Test a Perceptual Phenomenon: Stroop Effect

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Introduction

In psychology, the Stroop effect is a demonstration of interference in the reaction time of a task. When the name of a color (e.g., "blue", "green", or "red") is printed in a color that is not denoted by the name (e.g., the word "red" printed in blue ink instead of red ink), naming the color of the word takes longer and is more prone to errors than when the color of the ink matches the name of the color. Statistical Inference is done using `R Programming`

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

Independent variable: The condition of Congruency or Incongruency; whether the word represents the same color of the word.
Dependent variable: The time taken to recognize the color of the word.

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

H_0: The population mean response time is the same for both conditions (Congruent and Incongruent), in other words, true difference in mean is 0, ($\mu_1 = \mu_2$).
H_a: The population mean response time is different for both conditions (Congruent and Incongruent), in other words, true difference in mean is not 0, ($\mu_1 \neq \mu_2$)
where μ_1 and μ_2 are the mean response times for Congruent and Incongruent group respectively.

As you will see in an upcoming visualization time in both groups is approximately normal, we could conduct z-test or t-test for them. But we only have 24 datasets, also further more t-test has everything to do with whether or not we are using a known population standard deviation or whether we are estimating it by using the standard deviation calculated from the sample.

Since we are using a sample standard deviation to calculate the standard error (estimate of standard deviation of the sampling distribution) the reason for using t also feels right for the extra variability that is added when using an estimate from a sample rather than a known population parameter.

The paired t-test and confidence interval are parametric methods appropriate for examining difference in means for 2 populations that are paired or dependent on one another. For our case, we will be using a `two-tailed, paired t-test`

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

1. Mean

```
sapply(stroop, mean, na.rm=TRUE)
```

```
Congruent Incongruent
14.05113 22.01592
```

2. Standard Deviation

```
sapply(stroop, sd, na.rm=TRUE)
```

```
Congruent Incongruent
3.559358 4.797057
```

3. Median

```
sapply(stroop, median, na.rm=TRUE)
```

```
Congruent Incongruent
14.3565 21.0175
```

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.

1. The histogram below helps visualize the almost-normal distributions for time recorded in both groups. Changing binwidth, also changes the way the data is distributed.

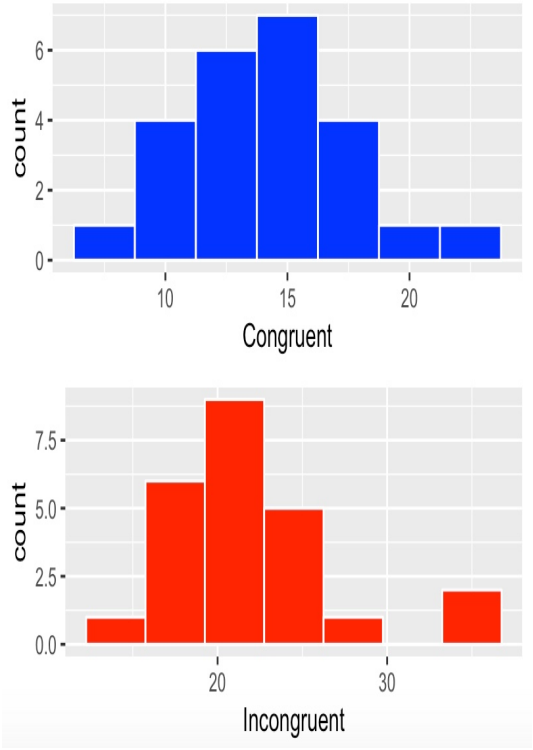

Figure 1: Histogram

Note also on the histogram for the Incongruent class, there are a bunch of outliers indicated by the right-most observations after the small gap.

2. The boxplot below helps visualize the differences in the median and distribution of values in time recorded in both groups. Changing binwidth, also changes the way the data is distributed. The outliers spotted in the histogram of Incongruent class is seen in the boxplot.

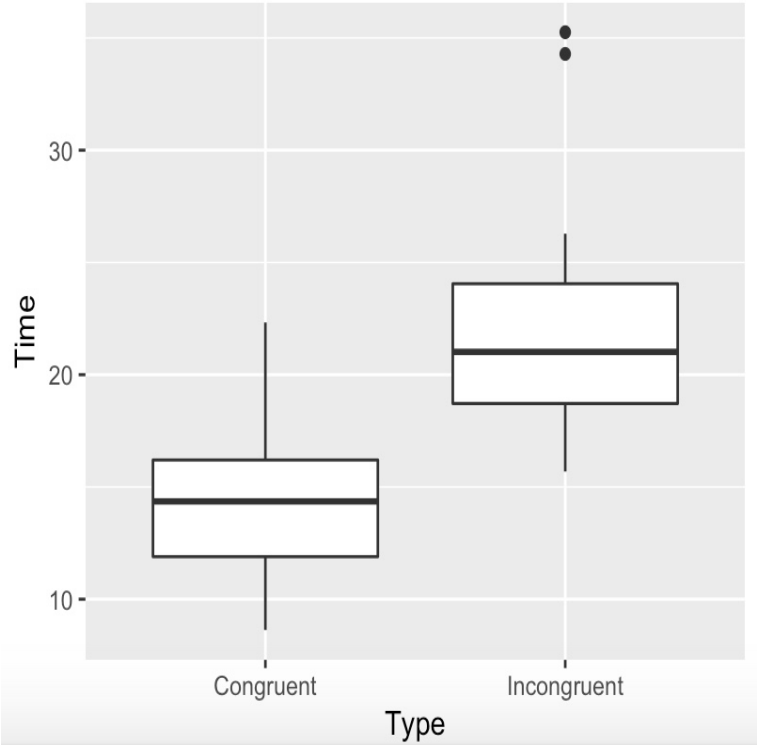

Figure 2: BoxPlot

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?

```
t.test(stroop$Incongruent, stroop$Congruent , mu=0, alt="two.sided", paired = T, conf.level = 0.95)
```

The `R` function t.test, performs the t-test. It takes as arguments, the columns we want to compare, in this case `Incongruent` and `Congruent`, setting `mu=0`, to let `R` know we would like to test if the mean difference is 0, in other words, we are testing for H_0, `alt` arguments informs `R` that we want the t-test to be two-sided with `paired = T`. We are setting the confidence level to 95%.

Running the above code returns

```
data:  stroop$Incongruent and stroop$Congruent
t = 8.0207, df = 23, p-value = 4.103e-08
alternative hypothesis:  true difference in means is not equal to 0
95 percent confidence interval:  5.910555 to 10.019028
sample estimates:  mean of the differences 7.964792
```

`t = 8.0207` represents the value of `t.statistic`
`df = 23` represents the value of `degrees of freedom`
`p-value` is used as an alternative to rejection points to provide the smallest level of significance at which the null hypothesis would be rejected. If the `p-value` is less than α which is `0.05`, used as the cutoff for significance, we reject the null hypothesis that there's no difference between the means and conclude that a significant difference does exist.

Also running, `abs(qt(0.05/2, 23))` returns `2.068658` which represents `t-critical`.

Since `t-critical (2.068659)` is less than `t-statistic (8.0207)` and `p-value 4.103e-08` is very small compared to α `(0.05)`, we `REJECT THE NULL HYPOTHESIS, AND ACCEPT THE ALTERNATIVE HYPOTHESIS` that the mean response time to name colours is significantly different between the Congruent and Incongruent categories.

To summarize, people do not name colours at the same speed when the word's color label and the actual colour do not match, as when they do match. The result confirms my expectations. This means that accurate word-color label do help people recognize color in Congruent category and words do interfere with people's ability recognize color in Incongruent category.

6. References

1. https://www.youtube.com/watch?v=yD6aU0fY2lo: `R` code to perform the t-test
2. Udacity Forum