

Statistics Project: Stroop Effect

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

Solution:

Independent Variable: The two conditions, the congruent words condition and the incongruent words condition.

Dependent Variable: The time taken to name the ink colors of the 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.

Solution:

Due to the limited sample size of the data, we proceed with the hypothesis testing in order to predict if this sample data is good enough to represent the entire population. Our hypothesis analyzes the mean time spent going through the list of words from the congruent and incongruent conditions.

H_0 (Null Hypothesis): The mean time taken to go through the list of congruent words ($\mu_{congruent}$) & the list of incongruent words ($\mu_{incongruent}$) is either equal or there is no significant difference between them.

H_A (Alternative Hypothesis): The mean time taken to go through the list of congruent words ($\mu_{congruent}$) & the list of incongruent words ($\mu_{incongruent}$) is significantly different.

$$H_0: \mu_{congruent} = \mu_{incongruent}$$

$$H_A: \mu_{congruent} \neq \mu_{incongruent}$$

OR

$$H_0: \mu_{interference} = 0$$

$$H_A: \mu_{interference} \neq 0$$

(From Wiki: Stroop Effect) The interference score is expressed as the difference between the times needed to read each of the two types of cards.

Statistical test: Paired t-test or dependent t-test for paired samples:

Why t-test?

- The size of the sample is really small, 24 in each list to be exact and with such small samples, t-distribution helps us estimate whether to:
 - *Retain the null*: Results are not statistically significant and p-value $> \alpha$ -value.
 - *Reject the null*: Results are statistically significant, i.e. p-value $\leq \alpha$ -value.
- t-distribution is more prone to error and hence more spread out and thicker at the tails but as the sample size increases, t-distribution would approach the normal distribution.

Why paired t-test? Since, the same participants were tested under two separate word conditions (congruent & incongruent) on the same dependent variable, i.e. the time taken to read through the ink colors.

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

Solution: Descriptive stats:

Central Tendency:

Mean:

$$\begin{aligned}\mu_{congruent} &= 14.05 \\ \mu_{incongruent} &= 22.02\end{aligned}$$

Median:

$$\begin{aligned}\tilde{x}_{congruent} &= 14.36 \\ \tilde{x}_{incongruent} &= 21.02\end{aligned}$$

Variability:

Variance:

$$\begin{aligned}\sigma_{congruent}^2 &= 12.67 \\ \sigma_{incongruent}^2 &= 23.01\end{aligned}$$

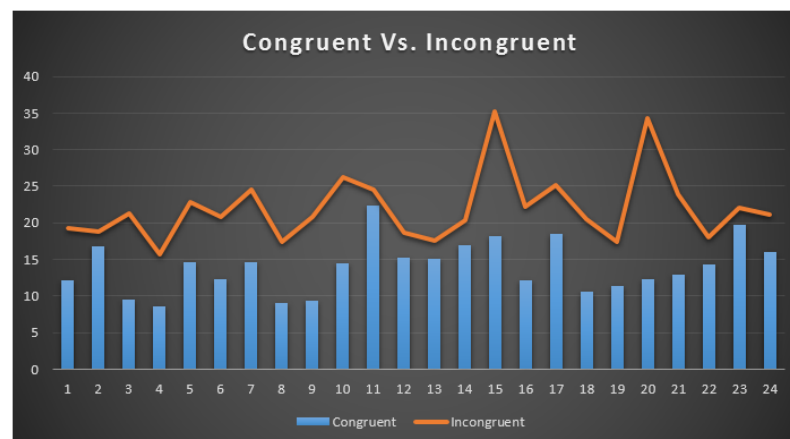
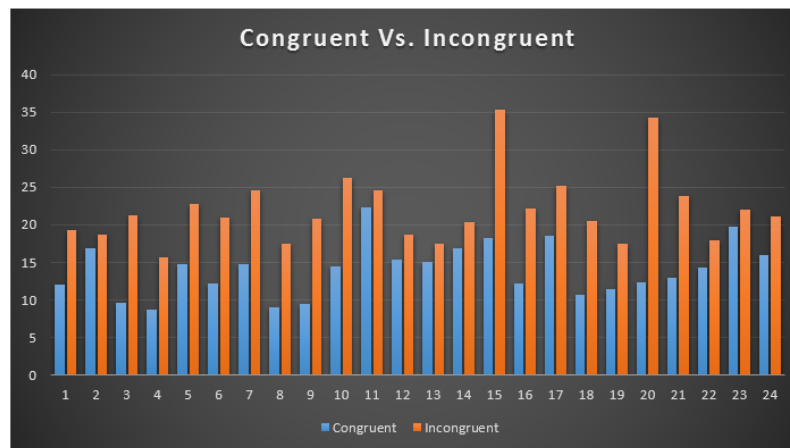
Standard Deviation:

$$\begin{aligned}\sigma_{congruent} &= 3.56 \\ \sigma_{incongruent} &= 4.80\end{aligned}$$

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.

Solution:



From both the above plots we can observe that time taken to go through the incongruent words is significantly higher than the congruent words, as our response time increases when recognizing the colors independent of the words they are written in.

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?

Solution:

Congruent	Incongruent	Difference (d)
12.079	19.278	-7.199
16.791	18.741	-1.95
9.564	21.214	-11.65
8.63	15.687	-7.057
14.669	22.803	-8.134
12.238	20.878	-8.64
14.692	24.572	-9.88
8.987	17.394	-8.407
9.401	20.762	-11.361
14.48	26.282	-11.802
22.328	24.524	-2.196
15.298	18.644	-3.346
15.073	17.51	-2.437
16.929	20.33	-3.401
18.2	35.255	-17.055
12.13	22.158	-10.028
18.495	25.139	-6.644
10.639	20.429	-9.79
11.344	17.425	-6.081
12.369	34.288	-21.919
12.944	23.894	-10.95
14.233	17.96	-3.727
19.71	22.058	-2.348
16.004	21.157	-5.153

Confidence Level = 95%

α -value = 0.05

t-critical value = ± 2.069

Mean Difference, \bar{d} = -7.96

Variance, σ_d^2 = 23.67

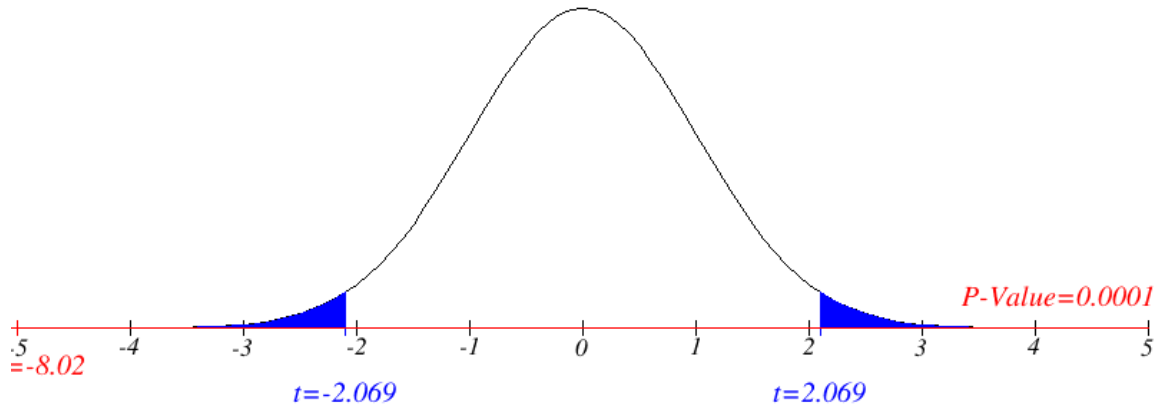
Standard Deviation, σ_d = 4.86

Degrees of Freedom, df_d = 23

Standard Error of the Mean Difference, $SE(\bar{d})$ = 0.99

t-statistic, t_d = -8.02

p-value = 0.0001



Since, $p\text{-value} < \alpha\text{-value}$, the results are statistically significant and we can **reject the null** (H_0).

Cohen's d = -1.64

$r^2 = 0.74$, the coefficient of determination here tells us that 74% of the differences is because of the incongruent list of words.

Margin of Error = 2.05

Lower Limit, LL = -10.02

Upper Limit, UL = -5.91

Yes, the results match the expectations, and with our LL & UL values, we can be certain (or 95% certain) that the true difference is likely to lie between -10 and -6.

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!**

Solution: The effects were most probably due to the substantial variations in timings between the two conditions, as one of the theories behind the lag, (from Wiki: Stroop Effect), is in the brain's ability to recognize the color of the word since the brain reads words faster than it recognizes colors. This is based on the idea that word processing is significantly faster than color processing.

Alternative task: Similar to the BBC Memory Test, we can observe how our sleep pattern affects our cognitive thinking. Sleep deprivation or sleeping too much or any kind of sleep disorder may have adverse effects on our long-term memory, attention-span, decision-making ability, etc. It would be a good study to examine, if there even exists an optimum sleeping pattern that would be equally beneficial for the mass or if it varies widely for each individual.

