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.

Question 1

What is our independent variable? What is our dependent variable?

In this experiment:

- The dependent variable is the response time it took each participant to identify the color of ink.
- The independent variable for the experiment is the congruency conditions; including congruent words and incongruent words conditions.

Question 2

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

• Null Hypothesis H_0 – That there is no significant change in time between congruent or incongruent word conditions.

- H_0 (Null Hypothesis): $\mu_i = \mu_c$
  - μ_i = population mean of incongruent values
  - μ_c = population mean of congruent values

• Alternate Hypothesis H_1 – That there is a significant change in time between congruent or incongruent word conditions.

- H_1 (Alternate Hypothesis): $\mu_i \neq \mu_c$
  - μ_i = population mean of incongruent values
  - μ_c = population mean of congruent values

My chosen statistical test: Paired Two Tailed T-Test

The kind of statistical test I will use is the Paired two tailed t-test. I need to compare the two related groups to determine if there is a significant change between their means. The same subjects were tested for congruent words followed by incongruent words.

Reason I selected the paired two tailed t-test

- There was no information provided about the population, only 24 samples were supplied.
- I wanted to consider both sides of the experimeter, upper and lower ranges
- I wanted personal bias removed from my analysis, by using one tail implies I already know the direction

Assumptions

- The data distributions are normal
- The observations were independent of each other.
- Sample size is below 30

Question 3

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

In [1]:
```
import math
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from scipy.stats import t

pd.options.display.float_format = '{:,.3f}'.format
plt.rcParams['figure.figsize'] = (12,8)
sns.set(style='whitegrid')
%matplotlib inline
```

In [2]:
```
stroop_data = pd.read_excel("stroopdata.xlsx")
```

In [3]:
```
stroop_data
```

Out[3]:

	Congruent	Incongruent
0	12.079	19.278
1	16.791	18.741
2	9.564	21.214
3	8.630	15.687
4	14.669	22.803
5	12.238	20.878
6	14.692	24.572
7	8.987	17.394
8	9.401	20.762
9	14.480	26.282
10	22.328	24.524
11	15.298	18.644
12	15.073	17.510
13	16.929	20.330
14	18.200	35.255
15	12.130	22.158
16	18.495	25.139
17	10.639	20.429
18	11.344	17.425
19	12.369	34.288
20	12.944	23.894
21	14.233	17.960
22	19.710	22.058
23	16.004	21.157

In [4]:
```
# Congruent values count, mean, median, and std
congruent_count = stroop_data['Congruent'].count()
congruent_mean = stroop_data['Congruent'].mean()
congruent_median = stroop_data['Congruent'].median()
congruent_std = stroop_data['Congruent'].std()
```

In [5]:
```
# Incongruent values count, mean, median, and std
incongruent_count = stroop_data['Incongruent'].count()
incongruent_mean = stroop_data['Incongruent'].mean()
incongruent_median = stroop_data['Incongruent'].median()
incongruent_std = stroop_data['Incongruent'].std()
```

In [6]:
```
stroop_details = pd.DataFrame(
    [
        [congruent_count, incongruent_count],
        [congruent_mean, incongruent_mean],
        [congruent_median, incongruent_median],
        [congruent_std, incongruent_std]
    ],
    index=[
        'Samples',
        'Mean',
        'Median',
        'Standard Deviation'
    ],
    columns=['Congruent', 'Incongruent'])
```

In [7]:
```
# Measure of Centrality & Measure of variability
stroop_details
```

Out[7]:

	Congruent	Incongruent
Samples	24.000	24.000
Mean	14.051	22.016
Median	14.357	21.017
Standard Deviation	3.559	4.797

In [8]:
```
# Additional details on the values, and validation of above table.
stroop_data.describe()
```

Out[8]:

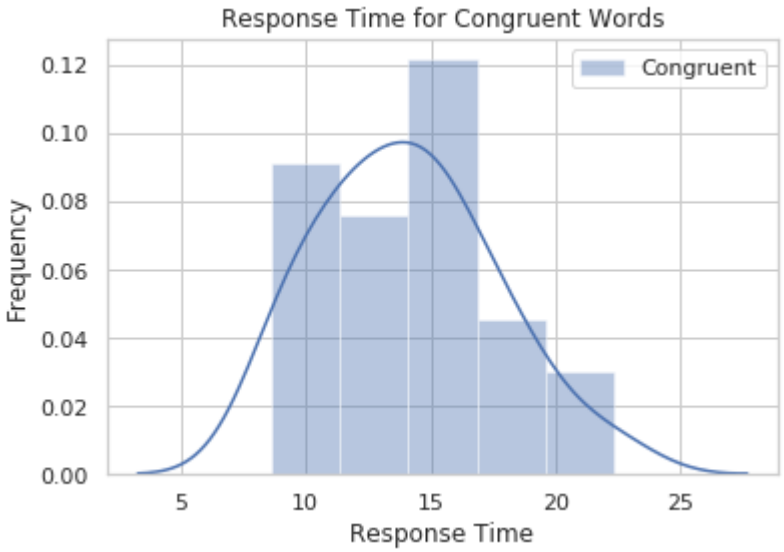
	Congruent	Incongruent
count	24.000	24.000
mean	14.051	22.016
std	3.559	4.797
min	8.630	15.687
25%	11.895	18.717
50%	14.357	21.017
75%	16.201	24.051
max	22.328	35.255

Question 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.

In [9]:
```
sns.distplot(stroop_data['Congruent'], label='Congruent')
plt.xlabel("Response Time")
plt.ylabel("Frequency")
plt.title("Response Time for Congruent Words")
plt.legend()
```

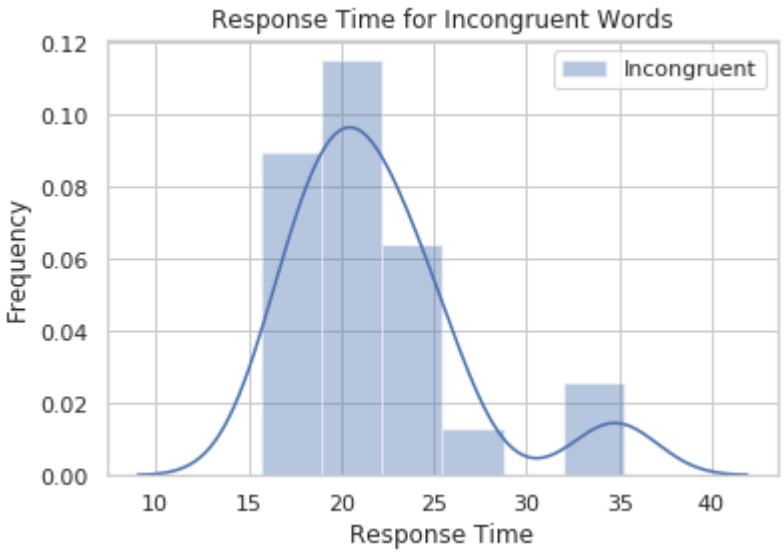
Out[9]: <matplotlib.legend.Legend at 0x7f5759bc6160>



The Congruent values are close to being normally distributed and the middle of the data is slightly less than 15.

In [10]:
```
sns.distplot(stroop_data['Incongruent'], label="Incongruent")
plt.xlabel("Response Time")
plt.ylabel("Frequency")
plt.title("Response Time for Incongruent Words")
plt.legend()
```

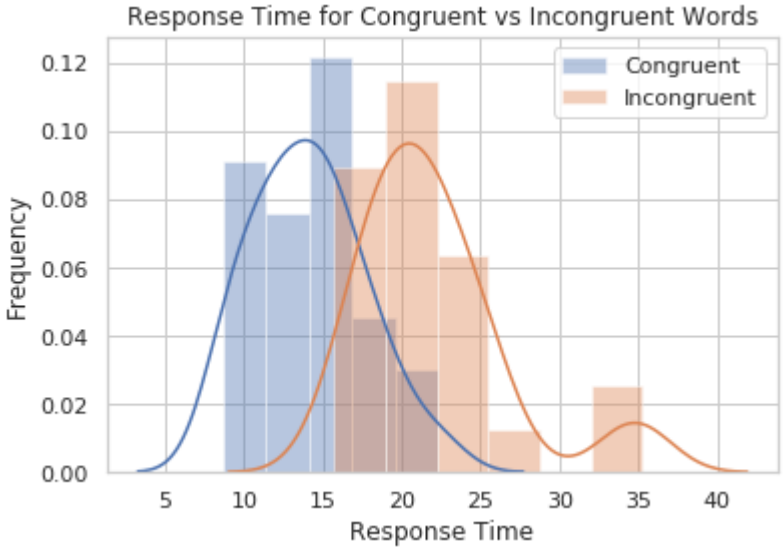
Out[10]: <matplotlib.legend.Legend at 0x7f5759b8e470>



For the Incongruent values, there's potential outliers in the dataset causing a slight right skew.

In [11]:
```
sns.distplot(stroop_data['Congruent'], label = 'Congruent')
sns.distplot(stroop_data['Incongruent'], label = 'Incongruent')
plt.xlabel("Response Time")
plt.ylabel("Frequency")
plt.title("Response Time for Congruent vs Incongruent Words")
plt.legend()
```

Out[11]: <matplotlib.legend.Legend at 0x7f5759a5d208>



Both Congruent and Incongruent observations look close to being normal distributions. We can also see that the mean is different for both conditions.

Question 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?

In [12]:
```
stroop_data.describe()
```

Out[12]:

	Congruent	Incongruent
count	24.000	24.000
mean	14.051	22.016
std	3.559	4.797
min	8.630	15.687
25%	11.895	18.717
50%	14.357	21.017
75%	16.201	24.051
max	22.328	35.255

The statistical test chosen is the Two Tailed T-Test

- The sample size is: 24
- Degrees of Freedom: n - 1 which equals 23

In [13]:
```
# Locate the t-critical value for a 95% confidence level with 23 degrees of fr
eedom for two tailed test
t_critical_value = t.ppf(.975, 23)
```

In [14]:
```
print(f"The t-critical value for a 95% confidence level with 23 degrees of fre
edom is {round(t_critical_value, 4)}")
```

```
The t-critical value for a 95% confidence level with 23 degrees of freedom is
2.0687
```

Reminder:

- Sample Size: 24
- Degrees of Freedom: 23
- t-critical value: 2.0687 (2.069 per t-table chart)

In [15]:
```
stroop_data['Difference'] = stroop_data['Congruent'] - stroop_data['Incongruent']
```

Find the difference between the datapoints

In [16]:
```
stroop_data.head(10)
```

Out[16]:

	Congruent	Incongruent	Difference
0	12.079	19.278	-7.199
1	16.791	18.741	-1.950
2	9.564	21.214	-11.650
3	8.630	15.687	-7.057
4	14.669	22.803	-8.134
5	12.238	20.878	-8.640
6	14.692	24.572	-9.880
7	8.987	17.394	-8.407
8	9.401	20.762	-11.361
9	14.480	26.282	-11.802

I need to find the std and mean of the differences

In [17]:
```
differences_count = stroop_data['Difference'].count()
differences_std = stroop_data['Difference'].std()
differences_mean = stroop_data['Difference'].mean()
```

In [18]:
```
print(f"Std of Differences:\t{round(differences_std,4)}\nMean of Differences:\t{round(differences_mean, 4)}")
```

```
Std of Differences:     4.8648
Mean of Differences:    -7.9648
```

In [19]:
```
# Calculate the point estimate for the difference of means:
point_estimate = incongruent_mean - congruent_mean
```

In [20]:
```
print(f"x̄: {round(point_estimate, 4)}")
```

```
x̄: 7.9648
```

In [21]:
```
# t-value = x̄ / (diff_std/math.sqrt(24))
t_value = 7.9648/(4.8648 / math.sqrt(24))
```

In [22]:
```
print(f"The t-Value is: {round(t_value,4)}")
```

```
The t-Value is: 8.0208
```

- The t-statistic value of 8.0208 is greater than the critical value of 2.0687 which means we can reject the null hypothesis.

This aligns up with my expectations and personal observation that the congruent task takes much less time to do than the incongruent task.

References

- https://docs.scipy.org/doc/scipy-0.14.0/reference/generated/scipy.stats.t.html (https://docs.scipy.org/doc/scipy-0.14.0/reference/generated/scipy.stats.t.html)
- https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faq-what-are-the-differences-between-one-tailed-and-two-tailed-tests/ (https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faq-what-are-the-differences-between-one-tailed-and-two-tailed-tests/)
- https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/hypothesis-testing/t-score-vs-z-score/ (https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/hypothesis-testing/t-score-vs-z-score/)
- https://pandas.pydata.org/pandas-docs/stable/reference/frame.html#computations-descriptive-stats (https://pandas.pydata.org/pandas-docs/stable/reference/frame.html#computations-descriptive-stats)
- https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/Two-Sample_T-Test.pdf (https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/Two-Sample_T-Test.pdf) http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf (http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf)

In [ ]:
```
```