Test a Perceptual Phenomenon

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

Independent variable: Whether the words were presented in the congruent or the incongruent condition.

Dependent variable: The time it took to name the ink colors.

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

H_0: $\mu_d = 0$, where $\mu_d = \mu_i - \mu_c$, and μ_i and μ_c are the population mean time under the incongruent and conditions respectively. Or the time it took to name the ink colors on average was equal under the incongruent and congruent conditions.

H_1: $\mu_d > 0$, where the definitions are the same as above. Or the time it took to name the ink colors on average was <u>longer</u> under the incongruent condition than under the congruent condition.

Test: A <u>one-tailed paired-samples t-test</u> is expected to be performed.

If the sample size had been large enough (when the population mean could be estimated by the central limit theorem from the sampling distribution of the mean), the more convenient Z-test could have been used.

However, due to the current small sample size (below 30), a t-test might be more appropriate where the population mean could be estimated using t-distributions, which in turn could be determined by the number of degrees of freedom.

The t-test should be a one-tailed paired-samples t-test, because the experiment has a repeated measures design where the time for the same participants to name the ink colors were recorded under two conditions, and the mean time is predicted to be longer under the incongruent condition than under the congruent condition.

Although the paired t-test assumes the data to be compared should be approximately normally distributed, it is quite robust and can still provide valid results even if the assumption is a little violated. In this case, since samples were drawn from presumably

normally-distributed populations (human abilities generally follow normal distributions), even if they were not perfectly normally-distributed, histograms show that they are pretty close, therefore the results won't be affected greatly.

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

	Mean	SD
Incongruent	22.016	4.797
Congruent	14.051	3.559

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.

Histogram of Congruent
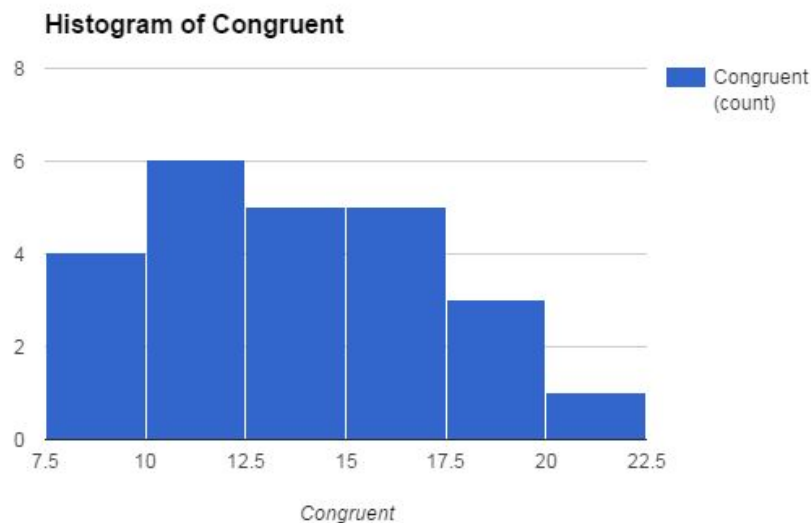
The distribution of the congruent group is somewhat flat and positively skewed.

Histogram of Incongruent
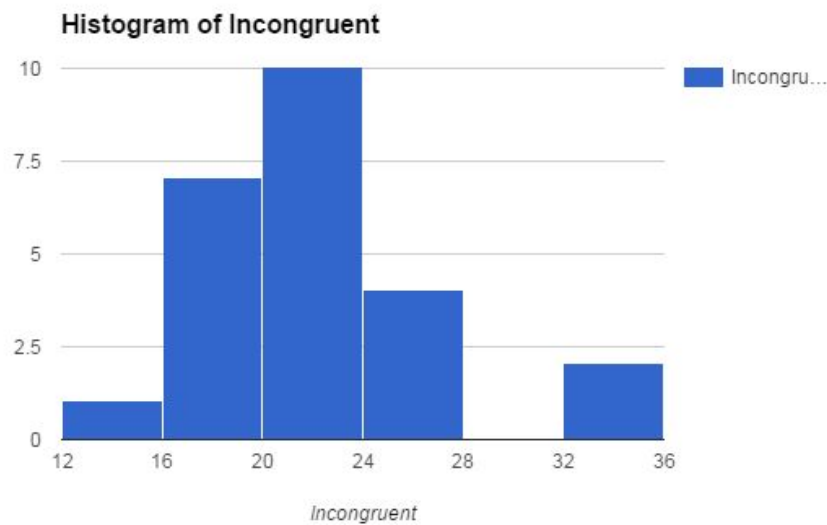
The distribution of the incongruent group is less flat and missing values in the range of 28 to 32.

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?

Since a huge difference of the means under the two conditions is predicted, let alpha level be set at a rather strict value: 0.001, so the confidence level is .999 accordingly and the t-critical value is 3.485 with 23 degrees of freedom in a one-tailed t-test.

A paired-samples t-test was performed with Google Sheets:
https://docs.google.com/spreadsheets/d/1IoBx-bLxGQPvftwZK108ZeLoLTtyr-moLYi3ut9bO34/edit?usp=sharing

| | Mean | SD | t | Sig (1-tailed) | d | 99.9% CI | |
						Lower	Higher
Incongruent - Congruent	7.965	4.865	8.020	0.00000002	1.637	4.504	11.425

The null hypothesis is rejected because the p-value is less than .001 by a great deal, which means if the null hypothesis is to be retained, there is only a far less than 0.1% probability of obtaining such a huge difference.

So the test indicated that the time it took to name the ink colors on average was statistically significantly longer under the incongruent condition (M = 22.0, SD = 4.80)

than under the congruent condition (*M* = 14.1, *SD* = 3.56), *t*(23) = 8.02, *p* < .001, *d* = 1.64. A one-tailed p-value is reported due to the strong prediction of this difference.

Yes, the results match up with my expectation.

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!

I suspect that the main factor responsible for the effects observed is that our cognitive processes for semantic and visual functions can interfere with each other when operating at the same time. Under the incongruous condition, when meanings of words do not match their actual colors, our semantic and visual processes probably try to compete for our brains' band widths, causing a mental congestion which prolongs the time we need to correctly name the colors.

Another task with a similar effect that I can think of is… well, I cannot think of any actually.

Resources:

t-table
http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf

TTEST function in Google Sheets
https://support.google.com/docs/answer/6055837?hl=en

Reporting Statistics in Psychology
http://evc-cit.info/psych018/Reporting_Statistics.pdf

Z-test
https://www.wikiwand.com/en/Z-test

Student's t-test
https://www.wikiwand.com/en/Student's_t-test

How to Use the t-Test to Handle Small Samples and Unknown Standard Deviations
http://www.dummies.com/education/math/statistics/how-to-use-the-t-test-to-handle-small-samples-and-unknown-standard-deviations/

Dependent T-Test using SPSS Statistics

https://statistics.laerd.com/spss-tutorials/dependent-t-test-using-spss-statistics.php