Statistics: The Science of Decisions

Questions For Investigation

Q1.What is our independent variable? What is our dependent variable?
Ans : Independent Variables : These are variables which are potential cause of variation in the sample output.
In our case independent variables is : **condition of the task**, i.e whether the congruent word condition or incongruent word condition.

Dependent Variables : These are variables whose variation in value is being studied.
In our case dependent variable is : **time taken to name the ink colour.**

Q2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

Ans : Appropriate hypotheses are :
Null hypothesis and Alternative Hypothesis.

Null hypothesis states that the population parameter will be equal to a value, in our case here 2 samples are provided so the samples belongs to same population.

Alternative hypothesis states that the population parameter is not equal to the value specified by Null hypothesis, i.e in our case the two samples does not belong to same population.

Since we are comparing two samples, our hypothesis would be:
Null hypothesis H_0: there is no significant difference between average congruent condition score and average incongruent condition score.
$H_0 : MU_{congruent} = MU_{incongruent}$

Alternate hypothesis H_A: average congruent score will be significantly different from average incongruent score.
$H_A : MU_{congruent} != MU_{incongruent}$

H_0 = Null hypothesis
$MU_{congruent}$ = population mean score of congruent data provided in the sheet.
$MU_{incongruent}$ = population mean score of incongruent data provided in the sheet.
H_A = Alternative hypothesis.

I would like to perform dependent t-test on the samples.
The choice of t-test here is due to the fact that we are unaware of the population parameters like mean, standard deviation etc, so we will use t-test.

t-test are used to compare two samples or sample and populations. Using t-test we will know the t-statistical value which is the indication of how many standard deviation away our observed value will lie from the sample mean value. If the value goes beyond the t-critical value (called t-critical region) we can say that we can reject the Null hypothesis, which means the 2 samples which are being compared are significantly different and they do not belong to same population.
Whereas if t-statistical value lies outside the t-critical region (t-statistical value less then t-critical value), we say that we can retain the Null hypothesis, because there is no significant difference between the two samples and they belong to same population.

This will be a two tailed test, which means the two samples can become significant on both the directions, i.e we can reject the Null hypothesis if the absolute value of difference between the samples will enter critical region.
$\mathbf{MU_{congruent} != MU_{incongruent}}$
Above condition will lead to rejection of Null hypothesis.

For rejection of Null hypothesis :
$t_{statistical} > t_{critica}$

Mathematical formula :
$t_{statistical} = (X_{mean}-MU)/Standard\ Error$
X = sample mean
MU = population mean
Standard Error = Standard Deviation / √(sample size)
Standard Deviation = $\sqrt{((\sum(X_i-Xmean))/(n-1))}$

$t_{critical}$ = this is the threshold value for t critical region, beyond this point if value lies that mean H_0(null hypothesis) fails.

Q3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

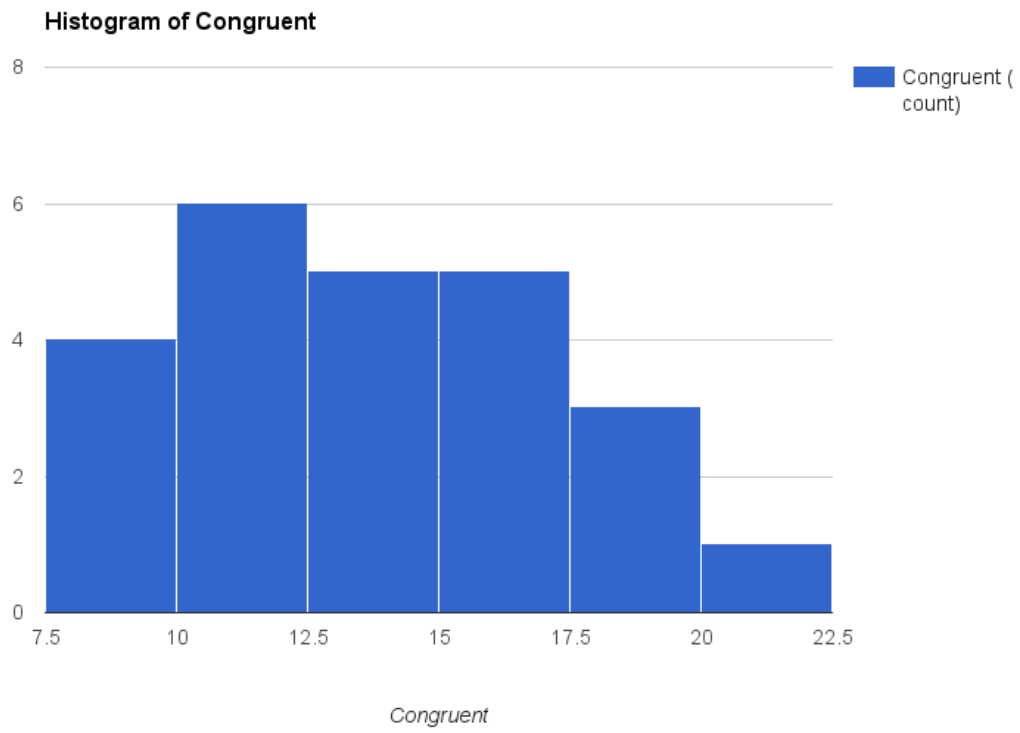
Ans : Descriptive Statistics regarding the dataset:

1. Measure of central tendency :
    a. Mean :
        Congruent : 14.05
        Incongruent : 22.016
    b. Median :
        Congruent : 14.36
        Incongruent : 21.02
2. Measure of variability:
    a. IQR :
        Congruent : -4.194
        Incongruent : -3.798
    b. Range :
        Congruent : 13.70
        Incongruent : 19.57
    c . Variance :
        Congruent : 12.67
        Incongruent : 23.01

    d. Standard Deviation :
        Congruent : 3.56
        Incongruent : 4.80

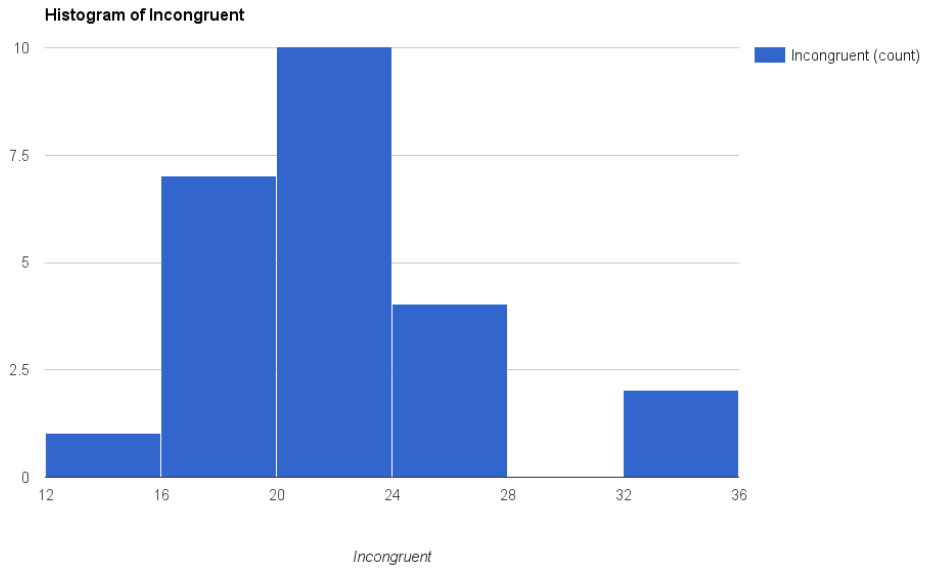
Q4. Provide one or two visualisations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.
Ans :

1. Histogram of Congruent words condition :



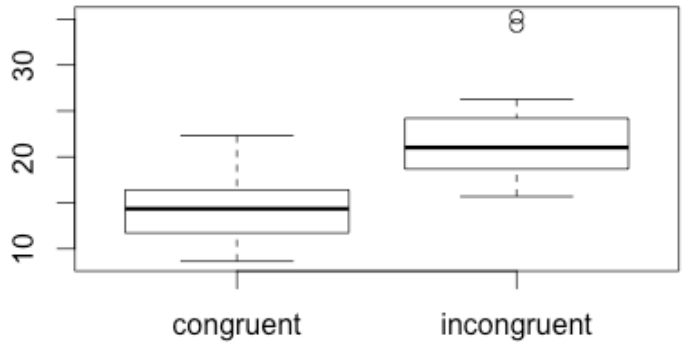
This is distribution of Congruent words condition, it clearly visible that the distribution is uniform also number of words that takes more then 20sec are very less.

2. Histogram of Incongruent words condition :



This is distribution of Incongruent words condition, this is normal distribution it indicates that users usually takes 20-24 sec to name the ink colour.
Since this is normal distribution, mean and median also lie in the range 20-24 sec.
Mean : 22.016
Median : 21.02

3. Box Plot



This is the box plot of both the sample data.
We can see that in incongruent data set we do have some outliers on the upper side of plot.
Clearly the mean has increased in incongruent dataset and IQR of congruent dataset is smaller as compared to incongruent data which shows that range of incongruent dataset is larger then the congruent dataset.

Q5. 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 :

For alpha level = .05, degree of freedom(df) = 23 and two-tailed test
1. $t_{critical}$ is calculated using t-table, degree of freedom is 23, so we will look into row where df = 23 and look for column which has value .025, the row and column coincides at :
$t_{critical}$ = 2.069 / -2.069
2. $t_{statistical}$ is calculated using the formula :
$t_{statistical}$ = (difference of mean value of congruent and incongruent (Xd)/ Standard Error (SE))

where SE = standard deviation for difference / √sample size
standard deviation for difference calculated = 4.86
SE = 4.86 / √24 = 0.993
Xd = -7.96
$t_{statistical}$ = -7.96/0.993
$t_{statistical}$ = -8.02

3. 95% confidence interval(CI):
CI = (Xd - $t_{critical}$ * SE, Xd + $t_{critical}$ * SE)
lower value =-10.02
higher value =-5.91
CI = (-10.02, -5.91)

4. **P-value = 0.0001**
since, P-value < alpha (0.05)
We reject the NULL hypothesis, the result is statistically significant.

The results shows that there is significant difference between time recorded for congruent word condition test and incongruent word condition test.
The two mean values are 8.02 standard deviation aways from each other in negative direction.
Also, if the difference of the two means are applied to some population data, 95% data will lie between the confidence interval i.e between (-10.02, -5.91).

Yes, this result matches my expectations, using the plot this was visible that these 2 samples are very different, and with these statistical tests confirms that these samples are very different.

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 : The thing responsible for above results are the word conditions.
When the word written is same the ink of the colour, it is very easy to name the colour as we read it without problems. But when ink colour changes from the word written, user has to read and think about the colour at the same time and it has to distinguish between the colour it is seeing and actual colour of the word.
In later condition user has to be twice attentive as compared to other condition.

Source : https://www.verywell.com/what-is-the-stroop-effect-2795832

Similar effect can be found in while driving car, when driver is only concentrating on road and driving, the chances of him identifying some road blockage and applying timely brakes are more as compared to when driver is also answering call on phone or doing something else while driving.
Effective braking time will be lesser in case when driver is attentively driving, and will more when driver is not attentive.

References :

1. For calculation of P-value : http://www.graphpad.com/quickcalcs/pValue1/
2. Stroop effect : https://en.wikipedia.org/wiki/Stroop_effect
3. Variability Statistics : http://stattrek.com/descriptive-statistics/variability.aspx?tutorial=ap
4. For visualisation google sheet charts are used and then copied those charts.
5. For calculation of mean, median, t-statistics, t-critical, confidence interval etc, google sheets is used.