

Stroop Test Statistics

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The Stroop Test tests reaction time. Participants are asked to name the ink *color* in two sets of words, one congruent and one incongruent. In the congruent case, the ink color matches the word (e.g., the word “Green” is written in green ink). In the incongruent case, the ink color is different (e.g., the word “Red” is written in purple ink). The test compares the time it takes for participants to correctly identify the ink *color* for both sets of words.

Q1. Identify variables in the experiment:

The independent variable is denoted by the word and color match (or mismatch) in the list of words.

The dependent variable is the time it takes a participant to name the colors of all words in the list.

Q2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

A paired samples test is conducted. Each participant is given two lists of words denoting colors. Each list has the same number of words (24 for our data set). A timer starts when the list is shown to the user. The timer ends once the user has correctly identified the color of the words (not the word itself).

In the congruent case, the color spelled out by the word matches the color of the ink (e.g., “Red” written in red ink). In the incongruent case, there is a mismatch (e.g., “Red” written in blue ink).

The times are measured in seconds. Each participant will take the congruent test immediately followed by the incongruent test.

The null hypothesis: Survey participants will successfully name the colors (out loud) of the ink for a list of words in the same number of seconds in the incongruent case as in the congruent case.

$\mu(\text{inc})$: The average number of seconds participants take to name the ink colors in the incongruent case

$\mu(\text{con})$: The average number of seconds participants take to name the ink colors in the congruent case

$H_0: \mu(\text{inc}) = \mu(\text{con})$

The alternative hypothesis: Survey participants will take significantly more or less time to name the ink colors for the incongruent list compared to the congruent list.

$H_A: \mu(\text{inc}) \neq \mu(\text{con})$

Assumptions (Participants):

- (1) The same participants take both tests.
- (2) Each participant has the eyesight to see the lists of words and the correct colors.

- (3) Each participant knows how to read words and identify colors correctly.
- (4) There is no degradation of each person's eyesight, reaction time, reading ability, nor color identification ability between the two tests.

Assumptions (Statistical Test):

- (1) The population standard deviation is unknown.
- (2) The congruent and incongruent mean times are normally distributed.

Q3. Report Descriptive Statistics.

Basic:

Number of Participants: 24

Degrees of Freedom: 23

Congruent:

Congruent Mean: 14.051 seconds

Congruent Standard Deviation: 3.559 seconds

Congruent Standard Error: 0.726 seconds

Incongruent:

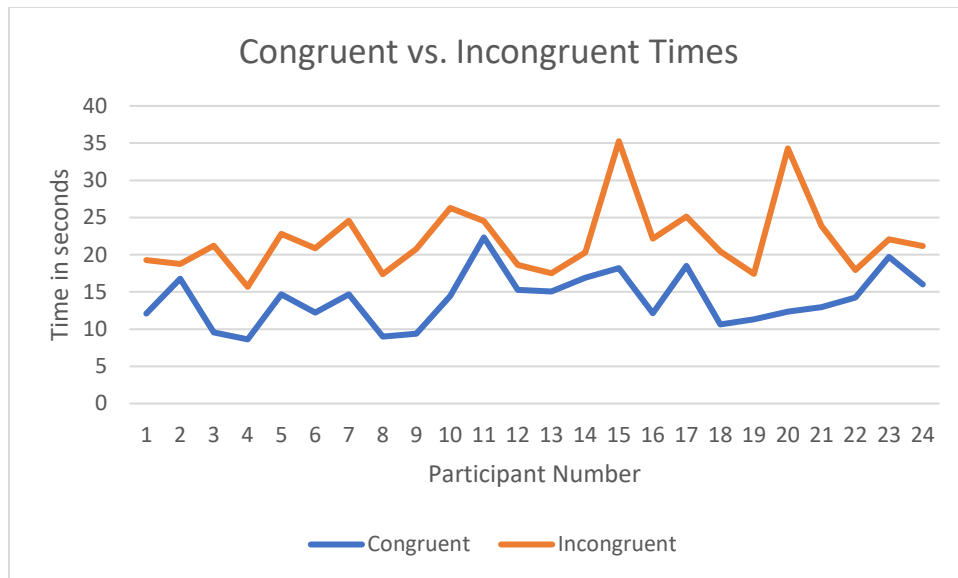
Incongruent Mean: 22.016 seconds

Incongruent Standard Deviation: 4.797 seconds

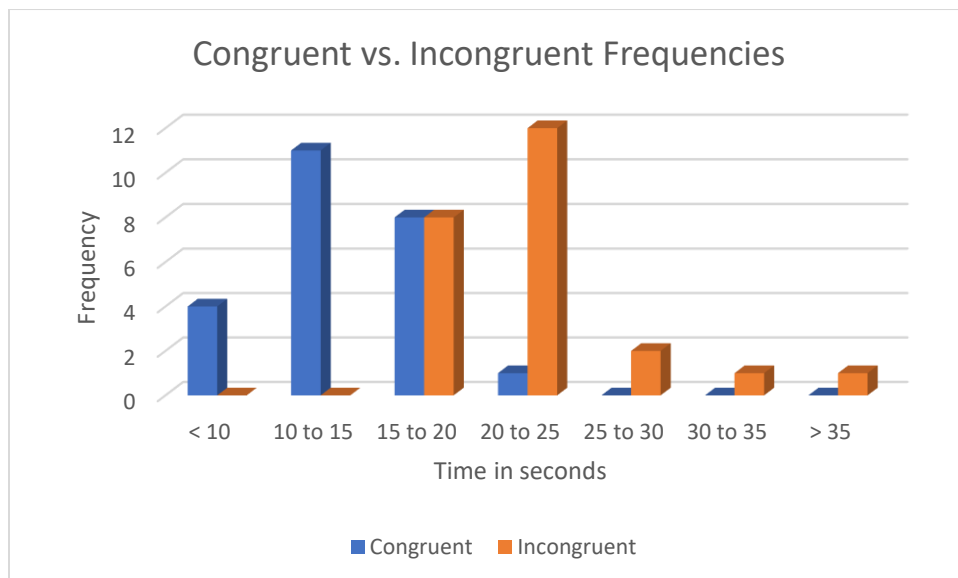
Incongruent Standard Error: 0.979 seconds

Q4. Plot the data.

The plot below shows the congruent and incongruent times for each participant. Each participant took more time to correctly identify colors in the incongruent case, when the word did not match the color.



The second plot shows the frequency of congruent and incongruent times. The most common congruent times are between 10 and 15 seconds. The 15 to 20 second bin is the second most frequent for congruent times. The incongruent times are longer. The most common bin is between 20 and 25 seconds. There are no congruent times above 25 seconds and no incongruent times below 15 seconds.



Note: I used Excel for plotting.

Q5. Perform the statistical test and interpret your results.

t-Critical Values:

Based on the hypothesis, a two-tailed test is performed. Since the population standard deviation is unknown, I will compute t-score for this experiment and compare to t-critical levels at alpha level = 0.05 to see if the null hypothesis shall be rejected.

$t(23) = 2.069$, $p < .05$, two-tailed

Compare Congruent and Incongruent Tests:

Mean (Difference): 7.965 seconds

Standard Deviation (Difference): 4.865 seconds

Standard Error (Difference): 0.993 seconds

t-score: 8.021

Cohen's d: 1.637

Correlation: .737

Probability (from www.graphpad.com): $< .0001$

The t-score (8.021) is much higher than the t-critical value (2.069) for an alpha level of 0.05; the probability is under 0.01%! Since the t-score is higher than the critical value, we must reject the null hypothesis. The time in which participants can name the ink colors is significantly larger for the incongruent case. Nearly 74% of the differences between these samples can be explained by the word/color mismatch in the incongruent case.

Q6. (Optional) Digging deeper and extending the investigation.

Before I performed the calculations, I performed the Stroop test on myself twice. In both cases, I needed nearly twice as much time to perform the incongruent case as the congruent case. I had to fight my natural instinct to read the word so that I could correctly identify its color. I had done the test in the past while watching an episode of Brain Games on the National Geographic channel, with about the same results.

Brain Games conducted another similar test where subjects were given a list of words paired with pictures. Each person had to identify the picture, not the word, shown for each pairing. There was a congruent case in which the picture matches the word. There was also an incongruent case where the picture did not match the word. The participants struggled to fight their instinct to identify the picture correctly in the incongruent case. One person, a four-year old girl, managed to succeed in both the congruent and incongruent cases because she is not yet literate. Therefore, she did not try to read the words and was able to simply identify the pictures. I suspect one will get similar results with this word/picture experiment as I saw for the word/color test.