Data Analyst Project 1

Statistically Testing a Perceptual Phenomenon

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0. The Dataset of the Experiement

Congruent	12,079	16,791	9,564	8,63	14,669	12,238	14,692	8,987	9,401	14,48	22,328	15,298
Incongruent	19,278	18,741	21,214	15,687	22,803	20,878	24,572	17,394	20,762	26,282	24,524	18,644
Congruent	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	17,51	20,33	35,255	22,158	25,139	20,429	17,425	34,288	23,894	17,96	22,058	21,157

1. Independent and Dependent Variable

The **independent** variable is whether the subject was presented with a list of word corresponding to their coloration (**congruent**) or differing from it (**incongruent**). The **dependent** variable was the overall time it took a subject to read the list of words.

The experiment constitutes a "**within-subject design**", that is, a test with dependent samples (repeated measures).

2. Hypothesis & Proposed Statistical Test

The **null-hypothesis** (H_0) is: There is no significant difference between the average time when reading an incongruent list of words from the average time when reading a congruent list of words ($\mu_I = \mu_C$).

The **alternative hypothesis** (H_A) is: The average time when reading an incongruent list of words differs significantly from the average time when reading a congruent list of words ($\mu_I \neq \mu_C$).

A suitable statistical test is a "**dependent samples**" (or "**paired samples**") **t-test**, as introduced in Introduction to Inferential Statistics, Lesson 10. This test applies nicely to experimental settings with subjects taking certain tests twice with a treatment in between, in this case, the modification of the coloration of the words.

3. Descriptive Statistics

The **number of samples** in each case is $n = 24$. Let $x_{C,i}$ and $x_{I,i}$ be the sample values for both the congruent and the incongruent case.

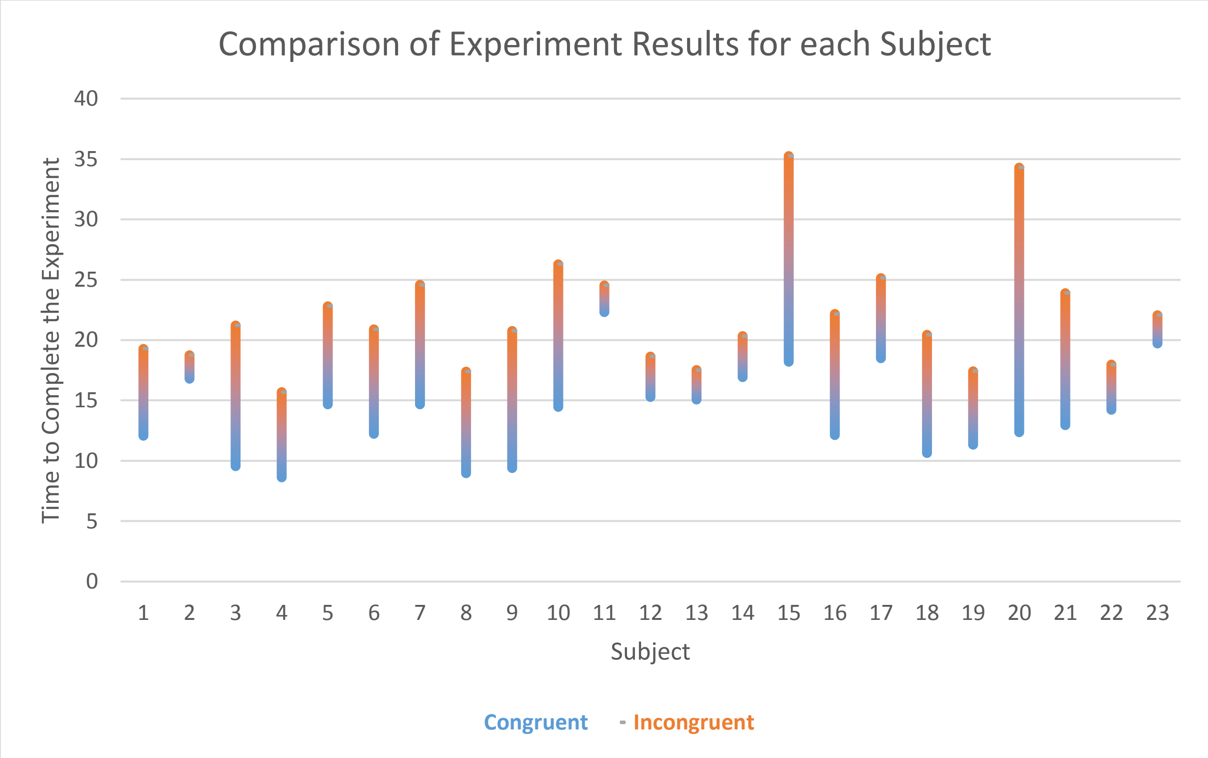
The **sample means** $\bar{x} = \frac{\sum x_i}{n}$ are for congruence $\overline{x_C} = 14.051$ and for incongruence $\overline{x_I} = 22.016$.

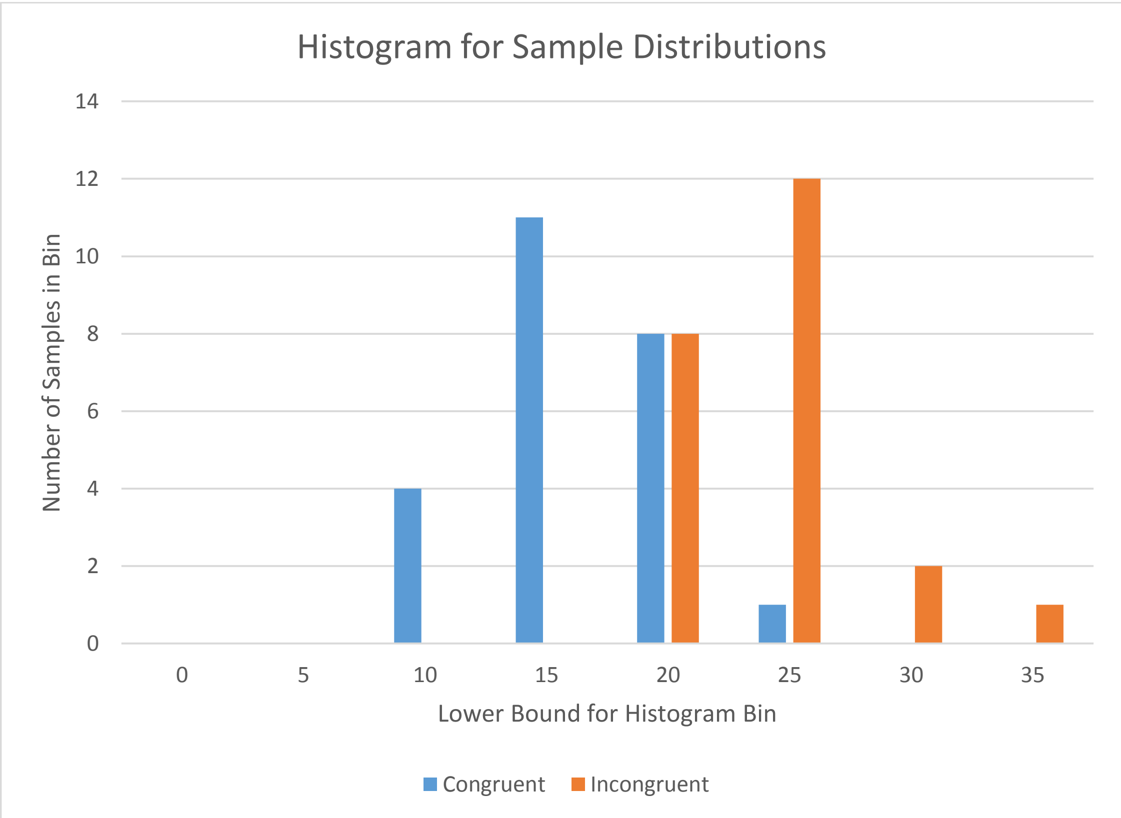
The **sample standard deviations** $s = \frac{\sum(x_i - \bar{x})^2}{n-1}$ are for congruence $s_C = 14.1369$ and for incongruence $\overline{x_I} = 4.7971$.

We have the **mean difference** $\overline{x_D} = \overline{x_I} - \overline{x_C} = 7.9648$ and the **combined standard deviation** $s_D = \sqrt{s_I^2 + s_D^2} = 14.9286$.

We can compute the **standard error** with $SE_D = \frac{s_D}{\sqrt{n}} = 3.0473$.

4. Visualizations of the Sample Data Distribution





The data in the histogram seems to be normally distributed in both different samples with means at around 15s (**congruent**) and 25s (**incongruent**) a considerably overlapping region.

5. Statistical Test, Confidence Level, Critical Value, Conclusion

The **degrees of freedom** for this experimental setup are $df_I = df_C = df = n - 1 = 23$. According to those, we can use the following **critical values t^*** for their corresponding α-level (two-tailed):

α-level	0.05	0.01	0.001
Critical value t^*	2.069	2.807	3.768

The **t-value** is computed as follows: $t = \frac{\overline{x_D}}{SE_D} = 2.6137$. The **$p$-value** as calculated by 2GraphPad QuickCalcs" [1] is $p = 0.0155$.

Therefore, we can **reject the null only for an alpha value $\alpha = 0.05$** and fail to reject the null for $\alpha = 0.01$ or $\alpha = 0.001$.

That means, **only with a certainty of 98,45% $(1 - p)$ can we conclude that there is a significant difference** between the average time it takes to read a "congruent" and an "incongruent" list of words ("congruent", again, meaning that the words are written in the color corresponding to the words literal meaning).

Should we choose to reject the null, that is, assume significance, the chance of commiting a **Type-II-error would be 1,55%**.

6. Contemplation

If there is indeed a significant difference, it could be explained neurologically by the brain confusing different actions potentials when perceiving inputs both from the visual, as well as from the language-related part of the brain.

To further explore this phenomenon, we could get more certainty by increasing our sample size ($n \uparrow \Rightarrow SE_D \downarrow = \frac{s_D}{\sqrt{n\uparrow}} \Rightarrow t \uparrow = \frac{\overline{x_D}}{SE_D\downarrow} \Rightarrow p \downarrow$).

Ressources

Included into this submission is a t-table (pdf) and an excel spreadsheet that was used to perform the calculations in this report and create the diagrams.

[1] The p-value was calculated using "GraphPad Quick Calcs":

http://www.graphpad.com/quickcalcs/ → Statistical Distributions and interpreting p-Values -> Calculate P value from z, t, F, r or chi-square.