P1: Test a Perceptual Phenomenon

Udacity Data Analyst Nanodegree
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Assignment: Use descriptive statistics and a statistical test to analyze the Stroop effect, a classic result of experimental psychology.

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

Independent variable: condition of *congruent words* or *incongruent words*

Dependent variable: time in seconds to name the ink colors of set of 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.**

The following are appropriate hypotheses for this test:

$H_0 : \mu_0 \geq \mu$

Null hypothesis: The average time it takes to name the ink colors of *congruent words* will be the same or longer than the average time it takes to name the ink colors of *incongruent words*.

$H_1 : \mu_0 < \mu$

Alternative hypothesis: The average time it takes to name the ink colors of congruent words will be less than the average time it takes to name the ink colors of *incongruent words*.

I propose these hypotheses because I am testing the Stroop effect, a well-studied, classic phenomenon from experimental psychology.[1] The effect is a demonstration of interference in the reaction time of a task. A classic demonstration of this effect is testing the time it takes for people to report ink colors of words that are either congruent with the ink color, i.e. the word is "red" and the color is red, or incongruent, i.e. the word is "red" and the color is blue. The Stroop effect is that naming the color of the word takes longer and is more prone to errors than when the color of the ink matches the name of the color.

[1] Stroop effect. (2016, March 9). In *Wikipedia, The Free Encyclopedia*. Retrieved 22:41, March 17, 2016, from https://en.wikipedia.org/w/index.php?title=Stroop_effect&oldid=709231038

Researchers have consistently shown that respondents take longer to name incongruent words. Thus I am proposing the alternative hypothesis that it will take longer to name incongruent words than congruous words.

In order to test this hypothesis, I will perform a one-tailed dependent t-test for paired samples. It will be one-tailed because of the one-directional nature of the null and alternative hypotheses presented above. I will conduct a t-test because we do not know population standard deviation, ruling out a z-test. I am choosing a dependent t-test for paired samples because this is a within-subjects study design, in which the same subject will be tested on the time it takes to name the ink colors of both *congruent words* and *incongruent words*.

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

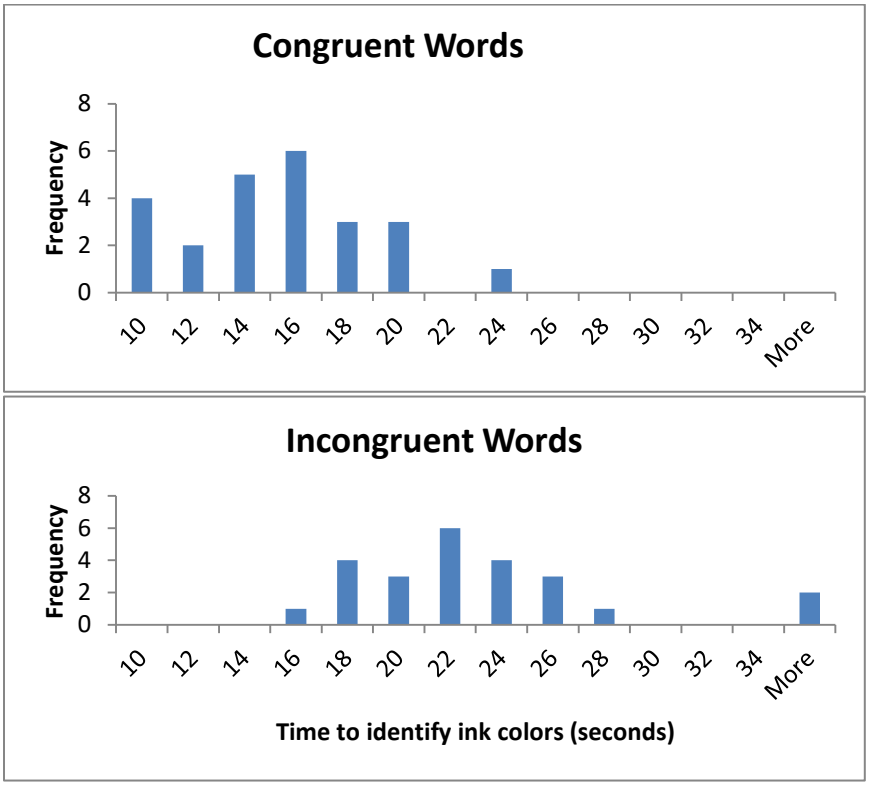
Table 1: Descriptive Statistics

	n	**median**	**$\bar{x}$**	**s**
Condition	*# of samples*	*median*	*mean*	*standard deviation*
Congruent words	24	14.36	14.05	3.56
Incongruent words	24	21.02	22.02	4.80

Table 1 above reports two measures of central tendency, median and mean, and one measure of variability, standard deviation, for this dataset.

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.

Figure 1: Histograms of Congruent Words and Incongruent Words Response Times



The histograms demonstrate that the mode is a shorter time for congruent words at 16 seconds, than for incongruent words at 22 seconds. They also demonstrate that both distributions appear to be normal, though the sample sizes are relatively small at only 24 samples so it is difficult to determine if the distribution would hold with more data. The *incongruent words* data demonstrates several respondents with higher response times, though this appears to be more outliers than bimodal distribution. Further data collection would better elucidate this point.

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?**

I ran a one-tailed dependent t-test for paired samples and calculated the t-statistic of -8.021. At a confidence level of 95% with 23 degrees of freedom, the critical t-statistic value was 1.714. At a p value of <0.0001, I reject the null hypothesis.

These results demonstrate that the average time it takes individuals to identify ink colors for *incongruent words* is significantly higher than for *congruent words*. The results matched my expectations, and supported the findings of research in decades past on the same effect.

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 Stroop effect is a demonstration that the brain's reaction time slows down when it deals with conflicting information.[2] As a widely studied phenomenon, there a number of theories about the reason for this delay. The two most common theories are:

(a) *Speed of processing theory*: the brain reads words faster than it recognizes colors, so there's a lag while the brain recognizes the color.
(b) *Selective attention theory:* the brain needs to use more attention to recognize a color than to read a word, so it takes a little longer.[3]

I find both theories surprising in their assumption that reading is either easier or faster than recognizing colors. Having participated in the Stroop Effect I recognize that is the case for me. However that would clearly not be the case for illiterate people. I am interested in results conducted on people in early stages of literacy, or fully illiterate people, to see if shape processing is easier than color recognition. I am interested in if it is simply because reading is a more habitualized skill for most test respondents that this is the case, or if there is something inherently easier for our brains in symbol recognition than color recognition.

The Stroop Effect has been utilized to design numerous other studies which demonstrate the same more generalized phenomenon of slowed brain processing with conflicting information. One example is asking people to say which number is bigger in terms of numeric value, while showing two numbers of different sizes. The conflict does not arise if the larger numeric value is also larger in size, but processing is slowed when the smaller numeric value is bigger in size, for example: 3 5.

There are also discussions of using this theory to demonstrate the danger of texting while driving. This is a real world example of the danger in slowed brain processing due to conflicting information, and can be utilized to advocate for stricter penalties to reduce the incidence of texting and driving.

[2] McMahon, M. "What Is the Stroop Effect?". Retrieved March 17, 2016
[3] Ibid