Awad Bin-Jawed
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Project 1

Test a Perceptual Phenomenon

1.) The independent variable is each displayed word to be read, whether it is in the congruent or incongruent list. The dependent variable is the reaction time of the respondents to correctly identify the ink color of each word vs the reaction time of simply reading the text.

2.) An appropriate set of hypotheses for this task would be the Null and Alternative Hypothesis, because we are examining two opposing possibilities about the how the test participants will fare the Stroop Test. We are taking a close look at the relationship between the two variables (the displayed word and the reaction time to read/name it). For example, we can say identifying the color leads to a longer reaction time than reading the text.

The Null Hypothesis (H_0) states that a population parameter is equal to a value. It is the initial claim that researchers specify using previous research or knowledge. The Alternative Hypothesis (H_1) states that the population parameter is different from the value of the population parameter in the Null Hypothesis. The Alternative Hypothesis is what you might believe to be true or hope to be true. We will determine whether one population mean (μ_1) is equal to or different from the other population mean (μ_2):

H_0 states that $\mu_1 = \mu_2$ --or-- H_1 states that $\mu_1 < \mu_2$
or
H_1 states that $\mu_1 > \mu_2$
or
H_1 states that $\mu_1 \neq \mu_2$

- Statistical Hypotheses, because we can use statistics to verify the hypothesis. We can have a large group of willing participants who will each undergo the experiment of reading both the congruent and incongruent lists. We can then take their measured results and see how they stand up to scrutiny of the hypothesis that it takes more time to correctly identify the ink color of a displayed word than it is to simply read its text.

In the study of the participants' reaction time, the ideal type of t-test to employ would be the dependent t-sample test to point out any similarity or dissimilarity between the means of the two groups. The reason for this choice is t-tests are meant for a sample size smaller than 30, as opposed to a z-test, which is for a larger sample size. I chose the 2-sample paired t-test, because the participants partaking in the study would undergoing both treatments (Congruent and Incongruent). Also, the standard deviation was initially unknown, as well as the variance. Lastly, the means for both groups are dependent on reaction time.

3.) The independent variables are the displayed words to be read. We assign values to the dependent variable (reaction time) by measuring how quickly participants identify the color of a

displayed word, as well as how quickly they read the text of the word. The sample is a group of willing participants, regardless of their gender, age, race or income. Each participant is a categorical variable, assigned a number from rows 2 through 25, giving us a total of 24. Column A represents the congruent list. Column B represents the incongruent list.

4) The central tendency was measured as a quantitative (Ratio/Interval) score.

First we calculate the mean:

Congruent:
12.079 + 16.791 + 9.564 + 8.63 + 14.669 + 12.238 + 14.692 + 8.987 + 9.401 + 14.48 + 22.328 + 15.298 + 15.073 + 16.929 + 18.2 + 12.13 + 18.495 + 10.639 + 11.344 + 12.369 + 12.944 + 14.233 + 19.71 + 16.004 = 337.227

$$\bar{x} = \frac{(\sum x)}{n} \rightarrow \frac{337.227}{24} = 14.051125$$

Incongruent:
19.278 + 18.741 + 21.214 + 15.687 + 22.803 + 20.878 + 24.572 + 17.394 + 20.762 + 26.282 + 24.524 + 18.644 + 17.51 + 20.33 + 35.255 + 22.158 + 25.139 + 20.429 + 17.425 + 34.288 + 23.894 + 17.96 + 22.058 + 21.157 = 528.382

$$\bar{x} = \frac{(\sum x)}{n} \rightarrow \frac{528.382}{24} = 22.01591667$$

Variability – which group varies a lot? Look at the deviations: $\bar{x}_i - \bar{x}$

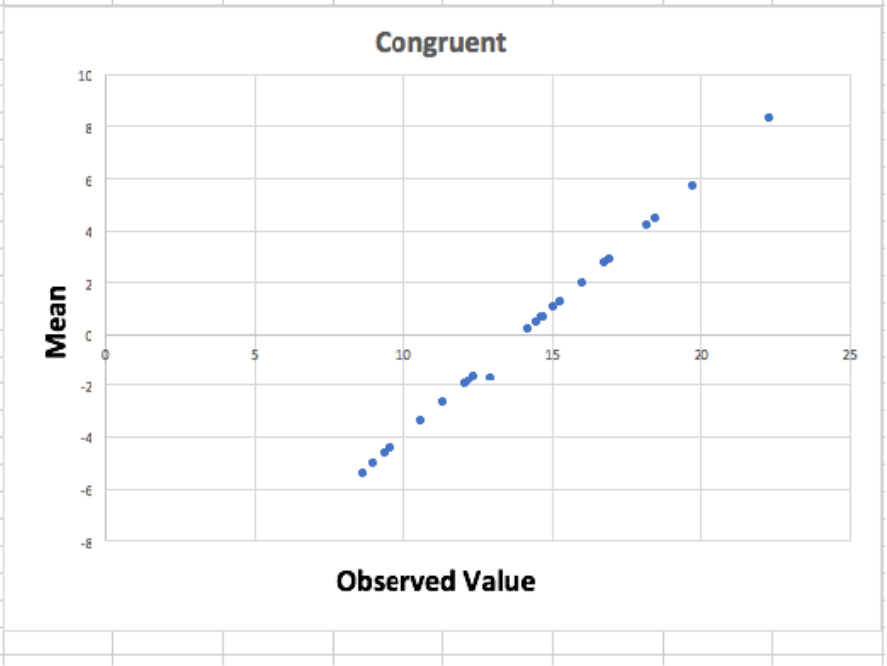
Congruent:
12.079 – 14.051125 = -1.972125
16.791 – 14.051125 = 2.739875
9.564 – 14.051125 = -4.487125
8.63 – 14.051125 = -5.421125
14.669 – 14.051125 = 0.617875
12.238 – 14.051125 = -1.813125
14.692 – 14.051125 = 0.640875
8.987 – 14.051125 = -5.064125
9.401 – 14.051125 = -4.650125
14.48 – 14.051125 = 0.428875
22.328 – 14.051125 = 8.276875
15.298 – 14.051125 = 1.246875
15.073 – 14.051125 = 1.021875
16.929 – 14.051125 = 2.877875
18.2 – 14.051125 = 4.148875
12.13 – 14.051125 = -1.921125
18.495 – 14.051125 = 4.443875
10.639 – 14.051125 = -3.412125
11.344 – 14.051125 = -2.707125
12.369 – 14.051125 = -1.682125

12.944 – 14.051125 = -1.107125
14.233 – 14.051125 = 0.181875
19.71 – 14.051125 = 5.658875
16.004 – 14.051125 = 1.952875

Incongruent:
19.278 – 22.01591667= -2.73791667
18.741 – 22.01591667 = -3.27491667
21.214 – 22.01591667 = -0.80191667
15.687 – 22.01591667 = -6.32891667
22.803 – 22.01591667 = 0.78708333
20.878 – 22.01591667 = -1.13719667
24.572 – 22.01591667 = 2.55608333
17.394 – 22.01591667 = -4.62191667
20.762 – 22.01591667 = -1.25319667
26.282 – 22.01591667 = 4.26680333
24.524 – 22.01591667 = 2.50808333
18.644 – 22.01591667 = -3.37191667
17.51 – 22.01591667 = -4.50591667
20.33 – 22.01591667 = -1.68591667
35.255 – 22.01591667 = 13.23908333
22.158 – 22.01591667 = 0.14208333
25.139 – 22.01591667 = 3.12308333
20.429 – 22.01591667 = -1.58691667
17.425 – 22.01591667 = -4.59091667
34.288 – 22.01591667 = 12.27208333
23.894 – 22.01591667 = 1.87808333
17.96 – 22.01591667 = -4.05591667
22.058 – 22.01591667 = 0.04208333
21.157 – 22.01591667 = -0.85891667

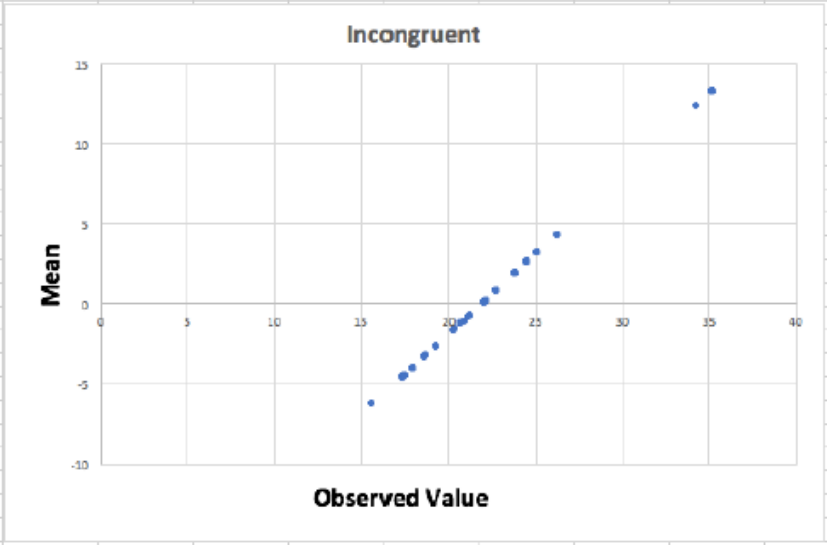
Now we make scatter plots of the data:

12.079	-1.972125
16.791	2.739875
9.564	-4.487125
8.63	-5.421125
14.669	0.617875
12.238	-1.813125
14.692	0.640875
8.987	-5.064125
9.401	-4.650125
14.48	0.428875
22.328	8.276875
15.298	1.246875
15.073	1.021875
16.929	2.877875
18.2	4.148875
12.13	-1.921125
18.495	4.443875
10.639	-3.412125
11.344	-2.707125
12.369	-1.682125
12.944	-1.707125
14.233	0.181875
19.71	5.658875
16.004	1.952875



It is apparent Incongruent has greater disparity (and thus more variability) along both the X (Observed) and Y (Mean) values; much so than Congruent.

19.278	-2.73791667
18.741	-3.27491667
21.214	-0.80191667
15.687	-6.32891667
22.803	0.78708333
20.878	-1.13719667
24.572	2.55608333
17.394	-4.62191667
20.762	-1.25319667
26.282	4.26680333
24.524	2.50808333
18.644	-3.37191667
17.51	-4.50591667
20.33	-1.68591667
35.255	13.23908333
22.158	0.14208333
25.139	3.12308333
20.429	-1.58691667
17.425	-4.59091667
34.288	12.27208333
23.894	1.87808333
17.96	-4.05591667
22.058	0.04208333
21.157	-0.85891667



Now we calculate the Standard Deviations:

- We already worked out the Means for both sets:

$$\text{Congruent} = \bar{x} = \frac{(\sum x)}{n} \rightarrow \frac{337.227}{24} = 14.051125$$

$$\text{Incongruent} = \bar{x} = \frac{(\sum x)}{n} \rightarrow \frac{528.382}{24} = 22.01591667$$

- Then we work out the Variances, and find their square roots to get the standard deviation:

$$\text{Congruent} = \frac{\sum(x-\bar{x})^2}{n-1} \rightarrow \frac{293.0762187}{23} = 12.74244429 \rightarrow \sqrt{12.74244429} = 3.569656046$$

C25 =SUM(C1:C24)

	A	B	C
1	12.079	-1.972125	3.889277016
2	16.791	2.739875	7.506915016
3	9.564	-4.487125	20.13429077
4	8.63	-5.421125	29.38859627
5	14.669	0.617875	0.381769516
6	12.238	-1.813125	3.287422266
7	14.692	0.640875	0.410720766
8	8.987	-5.064125	25.64536202
9	9.401	-4.650125	21.62366252
10	14.48	0.428875	0.183933766
11	22.328	8.276875	68.50665977
12	15.298	1.246875	1.554697266
13	15.073	1.021875	1.044228516
14	16.929	2.877875	8.282164516
15	18.2	4.148875	17.21316377
16	12.13	-1.921125	3.690721266
17	18.495	4.443875	19.74802502
18	10.639	-3.412125	11.64259702
19	11.344	-2.707125	7.328525766
20	12.369	-1.682125	2.829544516
21	12.944	-1.707125	2.914275766
22	14.233	0.181875	0.033078516
23	19.71	5.658875	32.02286627
24	16.004	1.952875	3.813720766
25			293.0762187
26			

$$\text{Incongruent} = \frac{\sum(x-\bar{x})^2}{n-1} \rightarrow \frac{529.2731123}{23} = 23.01187445 \rightarrow \sqrt{23.01187445} = 4.797069361$$

C25 =SUM(C1:C24)

	A	B	C
1	19.278	-2.73791667	7.496187692
2	18.741	-3.27491667	10.7250792
3	21.214	-0.80191667	0.643070046
4	15.687	-6.32891667	40.05518622
5	22.803	0.78708333	0.619500168
6	20.878	-1.13719667	1.293216266
7	24.572	2.55608333	6.53356199
8	17.394	-4.62191667	21.3621137
9	20.762	-1.25319667	1.570501894
10	26.282	4.26680333	18.20561066
11	24.524	2.50808333	6.29048199
12	18.644	-3.37191667	11.36982203
13	17.51	-4.50591667	20.30328504
14	20.33	-1.68591667	2.842315018
15	35.255	13.23908333	175.2733274
16	22.158	0.14208333	0.020187673
17	25.139	3.12308333	9.753649486
18	20.429	-1.58691667	2.518304518
19	17.425	-4.59091667	21.07651587
20	34.288	12.27208333	150.6040293
21	23.894	1.87808333	3.527196994
22	17.96	-4.05591667	16.45046003
23	22.058	0.04208333	0.001771007
24	21.157	-0.85891667	0.737737846
25			529.2731123

Now that we know the standard deviation, we can perform the t-test. The question still arises: did the participants have greater difficulty identifying the printed color of words than verbally reading the list of words?

By default, we will use an Alpha (α) of 0.05 for performing the t-test.

Next, we calculate the Degrees of Freedom:

$$n - 1$$
$$\downarrow$$
$$\text{Congruent} = 24 - 1 = 23$$
$$\text{Incongruent} = 24 - 1 = 23$$

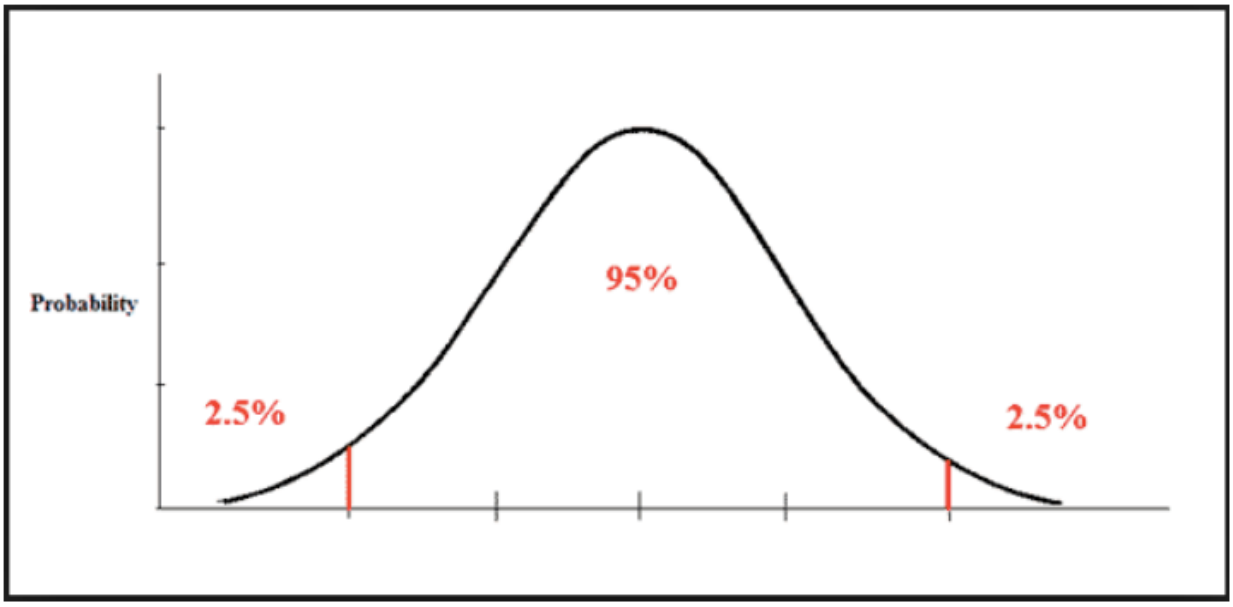
Next, we need to state the Decision Rule:

Since we have an Alpha of 0.05, we need to find the middle 95% of where we expect the Means to be situated. Outside of the 95% would be 5% split up into the two tails as two 2.5% ends. If our means land within the outer 2.5% area, this means our Means are highly unusual.

Significance level = α						
Degrees of Freedom	.005 (1-tail) .01 (2-tails)	.01 (1-tail) .02 (2-tails)	.025 (1-tail) .05 (2-tails)	.05 (1-tail) .10 (2-tails)	.10 (1-tail) .20 (2-tails)	.25 (1-tail) .50 (2-tails)
1	63.657	31.821	12.706	6.314	3.078	1.000
2	9.925	6.965	4.303	2.920	1.886	.816
3	5.841	4.541	3.182	2.353	1.638	.765
4	4.604	3.747	2.776	2.132	1.533	.741
5	4.032	3.365	2.571	2.015	1.476	.727
6	3.707	3.143	2.447	1.943	1.440	.718
7	3.500	2.998	2.365	1.895	1.415	.711
8	3.355	2.896	2.306	1.860	1.397	.706
9	3.250	2.821	2.262	1.833	1.383	.703
10	3.169	2.764	2.228	1.812	1.372	.700
11	3.106	2.718	2.201	1.796	1.363	.697
12	3.054	2.681	2.179	1.782	1.356	.696
13	3.012	2.650	2.160	1.771	1.350	.694
14	2.977	2.625	2.145	1.761	1.345	.692
15	2.947	2.602	2.132	1.753	1.341	.691
16	2.921	2.584	2.120	1.746	1.337	.690
17	2.898	2.567	2.110	1.740	1.333	.689
18	2.878	2.552	2.101	1.734	1.330	.688
19	2.861	2.540	2.093	1.729	1.328	.688
20	2.845	2.528	2.086	1.725	1.325	.687
21	2.831	2.518	2.080	1.721	1.323	.686
22	2.819	2.508	2.074	1.717	1.321	.686
23	2.807	2.500	2.069	1.714	1.320	.685
24	2.797	2.492	2.064	1.711	1.318	.685
25	2.878	2.485	2.060	1.708	1.316	.684
26	2.779	2.479	2.056	1.706	1.315	.684
27	2.771	2.473	2.052	1.703	1.314	.684
28	2.763	2.467	2.048	1.701	1.313	.683
29	2.756	2.462	2.045	1.699	1.311	.683
Large	2.576	2.327	1.960	1.645	1.282	.675

https://web.stanford.edu/dept/radiology/cgi-bin/classes/stats_data_analysis/principles/t_table.htm

When lining 23 on the Degrees of Freedom with the 0.05 Alpha, we get a critical value of 2.069. This means we expect most values to land between -2.069 and 2.069.
If t is less than -2.069 or greater than 2.069, then we reject the Null Hypothesis.



http://www.statisticslectures.com/images/onez2.gif

Now we calculate the Test Statistic:

$$SE_{difference} = \sqrt{\frac{s^2_{difference}}{n}} = \sqrt{\frac{23.67}{24}} = 0.9931.$$

$$t = \frac{\bar{x}_{difference}}{SE_{difference}}$$

↓

$$= \frac{(14.051125) - (22.01591667)}{0.9931}$$

↓

$$= \frac{-7.96479167}{0.9931}$$

↓

$$= -8.020130570939482$$

Based on the Test Statistics, we reject the Null Hypothesis. This means that the difference between Congruent and Incongruent was statistically significant. This means that the difference between Congruent and Incongruent was statistically significant. In light of this, we can extrapolate that there is substantial evidence to suggest less time is needed to recognize the color of printed words with the congruent condition as opposed to reading printed text with the incongruent condition.