Test a Perceptual Phenomenon

1. **What is our independent variable? What is our dependent variable?**
   Answer:
   - The independent variable is the congruency state of the printed words with their color of the ink i.e. whether they are congruent (e.g. "**RED**" printed in red ink) or incongruent (e.g. "**RED**" printed in blue ink)
   - The dependent variable is the time it takes for a participant to finish reading the color of the ink from a list of words

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

   Answer:

   - Hypothesis
     1. Null hypothesis: The time it takes for a participant to finish reading the colors of the ink from a list of words is not impacted by the congruency state of the words in that list

        $$H_0: \mu_C = \mu_I$$

        Where μ_C = population mean for Congruent state

        μ_I = population mean for Incongruent state

     2. Alternative hypothesis: The time it takes for a participant to finish reading the colors of the ink from a list of words is impacted by the congruency state of the words in that list

        $$H_A: \mu_C \neq \mu_I$$

        Where μ_C = population mean for Congruent state

        μ_I = population mean for Incongruent state

   - Statistical Test: A 'paired sample' dependent t-test can determine whether the Null hypothesis can 'be failed to be rejected' or 'rejected'. Alpha (α) = .05 will be used to determine statistical significance.
     1. Justification: Given that
        - We do not have parameters of the overall population
        - The sample size (24) is rather small

     Thus, with a small sample size and no information about the population, a Z-test would not be a preferred option. An F-test can be performed with small samples;

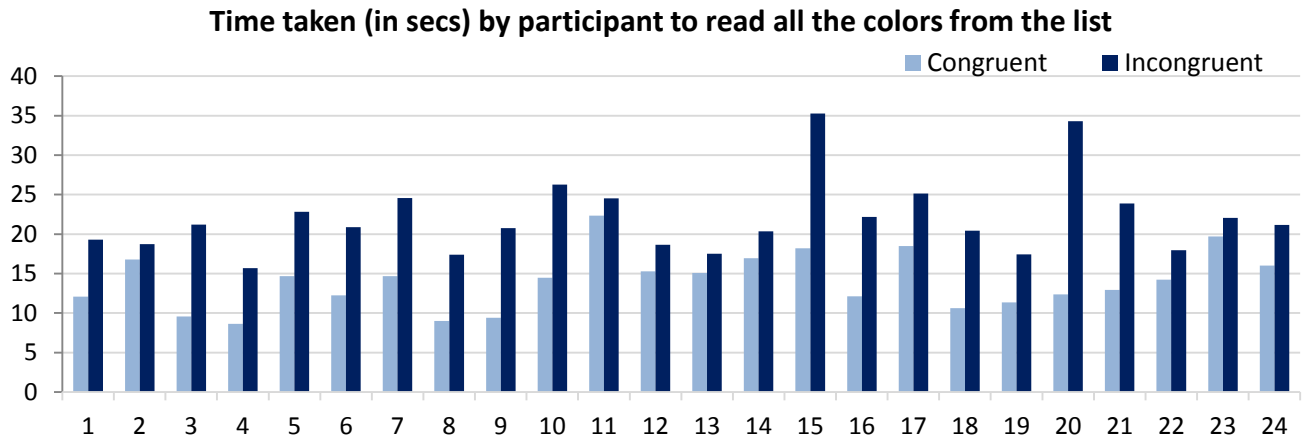
however, it is used to compare the variances between two samples, which is not the goal in this case.

Since each participant completes both the tests, a paired sample t-test would be able to determine if a group of values in one state (incongruent) is different enough from a group of values in the other state (congruent). Given our alternative hypothesis and to eliminate any pre-conceived bias, a two-tailed test will be performed to check for any significant increase or decrease.

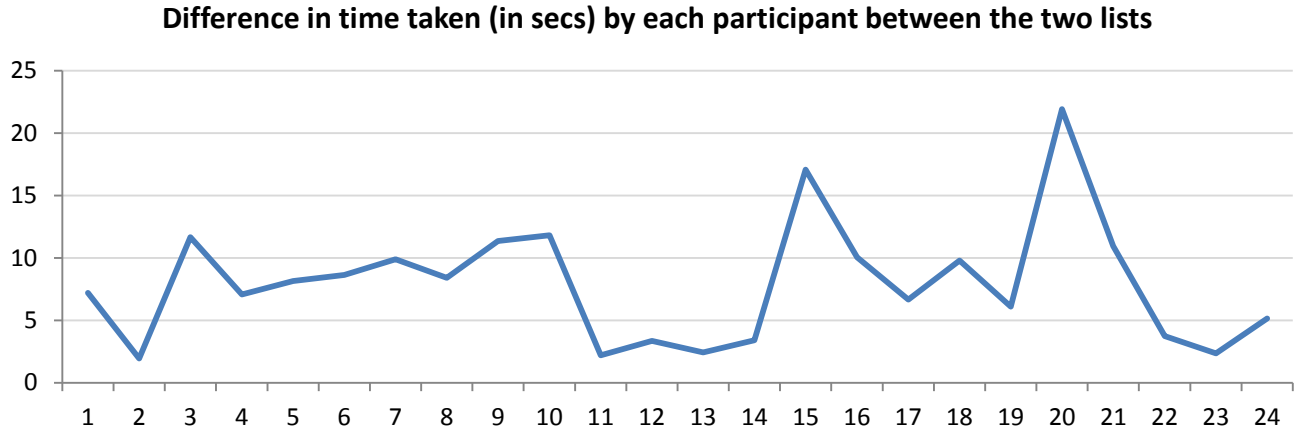
3. **Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.**
   Answer

Descriptive Statistics	Congruent Sample	Incongruent Sample
Mean	**14.05**	**22.02**
Median	**14.357**	**21.018**
Sample Size	**24**	**24**
Sample Standard Deviation	**3.56**	**4.80**

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**
   Answer



This graph shows the Time taken (in secs) by each participant to read all the colors from the Congruent list VS the Incongruent list. Visually, it is apparent that the time taken to read the incongruent list was higher for every participant.



This graph shows the difference in time taken by each participant to complete the incongruent VS congruent list. The Max difference seems to be ~20 secs and the Min difference seems to be ~ 2 secs

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?**

   Answer

   A dependent samples t test was conducted to evaluate the above problem. The results are as below

   a. Point Estimates of difference: $\mu_{I(incongruent)} - \mu_{C(congruent)}$ =22.02-14.05 =7.96
   b. SD for difference: 4.86
   c. t-Statistic: t(23) = 8.02
   d. P-value : 0.00000004103
   e. t critical for Alpha (α) = .05 , two tailed: ±2.069
   f. Cohen's D : 1.64
   g. Confidence Interval 95%: (5.91,10.02)

   As t statistic was greater than t critical, the null hypothesis was rejected and the alternative hypothesis was accepted. **The participants a statistically significant longer time to read the list in incongruent state (μ_2= 22.02$, σ_2 = 4.80) than the list in congruent state (μ_1= 14.05, σ_1 = 3.56), with t(23) = 8.02, p < .01, two tailed, d = 1.64**. The 95% confidence interval for the mean difference between the two conditions was 95% CI = (5.91, 10.02).

6. **Effect Explanation**

   Answer

   There are several possible theories to explain the Stroop effect, which broadly say that our brains process both relevant and irrelevant information in parallel, but these outcomes compete during response selection.

   Another interesting experiment could be to see a participant's first response when she hears the word "Cold" and simultaneously "Warm air" is blown on her. This could check if our brain's 'response competition' extends to other sensory processes.

7. **Summary**

   By performing a paired dependent samples t test, we found a statistically significant difference in the time taken to read colors from lists with congruent and incongruent states between the color names and the color inks.

References

1. **Stroop effect memory test**

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