Test a Perceptual Phenomenon

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February 8, 2017

1 The independent variable is the *condition*, to which participants are exposed. This can be either the *congruent words condition* C or the *incongruent words condition* I. The dependent variable is the *time* it takes the participant *to name the ink color* for all the words in the corresponding set. Let t_C and t_I denote the time to solve the words of the respective condition.

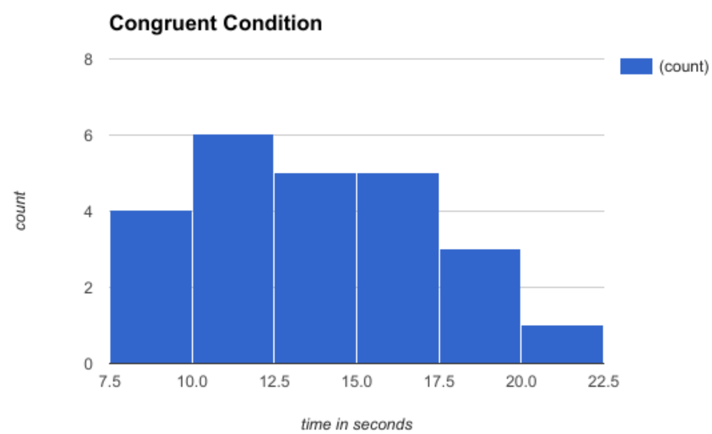
2 Let μ_C and μ_I denote the means of the solution times for the population of the respective condition U_C and U_I. The null hypothesis H_0 is that the average times to solve either problem set are equal, and the alternative hypothesis H_A is that they are not.

$$
\begin{aligned}
H_0 &: \mu_C = \mu_I \\
H_A &: \mu_C \neq \mu_I
\end{aligned}
$$

A t-test is appropriate here, because the standard deviation σ of the population is unknown and the sample size is below 30 (http://www.statisticshowto.com/when-to-use-a-t-score-vs-z-score/). We want to test if the sample means are different because the population means are different, or just by chance. It is a dependent t-test, because the same subject is tested in two different conditions.

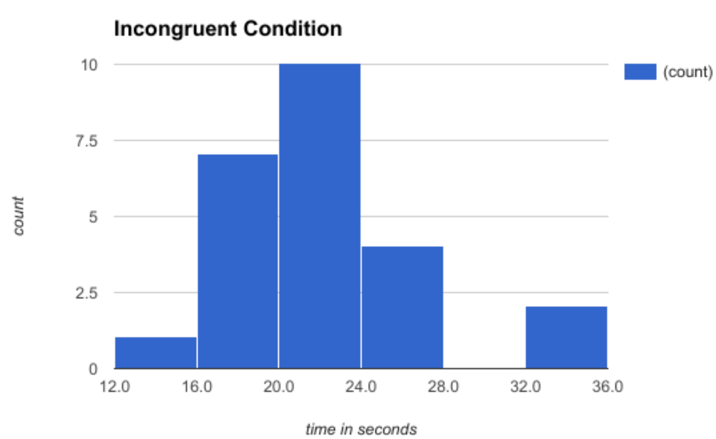
3 Let $\bar{x}_C$ and $\bar{x}_I$ denote the sample means, i.e. the average time it took the subjects from the table to complete either condition. For the given dataset we have $\bar{x}_C = 14.051$ and $\bar{x}_I = 22.016$. The standard deviation for each condition are $\sigma_C = 3.559$ and $\sigma_I = 4.797$. Other measures of central tendency (e.g. median, mode) or variability (variance) are not needed for the test we are going to conduct.

4 Lets have a look into the histogram. We start with the congruent words condition:



We can see that it the participants between 7.5 and 22.5 seconds to read out loud the words of this condition. Most of the subjects spent between 10.0 and 12.5 seconds on the task (considering the resolution of this plot). From the shape of the graph it looks as if the t_C are approximately normal distributed.

Next we compare with the histogram for the second condition:



Here, the participants took between 12.0 and 36.0 seconds (again, this is imprecise because of the histogram bucket size). The mode lies somewhere between 20.0 and 24.0 seconds. Again, this looks approximately normal distributed, although it is not sure given the small number of ten samples.

Clearly the two histograms are centered around the different averages of the samples.

5 To conduct the t-test for paired samples, we define the pairwise difference of samples as $D_i = t_{I,i} - t_{C,i}$. From the dataset we get the average difference

$\bar{D} = 7.965$. There are $n = 24$ samples and thus 23 degrees of freedom. We get our t from

$$t = \frac{\bar{D}}{s/\sqrt{n}}$$

where s is the sample standard deviation of the D_i:

$$s = \sqrt{\frac{\sum(D_i - \bar{D})^2}{n-1}}$$

In our dataset we have $s = 4.865$. Thus, we get

$$t = \frac{7.965}{4.865/\sqrt{24}} = 8.02$$

Using the t-table (with 23 degrees of freedom) we get a probability $p < 0.0005$. With a confidence level of 99.9% we can say that the sample means are not different by chance, but means of the two populations, μ_C and μ_I cannot not equal. Thus, we have to reject the null.

Personally, before doing the Stroop task I expected that the subjects (and I myself) will perform slower on the condition of incongruent words. However, I was surprised that the difference is so significant even with such a small number of participants.

6 I think the observed difference is caused by they way the human brain processes information. In the case of the Stroop effect each word comes with two interfering pieces of information: The meaning of the word and the ink color. The brain translates the input into a spoken word (the color of the ink). If the word's meaning and ink color are congruent, there is less "processing" involved. However, if the two are incongruent, the brain takes more effort to process the information and focus on the relevant part (the ink color).

According to Wikipedia (https://en.wikipedia.org/wiki/Stroop_effect) the "pieces of information" are called stimuli. I guess that the brain can be trained to this task in a way that the stimulus of the word's meaning is ignored or forgotten, so to say. One could consider it the other way around: if the subject does not know the meaning of the word (e.g. a person that does not speak English), it will not be distracted by the conflicting stimulus.

A similar task I can think of would use digits and repetition numbers as stimuli: The subject would be presented with two sets of numbers consisting, where each number consists of one repeated digit from 1 until 9. The task is to name speak out loud the number of repetitions. In the congruent set, the number of repetitions and the actual digit coincide, for example "22" and "55555", whereas in the second condition they are incongruent: "444" and "77". Like in the Stroop task, each subject would be presented a set of such numbers from each condition and the time to solve the task would be measured. I guess that in this experiment a similar interference of stimuli could be observed.