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Note: Thank you for your feedback. I revised my initial submission to be more precise and descriptive in various answers. In addition, although my math was correct, I inadvertently included my timed results with the samples giving us 25 samples instead of 24 samples. The calculations should reflect that change.

P1: Test a Perceptual Phenomenon
Statistics: The Science of Decisions Project Instructions

1. What is our independent variable? What is our dependent variable?

The independent variable, which is controlled, is the congruent condition and the dependent variable, which is measured, is time.

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

We are interested in the effects of reading congruent words vs. incongruent words and measuring whether there is a significant difference in time between the two conditions.

The Null Hypothesis states there is no significant difference (H_o: $\mu_C = \mu_I$). The Alternative Hypothesis states there is a difference (H_A: $\mu_C \neq \mu_I$).

We have 24 samples, which is a small sample size. We do not know the population standard deviation. However we can calculate the mean and standard deviation of the sample. Therefore we will be comparing sample means in a paired t-test, which will test whether the mean of the difference between paired observations is equal to a target value. The distribution of sample means is normal, i.e. the majority of participants will be within $1 - 2$ standard deviation of the sample mean.

One statistical tests I expect to perform is a t-test, (small sample size & unknown population standard deviation), which I will use to reject or accept the null hypothesis.

The formula for t-statistic: $t = (\mu_c - \mu_i) / S/(\sqrt{n})$

A second statistical test I expect to perform is a confidence interval (CI) for the mean population difference, which is a range of values we suspect the population parameter lies between. I will use a 95% confidence level.

The formula for confidence interval (CI): $M_D +/- t_{critical} (S_D/\sqrt{n})$

A third statistical test I will perform is Cohen's d, the effect size measure or margin of error. This calculation will give us the distance between means in standardized units.

The formula for Cohen's d: $M_D - S_D$

3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

The data below illustrates measures of central tendency including Mean, and Median. Measures of variability include Variance and Standard Deviation for the differences in sample means.

Congruent	Incongruent		Difference		

12.079	19.278		-7.199		0.586	
16.791	18.741		-1.950		36.178	
9.564	21.214		-11.650		13.581	
8.630	15.687		-7.057		0.824	
14.669	22.803		-8.134		0.029	
12.238	20.878		-8.640		0.456	
14.692	24.572		-9.880		3.668	
8.987	17.394		-8.407		0.196	
9.401	20.762		-11.361		11.534	
14.480	26.282		-11.802		14.724	
22.328	24.524		-2.196		33.279	
15.298	18.644		-3.346		21.333	
15.073	17.510		-2.437		30.556	
16.929	20.330		-3.401		20.828	
18.200	35.255		-17.055		82.632	
12.130	22.158		-10.028		4.257	
18.495	25.139		-6.644		1.744	
10.639	20.429		-9.790		3.331	
11.344	17.425		-6.081		3.549	
12.369	34.288		-21.919		194.720	
12.944	23.894		-10.950		8.911	
14.233	17.960		-3.727		17.959	
19.710	22.058		-2.348		31.548	
16.004	21.157		-5.153		7.906	

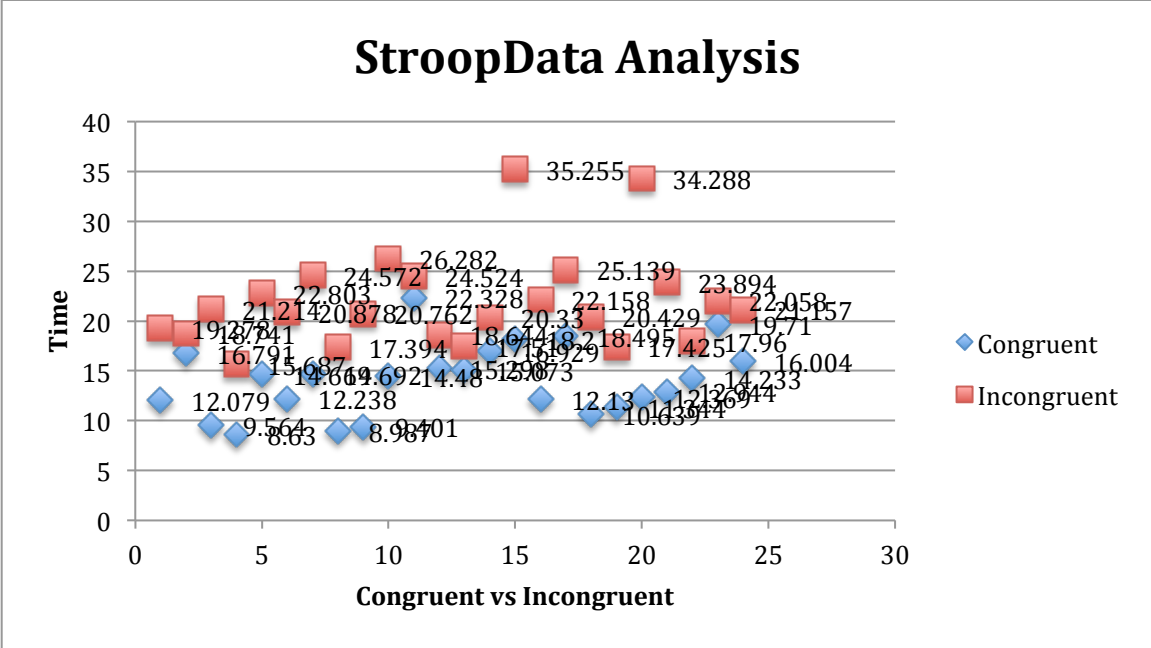|						
			-7.965			
14.051	22.016	<-- mean			23.667	<-- variance
14.357	21.018	<-- median			4.865	<-- stdv

Mean of congruent = 14.051
Mean of incongruent = 22.016
Variance of the differences = 23.667 (using Bessel's correction n – 1)
Standard deviation of the differences (S) = 4.865 (sqrt of the variance)

4. Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

Based on the scatter plot chart below of our sample data, the distribution of incongruent performance results is narrower than that of congruent results and contains fewer outliers. The incongruent times are higher on average than congruent times, indicating that it takes longer to read an equally sized list of words.

StroopData Analysis

Time

Congruent vs Incongruent

35.255   34.288
26.282
24.572   24.524   25.139   23.894
22.803   22.328   22.158   20.429   22.058
21.214 20.878 20.762   20.33   18.495 17.96 19.71 19.157
19.278 18.741   17.394   18.644 18.218   17.425   16.004
16.791   15.687   14.692   17.61 16.929   14.233
15.298 15.073 16.073   14.3
12.079   12.238   14.48   12.13   12.669 12.944
9.564   8.987 9.401   10.639 11.436
8.63

◆ Congruent

■ Incongruent

(y-axis: 0, 5, 10, 15, 20, 25, 30, 35, 40)
(x-axis: 0, 5, 10, 15, 20, 25, 30)

5. Now, perform the statistical test and report your results. What is your confidence level and your critical statistic value? Do you reject the null hypothesis or fail to reject it? Come to a conclusion in terms of the experiment task. Did the results match up with your expectations?

This statistical test is a dependent t-test for a paired sample, whereby the subject takes the same test twice. The Null Hypothesis (defined above) states that two population means will be the same. The Null assumes the difference in means will equal 0 (alternatively assumes they will not equal 0). We are testing to see if there is a significant difference in times between 2 population means and whether that is significantly different than 0.

Testing based on the following sample data:

Congruent	Incongruent		Difference		Sq Diff
12.079	19.278		-7.199		0.586
16.791	18.741		-1.950		36.178
9.564	21.214		-11.650		13.581
8.630	15.687		-7.057		0.824
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19.710	22.058		-2.348		31.548
16.004	21.157		-5.153		7.906

			-7.965		
14.051	**22.016**	<-- mean		**23.667**	<-- variance
14.357	**21.018**	<-- median		**4.865**	<-- stdv

Results:

Point estimation or difference between population of errors ($\mu_c - \mu_i$) = **-7.97**
Math: 14.051-22.016

Standard error (S) of the differences / stdv of each difference = **4.87**
Math: sqrt of 23.667

t-statistic (($\mu_c - \mu_i$) / S/($\sqrt{n}$)) = **-8.02**
Math: -7.965/(4.865/4.899)

t-critical value ($\alpha = 0.05$) = **+/- 2.069**
Math: using the t-table, 0.025 in each tail, and a df of 23 (n-1)

Cohen's d / effect size measure or margin of error ($M_D - S_D$) = **-1.64**
Math: -7.965/4.865

Confidence interval (M_D +/- $t_{critical}$ ($S_D / \sqrt{n}$)) = **-10.02   -5.91**
Math: -7.965 +/- 2.069 (4.865/4.899)

Conclusions:

Reject the Null (**Reject H_O**), since the t-statistic is in the critical region, past the t-critical value. Participant's times were significantly faster reading congruent vs. incongruent words. As a causal statement, the type of word had an effect on time. We can conclude on average participants were 1.6X faster reading congruent words vs. incongruent words.

Sources: Udacity, Wikipedia, Google