1. **What is our independent variable? What is our dependent variable?**
   - Independent variable: Stroop task type (Congruent or Incongruent)
   - Dependent variable: Time to complete a Stroop task

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

   Some people are more receptive of ink colors while others are more receptive of the words that spell out the colors. It may take the same person a different length of time to complete a congruent or an incongruent task.

   Thus, the hypothesis for this task would be: The length of time to complete a congruent vs an incongruent Stroop task is different.

   Since we only have a small sample of 24 people and their recorded times to complete each task (x), we are only able to use the sample statistic (the average time difference $\bar{x}_{diff}$) to make an inference of the population mean (μ_{diff}). To test this hypothesis, we need to conduct a t-test, specifically, a two-tailed t-test, since we are testing if the time required to complete two tasks are equal or not.

   The null hypothesis would be "*on average, there is no significant difference in time required to complete a congruent and an incongruent task*," while the alternative hypothesis would be "*there is indeed a significant difference in the average time required to complete a congruent and an incongruent task.*"

   To denote this hypothesis parameters:
   μ_i: $Average\ length\ of\ time\ required\ to\ complete\ an\ incongruent\ task$
   μ_c: $Average\ length\ of\ time\ required\ to\ complete\ a\ congruent\ task$
   μ_{diff}: $Average\ difference\ in\ length\ of\ time\ to\ complete\ two\ types\ of\ tasks$

   H_0: $\mu_{diff} = 0$
   H_A: $\mu_{diff} \neq 0$

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

   The average time required to complete the incongruent tasks is about 57% longer than that of congruent tasks – 22.02 seconds to complete an incongruent task vs 14.05 seconds to complete a congruent task.

   However, incongruent tasks have higher outlier than congruent tasks, with a skewness of 1.36 vs congruent task's skewness of 0.37, and it is very close to a normal distribution. Therefore, because there are more prevalent outliers for incongruent tasks, the average time to complete a incongruent task is higher than the median time by 1 second (mean = 22.02, median = 21.02), while the mean and median time to complete a congruent task is the same, indicating there isn't much skewness.

Lastly, the spread of time to completion for Incongruent tasks is also larger than Congruent tasks, with a standard deviation of 4.8 seconds, while Congruent tasks has a lower standard deviation of 3.56 seconds.

	n	mean	sd	median	min	max	skew
Congruent	24	14	3.6	14	8.6	22	0.37
Incongruent	24	22	4.8	21	15.7	35	1.36

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.**

As mentioned before, Incongruent tasks has more spread in average time to completion than congruent tasks. This can be seen in the frequency graph from *figure. 1*. Although incongruent tasks completion times mainly fall between about 15 seconds to 28 seconds, there are huge outliers that falls between 30-40 seconds.

On the other hand, the times to complete congruent tasks are less spread out, and all observations fall within 6 to 24 seconds, with the most people completed the tasks between 12 to15 seconds.
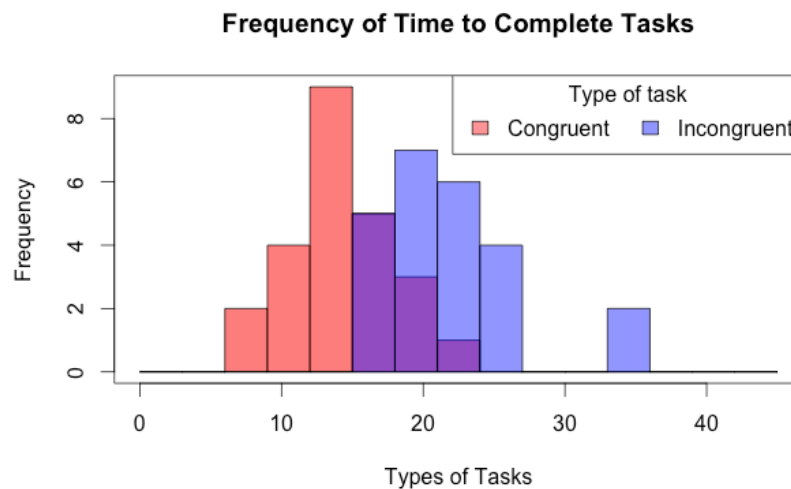

Figure 1 Congruent vs Incongruent tasks completion time frequency graph

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?**

Perform two-tailed t-test on the times (seconds) required to complete a congruent and incongruent task.

Hypothesis: There is a significant difference in the average time required to complete a congruent and incongruent task.

Recall our hypothesis test parameters:

μ_i: Average length of time required to complete an incongruent task
μ_c: Average length of time required to complete a congruent task
μ_{diff}: Average difference in length of time to complete two types of tasks

H_0: $\mu_{diff} = 0$
H_A: $\mu_{diff} \neq 0$

We are conducting the test with an α level of *0.05*.

Below is the outcome of the hypothesis test:

> *Tests Output Using R*
> *Paired t-test*
> *data: data$Incongruent and data$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 10.019028]*
> *sample estimates:*
> *mean of the differences: 7.964792*

From the paired t-test, we found out the difference between congruent and incongruent has a t-statistic of 8.02, which is much larger than the critical t- statistic value of 2.07 and the p-value is less than our α (α = 0.05).

When constructing a 95% confidence interval, the interval is between 5.91 seconds & 10.01 seconds.

Therefore, we would reject the null hypothesis, and there is a significant difference between the time required to complete a congruent task and an incongruent task. The result matched my expectation that there will be a difference in the time required to complete these two different kind of tasks for the same person.

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 effects responsible for the difference in time required to complete congruent and incongruent tasks may be due to how people are susceptible, or likely to be influenced by the meaning constructed by the words than the ink color itself. While some groups of people may be the opposite – it's easier for them to name the ink color as they are more susceptible of the color itself than the meaning constructed by the words.

Similar effect would be a numerical variation of Stroop task. In which, two numbers are presented to users at the same time, but with different font sizes.

Congruent tasks in this example would be the numbers that are numerically larger than the other, also has bigger font size, while incongruent task is the opposite – the font-size

is not necessary bigger for the larger number (eg. Congruent task: 9 vs 5; incongruent task: 1 vs 8).