P1: Test a Perceptual Phenomenon

Udacity - Data Analyst Nanodegree
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1. Define dependent variable and independent variable.

- Dependent Variable: The performance in congruent/incongruent task.
- Independent Variable: Congruent/Incongruent task.

The operational define of dependent variable, performance, was the time spent on reading the words with congruent or incongruent color. And the operational define of the independent variable, different task, was the words were congruent with the color on it or not.

2. Define hypotheses and statistics test.

I was interested in that the incongruence of word and color affect the performance or not, thus the hypotheses were set as follows (C: congruent; I: incongruent):

$H_0: \mu_C = \mu_I$

which means the incongruence of word and color did not affect the performance.

$H_0: \mu_C \neq \mu_I$

which means the incongruence of word and color did affect the performance.

About the statistics test, this was a two-condition case, and the parameters of the population was not available. Besides, two data sets were carried out by the same group of participants, which means that they were paired samples.

Therefore, **dependent *t*-test for paired samples (*t*-Test)** was used to perform the statistics test.

3. Descriptive Statistics

The information of the descriptive statistics was presented in Table 1 and 2. The information about the IQR and the outliers are shown in next section.

Table 1. Descriptive Statistic Infromation of Original Data Sets.

	sample size	MEAN ($\bar{x}$)	MEDIAN ($\tilde{x}$)	SAMPLE STANDARD DEVIATION (S)
Congruent	24	14.051	14.357	3.559
Incongruent	24	22.016	21.018	4.797

Table 2. Descriptive Statistic Infromation of Data Sets without Outliers

	sample size	MEAN ($\bar{x}$)	MEDIAN ($\tilde{x}$)	SAMPLE STANDARD DEVIATION (S)
Congruent	22	13.939	14.357	3.593
Incongruent	22	20.856	20.820	2.877

4. Visualisation of Data

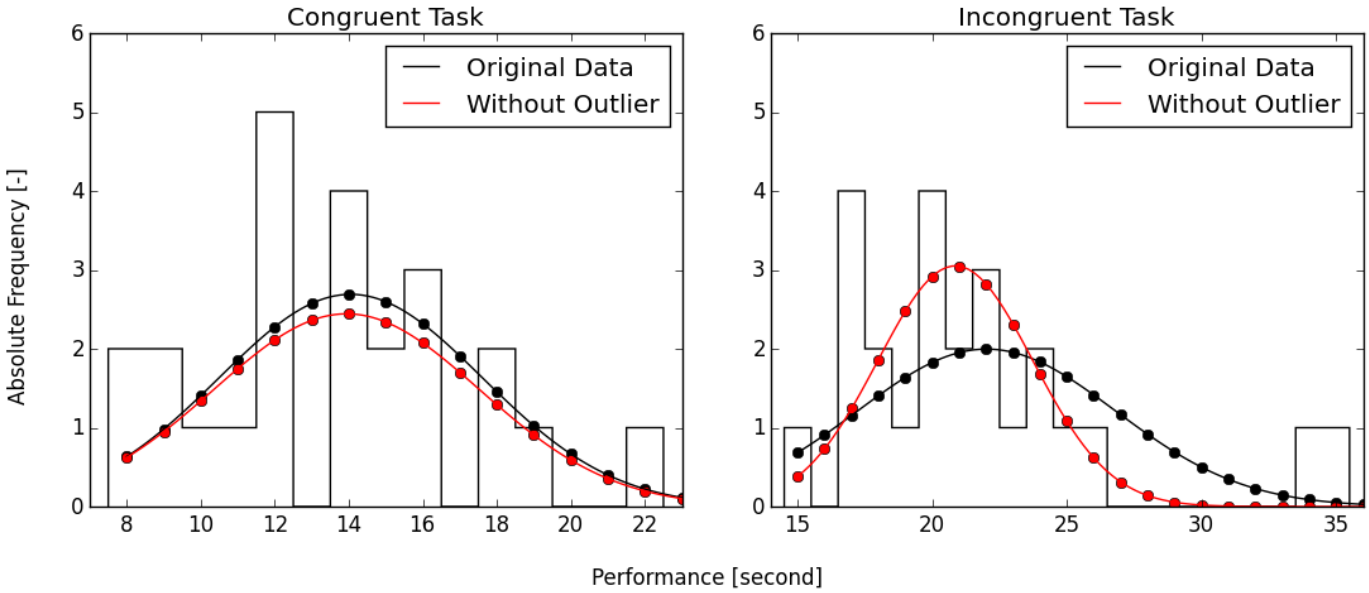

Fig. 1. Histogram and Fitted NormalDistribution of Data Sets.

First of all, both histogram graphs showed that they were approximately normal distribution in figure 1. In congruent task, mode was in the interval from 11 to 13. It was in the different range from the mean and median in the interval from 13 to15. In incongruent task, there were two modes in the interval from 16 to 18 and 19 to 21 respectively.

Then I fitted the normal distribution curves to both histogram. However, the fitting curves were worse than what I expected, especially the one in incongruent task.

I noticed that two data were likely outliers in incongruent task. I did the simple test with the equation below and results were shown in table 3.

$$\text{outlier} < 1Q - 1.5\times IQR$$
$$\text{outlier} > 3Q + 1.5\times IQR$$

Table 3. IQR and Outliers Information

	Q1	Q3	IQR	Outlier	
Incongruent	18.717	24.502	5.335	35.225	34.288

I deleted the outliers in incongruent task and the corresponding data in congruent task. I fitted another normal distribution curves to histogram. It almost did not change in congruent task because the corresponding data, 18.200 and 12.369, were not the outliers in that data set. However, the curve fitted much better in incongruent task. The mean and median were much closer to the second mode, and sample standard deviation was also getting smaller.

Besides, I found an interesting phenomenon when I was doing the experiments in different languages which are Chinese (mother language), Japanese and English. The times difference between congruent task and incongruent task were smallest in Japanese and greatest in Chinese. I was thinking that the familiarity of a language would affect the results. The more I familiar with the language, the greater the time difference is. Besides, I spent least time on the congruent task in Chinese, but most in Japanese.

Therefore, I made a hypothesis that the more one is familiar with a language, the less time he will spend on the congruent task, and the greater the time difference is in that language. Then I did the linear regression to the both data sets.

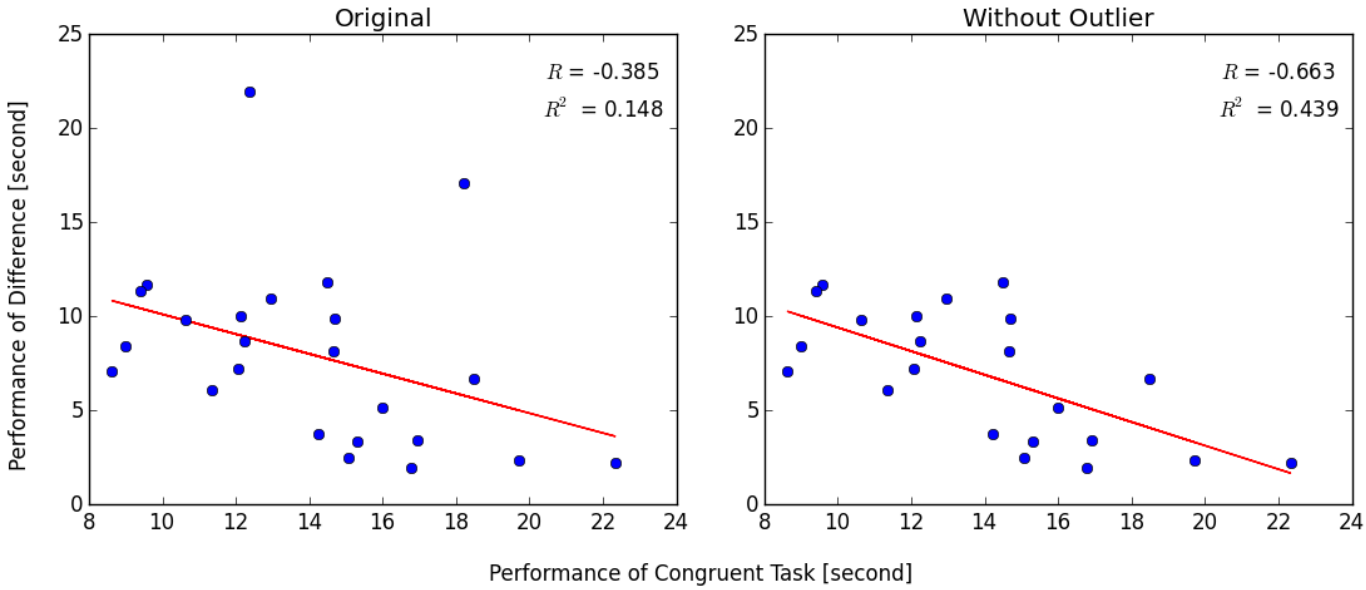

Fig. 2. Correlation between the Performances of Congruent Task and Difference.

First of all, *R* value, -0.385, of original data indicated that it was a weakly negative correlation. And R^2 value showed that only 14.8% of the total variation in the performance of difference can be explained by the linear relationship between the performance of congruent task and the performance of difference. On the other hand, *R* value, -0.663, of the data set without the outliers indicated that is was a negative correlation, and R^2 value showed that 43.9% of the total variation in the performance of difference can be explained by the linear relationship.

Of course, it was still not a strong result to support the hypothesis I made. However, the results could conclude that the correlation between the performance of the congruent task and difference might be (weakly) negative correlation or even no correlation, but never positive correlation. It was an interesting topic to do further study with more data sets or larger sample size.

5. Statistic Test and Interpretation

Table 4. Computed Results of t-Test

MEAN of DIFFERENCE ($\bar{x}_C$ - $\bar{x}_I$)	SAMPLE STANDARD DEVIATION (S)	STANDARD ERROR (SEM)	*t*-STATISTIC (*t*)
-7.965	4.865	0.993	-8.021
CRITICAL t VALUE[1)] (t^*)	P-VALUE[2)] (-)	Cohen's d (d)	r^2 (-)
± 2.069	Less than 0.0001	-1.637	0.728

Table 4 shows the information to perform the statistics test. First of all, the difference between two data set was focused. The point estimate is $\bar{x}_C$ - $\bar{x}_I$. The statistics test was performed with α = 0.05. figure n shows the visualised result.

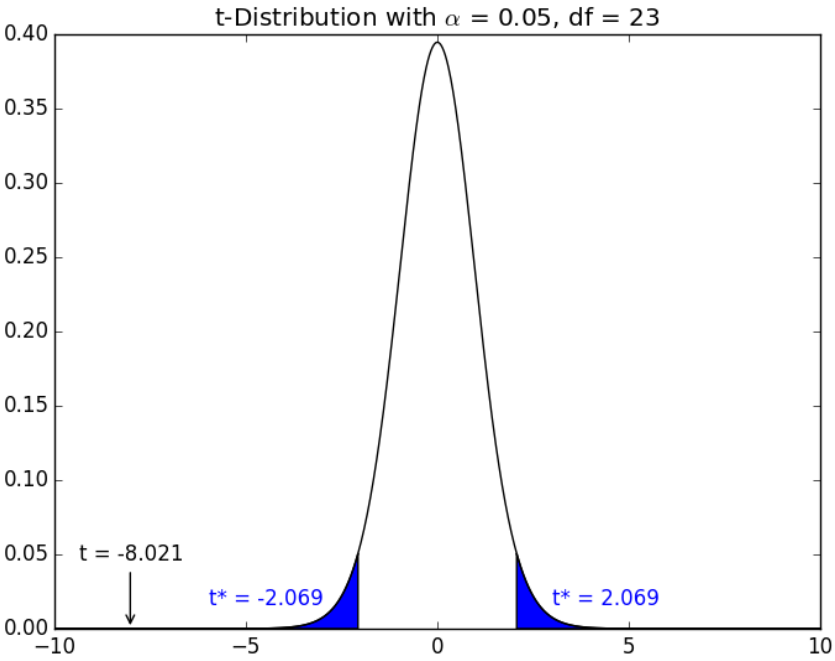

Fig. 3. *t*-Test Result.

According to figure 3, it is apparently to say null hypothesis (H_0: $\mu_C = \mu_I$) was rejected, which means incongruence of word and color does affect the performance. *t*-statistics and P-value also tell that this difference is considered to be **extremely statistically significant**, and incongruent task costs more time in the performance. 95% confident interval was from **-10.019** to **-5.091**. This result indicated 95% of the participants spent 5.091 to 10.019 seconds more on the incongruent task. Cohen's d also shows that **the effect size was quite large**. Finally, r^2 indicates that **72.8%** of the difference in performance was contributed by the difference between congruent task and incongruent task.

The result of the statistics test matched my expectation that incongruence of word and color does affect the performance. And according to the results of linear regression in section4, it might be that the fast you read in congruent task, the slower you read in incongruent task. I think this phenomenon is somehow relative to the familiarity of language.

REFERENCE

1. t-TABLE, https://s3.amazonaws.com/udacity-hosted-downloads/t-table.jpg

2. GraphPad, http://www.graphpad.com/quickcalcs/