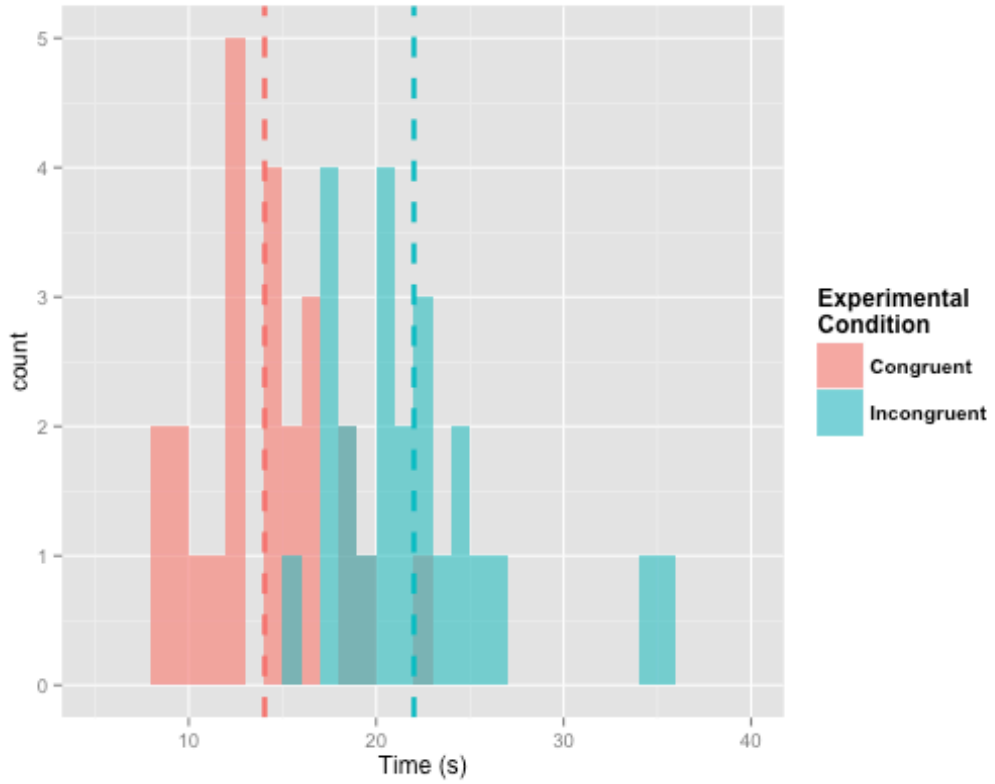
Stroop Task

1. Identify independent and dependent variable in the experiment
    - Independent variable: the congruence of words displayed (congruent, incongruent)
    - Dependent variable: the response time that participants take to name the ink colors in equally-sized lists.
2. Establish hypotheses and statistical test
    - Q2a: Null and alternative hypotheses:
        - Hypotheses:
            - Null hypotheses $\mathbf{H_0}$: $\mathbf{\mu_{ic}-\mu_c \leq 0}$ (There is no impact on mean response time for incongruent condition comparing congruent conditions). In other words, there will not be a difference in average response time between incongruent and congruent conditions.
            - Alternative hypotheses $\mathbf{H_A}$: $\mathbf{\mu_{ic}-\mu_c > 0}$ (The average response time for incongruent condition is longer than the congruent condition)
        - $\mathbf{\mu_{ic}}$ and $\mathbf{\mu_c}$ represent the true population mean difference in average response time for two congruency conditions
        - since we don't have the entire population who took the stroop test, the sample data with size 24 will be used later for population parameter estimation
    - Q2b: Statistical test:
        - Based on the alternative hypothesis, one-tailed test would be appropriate for this analysis.
        - In this case, t-test is selected over z-test based on the below reasons: mainly, it is because that the true population mean and standard deviation are unknown. Besides, the sample size is less than 30 . Thus, **one-tailed t test in positive direction** is proposed for performing statistical test with the following assumptions met:
            - the sample observations are made on randomly selected indiduals
            - observations in the sample are independent of each other
            - observations are drawn from a larger population can be approximated by Gaussian distribution
        - for this t-test, $\mathbf{\partial=.05}$ is selected as significance level
3. Below is the summary of descriptive statistics for the difference between incongruent and congruent condition, at which one-sample t test will be performed.
    - Measure of Location:
        - The arithmetic mean: 7.965
            - this is also the point estimate for the mean difference $\mathbf{\mu_d = \mu_{ic}-\mu_c}$
        - Median: 7.666
        - Mode: 7.199
    - Measure of Spread
        - sample variance for the difference between two groups: 23.67
        - sample standard deviation $\mathbf{S_d}$ = 4.86

4. Histogram for two groups:
    - The below plot shows the overlaid histograms for each experimental group with their means marked as dashed lines.
    - Bin size is 1s
    - Findings:
        - As the dashed lines indicated, it is noticeable that the average response time for Incongruent group is greater than the average response time for congruent group. The exact mean values for Incongruent and Congruent group are 22.016 and 14.051 seconds, respectively.
        - Both group seem positive distributed, with tail on the right hand side.



5. One-sample t test for the difference in response time between Incongruent and Congruent conditions:
    - based on the mean difference (μ_d = 7.965), sample standard deviation (S_d = 4.86), degree of freedom of 23 (sample size n=24),
        - t_statistical=8.0207
        - t_critical=1.714 (assume one-sided **∂=.05, df=23)**
        - p-value=2.052e-08 < **∂,** the result is statistical significant.
    - Therefore, we reject the Null hypotheses H_0 , and we in favor of alternative hypothesis, which means the true difference in means greater than 0 is not likely by chance.
    - Since statistical significance is not always mean practical significance, effective size also needs to be considered.

        - Cohen's d = 1.632, which can be interpreted as "Large" effective size based on Cohen's interpretation convention
        - **R^2** = 73.7%, which means that 74% of the variance in response time difference can be explained by the congruency of words displayed.
    - 95% confidence interval for true mean difference is CI (5.91,10.01)
    - In conclusion, the results suggested that the difference in average response time for incongruent and congruent group is statistically significant. And it confirms with my expectations.
6. There are two major theories to provide possible explanation for the observed effect:
    - The time that brain takes for words processing is faster than color processing.[1]
    - The theory of Automaticity believes that recognizing colors is not a "automatic process" whereas "reading out loud words" is a more automatic habit for most people. [2]

Another related and similar example from my own experience is that I found the response time difference in incongruent group in my native language is greater than the response time if the words written in my second language. This might also be explained as the automaticity theory, which is that words processing in native language is in highest rank of auomaticity in this situation.

Reference:

1. McMahon M. "What Is the Stroop Effect". Retrieved November 11, 2013.
2. Monahan, J. S. (2001). Coloring single Stroop elements: Reducing automaticity or slowing color processing?. *The Journal of general psychology*, *128*(1), 98-112.
3. Stoop Effect from Wikipedia (https://en.wikipedia.org/wiki/Stroop_effect#Theories)