Test a Perceptual Phenomenon - Analysis Report

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Experiment

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participant's task is to say out loud the color of the ink in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition. In the congruent words condition, the words being displayed are color words whose names match the colors in which they are printed: for example RED, BLUE. In the incongruent words condition, the words displayed are color words whose names do not match the colors in which they are printed: for example PURPLE, ORANGE. In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

Online Experiment: https://faculty.washington.edu/chudler/java/ready.html

Approach

We do not know the population parameters.
The same subjects are tested.
We have here two dependant samples with 2 conditions:

- congruent words condition
- and incongruent words condition

Use of dependant t-test for paired samples is applicable. The recommended approach is to compute the difference.
After performing the online experiment, the intuition is that the reaction time is increasing with incongruent words condition.

Variables

Our dependant variable is 'Reaction Time' expressed in seconds
Our independent variable is the type of condition:

- either the congruent word condition,
- or the incongruent word condition.

Hypotheses

The hypotheses in terms of statistical symbols:

- $H_0: \mu_I = \mu_C$

- $H_a: \mu_I \neq \mu_C$

where:

- H_0 is the null hypothesis
- H_a is the alternate hypothesis
- μ_C is the population mean of 'Reaction Time' under the congruent condition,
- μ_I is the population mean of 'Reaction Time' under the incongruent condition,

The null hypothesis (H_0) states that the population mean of the reaction time of the task under the incongruent words condition (μ_I) is equal to population mean of the reaction time of the task under the congruent words condition (μ_C).
The alternate hypothesis (H_a) states that the population mean of the task under the incongruent condition (μ_I) is different from the population mean of the task under the congruent condition (μ_C).
Based on the alternate hypothesis, we will use a two-tailed t-test

Descriptive statistics

The statistics are computed and extracted from the coding part.
See Coding in § Data Summary

Statistics	Congurent	Incongruent	Difference
count	24	24	24
mean	14.051125	22.015917	7.964792
std	3.559358	4.797057	4.864827
min	8.630000	15.687000	1.950000
25%	11.895250	18.716750	3.645500
50%	14.356500	21.017500	7.666500
75%	16.200750	24.051500	10.258500
max	22.328000	35.255000	21.919000

Data visualization
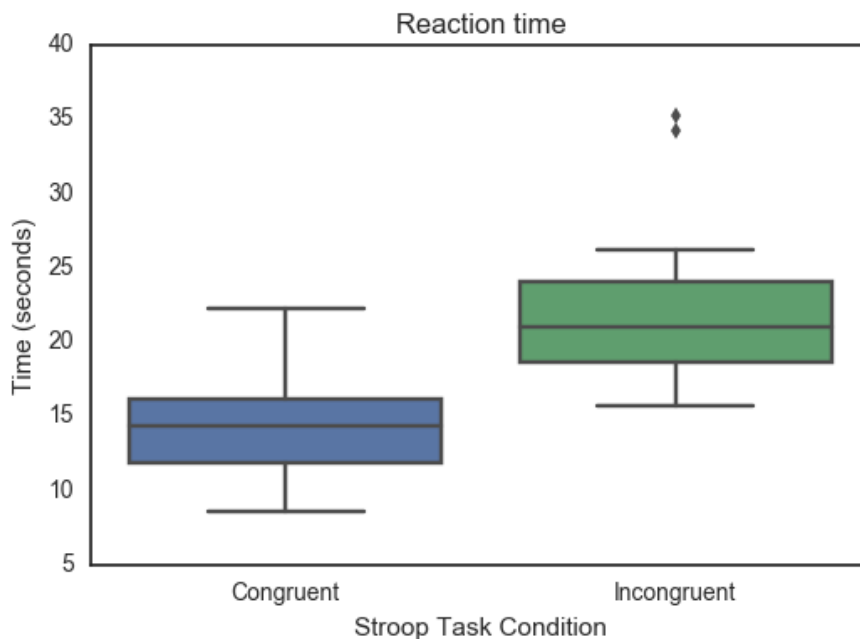
We can see that the mean of the incongruent condition is greater than the mean of the congruent condition.

In the case of Incongruent, we have outliers
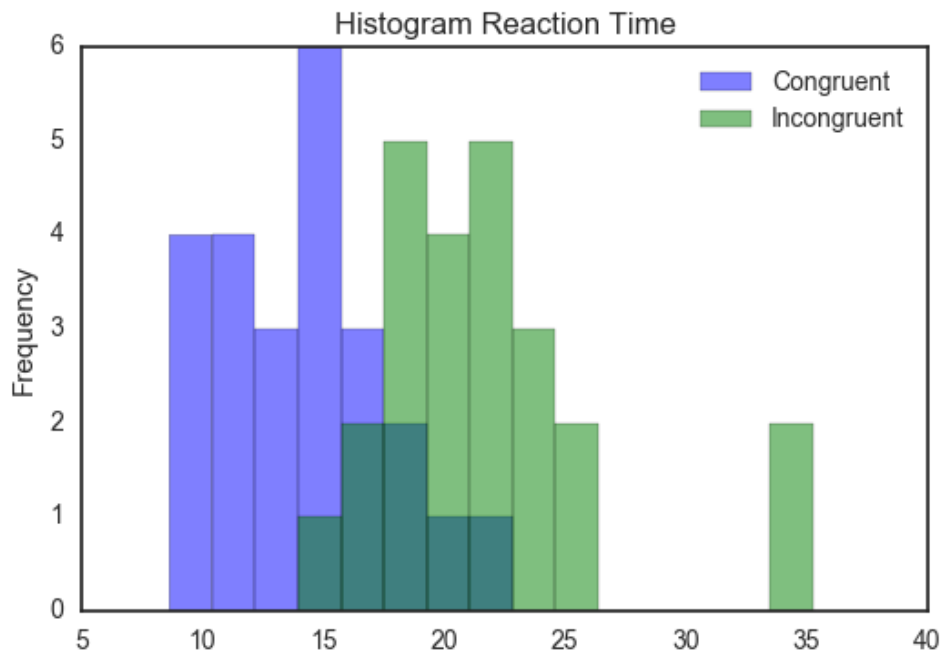
The Incongruent distribution is left-skewed.

The spread of the Incongruent condition is greater than the Congruent condition (based on sigma or IQR)
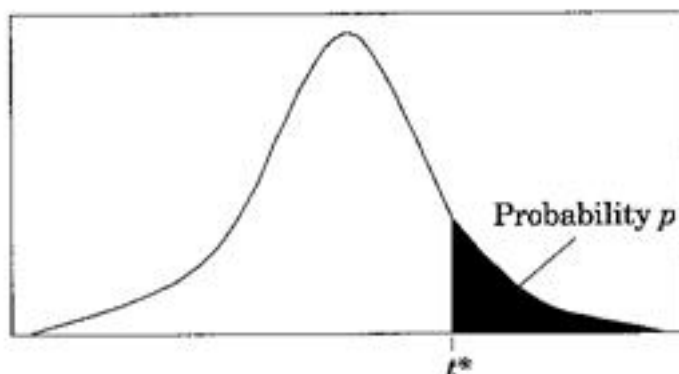
Statistical test and findings

The sample size is n = 24. The degree of freedom is DoF = n - 1 = 23.
The critical value for α=.05 (two-tailed) is:
t_c=2.069 from the t-table

Table entry for p and C is the point t^* with probability p lying above it and probability C lying between $-t^*$ and t^*.

Probability p

t^*

Table B — t distribution critical values

df	\.25	\.20	\.15	\.10	\.05	\.025	\.02	\.01	\.005	\.0025	\.001	\.0005
					Tail probability p							
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	.765	.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	.741	.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	.727	.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	.718	.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	.711	.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	.706	.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	.703	.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	.700	.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	.697	.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	.695	.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	.694	.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	.692	.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	.691	.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	.690	.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	.689	.863	1.069	1.333	1.740	2.110	2.224	2.567	2.808	3.222	3.646	3.965
18	.688	.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	.688	.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	.687	.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	.686	.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	.686	.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	.685	.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	.685	.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	.684	.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	.684	.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	.684	.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	.683	.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	.683	.854	1.055	1.311	1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	.683	.854	1.055	1.310	1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	.681	.851	1.050	1.303	1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	.679	.849	1.047	1.299	1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	.679	.848	1.045	1.296	1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	.678	.846	1.043	1.292	1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	.677	.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	.675	.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
∞	.674	.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291
	50%	60%	70%	80%	90%	95%	96%	98%	99%	99.5%	99.8%	99.9%
					Confidence level C							

Sample Differences:

μ_D=7.96 Sample mean of the differences

σ_D=4.86 Sample standard deviation of the differences

The paired sample t-statistics is (see Coding § T-Test):

t_s=8.021

Our sample mean falls within the critical region.

The two-tailed P-value is less than .0001 (use of tool [Find p-value]).

Coding § T-Test) gives p = .00000004

By conventional criteria (α=.05), this difference is considered extremely statistically significant.

The probability of obtaining the sample mean is less than the alpha (p<α)

Therefore, we reject the null

Conclusion:¶

The test performed is a two-tailed t-test with (1 - α) = 95% confidence level.

The reaction time of the task under the incongruent words condition is significantly longer than that of the congruent words condition.

The results match up with my expectations.

Documentation/References

Here is the list of references - including Web sites, books, blog posts - used for my submission:

[Wikipedia] Wikipedia article - Stroop effect wikipedia

[Experiment] Original experiment of Stroop effect experiment

[OnlineExperiment] https://faculty.washington.edu/chudler/words.html#seffect

[repo] https://github.com/thrabchak/Udacity-Data-Analysis/tree/master/P1%20Stroop%20Effect

[t-table] t table: https://s3.amazonaws.com/udacity-hosted-downloads/t-table.jpg

[Find p-value] http://www.graphpad.com/quickcalcs/

[dataset] https://drive.google.com/file/d/0B9Yf01UaIbUgQXpYb2NhZ29yX1U/view