,71	7,33	12,67	18,644		-3,37	11,37	23,01
12,079		-1,97	3,89	Standard Deviation:	18,741		-3,27	10,73	Standard Deviation:
12,13		-1,92	3,69	3,56	19,278		-2,74	7,50	4,80
12,238		-1,81	3,29		20,33		-1,69	2,84	
12,369		-1,68	2,83		20,429		-1,59	2,52	
12,944		-1,11	1,23		20,762		-1,25	1,57	
14,233		0,18	0,03		20,878		-1,14	1,29	
14,48		0,43	0,18		21,157		-0,86	0,74	
14,669		0,62	0,38		21,214		-0,80	0,64	
14,692		0,64	0,41		22,058		0,04	0,00	
15,073		1,02	1,04		22,158		0,14	0,02	
15,298		1,25	1,55		22,803		0,79	0,62	
16,004		1,95	3,81		23,894		1,88	3,53	
16,791		2,74	7,51		24,524		2,51	6,29	
16,929		2,88	8,28		24,572		2,56	6,53	
18,2		4,15	17,21		25,139		3,12	9,75	
18,495		4,44	19,75		26,282		4,27	18,20	
19,71		5,66	32,02		34,288		12,27	150,60	
22,328		8,28	68,51		35,255		13,24	175,27	

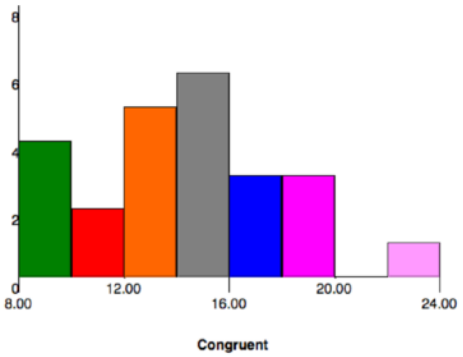
Congruent test:
Congruent mean = 14.05
Congruent median = 14.36
Congruent variance = 12.67
Congruent standard deviation = 3.56

Incongruent test:
Incongruent mean = 22.02
Incongruent median = 21.02
Incongruent variance = 23.01
Incongruent standard deviation = 4.80

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.

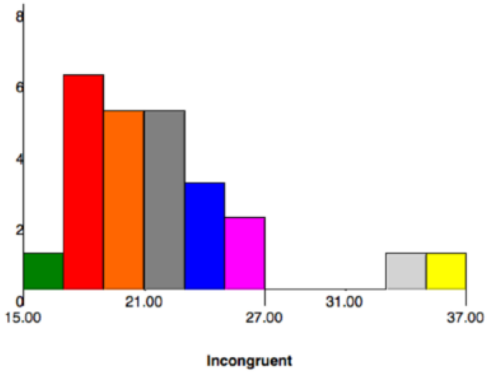
On the Congruent histogram, we can notice with an interval size of 2 sec that the mode is 14;16.

The global shape of the histogram looks roughly like a normal distribution. Furthermore the mean, median and mode are close to be equal which confirms that there is a normal distribution shape tendency.



On the Incongruent histogram, we can notice with an interval size of 2 sec that the mode is 17;19.

The global shape of the histogram looks roughly like a positively skewed distribution with the mode > median > mean.



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?

It is an one tailed t test with an alpha level = 0.05

So according to the t table, the t critical value = 1.714

The respective means are:

$$\overline{X}_{Con} = 14.05$$
$$\overline{X}_{Incon} = 22.05$$

And the means difference is:

$$\mu_{Incon} - \mu_{Con} = 7.96$$

Now we have to find the standard deviation of the difference = **4.86**

Congruent	Incongruent	D = Inc - Con		D - Average diff	(D - Average diff)^2	
12,079	19,278	7,20	Average difference:	-0,77	0,59	Sum:
16,791	18,741	1,95	7,96	-6,01	36,18	544,33
9,564	21,214	11,65		3,69	13,58	Sum / n-1:
8,63	15,687	7,06		-0,91	0,82	23,67
14,669	22,803	8,13		0,17	0,03	Standard Deviation:
12,238	20,878	8,64		0,68	0,46	4,86
14,692	24,572	9,88		1,92	3,67	
8,987	17,394	8,41		0,44	0,20	
9,401	20,762	11,36		3,40	11,53	
14,48	26,282	11,80		3,84	14,72	
22,328	24,524	2,20		-5,77	33,28	
15,298	18,644	3,35		-4,62	21,33	
15,073	17,51	2,44		-5,53	30,56	
16,929	20,33	3,40		-4,56	20,83	
18,2	35,255	17,06		9,09	82,63	
12,13	22,158	10,03		2,06	4,26	
18,495	25,139	6,64		-1,32	1,74	
10,639	20,429	9,79		1,83	3,33	
11,344	17,425	6,08		-1,88	3,55	
12,369	34,288	21,92		13,95	194,72	
12,944	23,894	10,95		2,99	8,91	
14,233	17,96	3,73		-4,24	17,96	
19,71	22,058	2,35		-5,62	31,55	
16,004	21,157	5,15		-2,81	7,91	

The t statistic calcul is :

$$t = \frac{\mu_{Incon} - \mu_{Con}}{\frac{SD}{\sqrt{n}}} = \frac{7.96}{\frac{4.86}{\sqrt{24}}} = 8.02$$

As the t statistics value (8.02) pass the t critical value (1.714) **we can reject the null hypothesis**.

This result confirms that a different color name has an impact on the annunciation of the ink color. We expected this result because each value for the Incongruent test is strictly higher than for the Congruent test.

We can use the Cohen's d in order to measure the effect size:

$$d = \frac{MeansDifference}{\text{StandardDeviation}} = \frac{7.96}{4.86} = 1.64$$

Now we want to define the Confidence Interval:

$$CI = MeansDifference \pm tcritical \frac{\text{StandardDeviation}}{\sqrt{n}}$$

$$CI = 7.96 \pm 1.714 \frac{4.86}{\sqrt{24}}$$

$$CI = 7.96 \pm 1.70$$

$$CI = [6.26, 9.67]$$

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!

Most of the theories which explain the Stroop effect are based on the fact that the color information arrive to the brain after the word information.
It could be interesting to challenge this test by making the word information slower to come to the brain:
- By using people whose native language is not english
- By changing the order of the color (e.g. "bleu","rde","eengr"...)

We could obtain the same effect with each pair of information which demand a different speed to be decoded by the brain.

Source:
https://en.wikipedia.org/wiki/Stroop_effect