The Science of Decisions

Background Information

In this project, we've investigated a classic phenomenon from experimental psychology called the Stroop Effect.
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.

Questions For Investigation

We have a data set of two samples i.e. time for *congruent* and *incongruent* tasks.

Q1. What is our independent variable? What is our dependent variable?

Ans. Independent variable - ***color of the ink (the word is written in.)***
Dependent variable - ***time taken by the participant to complete the task(s).***

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

Ans.
H_0: $\mu_1 - \mu_2 = 0$
H_A: $\mu_1 - \mu_2 \neq 0$

μ_1 : The mean time taken to complete task 1(*congruent* task).
μ_2 : The mean time taken to complete task 2(*incongruent* task).

Null Hypothesis H_0: There is no difference in mean time taken to complete both the tasks(*congruent* and *incongruent)*.

Alternative Hypothesis H_A: The difference of the mean time taken to complete the *incongruent* task and *congruent* task is not equal to zero.

Since each participant performs the 2 conditions and the measurements are coupled, we will perform a **dependent *t-test.*** As we have set our hypotheses, we can safely say that we would be conducting a **two-tailed t-test** because we would be checking if the mean time taken to complete task two is different than zero i.e. **$\mu_2 - \mu_1 \neq 0$.**

Note: μ represents the population mean response time.

Q3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

Ans. Say we denote the mean of first sample (mean time taken for congruent task) as $\bar{x}$ and mean of the second sample (mena time taken for incongruent task) as $\bar{y}$.

On calculating(Mean - measure of central tendency):
Mean = $\Sigma(x) \div n$ | n being the number of data points in the set

$\bar{x}$ = 14.05 ,and
$\bar{y}$ = 22.02

Mean difference = -7.97
Note: The mean values are in seconds and have been rounded off to two decimal places.

On calculating (Standard deviation - measure of variability):
Note: Population standard deviation is denoted by σ but here we are calculating the sample parameters, and so the sample standard deviation, we denote it with S.

S = $\sqrt{\Sigma(x - \bar{x})^2 \quad = \quad \div n - 1}$

Where $s^2 = \Sigma(x - \overline{x})^2 \div n - 1$ is the sample variance.

But here we have two dependent samples of data, in that case the sample standard deviation,
S = Standard_deviation(a-b), i.e. we calculate the difference of data points in both the data sets and calculate the standard deviation for the resulting data set.
And that amounts to

S = 4.86

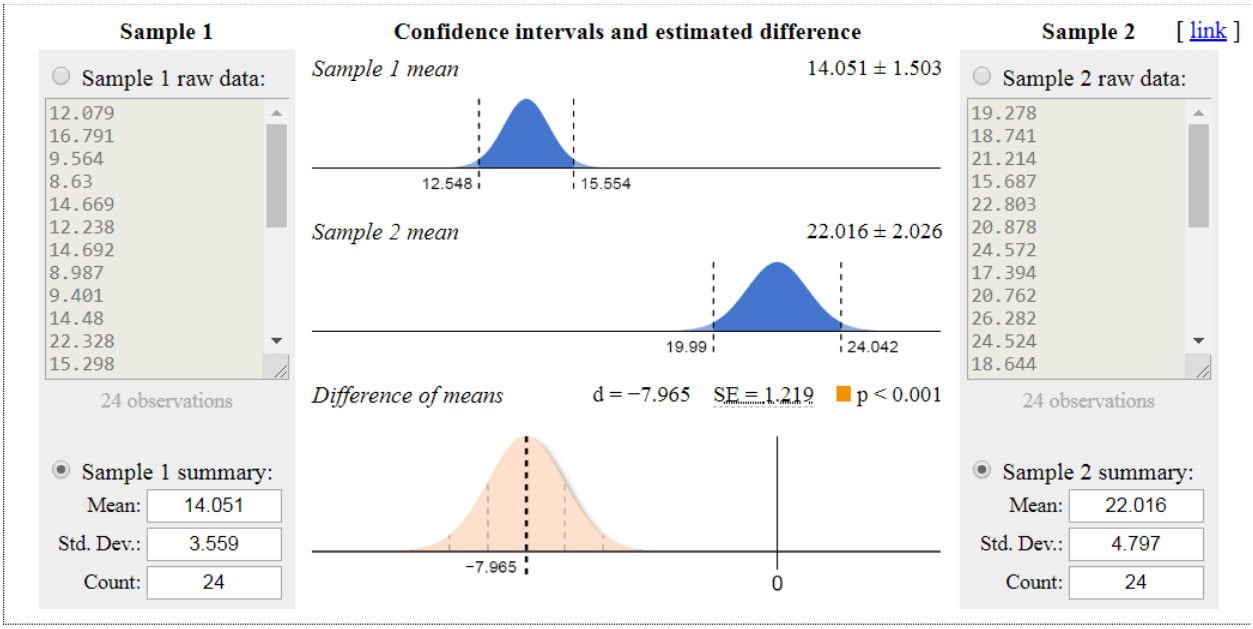
We can calculate the standard error i.e. **standard deviation** of a statistic's **sampling** distribution or an estimate of that **standard deviation** and is denoted by S.E.
S.E. = S/ $\sqrt{n}$, where S is the sample standard deviation and n is the sample size.

For the independent samples,
S.E = $S/\sqrt{n}$ = 0.99 **S.E = 0.99**

Descriptive Statistic	**Values**
$\overline{x}$ (Mean time for congruent task)	14.05
$\overline{y}$ (Mean time for incongruent task)	22.02
Mean difference	-7.97
S (Standard deviation)	4.86
Standard error of the mean (S.E.)	0.99

Q4. 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.

Ans.



Source: https://www.evanmiller.org/ab-testing/t-test.html

In the first image we can see the plot for sample 1(congruent task), and its critical regions at **12.548 and 15.554** at the confidence interval of 95% i.e the area behind both **critical regions is 2.5% each**. Same goes for the second sample in image 2, where the critical regions are behind **19.99 and 24.042.**

In the third image we can see the plot for difference of the means at mean = -7.965, **standard error at 1.219.**

Q5. 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?

Ans. We have already calculated more than a few sample statistics, we can recall them here:

Mean difference = -7.97, S = 4.86, S.E. = 0.99, n=24, degrees of freedom = n-1
= 24-1
= 23

And we set our significance level **$\alpha = 0.05$**

t-statistic = $(\bar{x} - \bar{y})$ - $(\mu_2 - \mu_1) \div$ S.E
On calculating:
t-statistic = -7.97 $\div$ 0.99
t-statistic = -8.05

Now, we find the t-critical using a t-table. We will be looking for 23 degrees of freedom and 0.025 probability(since this is a two tailed test)

t-critical = ± 2.069

Now, we calculate our p-value using **graphpad.com**:

p-value < 0.0001 , which is considered to be extremely statistically significant.

Since our p < 0.05 and t-statistic < -2.069, it will fall inside the critical region and it would be conclusive to say the we reject the null hypothesis and accept the alternative.

Conclusion: Reject H_0, i.e. there is a significant difference between the mean times taken to complete the congruent and incongruent task.

Q6. Optional: What do you think is responsible for the effects observed? Can you think of an alternative or similar task that would result in a similar effect?

Ans. The functioning of the human brain, the selective attention and other psychological factors might be responsible for the effects observed.

To answer the second part of the question, there are couple of other similar tasks, namely, **The reverse Stroop effect** and **Simon effect.**

References:
Graphpad.com,
Evanmiller.org,
Wikipedia.com
stats.stackexchange.com