# Udacity Data Science Project Submission # 1 : Statistics

- Submission included: Excel Spreadsheet with data, graphs, calculations and results.

## BACKGROUND: "The Stroop Task"

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.

## PROJECT TASKS: Questions for Investigation

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

- **Independent Variable:** List of Words ( Congruent & Incongruent )
- **Dependent Variable**: Time

**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** Hypotheses : There is **NO** statistical *difference* between the scores (Congruent & Incongruent).
- **Alternative** Hypotheses : There is a **definite** statistical *difference* between the scores (Congruent & Incongruent).

**Statistical Tests** to perform:

- 2 Tailed T-Test of Paired Sample Means
- Confidence Interval 95%
- Cohen's d
- Descriptive Statistics

**Justification** of test choices:

- This *test design* of a ***Dependent Samples (Repeated Measures) Design*** (the same subject takes the test twice) and the results are then observed. The test design uses **Paired Data**, with the analysis occurring on the **Differences** between the populations, so our tests are on the differences.
- The **T-Test** is used to determine whether the mean of a population **significantly differs** from a specific value (called the hypothesized mean) or from the mean of another population. Since we have a **small** population and are **not** given the standard deviation, we are relegated to using a **T-Test**, instead of a Z-Test.
- **Confidence Intervals** just *bound* the mean and give us a range that is likely to contain the value of an unknown population parameter. It also permits us (given the test design) to ***make causal statements*** about the results.
- **Cohen's d** affords us the ability to articulate the **effect size** of the treatment.

**My Record the times** for the test: [ C: **16.96**, I: **41.449** ]

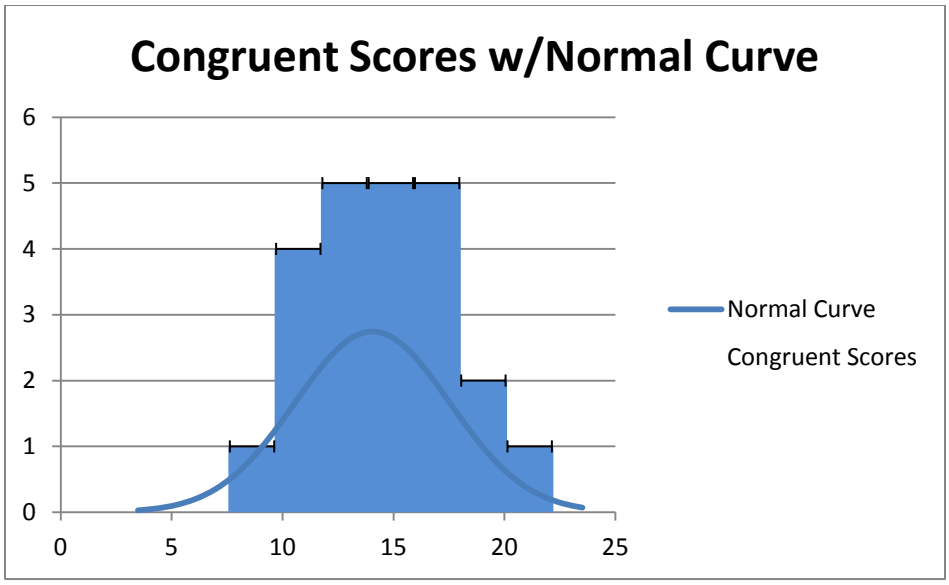
**3. Report some descriptive statistics regarding this dataset. Include at <u>least one</u> measure of central tendency and at <u>least one</u> measure of variability.**

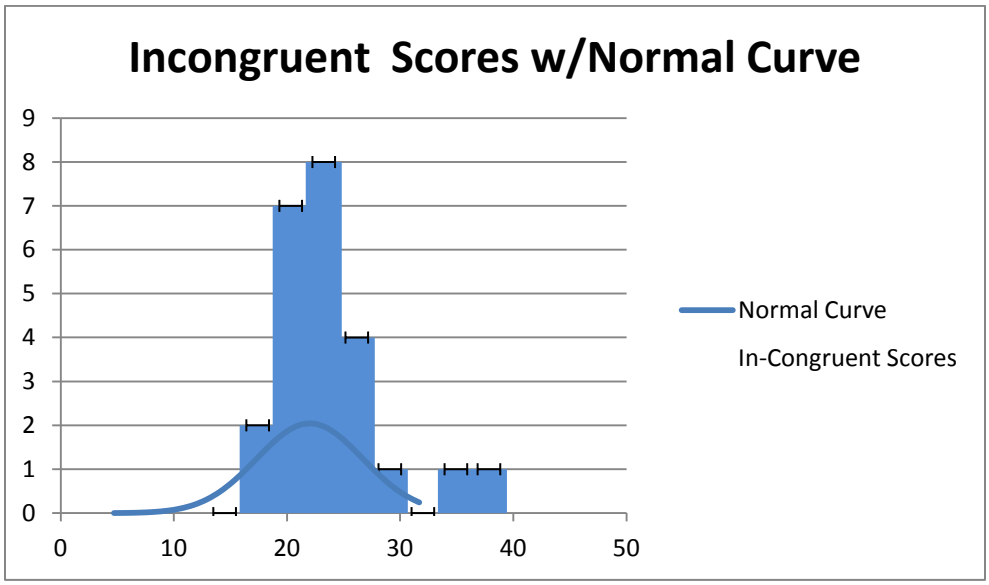
**DESCRIPTIVE STATISTICS** (Central Tendency & Variability)

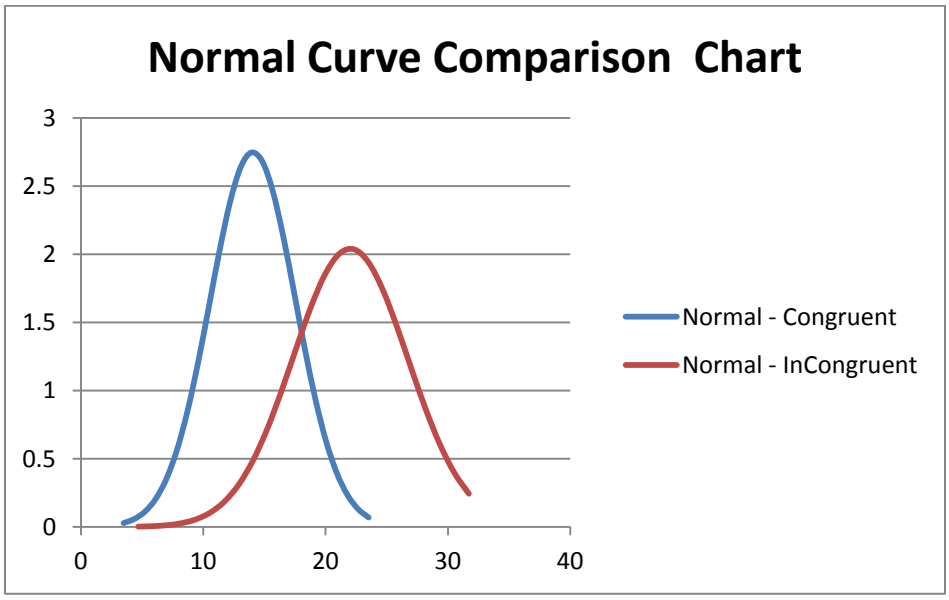
| *Scores Congruent* | | *Scores Incongruent* | |
|---|---|---|---|
| **Mean** | 14.051125 | **Mean** | 22.01591667 |
| **Standard Error** | 0.726550901 | **Standard Error** | 0.979195185 |
| **Median** | 14.3565 | **Median** | 21.0175 |
| **Mode** | #N/A | **Mode** | #N/A |
| **Standard Deviation** | 3.559357958 | **Standard Deviation** | 4.797057122 |
| **Sample Variance** | 12.66902907 | **Sample Variance** | 23.01175704 |
| **Kurtosis** | -0.205224823 | **Kurtosis** | 2.688900198 |
| **Skewness** | 0.416899874 | **Skewness** | 1.547590026 |
| **Range** | 13.698 | **Range** | 19.568 |
| **Minimum** | 8.63 | **Minimum** | 15.687 |
| **Maximum** | 22.328 | **Maximum** | 35.255 |
| **Sum** | 337.227 | **Sum** | 528.382 |
| **Count** | 24 | **Count** | 24 |
| **Confidence Level(95.0%)** | 1.502985041 | **Confidence Level(95.0%)** | 2.025619559 |

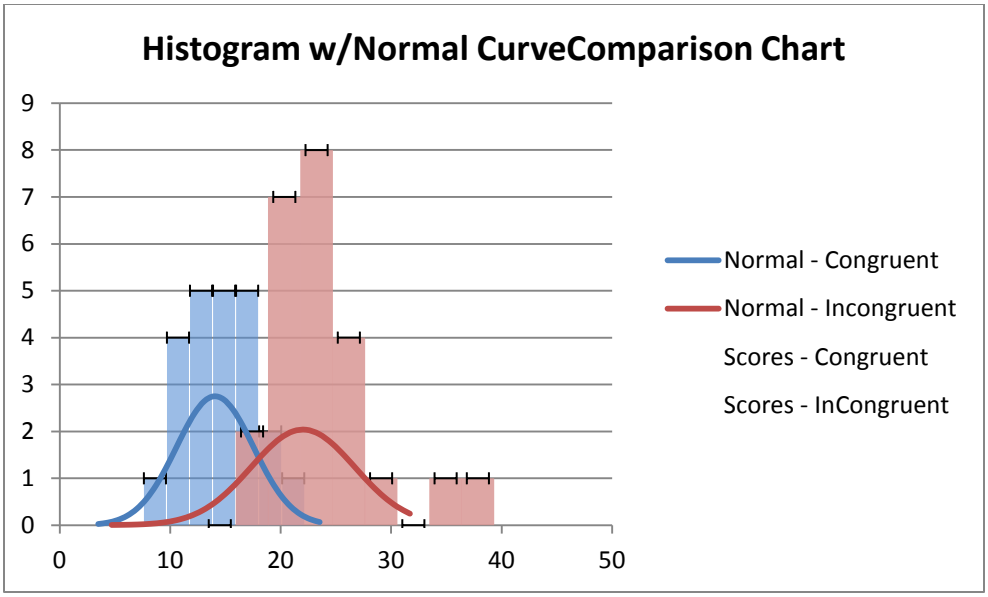
| *Scores Difference* | |
|---|---|
| **Mean** | -7.964791667 |
| **Standard Error** | 0.993028635 |
| **Median** | -7.6665 |
| **Mode** | #N/A |
| **Standard Deviation** | 4.86482691 |
| **Sample Variance** | 23.66654087 |
| **Kurtosis** | 1.710013635 |
| **Skewness** | -1.073209987 |
| **Range** | 19.969 |
| **Minimum** | -21.919 |
| **Maximum** | -1.95 |
| **Sum** | -191.155 |
| **Count** | 24 |
| **Confidence Level(95.0%)** | 2.054236231 |

**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.**






**ANALYSIS OF (4) PLOTS:**

- **The first two plots** simply confirm the fact that the results are indeed distributed in a **normal curve** type fashion.
- **The second two plots** really tell the results story of the overall research test. You can see that the **Incongruent** distribution is (statistically significantly) far **right** of the **Congruent** distribution, which means those larger scores clearly indicate that the ***effects of the treatments are indeed significant***.
- **In Layman's terms** - the Stroop effect in this study is *clearly* demonstrable.

**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?**

- **RESULTS REPORT: Statistical Tests for Mean Differences @ Alpha of .05 ( 95% Confidence level )**

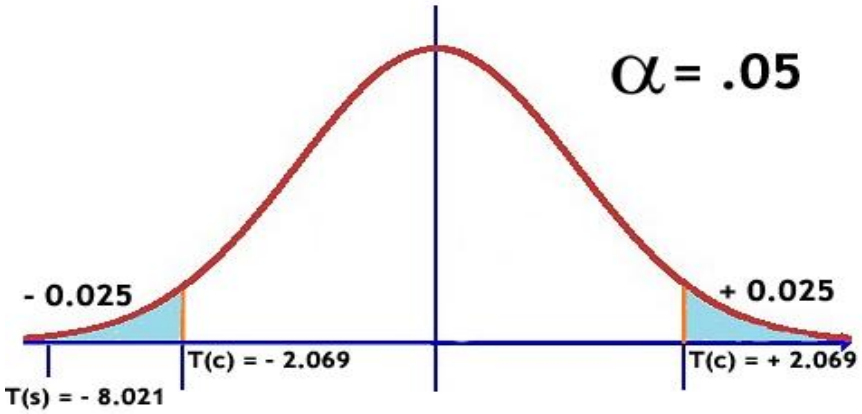
**t-Test: Paired Two Sample for Means**

| | *Scores Congruent* | *Scores Incongruent* |
|---|---|---|
| **Mean** | 14.051125 | 22.01591667 |
| **Variance** | 12.66902907 | 23.01175704 |
| **Observations** | 24 | 24 |
| **Pearson Correlation** | 0.351819527 | |
| **Hypothesized Mean Difference** | 0 | |
| **df** | 23 | |
| **t Stat** ***** | -8.020706944 | |
| **P(T<=t) one-tail** | 2.0515E-08 | |
| **t Critical one-tail** | 1.713871517 | |
| **P(T<=t) two-tail** | 4.103E-08 | |
| **t Critical two-tail** | 2.068657599 | |

**Confidence Interval** - CI(d): **Lower Bound**: -10.019, **Upper Bound**: -5.912
**Cohen's d:** -1.64

**ANALYSIS OF STATISTICAL TEST RESULTS**

- **Confidence Level: Alpha** = .05 (95%)
- **T-Statistic**: - 8.021
- **T-Critical**: (+/-) 2.069
- **Confidence Interval**: (L): -10.019, (U): -5.912
- **Cohen's d**: -1.64
- **Hypothesis**: Reject the Null




**RESULTS COMMENTARY**

- I **rejected the null** because the **T-Statistic** (-8.021) was **so much greater** that the **T-Critical** value (-2.069) that statistical significance (difference) was indeed **established**. The populations that this score came was statistically different that the one we were measuring it against.

**CONCLUSIONS**

- **The conclusion** I arrived at after executing a proper statistical analysis on the results of the research data was that the effect in question (The Stroop Effect) **is indeed verifiable** and clearly so. **My first clue** was the differences in the means of the normal distributions between the Congruent scores and the Incongruent scores. That really tells the story. **The verification** of the statistical differences were established after running a proper series of statistical tests on the data, obtaining a T-Statistic and comparing it against a T-Critical value based upon the differences of the two scores populations.
- The results absolutely **matched up** with my expectations, in fact they were spot on.

**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?**

**RESPONSIBLE FOR THE EFFECTS - THEORIES**

**Theories**: There are several theories used to explain the Stroop effect and are commonly known as '**race models'**. This is based on the underlying notion that both relevant and irrelevant information ***are processed in parallel***, but "race" to enter the single central processor during response selection.[12]

**They are:**

- **Processing speed:** This theory suggests there is a lag in the brain's ability to recognize the color of the word since the brain *reads words faster than it recognizes colors*.[13] This is based on the idea that word processing is significantly faster than color processing. In a condition where there is an regarding words and colors (e.g. Stroop test), if the task is to report the color, the word information arrives at the decision-making stage before the color information which presents processing confusion. Conversely, if the task is to report the word, because color information *lags* after word information, a decision can be made ahead of the conflicting information.[14]

- **Selective attention:** The Selective Attention Theory suggests that color recognition as opposed to reading a word, requires *more attention*, the brain needs to use more attention to recognize a color than to word encoding, so it takes *a little longer*.[15] The responses lend much to the interference noted in the Stroop task. This may be a result of either an allocation of attention to the responses or to a *greater inhibition* of distractors that are not appropriate responses.

- **Automaticity:** This theory is the most common theory of the Stroop effect.[16] It suggests that since recognizing colors is **not** an "automatic process" there is *hesitancy to respond*; whereas, the brain automatically understands the meaning of words as a result of habitual reading. This idea is based on the premise that automatic reading does not need controlled attention, but still uses enough attentional resources to reduce the amount of attention accessible for color information processing.[17] Stirling (1979) introduced the concept of response automaticity. He demonstrated that changing the responses from colored words to letters that were not part of the colored words *increased* reaction time while *reducing* Stroop interference.[18]

- **Parallel distributed processing:** This theory suggests that as the brain analyzes information, different and *specific pathways are developed for different tasks*.[19] Some pathways, such as reading, are *stronger* than others, therefore, it is the ***strength of the pathway and not the speed of the pathway that is important***.[16] In addition, automaticity is a function of the strength of each pathway, hence, when two pathways are activated simultaneously in the Stroop effect, interference occurs between the stronger (word reading) path and the weaker (color naming) path, more specifically when the pathway that leads to the response is the weaker pathway.[20]

**ALTERNATIVE TASKS - SIMILAR RESULTS**

**Variations**: The Stroop test has been modified to include **other** *sensory modalities and variables*.

- **Warped words**: For example, the warped words Stroop effect produces the same findings similar to the original Stroop effect. Much like the Stroop task, the printed word's color is different from the ink color of the word; however, the words are printed in such a way that it is more difficult to read (typically curved-shaped).[34] The idea here is the way the words are printed slows down both the brain's reaction and processing time, making it harder to complete the task.

- **Emotional**: The emotional Stroop effect serves as an information processing approach to *emotions*. In an emotional Stroop task, an individual is given negative emotional words like "grief," "violence," and "pain" mixed in with more neutral words like "clock," "door," and "shoe".[34] Just like in the original Stroop task, the words are colored and the individual is supposed to name the color. Research has shown that individuals that are *depressed* are more likely to say the color of a *negative* word **slower** than the color of a neutral word.[35] The emotional Stroop effect emphasizes the conflict between the emotional relevance to the individual and the word; whereas, the classic Stroop effect examines the conflict between the incongruent color and word.[34]

- **Spatial**: The spatial Stroop effect demonstrates interference between the stimulus *location with the location information* in the stimuli.[36] In one version of the spatial Stroop task, an up or down-pointing arrow appears randomly above or below a central point. Despite being asked to discriminate the direction of the arrow while ignoring its location, individuals typically make faster and more accurate responses to congruent stimuli (a down-pointing arrow located below the fixation sign) than to incongruent ones (an up-pointing arrow located below the fixation sign).[36]

- **Numerical**: The Numerical Stroop effect demonstrates the close relationship between *numerical values and physical sizes*. Digits symbolize numerical values but they also have physical sizes. A digit can be presented as big or small (e.g., 5 vs. 5), irrespective of its numerical value. Comparing digits in incongruent trials (e.g., 3 5) is *slower* than comparing digits in congruent trials (e.g., 5 3) and the difference in reaction time is termed the numerical Stroop effect.

- **Reverse**: Another variant of the classic Stroop effect is the reverse Stroop effect. It occurs during a pointing task. In a reverse Stroop task, individuals are shown a page with a black square with an incongruent colored word in the middle — for instance, the word "red" written in the color green — with four smaller colored squares in the corners.[38] One square would be colored green, one square would be red, and the two remaining squares would be other colors. Studies show that if the individual is asked to point to the color square of the written color (in this case, red) they would present a *delay*.[38] Thus, incongruently-colored words significantly interfere with pointing to the appropriate square.

# RESOURCES

**WIKI:** https://en.wikipedia.org/wiki/Stroop_effect


[12] Johnson, A (2004). Attention: theory and practice. Thousand Oaks, Calif: Sage Publications.

[13] McMahon, M. "What Is the Stroop Effec". Retrieved November 11, 2013.

[14] Lamers, M.J.; et al. (2010). "Selective Attention And Response Set In The Stroop Task". Memory & Cognition 38 (7): 893–904. doi:10.3758/mc.38.7.893.

[15] McMahon, M. "What Is the Stroop Effect". Retrieved November 11, 2013.

[16] McMahon, M. "What Is the Stroop Effect?". Retrieved November 11, 2013.

[17] Monahan, J.S (2001). "Coloring single Stroop elements: Reducing automaticity or slowing color processing". Journal of General Psychology 128 (1): 98–112. doi:10.1080/00221300109598901.

[18] Stirling, N (1979). "Stroop interference: An input and an output phenomenon". Quarterly Journal of Experimental Psychology 31: 121–132. doi:10.1080/14640747908400712.

[19] Cohen, J.D. (1990). "On The Control Of Automatic Processes: A Parallel Distributed Processing Account Of The Stroop Effect". Psychological Review 97 (3): 332–361. doi:10.1037/0033-295x.97.3.332.

[20] Cohen, J.D.; et al. (1990). "On The Control Of Automatic Processes: A Parallel Distributed Processing Account Of The Stroop Effect". Psychological Review 97 (3): 332–361. doi:10.1037/0033-295x.97.3.332.

[34] The Stroop Effect". Brainstorm Psychology. Retrieved November 11, 2013.

[35] Frings, C; et al. (2010). "Decomposing the emotional Stroop effect". Quarterly Journal Of Experimental Psychology 1: 42–49. doi:10.1080/17470210903156594.

[36] Wuhr, P (2007). "A Stroop Effect For Spatial Orientation". The Journal of General Psychology 134 (3): 285–294. doi:10.3200/genp.134.3.285-294.

[38] Durgin, F (2000). "The Reverse Stroop Effect". Psychonomic Bulletin & Review 7 (1): 121–125. doi:10.3758/bf03210730.


**Statistics HowTo**
http://www.statisticshowto.com/

**Real Statistics in Excel**
http://www.real-statistics.com/

**Histogram:**
http://www.saferpak.com/histogram_articles/howto_histogram.pdf

**Advanced graphs in Excel**
http://excelgraphs.blogspot.com/2013/03/historgrams-and-overlayed-normal-curves.html

**Multiple Histograms (Excel)**
http://excelgraphs.blogspot.com/2013/03/overlayed-multiple-histograms.html

**More ...**
https://www.ncsu.edu/labwrite/res/gt/gt-bar-home.html

**ExcelGraphs:**

- http://excelgraphs.blogspot.com/
- http://excelgraphs.blogspot.com/2013/03/historgrams-and-overlayed-normal-curves.html
- http://excelgraphs.blogspot.com/2013/03/overlayed-multiple-histograms.html

**Mean, Median, Mode:**
https://www.youtube.com/watch?v=2rEhWFhSqnI

**T-Test in Excel**
https://www.youtube.com/watch?v=BlS11D2VL_U

**Z-Test in Excel**
https://www.youtube.com/watch?v=gJZNpfrjYEA

**Z-Score vs T_Score**
http://www.statisticshowto.com/when-to-use-a-t-score-vs-z-score/

**Excel to do confidence intervals: (manual)**
https://www.youtube.com/watch?v=siqx4PbqJ6s

**Confidence Interval For the Mean (Useful - got right answers w/Udacity)**
http://www.statisticshowto.com/how-to-calculate-confidence-interval-for-the-mean-excel/

**Cohens d in Excel**

- https://www.youtube.com/watch?v=OBQIKIcrAGI
- https://www.youtube.com/watch?v=J5nSEIFP7Mo
- http://mathewmitchell.net/tutorials/effectsize/

**Java Stroop Test:**
https://faculty.washington.edu/chudler/java/ready.html

**Neuroph: Tutorial:**
http://neuroph.sourceforge.net/tutorials/MultiLayerPerceptron.html

**Site:**
http://neuroph.sourceforge.net/

**Building Neural Nets in Excel: (Book)**
http://www.xlpert.com/ebook/Build_Neural_Network_With_MS_Excel_sample.pdf

**Site:**
http://www.xlpert.com/nn_Solve.htm

**Excel Data Miner**
http://www.dataminerxl.com/

**R&D:**

- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.395.595&rep=rep1&type=pdf
- http://munin.uit.no/bitstream/handle/10037/354/Paper_IV.pdf;jsessionid=219BEF976966EB02602B1FF4125A0764?sequence=2
- http://www-psych.stanford.edu/~ashas/Cognition%20Textbook/chapter7.pdf

**Cognition TextBook:**
http://www-psych.stanford.edu/~ashas/Cognition%20Textbook/

**Descriptive Statistics**
http://study.com/academy/lesson/what-is-descriptive-statistics-examples-lesson-quiz.html
https://faculty.unlv.edu/sloe/Courses/EPY%20703/Lecture%20Slides_08/Class5.pdf

**Paper:**
http://journal.frontiersin.org/article/10.3389/fncom.2013.00166/full