Statistics: The Science of Decisions

Background Information

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participant's task is to say out loud the *color of the ink* in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition. In the *congruent words* condition, the words being displayed are color words whose names match the colors in which they are printed: for example RED, BLUE. In the *incongruent words* condition, the words displayed are color words whose names do not match the colors in which they are printed: for example PURPLE, ORANGE. In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

Questions For Investigation

As a general note, be sure to keep a record of any resources that you use or refer to in the creation of your project. You will need to report your sources as part of the project submission.

1. What is our independent variable? What is our dependent variable?
Ans:-
Independent variable – Two conditions to determine Stroop Effect – Congruent and Incongruent
Dependent variable – Time taken to name the ink in equally-sized lists

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

Ho : Time to name the colors of ink in equally sized lists is same irrespective of the condition implemented -> $\mu_c = \mu_i$ or $\mu_c - \mu_i = 0$
Ha : It takes more to read the colors of ink in equally sized lists if the names of words do not match the colors of ink. -> $\mu_c < \mu_i$ or $\mu_c - \mu_i < 0$

What kind of statistical test do we need:

1. The experiment collects time taken in seconds, so the kind of data we have here is interval and ratio.
2. There is one sample for 24 people, each with two scores, one for congruent condition and the other score is for incongruent. So, the samples we have are called dependent paired samples.
3. The purpose is to identify whether there is a difference in the amount of time taken to answer the two conditions and hence the test we use is difference of two means (dependent paired samples). We have read about z-test and t-tests. We cannot use z-test because we do not know the population parameters. I recently read about f-test, from what I understand it's used to find variances between populations, so it is used for independent samples. So, we cannot use it. T-test on the other hand can make use of

sample parameters and can be used on dependent paired samples. So we will use t-test.

Since we want to check if incongruent list leads to more we will perform a positive one-tailed test. If we had said that incongruent words just lead to different times compared to congruent then we would have employed a two-tailed approach.

3. Now it's your chance to try out the Stroop task for yourself. Go to this link, which has a Java-based applet for performing the Stroop task. Record the times that you received on the task (you do not need to submit your times to the site.) Now, download this dataset which contains results from a number of participants in the task. Each row of the dataset contains the performance for one participant, with the first number their results on the congruent task and the second number their performance on the incongruent task.

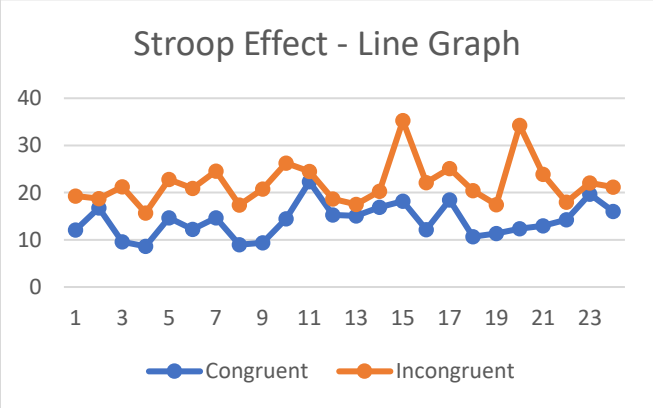
Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

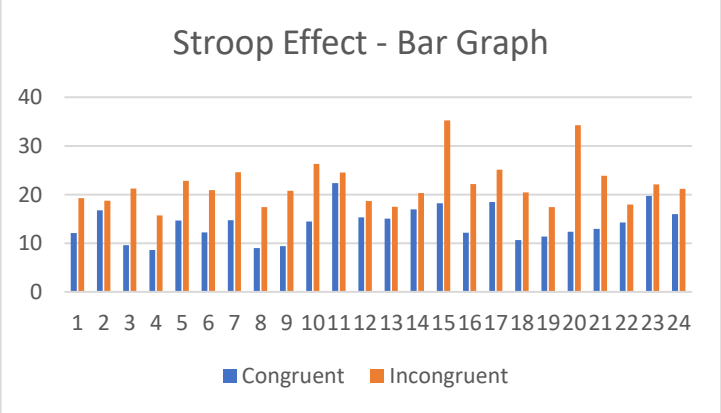
Ans:-

Central tendency	Congruent	Incongruent
mean	14.05	22.02
median	14.36	21.02

Variability	Congruent	Incongruent
variance	12.67	23.01
std dev	3.56	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.





Ans:-

For our sample, I observed from the graph that for all occasions, the same person has taken more time to answer for the incongruent method.

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?

Ans:- Our experiment has dependent samples so we will have to use dependent t-test for paired samples with two conditions (repeated measures design), meaning, that the same subject participates in the experiment for two conditions, namely, congruent words condition and incongruent words condition.

Ho: $\mu_c = \mu_i$ or $\mu_c - \mu_i = 0$
Ha: $\mu_c < \mu_i$ or $\mu_c - \mu_i < 0$
Since we want to check if incongruent list leads to more we will perform a positive one-tailed test. If we had said that incongruent words just lead to different times compared to congruent then we would have employed a two-tailed approach.

$\mu_c = 14.05$ and $\mu_i = 22.02$

Point estimate = $\mu_c - \mu_i = -7.96$
SD of differences = 4.86
t-statistic = -8.02
Affect measure = cohen's d = -1.64

at $\alpha = 0.01$ or 99% CI, t critical point for one-direction t-test is -2.5

Since t-statistic is less than t-critical, we can say that the t-statistic falls in the critical region and hence we **reject** the null hypothesis.

Conclusion: $\mu_c - \mu_i < 0$ i.e. It takes more to read the colors of ink in equally sized lists if the names of words do not match the colors of ink.

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!

Ans:

Reasons - Human beings learn by association. For e.g. our mind has learnt to associate color green with the characters g.r.e.e.n. Even during an experiment with clear defined conditions, it's quite difficult to ignore the association and hence the subject takes more time for incongruent words condition.

From what I read online there are multiple theories around this-

1. Its faster to process words than colors, so when asked to identify color red on the word 'green', the mind reads green first and then it processes the color red.
2. Processing a color takes more attention and so there is a lag when color and word don't match
3. Recognizing colors is not a automatic process like reading which is automatic hence the mind hesitates to respond.

4. The brain analyzes information and there are different paths developed for different tasks. Since most humans spend a lot of time reading words versus identifying color the path for reading is quite strong. Hence, it is the strength of the reading path and not the speed of the path that is important.

Alternative – (found a couple of good examples online)

1. Emotional stroop effect: Subjects are given emotion words in different colors. Instructions are to ignore the word and to name the color of the word. When people with disorders (anxiety, depression, anorexia) take the test, they find it harder to read words which associate with their problem.
2. Numerical stroop effect: The Numerical Stroop shows the close relationship between numerical values and font sizes. A number can be written in big font or small font (3 vs. 3). Comparing numbers in incongruent condition (e.g., 3 5) is slower than comparing numbers in congruent condition (e.g., 5 3) and the difference in reaction time is the numerical Stroop effect.

Real Life –

1. Whenever we are installing any software, we tend to overlook things which are written in small print and focus on sentences which are written in larger font. The mind perceives smaller font as less consequential and ignore it.
2. Advertisers using illusion of scarcity. In a classic study in 1975, researchers showed 200 people two identical cookie jars, except one had 10 cookies and the other had just two. Surprisingly, people rated the cookies in the empty jar as more valuable. Today, airlines and other companies use the scarcity principle all the time (think "only a few tickets left at this price!").

Sources:

https://en.wikipedia.org/wiki/Stroop_effect#Variations
http://www.swarthmore.edu/SocSci/fdurgin1/ReverseStroop/PBRStroop.html
http://www.businessinsider.com/9-sneaky-psychology-tricks-companies-use-to-get-you-to-buy-stuff-2016-2/#the-decoy-effect-2

StroopData

Congruent	Incongruent	C:squares	I:squares
12.079	19.278	3.889277	7.496188
16.791	18.741	7.506915	10.72508
9.564	21.214	20.13429	0.64307
8.63	15.687	29.3886	40.05519
14.669	22.803	0.38177	0.6195
12.238	20.878	3.287422	1.294854
14.692	24.572	0.410721	6.533562
8.987	17.394	25.64536	21.36211
9.401	20.762	21.62366	1.572307
14.48	26.282	0.183934	18.19947
22.328	24.524	68.50666	6.290482
15.298	18.644	1.554697	11.36982
15.073	17.51	1.044229	20.30329
16.929	20.33	8.282165	2.842315
18.2	35.255	17.21316	175.2733
12.13	22.158	3.690721	0.020188
18.495	25.139	19.74803	9.75365
10.639	20.429	11.6426	2.518305
11.344	17.425	7.328526	21.07652
12.369	34.288	2.829545	150.604
12.944	23.894	1.225726	3.527197
14.233	17.96	0.033079	16.45046
19.71	22.058	32.02287	0.001771
16.004	21.157	3.813721	0.737738

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mean	14.05	22.02
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std dev	3.56	4.80

Point Estimate	-7.96
SD of differences	4.86
t-statistic	-8.02
cohens d	-1.64
n	24.00
df	23.00
t-critical at 99%	-2.50

$\mu_c - \mu_i$	**D**	Dss
-7.96	-7.199	0.59
	-1.95	36.18
Davg	-11.65	13.58
-7.96	-7.057	0.82
	-8.134	0.03
Dstdev	-8.64	0.46
4.86	-9.88	3.67
	-8.407	0.20
t-stat	-11.361	11.53
-0.33	-11.802	14.72
	-2.196	33.28
	-3.346	21.33
	-2.437	30.56
	-3.401	20.83
	-17.055	82.63
	-10.028	4.26
	-6.644	1.74
	-9.79	3.33
	-6.081	3.55
	-21.919	194.72
	-10.95	8.91
	-3.727	17.96
	-2.348	31.55
	-5.153	7.91