

# Statistics: The Science of Decisions Project

## Instructions

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

Independent - whether the words are displayed in incongruent or congruent conditions.

Dependent - the duration of the test in seconds.

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

Hypothesis null: there is not difference between tests duration for congruent and incongruent conditions:  $\mu_c = \mu_{ic}$

Alternative hypothesis: there is difference between tests duration for congruent and incongruent conditions:  $\mu_c \neq \mu_{ic}$

There is not information about the population.

I would choose t-test for dependent samples, because the same subject/participant takes the test twice. One task per each participant with two conditions: incongruent and congruent.

I am choosing a two tail test, because I want to find out with alternative hypothesis if one population mean is either less than or greater than the other population mean.

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

Average of congruent sample	$\bar{x}_c$	14.051
Average of incongruent sample	$\bar{x}_{ic}$	22.01
Standard dev. of congruent sample	$S_c$	3.559
Standard dev. of incongruent sample	$S_{ic}$	4.797

### 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.

Tables with the frequencies:

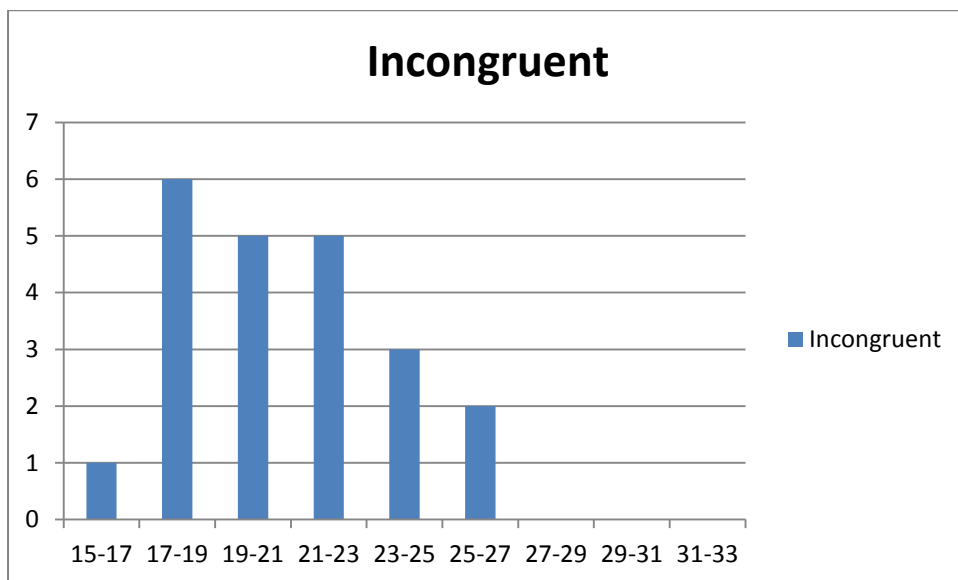
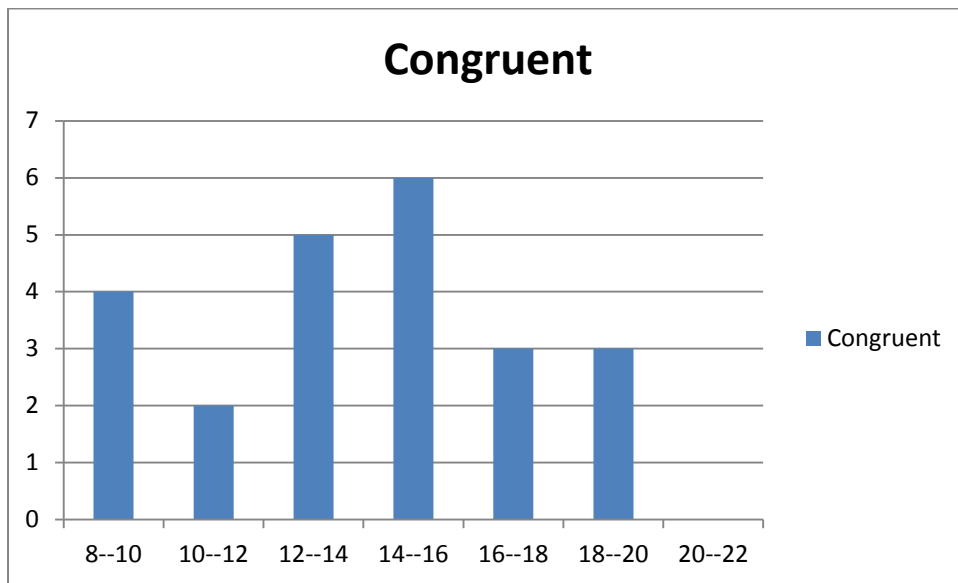
	Congruent
8-10	4
10-12	2
12-14	5
14-16	6
16-18	3
18-20	3
20-22	0

	Incongruent
15-17	1
17-19	6

19-21	5
21-23	5
23-25	3
25-27	2
27-29	0
29-31	0
31-33	0

(Some outliers were removed)

Histograms:



The comment:

Histogram of congruent values is bipolar and a histogram of incongruent values is positively skewed. For a bigger bins and after exclusion of the outliers histograms for both the type values form normal distribution.

- 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?**

Calculations:

	$M_D$	7.964
	$S$	4.864
Standard error	$SEM$	0.993
	$n$	24
	$df$	23
t – test value	$t(\bar{x}_{ic} - \bar{x}_c)$	8.021
critical t – test value	$t_{crit}(0,05;2\text{-tail};df=23)$	$\pm 2.069$
Confidence interval	$CI$	(5.910 ;10.019)

For  $\alpha$ -level equal to 0,05 (0,025 for each tail) the two tail t critical value is 2.069.

Calculate t-test value 8.021 is bigger than t critical value 2.069.

$$t(\bar{x}_{ic} - \bar{x}_c) - t_{crit}(0,05;2\text{-tail};df=23) > 0$$

Based on calculations above we have to reject null hypothesis.  $\mu_{ic}$  and  $\mu_c$  are statistically significantly different.  $\mu_{ic}$  is significantly higher than  $\mu_c$ .

**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!**

Based on information from Wikipedia there few theories:

- **Automaticity** – (the most common theory) 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.
- **Processing speed** - word processing is significantly faster than color processing.
- **Selective attention** - 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.
- **Parallel distributed processing** - This theory suggests that as the brain analyzes information, different and specific pathways are developed for different tasks. 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.

And alternative tasks:

- **Warped words** - 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). 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". Just like in the original Stroop task, the words are colored and the individual is

supposed to name the color. Research has revealed that individuals that are depressed are more likely to say the color of a negative word slower than the color of a neutral word. While both the emotional Stroop and the classic Stroop involve the need to suppress irrelevant or distracting information, there are differences between the two. 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.

- Spatial - The spatial Stroop effect demonstrates interference between the stimulus location with the location information in the stimuli. 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 (i.e., an down-pointing arrow located below the fixation sign) than to incongruent ones (i.e., a up-pointing arrow located below the fixation sign). A similar effect, the Simon effect, uses non-spatial stimuli.
- 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. The effect of irrelevant numerical values on physical comparisons (similar to the effect of irrelevant color words on responding to colors) suggests that numerical values are processed automatically (i.e., even when they are irrelevant to the task).
- 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. 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. Thus, incongruently-colored words significantly interfere with pointing to the appropriate square. However, some research has shown there is very little interference from incongruent color words when the objective is to match the color of the word.