Test a Perpetual Phenomenon

Stroop Task

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.

Q1: Question response correctly identifies the independent and dependent variables in the experiment.

Answer: In this Experiment following are our variables-

1) **Independent Variable** – *Equally Sized list* of either *Congruent words* or *Incongruent words*.
2) **Dependent Variable** – Time taken by each participant to name ink colors in above type of equally sized list.

Q2a: Null and alternative hypotheses are clearly stated in words and mathematically. Symbols in the mathematical statement are defined.

Answer: In this Experiment following are our Hypothesis-

1) **Null Hypothesis** – There is ***no significant difference*** between μ_{cg} - the Mean time taken by participants (representing the population as a whole) to name the *Congruent words list* and μ_{icg} - the Mean time taken by participants (representing the population as a whole) to name the *Incongruent words list.*

   Denoted as H_0 : $\mu_{cg} = \mu_{icg}$

2) **Alternative Hypothesis** – There ***is significant difference*** between μ_{cg} - the Mean time taken by participants (representing the population as a whole) to name the *Congruent*

words list and μ_{icg} - the Mean time taken by participants (representing the population as a whole) to name the *Incongruent words list.*

Denoted as H_a : $\mu_{cg} \# \mu_{icg}$

Q2b: A statistical test is proposed which will distinguish the proposed hypotheses. Any assumptions made by the statistical test are addressed.

Answer: Generally, **z-tests** are used when we have **large sample sizes (n > 30),** whereas **t-tests** are most helpful with a **smaller sample size (n < 30)**. Both methods assume a normal distribution of the data, but the **z-tests** are most useful when the standard deviation is known, which is not the case here so this gives us a reason to stick with ***t-test***.

Assumptions made in ***t-test*** for **dependent means**:

And it is also to be noted that random sampling is done from predefined population and the difference of the scores are normally distributed across the population, which is what we will accomplish in the report below later on(Sources- *Study.com*)

Then we know that the **t-test** is used to compare whether two groups have ***different mean values or not***. And Since here we are trying to compare two mean times one for congruent list and other for incongruent list so **t-test** is best suited under such situation.

Particularly we will do **Dependent t-test** for **paired samples**.

Samples are said to be dependent when the **same subject/participant** takes the test **twice** which is aka **within-subject design**.

For Eg. In our case each participant is assigned two conditions(*Congruent words list/ Incongruent words list*) in random order.

Assumptions made in t-test include saying that **α=0.05** to attain **95% confidence level**, this will be elaborated later on.

Q3: Descriptive statistics, including at least one measure of centrality and one measure of variability, have been computed for the dataset's groups.

Answer: We want to see/check if there is significant difference between timings for each condition as stated by our **Null Hypothesis**.

H_0 : $\mu_{cg} = \mu_{icg}$

i.e Mean of time taken on ***Congruent words list*** when extended to the whole population not just the sample equals the Mean of time taken on ***Incongruent words list*** when extended to the whole population.

Alternative Hypothesis.

H_a : $\mu_{cg} \# \mu_{icg}$

i.e Mean of time taken on ***Congruent words list*** when extended to the whole population not just the sample does not equals the Mean of time taken on ***Incongruent words list*** when extended to the whole population.

For this we will generate descriptive statistic report which will contain the following –

Measures of Centrality – Mean.

Measures of Variability – Standard Deviation.

Our Sample Data

Congruent	Incongruent	x-cg	x-icg	P-E
12.079	19.278	14.05113	22.01592	-7.964791667
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 that Samples represent the whole population as a whole.

Where X represents the means of sample and μ that of population

So $\mathbf{X_{cg} = \mu_{cg}}$, $\mathbf{X_{icg} = \mu_{icg}}$ **.....(i)**

Details:

Sample Size or n= 24.

x-cg or μ_{cg} ***:*** *mean/ average of time taken by 24 participants or population as a whole in naming* ***Congruent words list***

x-icg or μ_{icg} ***:*** *mean/ average of time taken by 24 participants or population as a whole in naming* ***Incongruent words list***

P-E : P-E is Point Estimate denoted by μ_D , which is based on our samples. We want to know how this P-E compares other differences and so we need to find the standard error for the differences.

$\mu_D = \mu_{cg} - \mu_{icg} =$ 14.0511 – 22.0159

$\mu_D =$ -7.9648

This is our **Measures of Centrality** the Mean

Congruent	Incongruent	Difference	STDEV=S_D
12.079	19.278	-7.199	4.864827
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	

Since P-E compares other differences and so we need to find the standard error for the differences.

For this we calculate the Differences between each of the times for each conditions i.e for eq.

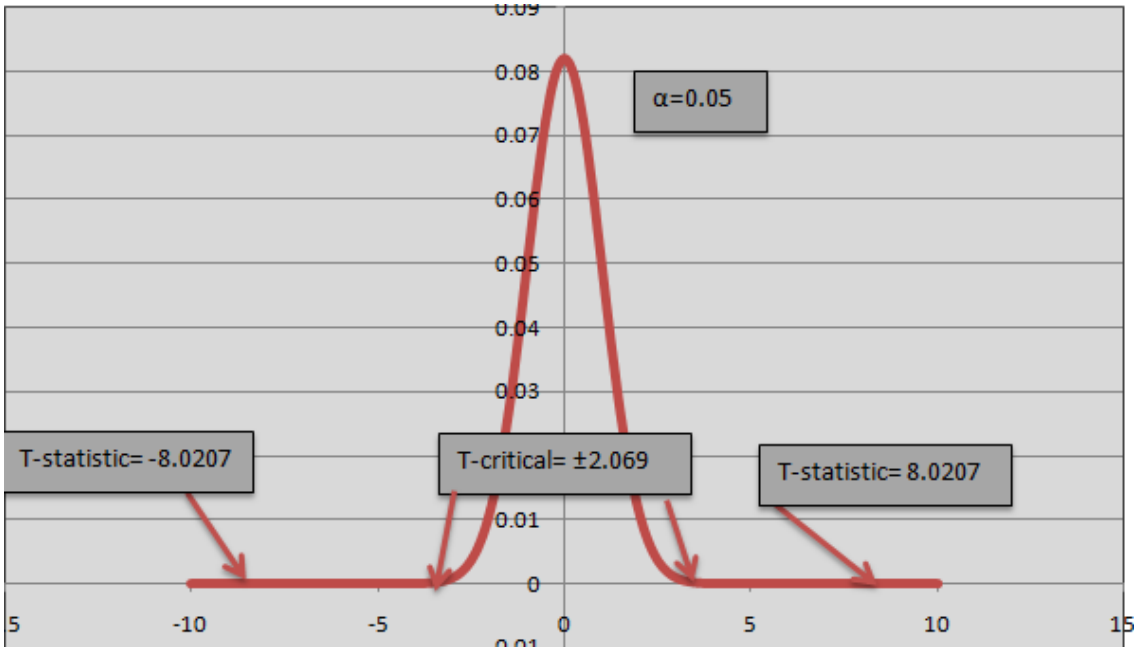
12.079 - 19.278 = -7.199 and so on.

Then with respect to each of the differences we calculate standard deviation using STDEV function in excel. Denoted by $\mathbf{S_D}$.

S_D = 4.864827

This is our **Measures of Variability** Standard Deviation.

Q4: One or two visualizations have been created that show off the data, including comments on what can be observed in the plot or plots.



Answer : Plot Show the Following:

- The distribution shows the **difference** between congruent and incongruent times.
- The distribution is more mean-centric. Meaning more values are concentrated towards the mean of the t-distribution.
- Distribution is normal as is obviously the case with any t-distribution
- Skewness =0
- We will reject our Null Hypothesis as t-stat lies in the critical region, this is explained later on in the analysis.

Q5: A statistical test has been correctly performed and reported, including test statistic, p-value, and test result. The test results are interpreted in terms of the experimental task performed.

Answer: Now to further evaluate that whether our Hypothesis is true or not we will calculate the following –

- t-statistic or t-score.
- t-critical
- Cohen's d
- Confidence Interval for 95% level.

- P-value

And only after calculating the above we will be able to conclude something about our Hypothesis.

t-statistic or t-score

$$t = \frac{\mu_D}{\frac{S_D}{\sqrt{n}}}$$

$$t = \frac{-7.9648}{\frac{4.864}{\sqrt{24}}}$$

$$t = \frac{-7.9648 * \sqrt{24}}{4.864}$$

$$t = -1.6375 * 4.898$$

$$\boldsymbol{t = -8.0204}$$

So we found that our t-score or t-statistic = ***-8.0204***

t-critical

In our t-test we used **α=0.05** to attain **95% confidence level,** this gives us an assurance to 95% for t-test we are performing.

Next also note that we had done a **2-tailed test** because the **experiment does not have a direction** which is the reason we use the 2-tailed test.

For a 2-tailed test in the Probability density function 0.025% will lie on either sides of the mean as denoted in the **visualization above**.

And hence using the **t-table** we have the t-critical value for **0.025%** as for degree of freedom

DF=n-1 = 24-1 = 23

*So using t-table and DF=23 for **0.025%** we get the value of t-critical as :*

t-critical = ± 2.069

Since **t-score or t-statistic** lies in the **critical region** as denoted in the visualization above it is unlikely to happen and **hence we reject the NULL.**

Rejecting the Null **means** we **accept** the **Alternate Hypothesis** viz:

H_a : $\mu_{cg} \# \mu_{icg}$

Which illustrates that **there is** significant difference between the time taken in naming the two types of lists.

And particularly the time taken to name the items in ***Incongruent words list*** is comparatively higher than that of ***Congruent words list*** since μ_D **= -ve**

Cohen's d

$$\boldsymbol{d = \frac{|\mu_D|}{S_D}}$$

d is distance that is why positive.

$$d = \frac{|-7.9648|}{4.864}$$

$$d = 1.6375$$

Confidence Interval for 95% level

$$\boldsymbol{CI = \mu_D \pm t - critical * \left(\frac{S_D}{\sqrt{n}}\right)}$$

$$\text{CI} = -7.9648 \pm 2.069 * \left(\frac{4.864}{\sqrt{24}}\right)$$

$$\text{CI} = -7.9648 \pm 2.069 * 0.9930$$

$$\text{CI} = -7.9648 \pm 2.054517$$

$$CI = (-10.019317, -5.910283)$$

So we calculated 95% Confidence Interval and from it we can conclude that participants will take around ***(10 to 6)*** fewer time units on ***Congruent words list*** as compared to ***Incongruent words list.***

P-value

p-value for **t-statistic or t-score = -8.0204** and **n= 24 or DF(degree freedom)=23** is to be calculated.

To calculate p-value we will make use of ***graphpad.com*** and to calculate p-value we will use the section Statistical distributions and interpreting P values under this section will make enter t-score and n , then press Compute it will show us the following results –

The two-tailed **P value** is less than **0.0001**

By conventional criteria, this difference is considered to be **extremely statistically significant**.

This happens because **p< α=0.05** and hence **we reject the Null Hypothesis** viz what we have already done.

Rejecting the Null **means** we **accept** the **Alternate Hypothesis** viz:

H_a : $\mu_{cg} \# \mu_{icg}$

Which illustrates that **there is** significant difference between the time taken in naming the two types of lists.

Q6: Hypotheses regarding the reasons for the effect observed are presented. An extension or related experiment to the performed Stroop task is provided, that may produce similar effects.

From our above analysis of Stroop effect we can conclude that under experimental designs different modes of information or different conditions rigoursly effect the processing time or the time taken to complete the task.

Stroop effect was a demonstration of interference in the **reaction time** of a task.

In layman language , when we are used to something our reaction time is usually **very less** as compared to when we are not used to something**.** So in our Stroop effect interference in the reaction time could be because of **external factors** as we know.

Like Stroop effect a similar experiment as stated in the lessons was the ***Keyboard experiment*** in which we tested the number of errors when we changed the type of Keyboard , **produced similar effects** as stated above**.**

***Last Conclusion* –** Since this was an **experimental design** we can make **causal statement** that the **type of list (*Incongruent / Congruent*)** presented to the participant **had** a causal effect on the **time taken** to name the list items.
