Project 1: Test a Perceptual Phenomenon

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1 Introduction

For this project, we investigate the Stroop effect by analyzing the results of an experiment in which 24 participants completed tasks and recorded the time it took to complete each one.

In each task, a list of color names was displayed, and the participant said aloud the color in which each word is displayed. The time to complete each task was recorded in seconds.

There are two versions of the task. In one version, each word is shown in the color indicated by the name. For example, in this congruent words condition, the word "red" would be displayed in red. In the second version, each word is shown in a color that differs from that indicated by the name. In this incongruent words condition, the word "red" may be displayed in purple. Each participant completed both versions of the task, recording a time for each.

In this experiment, the independent variable is the condition in which words are presented, i.e. congruent words or incongruent words. The dependent variable, then, is the length of time in seconds a participant takes to say out loud the displayed colors from lists of equal sizes.

We establish some useful notation. Let μ_C denote the population mean time needed to complete the task for the congruent words condition, and let μ_I denote the population mean time needed to complete the task for the incongruent words condition. Then $\mu_D = \mu_I - \mu_C$ will denote the difference between the two means.

Our goal is to determine whether, for any possible participant in the entire population, we can expect the task with incongruent words to be completed more slowly than the task with congruent words. To test this, our null hypothesis is that given the incongruent words condition the task takes no longer than it does given the congruent words condition. Our alternative hypothesis is that the time needed to complete the task for the incongruent words condition is greater than that for the congruent words condition.

We can present this symbolically:

$$H_0 : \ \mu_I \leq \mu_C$$

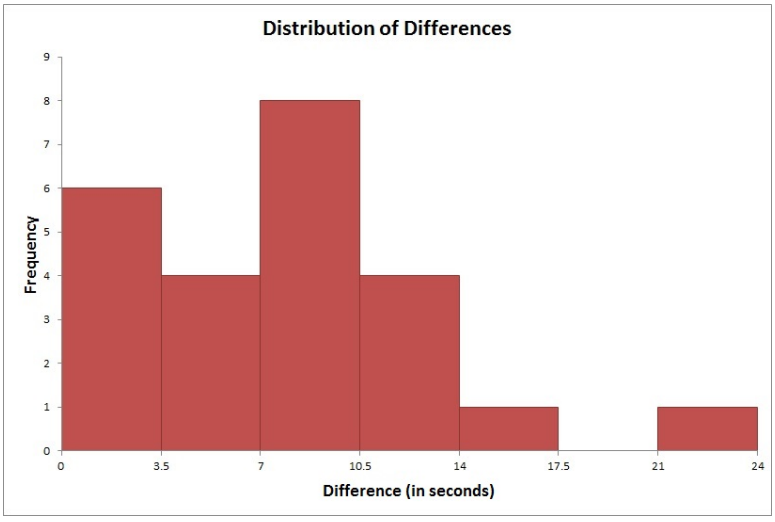
$$H_A : \ \mu_I > \mu_C$$

We will perform a paired t-test, since the population mean and standard deviation for time to complete the tasks are unknown. Because the Stroop task is a repeated measures design (that is, the same participants complete a task twice under different conditions), the two samples in the data set are dependent. The data in the sample suggest that if there is a significant difference in time required for each task, it is likely to be that the incongruent words task takes longer. Namely, for each participant, the time to complete the incongruent words task was greater than time to complete the congruent words task. Thus, we will use a one-tailed test. We will use a confidence level of $\alpha = .05$. Because there were 24 participants in this study, there are 23 degrees of freedom. Therefore, for this test the t-critical value is $t_\alpha = 1.714$.

2 Descriptive Statistics & Visualization

We examine the central tendency and variability of the data. The sample mean $\overline{X}_C$ for the congruent words condition is approximately 14.05 seconds. The sample mean $\overline{X}_I$ for the incongruent words condition is approximately 22.02 seconds. The difference $\overline{X}_D = \overline{X}_I - \overline{X}_C \approx 7.96$ gives us a point estimate for μ_D. The standard deviation of the differences between the times in the two samples is $s \approx 4.86$.

The histogram below displays the distribution of differences between the times for each task. We observe that the mean of the differences, $\overline{X}_D \approx 7.96$, falls into the bin with the highest frequency, and that the differences are not normally distributed. Due to the Central Limit Theorem, however, we can expect the distribution of sample means from all possible samples to be approximately normal. Thus it is appropriate to use a t-test, as this will reveal the probability of selecting a sample with $\overline{X}_D \approx 7.96$ purely by chance.



3 Results

We now test our stated hypotheses using a one-tailed t-test for paired samples with an α-level of .05. Recall that the t-critical value is 1.714. The t-statistic for the given sample data is

$$t = \frac{\overline{X}_D}{s/\sqrt{n}} \approx 8.02.$$

This t-statistic is greater than the t-critical value for this test. This implies that the difference in means is statistically significant. In other words, it is very unlikely that the greater time required to complete the incongruent words task for participants in this sample is due to random chance. We reject the null hypothesis with $p < .05$ and conclude that the incongruent words task takes longer than the congruent words task.

This result is not surprising; in general, it seems natural that our brains will process consistent information significantly more quickly than they can process inconsistent information. Several theories have been developed to explain the Stroop effect. One theory suggests that we process words more quickly than we can identify colors, creating a lag in the incongruent words condition. One might test this theory by comparing the time required to read a list of common words with the time required to identify the colors in a collection of colored dots. A second theory takes this further by proposing that identifying colors takes longer because it requires more attention than does reading words. This could be tested by repeating the previously described test, introducing distractions in order to measure the level of attention required. Other theories exist, though at this time, no single theory fully and unequivocally explains the Stroop Effect.

References

[1] Stroop effect. (n.d.). In *Wikipedia: The Free Encyclopedia*. Retrieved September 8, 2015, from https://en.wikipedia.org/wiki/Stroop_effect

[2] What is the Stroop Effect? (n.d.). Retrieved September 8, 2015, from http://www.wisegeek.org/what-is-the-stroop-effect.htm