

Question 1: Identify variables in the experiment

Dependent variable: The reaction time between the appearance of the words (congruent or incongruent) and participant's response.

Independent variable: Whether font color and word name are same (congruent) and different (incongruent)

Question 2: Establish a hypothesis and statistical test

Hypothesis:

Let us assume the population mean of the congruent case is μ_1 and the population mean for the second (i.e. incongruent) case is μ_2

Null hypothesis (H_0): The population mean for the congruent case is the same as the population mean for the incongruent case

$$H_0 = \mu_2 = \mu_1$$

Alternative hypothesis (H_1): The population mean for the incongruent case is greater than the population mean for the congruent case

$$H_1 = \mu_2 > \mu_1$$

Since the experiment is conducted on the same individuals for two different conditions the two samples are dependent. In addition since the standard deviation of the population is unknown and the sample size are less than 30, we should use the t-test rather than the Z-score, that otherwise requires the standard deviation known or can be determined and the sample size to be larger (>30).

The alternative hypothesis states that the mean reaction time is greater for the incongruent words; one-tailed t-test will be conducted. The most commonly used significant level (0.05) is used for this test, other significant level (i.e. 0.01, 0.001, etc) could be used, had we have a large amount of dataset that support to prove or disprove the null hypothesis.

Question 3: Report descriptive statistics

The mean of a given sample can be given as

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \text{ Where } \bar{x} \text{ is the mean of the sample and } x_i \text{ is each element in the sample}$$

Accordingly the mean for the two samples is calculated in table 1 below, where the mean of sample 1 (congruent word) is 14.05 and the mean of the second sample is 22.015. Comparing the two means shows that there is a significant difference between the two means.

The standard deviation of a sample is calculated as

$$\sigma = \sqrt{\sum_{i=1}^n \frac{(x_i - \bar{x})^2}{n-1}}$$

Where σ is the symbol for standard deviation

Therefore the standard deviation for the samples are computed in the table below

Table 1. Mean and standard deviation of the two samples

Participants	Congruent	Incongruent	cong_diff	sq_cong_diff	incong_diff	sq_incong_diff
P1	12.08	19.28	-1.97	3.89	-2.74	7.50
P2	16.79	18.74	2.74	7.51	-3.27	10.73
P3	9.56	21.21	-4.49	20.13	-0.80	0.64
P4	8.63	15.69	-5.42	29.39	-6.33	40.06
P5	14.67	22.80	0.62	0.38	0.79	0.62
P6	12.24	20.88	-1.81	3.29	-1.14	1.29
P7	14.69	24.57	0.64	0.41	2.56	6.53
P8	8.99	17.39	-5.06	25.65	-4.62	21.36
P9	9.40	20.76	-4.65	21.62	-1.25	1.57
P10	14.48	26.28	0.43	0.18	4.27	18.20
P11	22.33	24.52	8.28	68.51	2.51	6.29
P12	15.30	18.64	1.25	1.55	-3.37	11.37
P13	15.07	17.51	1.02	1.04	-4.51	20.30
P14	16.93	20.33	2.88	8.28	-1.69	2.84
P15	18.20	35.26	4.15	17.21	13.24	175.27
P16	12.13	22.16	-1.92	3.69	0.14	0.02
P17	18.50	25.14	4.44	19.75	3.12	9.75
P18	10.64	20.43	-3.41	11.64	-1.59	2.52
P19	11.34	17.43	-2.71	7.33	-4.59	21.08
P20	12.37	34.29	-1.68	2.83	12.27	150.60
P21	12.94	23.89	-1.11	1.23	1.88	3.53
P22	14.23	17.96	0.18	0.03	-4.06	16.45
P23	19.71	22.06	5.66	32.02	0.04	0.00
P24	16.00	21.16	1.95	3.81	-0.86	0.74
mean	14.05	22.02		291.39		529.27
sum						
stdv				3.56		4.80

Question 4: Plot the data

The plot (plotted in R) in figure 1 depicts distribution of the amount of time taken by each participant to call out the congruent and incongruent words loud. The distribution for both words is skewed to the right. The time taken to for most of the participants to call the words loud is about 15 and 23 for congruent an incongruent words respectively. Generally the amount of time required to call out the incongruent words is high as compared to that of the congruent words.

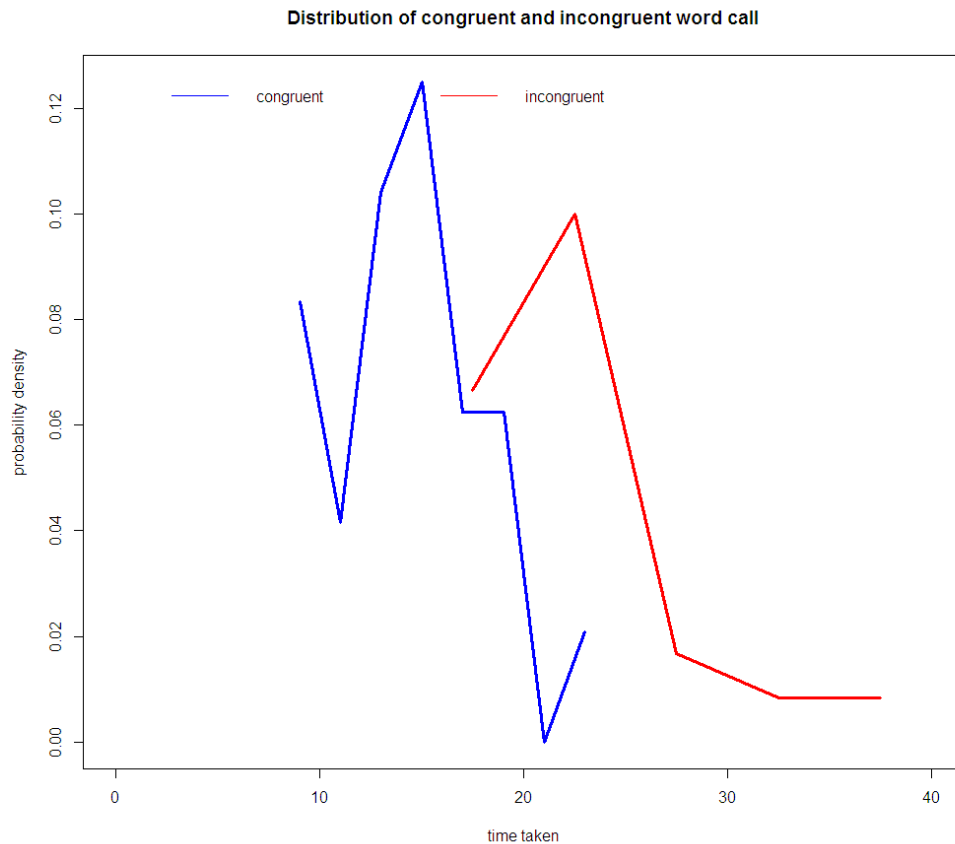


Figure 1. The probability distribution of the two samples (congruent and incongruent words)

Question 5: Perform the statistical test and interpret your results

The data set used and the steps followed to calculate the t-test is shown in table 2 below. The t-statistics can be computed using the formula below

$$t = \frac{\bar{x}_{incon} - \bar{x}_{cong}}{S_d / \sqrt{N}}$$

Where: \bar{x}_{incon} and \bar{x}_{con} are the mean of the incongruent sample and the congruent sample respectively, S_d is the standard deviation of \bar{x}_{diff} (the mean of the difference between the two samples) and N is the dimension of freedom

Table 2. The steps followed in calculating t-test for paired data sets

Participants	Congruent	Incongruent	diff
P1	12.08	19.28	7.20
P2	16.79	18.74	1.95
P3	9.56	21.21	11.65
P4	8.63	15.69	7.06
P5	14.67	22.80	8.13
P6	12.24	20.88	8.64
P7	14.69	24.57	9.88
P8	8.99	17.39	8.41
P9	9.40	20.76	11.36
P10	14.48	26.28	11.80
P11	22.33	24.52	2.20
P12	15.30	18.64	3.35
P13	15.07	17.51	2.44
P14	16.93	20.33	3.40
P15	18.20	35.26	17.06
P16	12.13	22.16	10.03
P17	18.50	25.14	6.64
P18	10.64	20.43	9.79
P19	11.34	17.43	6.08
P20	12.37	34.29	21.92
P21	12.94	23.89	10.95
P22	14.23	17.96	3.73
P23	19.71	22.06	2.35
P24	16.00	21.16	5.15
mean	14.05	22.02	
mean-diff			7.96
sqrt(n)=sqrt(24) =sqrt(N)			4.90
stdv(diff) =Sd			4.86
t-test			8.021

The number of degree of freedom is given as $(n-1)$, where n is the sample size of the sample. Accordingly

$$\text{Number of freedom} = 24-1=23$$

Then the critical value for the t-test, for significance level of 0.05 can be obtained from t-table, which is 1.71.

From the result of the t-test in table 2 above which is 8.021 is much higher than the t-critical value. Therefore at $\alpha = 0.05$ significant level, we can conclude that the mean reaction time between the appearance of the incongruent words and participant's response is greater than that of the congruent words case.

Question 6: Digging deeper and extending the investigation

The amount of time required to call the is much greater than that of the incongruent words for all participants. This could be due to the fact that, in congruent words, the ink colors the words are printed in match that of the meaning of words and so takes small time to call the words loud. And in the incongruent worlds the inconsistency of the ink color worlds are print in and their meaning could make confusion in participants, consequently takes more time to call the words loud. In addition to that there could be other factor that should be taken into consideration as the age, health (eye), education level etc...

Reference.

1. <https://www.statisticssolutions.com/manova-analysis-paired-sample-t-test/>
2. <http://archive.bio.ed.ac.uk/jdeacon/statistics/tress5.html>
3. <https://statistics.laerd.com/statistical-guides/hypothesis-testing-3.php>