Statistics: The Science of Decisions

Udacity Data Analyst Nanodegree Project #1

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Background Information

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participant's task is to say out loud the *color of the ink* in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition. In the *congruent words* condition, the words being displayed are color words whose names match the colors in which they are printed: for example `RED`, `BLUE`. In the *incongruent words* condition, the words displayed are color words whose names do not match the colors in which they are printed: for example `PURPLE`, `ORANGE`. In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

Questions For Investigation

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

Independent Variable: Congruence (i.e. text same color as word) or incongruence (i.e. text different color than word) of words displayed

Dependent Variable: Time it takes each participant to name the ink colors in equally sized lists (one congruent one incongruent)

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

There are two sets of hypotheses that are potentially reasonable depending on one's judgment of the effect of incongruence on naming times. A person who with no priors might think there will be a difference between the times for naming the congruent and incongruent words, but have no opinion as to what that difference will be. That is:

$H_O: \mu_{congruence} = \mu_{incongruence}$

$H_A: \mu_{congruence} \neq \mu_{incongruence}$

However, given my background reading about the Stroop effect and the dissonance that I experience when reading a color in text other than the named word, I expect that it will take significantly longer to name the list of incongruent words compared to the list of congruent words. Thus my set of hypotheses are:

$H_O: \mu_{congruence} \geq \mu_{incongruence}$

$H_A: \mu_{congruence} < \mu_{incongruence}$

That is, it will take significantly longer to name the list of incongruent words.

I prefer this directional hypothesis because it gives my potential tests more power.

Because the experiment involves the manipulation of just one independent variable (congruence vs. incongruence) and only one outcome variable (time to name word) is measured, I believe that using a t-test to compare the differences between the treatment means is warranted. More specifically, because the same participant's time to name the colors is measured under both experimental conditions (i.e. outcomes are "paired") I will use a ***Dependent-means t-test*** to test for significance in the difference in the mean time it took to name the words under the congruent and incongruent conditions.

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

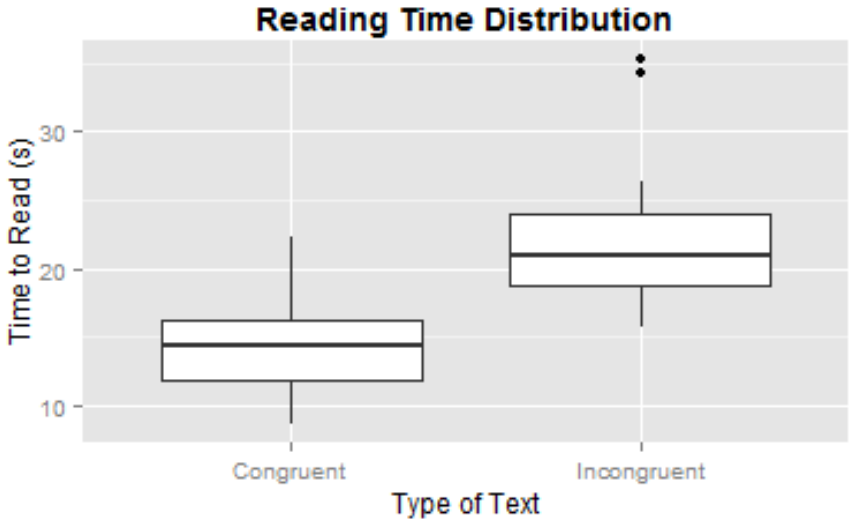
Congruent Times

Measure	Value
Mean	14.05
Median	14.36
Range	13.70
Standard Deviation	3.56

Incongruent Times

Measure	Value
Mean	22.02
Median	21.02
Range	19.57
Standard Deviation	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.



The above box and whisker plot visualizes the distribution of the Stroop data. The "whiskers" (lines emanating from the boxes) indicate the range of the values. The "boxes" themselves indicate the interquartile range: the bottom of the box represents the 25% quartile while the top represents the 75% quartile. The line inside the box represents the median value. Finally, the dots above or below the "whiskers" represent outliers (values significantly different than the rest) if present.

The above graph demonstrates that the median and interquartile range of values for completing the incongruent reading task are much higher than those for the congruent reading task; in fact the 25% quartile for the incongruent task took longer than the 75% quartile for the congruent task! Interestingly, only the incongruent task appears to have significant outliers and both on the high end. This indicates that two out of 12 people really struggled with the incongruent task.

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?

Using a **Dependent-means t-test**, the test statistic for the Congruent and Incongruent times is -8.02 which means ***the mean difference is significant at the 99.9% confidence level***. At 23 degrees of freedom this implies a ***p-value of 4.10×10^{-8}***. The 95% confidence interval for the mean difference is ***-10.02 to -5.91***. These values are summarized in the table, below:

Statistic	Value
Test statistic (paired t-test)	-8.02
p-value	4.10×10^{-8}
95% confidence interval - lower bound	-10.02
95% confidence interval - upper bound	-5.91

These results indicate a significant difference at 99.9% confidence: reading the congruent color names is significantly easier (i.e. mean time to read is significantly lower) than reading the incongruent color names. ***The null hypothesis is rejected and the alternative hypothesis that it is significantly easier to read the congruent color names is accepted.***

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!

The most common explanation for the Stroop effect is known as "Automaticity". Because most adults are so thoroughly habituated to reading, the process of reading a word is essentially "automatic" - it happens without any prior intention and requires little or no attention or thought. When presented with the incongruent condition this automatic process has to be consciously combated by the brain - which explains the "interference" that characterizes the Stroop effect and produces the significantly longer naming times.

A task that produces a similar sort of interference is known as the spatial Stroop effect. In this task an up or down arrow randomly appears above or below a central point and the participant must name the direction of the arrow. Interference occurs when an up arrow occurs below the central point or a down arrow occurs above the central point because the brain expects there to

be congruence between the direction of the arrow and it's spatial location relative to the central point. A lag is caused by the "interference" of an arrow pointing in an unexpected direction.

Citations

Field, Andy P., Jeremy Miles, and Zoë Field. *Discovering Statistics Using R*. London: Sage, 2012. Print.

"Stroop Effect." *Wikipedia*. Wikimedia Foundation, n.d. Web. 12 Oct. 2015.