Udacity Project - Test a Perceptual Phenomenon

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

As a general note, be sure to keep a record of any resources that you use or refer to in the creation of your project. You will need to report your sources as part of the project submission

Question 1

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

Our independent variable is the variation of the test. It can take two value: congruent and incongruent.

Our dependent variable is the time it takes for participants to finish each test.

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

An appropriate set of hypothesis would be:

- The null hypothesis is that there is no significant difference between the population mean for the congruent test and the population mean for the incongruent test.
- The alternative hypothesis is that there is significant difference between the population mean for the congruent test and the population mean for the incongruent test.

$$H_0 : \mu_c = \mu_i$$
$$H_a : \mu_c \neq \mu_i$$
$$\mu_c \text{ is the population mean for the congruent test}$$
$$\mu_i \text{ is the population mean for the incongruent test}$$

We would use the t-test since:

- The sample size is under 30.
- The two tests are made by the same people, the samples are dependant.

I would therefore expect to do a dependent two-tailed t-test for paired samples (two-conditions)

Assumptions :

- The data is continuous.
- The data is normally distributed.
- The data has no outliers.

We will set our significance level at 0.05, so that we only have 5% chance to conclude that there is a relationship when there is not.

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 [8]:
```
#Load necessary data & packages
import numpy as np
import matplotlib.pyplot as plt
import seaborn
import math
from scipy import stats
%matplotlib inline

congruent = np.array([12.079, 16.791, 9.564, 8.63, 14.669,
                      12.238, 14.692, 8.987, 9.401, 14.48,
                      22.328, 15.298, 15.073, 16.929, 18.2,
                      12.13, 18.495, 10.639, 11.344, 12.369,
                      12.944, 14.233, 19.71, 16.004])

incongruent = np.array([19.278, 18.741, 21.214, 15.687, 22.803,
                        20.878, 24.572, 17.394, 20.762, 26.282,
                        24.524, 18.644, 17.51, 20.33, 35.255,
                        22.158, 25.139, 20.429, 17.425, 34.288,
                        23.894, 17.96, 22.058, 21.157])
```

In [9]:
```
#Calculate some descriptive statisitcs

print('Congruent Data')
print('mean:               %6.3f' % np.mean(congruent))
print('median:             %6.3f' % np.median(congruent))
print('standard deviation: %6.3f' % np.std(congruent,ddof=1))
print('')
print('Incongruent Data')
print('mean:               %6.3f'% np.mean(incongruent))
print('median:             %6.3f' % np.median(incongruent))
print('standard deviation: %6.3f' % np.std(incongruent, ddof=1))
```

```
Congruent Data
mean:               14.051
median:             14.357
standard deviation:  3.559

Incongruent Data
mean:               22.016
median:             21.017
standard deviation:  4.797
```

the difference betwwen mean and median is not really large for both the congruent and incongruent test. Nothing to see here.

However, more interestingly and as expected: there is a big difference in mean, median and standard deviation between the 2 tests. Ther is almost a 50% increase in mean time and median for the Incongruent test compared to the congruent test.

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 [10]:
```
#based on matplotlib boxplot demo (http://matplotlib.org/examples/pylab_examples/boxplot_demo2.html)

fig, ax1 = plt.subplots(figsize=(10, 6))
ax1.set_title('Comparison of Congruent and Incongruent Stroop tests')
ax1.set_xlabel('Type of test')
ax1.set_ylabel('Reaction time (in seconds)')
plt.boxplot([congruent, incongruent], 0, 'rs', labels = ['Congruent', 'Incongruent'])
```

Out[10]:
```
{'boxes': [<matplotlib.lines.Line2D at 0x5eeca50>,
  <matplotlib.lines.Line2D at 0x5f0cd30>],
 'caps': [<matplotlib.lines.Line2D at 0x5efe5b0>,
  <matplotlib.lines.Line2D at 0x5efea90>,
  <matplotlib.lines.Line2D at 0x5f21810>,
  <matplotlib.lines.Line2D at 0x5f21cf0>],
 'fliers': [<matplotlib.lines.Line2D at 0x5f0c490>,
  <matplotlib.lines.Line2D at 0x5f286d0>],
 'means': [],
 'medians': [<matplotlib.lines.Line2D at 0x5efef70>,
  <matplotlib.lines.Line2D at 0x5f285d0>],
 'whiskers': [<matplotlib.lines.Line2D at 0x5eecb30>,
  <matplotlib.lines.Line2D at 0x5efe130>,
  <matplotlib.lines.Line2D at 0x5f0ce50>,
  <matplotlib.lines.Line2D at 0x5f0c370>]}
```

First Visualization: Boxplots

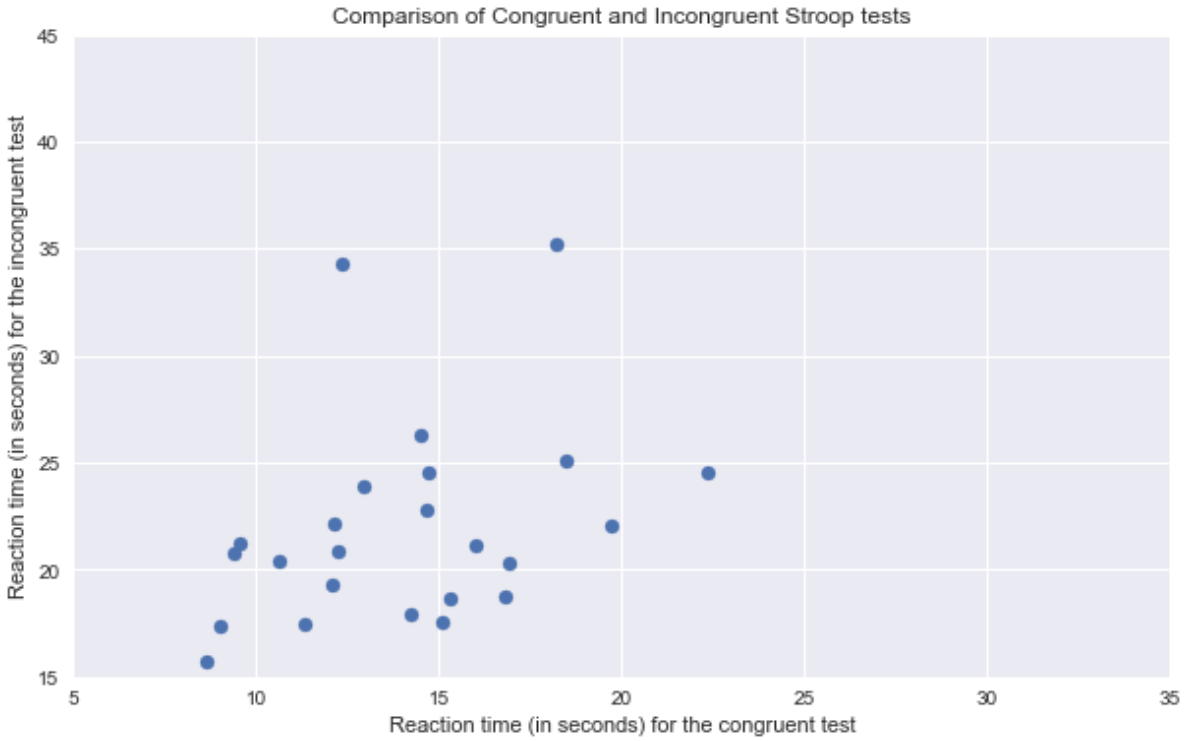
The above boxplot is really interesting, it shows the followings:

- People are faster to take the congruent test.
- Althought the distance between the first and thrid quartile of the congruent test are slightly smaller than the ones for the incongruent test, the distance between the fences is larger.
- There are two outliers for the incongruent test (what does it means for our t-test?).

I wonder if there is a relationship between the rapidity to do the congruent test and the rapidity to do the Incongruent test. That's what we are gonna explore in the second visualization.

In [11]:
```
#
fig, ax1 = plt.subplots(figsize=(10, 6))
plt.axis([5, 35, 15, 45])
ax1.set_title('Comparison of Congruent and Incongruent Stroop tests')
ax1.set_xlabel('Reaction time (in seconds) for the congruent test')
ax1.set_ylabel('Reaction time (in seconds) for the incongruent test')
plt.scatter(congruent, incongruent)
```

Out[11]: <matplotlib.collections.PathCollection at 0x5f66410>



Second Visualization: Scatterplot

The above scatterplot is also really interesting, it shows the following:

- There seems to be a correlation between speed in the congruent test and soeed in the incongruent test although not as strong as I would expect.
- We can see the two outliers that we were previously speaking about, they were surprisingly (especially for one) far from being the slowests on the congruent test.

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]:
```
#Calculate the difference between the two set of observation
obs_diff = congruent - incongruent

#Calculate the mean of the difference
mean_diff = obs_diff.mean()

#Calculate the Standard Deviation of the difference
sd_diff = np.std(obs_diff, ddof=1)

#Calculate the Standard Error of the Mean Difference
SEM = sd_diff / math.sqrt(obs_diff.shape[0])

#Calculate the t-statistic
t_stat = mean_diff / SEM

#Report the t-critical value (henderso's answer to Python function to get the
 t-statistic
#(http://stackoverflow.com/questions/19339305/python-function-to-get-the-t-sta
tistic)
t_crit = stats.t.ppf(1-0.025, 24)

#Calculate the confidence interval
margin_error = t_crit * SEM
CI_lowerb = mean_diff - margin_error
CI_higherb = mean_diff + margin_error


#report the p-value (Andrew Latham's answer to Python p-value from t-statistic
#(http://stackoverflow.com/questions/17559897/python-p-value-from-t-statistic)
p_val = stats.t.sf(np.abs(t_stat), obs_diff.shape[0] - 1) * 2

print ('t-statistic: %6.3f' % t_stat)
print ('t-critical: (%6.3f, %6.3f) '% (-t_crit, t_crit))
print ('p-value: %6.f' % p_val)
print ('Confidence Interval: (%6.3f , %6.3f)' % (CI_lowerb, CI_higherb))
```

```
t-statistic: -8.021
t-critical: (-2.064,  2.064)
p-value:      0
Confidence Interval: (-10.014 , -5.915)
```

t-test

t-critical: -2.064, 2.064 t-statistic: 8.021

8.021 > 2.064 Since the t-statistic is in the critical region, we will reject the Null hypothesis.

We can say that the type of test had a influence on the time it took people to complete the test.

p-value

p-value = 0.000

By convention, with a p-value under 0.0001, the difference between the results of the congruent and the results of the incongruent is **extremely significant.**

confidence interval

Confidence Interval: (-10.014 , -5.915)

we are confident that the results of the congruent test will be between -10.014 and -5.915 seconds.

Conclusion

The congruent test takes less time to undertake than the incongruent time.

It is easier to identify the color when it matches with the word than to identify the color when it does not match with the word.

Question 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!

I think that the way our brain process the color of the word and the meaning of the world conflict. However, I wonder if there would still be a difference if it was just reading words with the color being irrelevant.

I can think of two different test were we could observe the same effect (not sure it would work though):

- Supposed to say the number of words. The congruent test is with words saying the number of words we should say. The incongruent test would be with a mismatch between words and number of words.
- Supposed to say what is on a picture. The congruent test would be a picture of an animal with a matching word. The incongruent test would be a mismatch between the word and the picture.

Ressources

List of ressources used:

- http://matplotlib.org/examples/pylab_examples/boxplot_demo2.html (http://matplotlib.org/examples/pylab_examples/boxplot_demo2.html)
- http://stackoverflow.com/questions/19339305/python-function-to-get-the-t-statistic (http://stackoverflow.com/questions/19339305/python-function-to-get-the-t-statistic)
- http://stackoverflow.com/questions/17559897/python-p-value-from-t-statistic (http://stackoverflow.com/questions/17559897/python-p-value-from-t-statistic)
- http://www.swarthmore.edu/SocSci/fdurgin1/ReverseStroop/PBRStroop.html (http://www.swarthmore.edu/SocSci/fdurgin1/ReverseStroop/PBRStroop.html)