Statistics: The Science of Decisions Project Instructions

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

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

For Stroop test our independent variables are the Coloured words, whether they are congruent or incongruent.

- Congruent words - The words are coloured words and the name matches the color of the words.
- Incongruent words - The words are color words whose names do not match the colors in which they are written.

Our dependent variable is the Reaction time stimulus and response of our sample for both these conditions stated above.

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

According to the Stroop test, there can be different set of Hypotheses stated. But for me The Null and Alternate Hypothesis are as follows:

Null Hypothesis(H_0): The mean reaction time between stimulus and response for congruent test and incongruent is same and there is no significant difference.

So here mathematically $\mu_{congruent} = \mu_{incongruent}$

Alternate Hypothesis (H_1): The mean reaction time between stimulus and response for congruent test is less than that of mean reaction time for incongruent test.

And in this case mathematically $\mu_{congruent} < \mu_{incongruent}$

Now for deciding what type of test we need to conduct we need to check the following factors.

1. Size of Sample: Here sample size is 24 which is less than 30
2. The Standard deviation and mean of population is unknown.

So according to the above factors it is better to use t-score as stated in http://www.statisticshowto.com/when-to-use-a-t-score-vs-z-score/ for hypothesis testing. And as you go below you will see that the sample distributions are not very skewed, so we can perform a t-test on this sample for our Hypothesis test.

Here we will conduct a paired one tailed t-test in negative direction. Since our alternate hypothesis states that "The mean reaction time between stimulus and response for congruent test is less than that of mean reaction time for incongruent test." So for this reason I have chosen the t-test in negative direction, because if the reaction time is low for congruent test , our sample will be in the left side of the t-distribution curve and we can check for ourselves how low is the data. Are we able to accept the null or reject the null hypothesis.

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

For the data provided to us, following are the Desciptive statistics measures.

Congruent Test:

Mean($\bar{X}_{congruent)} = 14.05$

Standard Deviation($SD_{congruent}$) = 3.56 (used Bessel's correction since this is a sample)

Congruence Test

Mean	14.05
Standard Error	0.73
Median	14.36
Standard Deviation	3.56
Sample Variance	12.67
Range	13.70
Minimum	8.63
Maximum	22.33

Incongruent Test:

Mean($\bar{X}_{incongruent)} = 22.02$

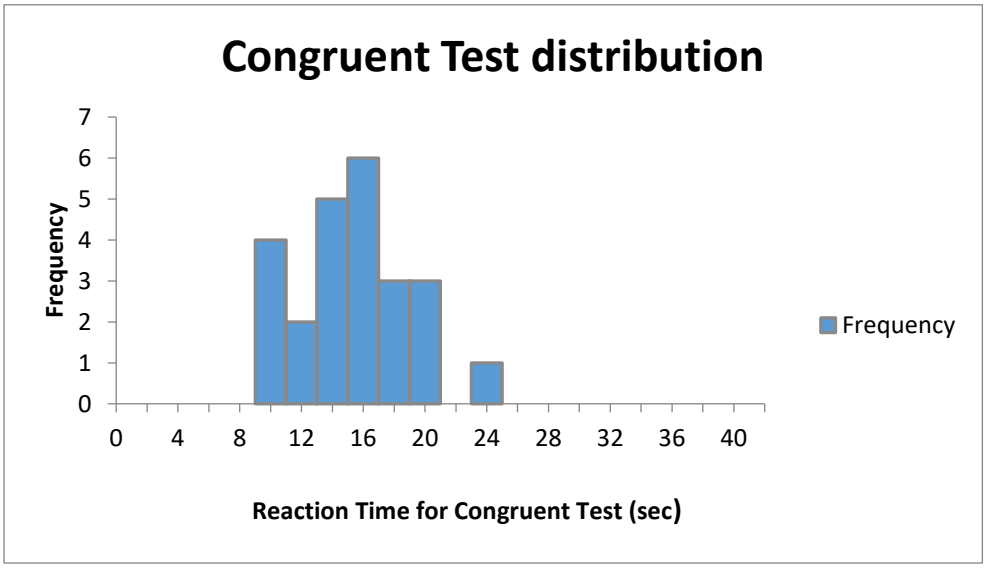
Standard Deviation($SD_{congruent}$) = 4.80 (used Bessel's correction since this is a sample)

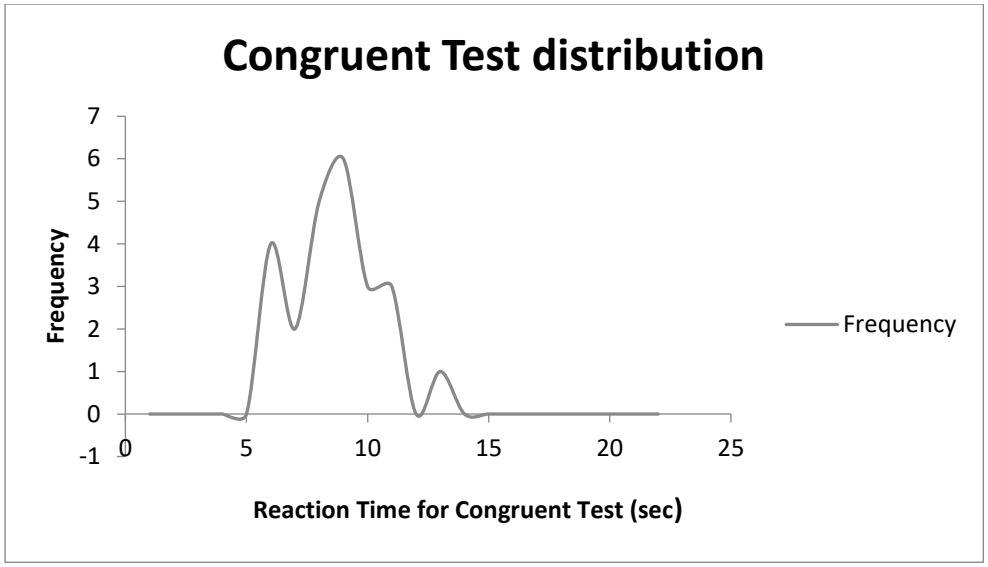
Incongruent Test

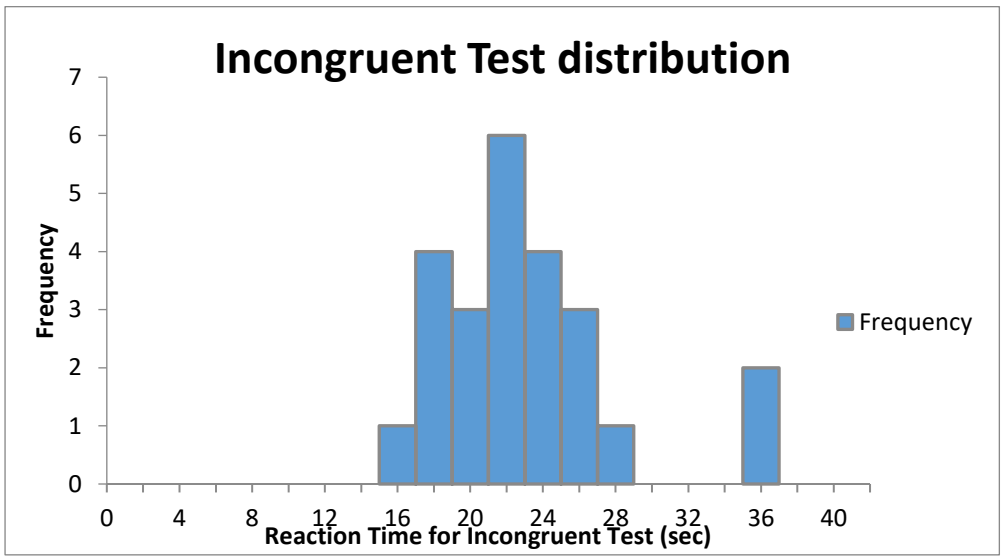
Mean	22.02
Standard Error	0.98
Median	21.02
Standard Deviation	4.80
Sample Variance	23.01
Range	19.57
Minimum	15.69
Maximum	35.26

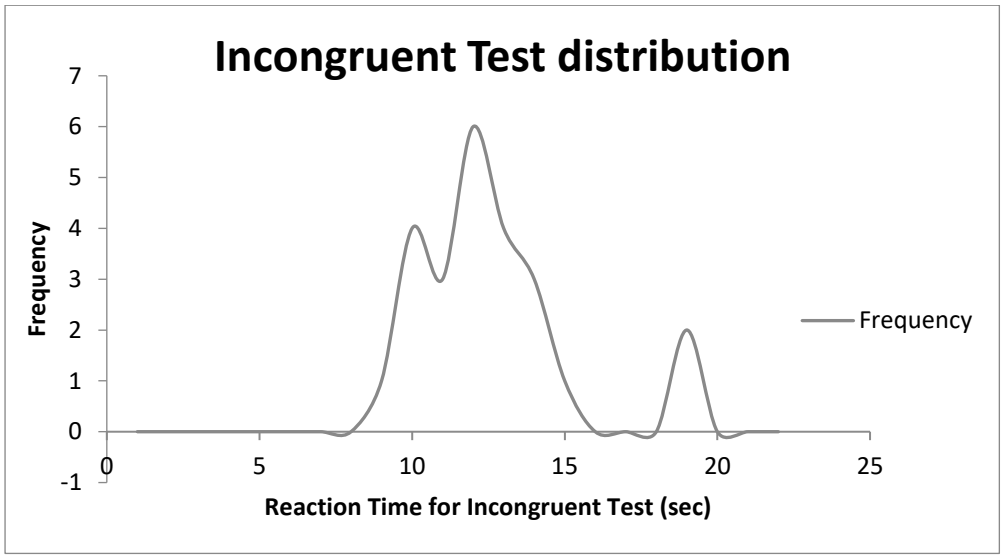
4. **Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.**

Following are the frequency distribution of the two datasets provided:




Congruent Test distribution
Frequency
7
6
5
4
3
2
1
0
-1
0
5
10
15
20
25
Reaction Time for Congruent Test (sec)
Frequency


Incongruent Test distribution
Frequency
7
6
5
4
3
2
1
0
0
4
8
12
16
20
24
28
32
36
40
Reaction Time for Incongruent Test (sec)
Frequency


Incongruent Test distribution
Frequency
7
6
5
4
3
2
1
0
-1
0
5
10
15
20
25
Reaction Time for Incongruent Test (sec)
Frequency

As we can see from the above histograms, the reaction time of congruent tests are less than that of the incongruent tests.

Both the distributions are normal.

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?**

I have performed the t-test assuming confidence level of $\alpha = 0.05$ since this is the default value.

$t_{critical}$ for alpha(0.05) = -1.714 (-ve since we are testing paired one tailed t- test in negative direction)

Mean difference in reaction time for the two datasets ($\bar{X}congruent - \bar{X}incongruent$) = -7.96

Standard Deviation of difference: 4.86

Degrees of freedom(df) : 23 since this a dependent sample t test.

Standard Error: 0.99

$t_{statistic}(23)$: -8.02

Here we can see that the $t_{statistic}$ is way lower than $t_{critical}$. From this link http://www.socscistatistics.com/pvalues/tdistribution.aspx we can see that for one tailed test P-value < .00001.

Thus the result is significant at $p < .05$, so we reject the null hypothesis. Since it proves that reaction time between stimulus and response is lower for congruent test.

A 95% Confidence Interval for the mean difference is (-10.01, -5.91)

Some Effect size measures are as follows:

Cohen's d = -1.63

$r^2 = 0.73$

So we can see that 73% of the difference in response is due to the colored words or tests involved. The rest 27% may be due to lurking variables, may be the environment around or other conditions.

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!**

The Stroop effect is widely used in psychology. As recognizing colors is not an "automatic process" by “automatic process” I mean the ability to do things without occupying the mind with the low-level details required, allowing it to become an automatic response pattern or habit. It is usually the result of learning, repetition, and practice.

Since recognizing colors is not an "automatic process" there is hesitancy to respond; whereas, the brain automatically understands the meaning of words as a result of habitual reading. So there is delay in response when the colors and words are mixed up.

Among the most important uses is the creation of validated psychological tests based on the Stroop effect permit to measure a person's selective attention capacity and skills, as well as their processing speed ability. This can also help in the diagnosis and characterization of different psychiatric and neurological disorders in people.

Many variations of the Stroop test have been carried out since the original to further test individual's attention and the allocation of resources in both controlled and automatic processing. One such variation is the reverse Stroop test.(Wikipedia) In this experiment there were still two conditions; one where the participant was given a list of colour words and had to point to a block of colour which matched the colour word stated. The second condition was the same as in the original Stroop test where the colour ink the word was written in had to be stated. Studies have shown that if the individual is asked to point to the color square of the written color they would present a delay. Thus, incongruently-colored words significantly interfere with pointing to the appropriate square.

Bibliography

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6. http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/hypothesis-tests/tests-of-means/types-of-t-tests/
7. http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/hypothesis-tests/basics/null-and-alternative-hypotheses/