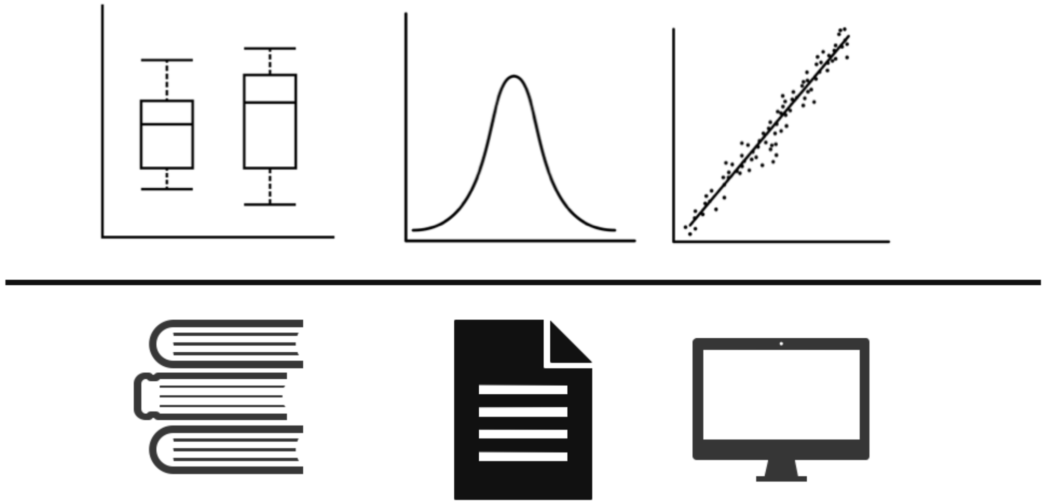
PSYC 2300

Introduction to Statistics



Lecture 10: Differences Between Two Groups (Part I)

Outline for today

- **Review**
  - Parts of last class
- **Independent-samples *t*-test**
  - Practice activity
- **Effect size for independent-samples *t*-test**
- **Independent-samples *t*-test in JASP**
  - Download `Stats Class 12 Dataset (Independent-Samples T-Test).jasp`

Review

Statistics: A set of tools and techniques that are used for describing, organizing, and interpreting information or data

Inferential Statistics: Used to make inferences (reach a conclusion) about the data

Review

Hypothesis testing involves using samples to make inferences about the population

Null Hypothesis: there is no change, no difference, or no relationship between variables

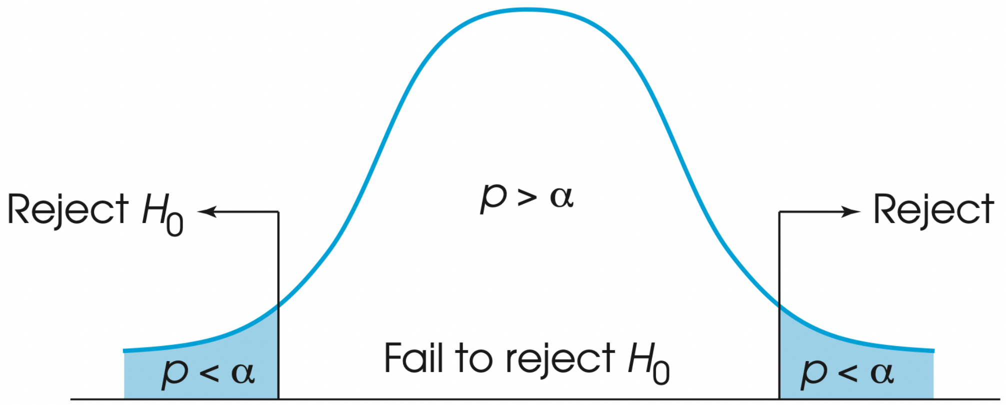
$$H_0 = \epsilon$$

Research Hypothesis: there is change, a difference, or a relationship between variables

$$H_1 = \tau + \epsilon$$

Review

Statistical Significance: A result is said to be *significant*, or *statistically significant*, if it is very unlikely to occur when the null hypothesis is true. That is, the result is sufficient to reject the null hypothesis. Thus, a treatment has a significant effect if the decision from the hypothesis test is to reject H_0



Review

Independent variable: The variable that is hypothesized to have an effect on some outcome of interest

Dependent variable: The outcome of interest that the independent variable might have an effect on

Review

Inferences about a population with one sample

z-test statistic

$$z_{\overline{x}} = \frac{\overline{x} - \mu_{\overline{x}}}{\sigma_{\overline{x}}}$$

Standard Error

$$\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$$

One-sample *t*-test statistic

$$t_{\overline{x}} = \frac{\overline{x} - \mu_{\overline{x}}}{s_{\overline{x}}}$$

Estimated standard error

$$s_{\overline{x}} = \frac{s}{\sqrt{n}}$$

Independent samples *t*-test

t-test statistic

General form of t-test statistics

$$t = \frac{sample\ statistic\ - population\ parameter}{estimated\ standard\ error\ of statistic}$$

Three types we'll learn:

- One sample *t*-test
- **Independent samples *t*-test**
- Dependent samples *t*-test

Goal

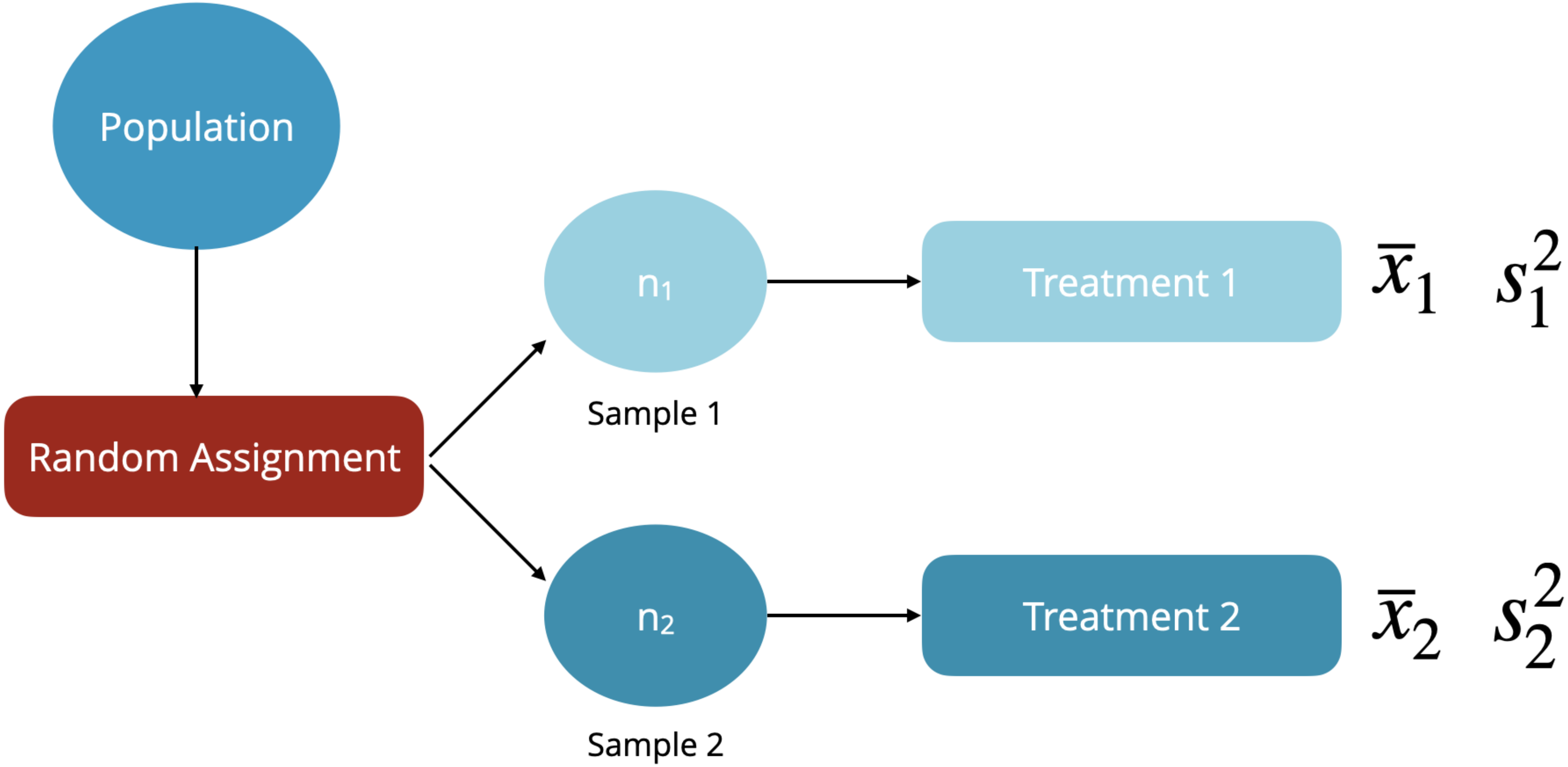
Independent samples *t*-test

- To investigate whether two independent groups differ significantly along a dimension of interest

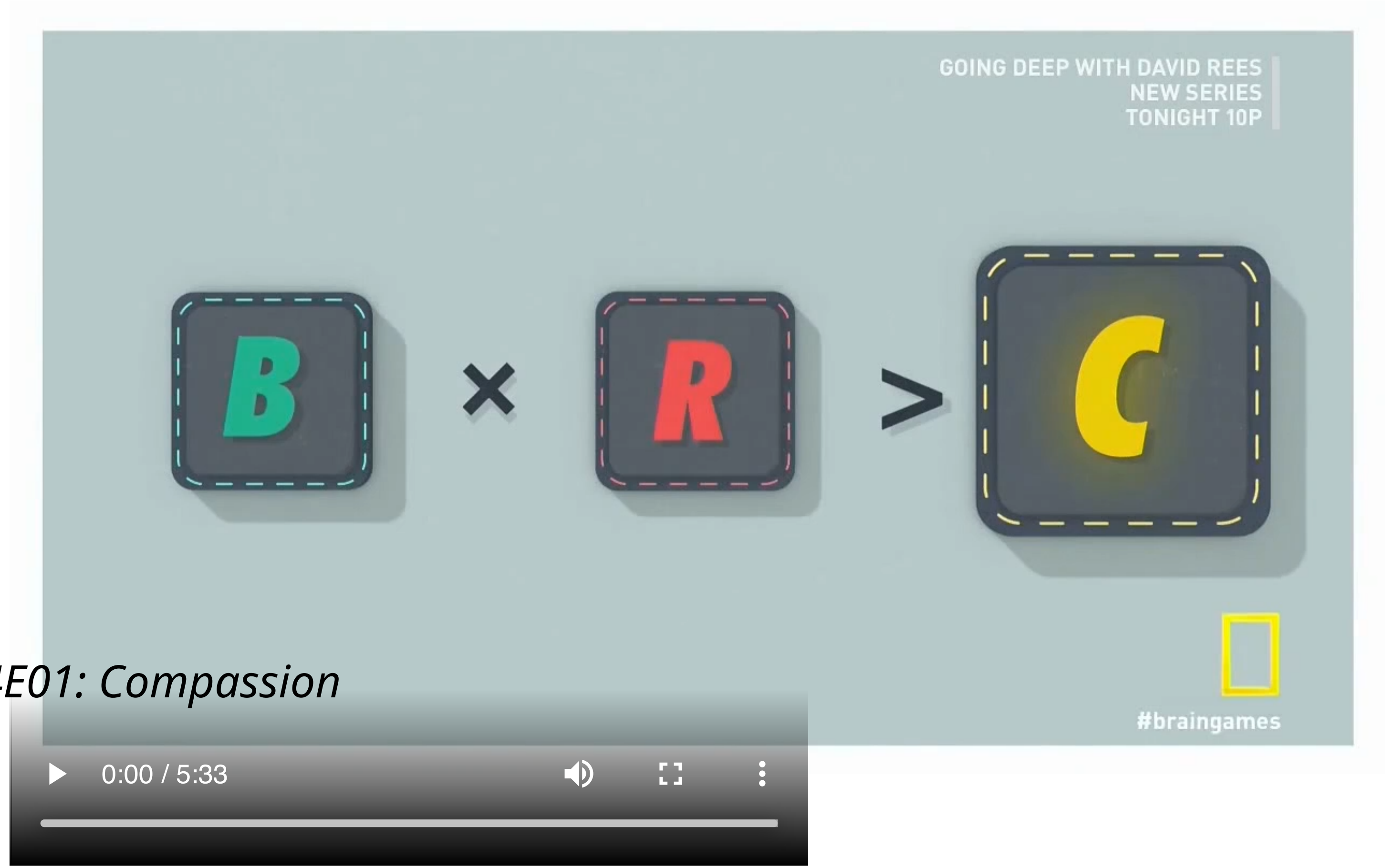
- “Independent” here means unrelated (e.g., they were only tested once)

    - This is a situation where we are measuring *separate* groups of individuals, and we want to compare the means of those separate groups (also called a between-subjects design)

Independent Samples



Independent samples *t*-test



Brain Games S04E01: Compassion
Link here

Group Activity

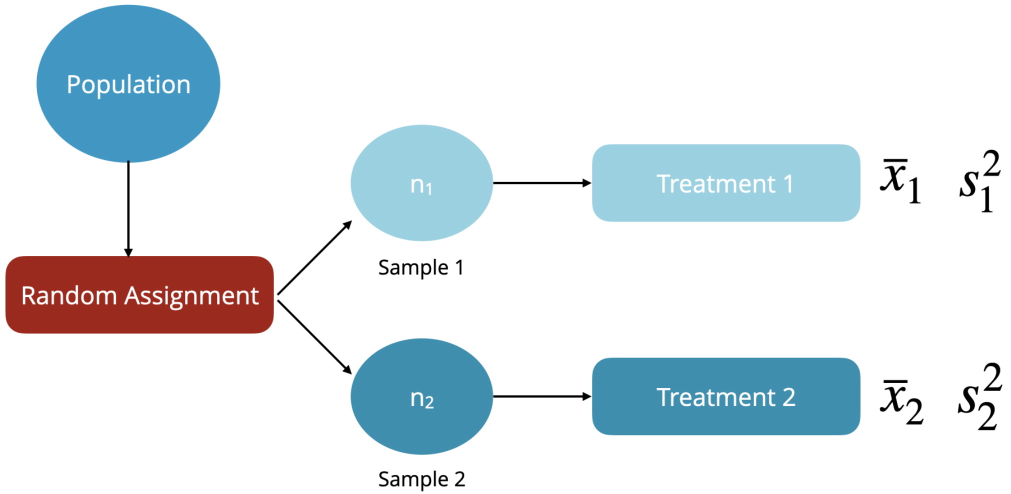
For the 1st experiment:

What was the independent variable?

What was the dependent variable?

What is the null hypothesis?

What is the alternative hypothesis?



Group Activity

Independent variable

- Hallway bump (absent, present)
  - $\bar{x}_1 = \bar{x}_{absent}$
  - $\bar{x}_2 = \bar{x}_{present}$

Dependent variable

- Compassion: Type and amount of hot sauce (Mild, Medium, Death)

Null Hypothesis H_0

$\bar{x}_1 = \bar{x}_2$

Compassion is not different for people who are bumped in the hallway compared to those who are not bumped in the hallway

Alternative Hypothesis H_a

$\bar{x}_1 \neq \bar{x}_2$

Compassion is different for people who are bumped in the hallway compared to those who are not bumped in the hallway

t-test statistic

General form of t-test statistics

$$t = \frac{sample\ statistic\ - population\ parameter}{estimated\ standard\ error\ of statistic}$$

Three types we'll learn:

- One sample *t*-test
- **Independent samples *t*-test**
- Dependent samples *t*-test

Building the t-test statistic

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - population\ parameter}{estimated\ standard\ error\ of\ statistic}$$

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - (\mu_1 - \mu_2)}{estimated\ standard\ error\ of\ statistic}$$

Building the t-test statistic

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - (\mu_1 - \mu_2)}{estimated\ standard\ error\ of\ statistic}$$

Null Hypothesis H_0: $\mu_1 = \mu_2$

Equivalently, if H_0 is true, $\mu_1 - \mu_2 = 0$

In other words, under the null hypothesis, the population means for these two groups will be equal to one another, meaning this new term ($\mu_1 - \mu_2$) will cancel out

Building the t-test statistic

$$t = \frac{(\overline{x}_1 - \overline{x}_2)}{estimated\ standard\ error\ of\ statistic}$$

$$t = \frac{(\overline{x}_1 - \overline{x}_2)}{estimated\ standard\ error\ of\ the\ mean\ difference}$$

Independent samples t-test

Independent samples *t*-test

$$t_{(\overline{x}_1 - \overline{x}_2)} = \frac{\overline{x}_1 - \overline{x}_2}{s_{(\overline{x}_1 - \overline{x}_2)}}$$

Note that to use this test, we must assume that the variance in the population for our groups is equal (called the **homogeneity of variance** assumption).

- If we think the two treatments would differentially affect the spread of the data in the population, we would need to use a different version of this test.

Independent samples *t*-test

Estimated standard error of the mean difference

$$s_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}\right]\left[\frac{n_1 + n_2}{n_1 n_2}\right]}$$

$\bar{x}_1$ is the mean for Sample 1

$\bar{x}_2$ is the mean for Sample 2

s_1^2 is the variance of Sample 1

s_2^2 is the variance of Sample 2

n_1 is the number of subjects in Sample 1
n_2 is the number of subjects in Sample 2

Independent samples *t*-test

Independent samples *t*-test

$$t_{(\bar{x}_1 - \bar{x}_2)} = \frac{\overline{x}_1 - \overline{x}_2}{s_{(\bar{x}_1 - \bar{x}_2)}}$$

Estimated standard error of the mean difference

$$s_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}\right]\left[\frac{n_1 + n_2}{n_1 n_2}\right]}$$

Practice Activity

No hallway bump

$n_1 = 10$

$\bar{x}_1 = 5.5$

$s_1^2 = 2.5$

Hallway bump

$n_2 = 10$

$\bar{x}_2 = 8.5$

$s_2^2 = 3$

Independent samples *t*-test

$$t_{(\bar{x}_1 - \bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{s_{(\bar{x}_1 - \bar{x}_2)}}$$

Estimated standard error of the mean difference

$$s_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}\right]\left[\frac{n_1 + n_2}{n_1 n_2}\right]}$$

Estimated standard error of the mean difference

$$s_{(\bar{x}_1-\bar{x}_2)} = \sqrt{\left[\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}\right]\left[\frac{n_1+n_2}{n_1 n_2}\right]}$$

$$s_{(\bar{x}_1-\bar{x}_2)} = \sqrt{\left[\frac{(10-1)2.5+(10-1)3}{10+10-2}\right]\left[\frac{10+10}{(10)(10)}\right]}$$

$$s_{(\bar{x}_1-\bar{x}_2)} = \sqrt{\left[\frac{(9)2.5+(9)3}{18}\right]\left[\frac{20}{100}\right]}$$

Estimated standard error of the mean difference

$$s_{(\bar{x}_1-\bar{x}_2)} = \sqrt{\left[\frac{22.5+27}{18}\right]\left[\frac{20}{100}\right]}$$

$$s_{(\bar{x}_1-\bar{x}_2)} = \sqrt{\left[2.75\right]\left[0.20\right]} = .7416$$

$$s_{(\bar{x}_1-\bar{x}_2)} = .74$$

Independent samples *t*-test statistic

$$t_{(\bar{x}_1 - \bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{s_{(\bar{x}_1 - \bar{x}_2)}}$$

$$t_{(\bar{x}_1 - \bar{x}_2)} = \frac{5.5 - 8.5}{0.74}$$

$$t_{(\bar{x}_1 - \bar{x}_2)} = -4.054$$

Independent samples *t*-test: Interpretation

Null Hypothesis H_0: $\mu_1 = \mu_2$

There is no difference in compassion for people who are bumped compared to not bumped in the hallway.

Alternative Hypothesis H_a: $\mu_1 \neq \mu_2$

There is a difference in compassion for people who are bumped compared to not bumped in the hallway.

Independent samples *t*-test: Interpretation

No hallway bump

$n_1 = 10$

$\bar{x}_1 = 5.5$

$s_1^2 = 2.5$

Hallway bump

$n_2 = 10$

$\bar{x}_2 = 8.5$

$s_2^2 = 3$

$t_{\bar{x}_1 - \bar{x}_2} = -4.054$

$p = 0.0008$

$\alpha = .05$

$p < \alpha$

We reject the null hypothesis. People who are bumped in the hallway are less compassionate than people who are not bumped in the hallway.

Effect Size for Independent Samples *t*-test

Effect size: independent samples *t*-test

Cohen's *d* for independent samples *t*-test

$$d_{(\bar{x}_1 - \bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{s_p}$$

Pooled standard deviation

$$s_p = \sqrt{\frac{s_1^2 + s_2^2}{2}}$$

Calculating Effect Size

$$d_{(\bar{x}_1-\bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2+s_2^2}{2}}}$$

$$d_{(\bar{x}_1-\bar{x}_2)} = \frac{5.5 - 8.5}{\sqrt{\frac{2.5+3}{2}}}$$

$$d_{(\bar{x}_1-\bar{x}_2)} = \frac{-3}{\sqrt{2.75}} = \frac{-3}{1.658312} = -1.809068$$

Independent samples *t*-test in JASP

Example Experiment

Research question: Does exercising in a group (e.g., group classes) affect anxiety compared to solo exercise (i.e., working out alone)?

Null hypothesis H_0

$\mu_1 = \mu_2$

$\mu_{classes} = \mu_{solo}$

There is no difference in anxiety levels when taking a group class compared to exercising alone

Alternative hypothesis H_a

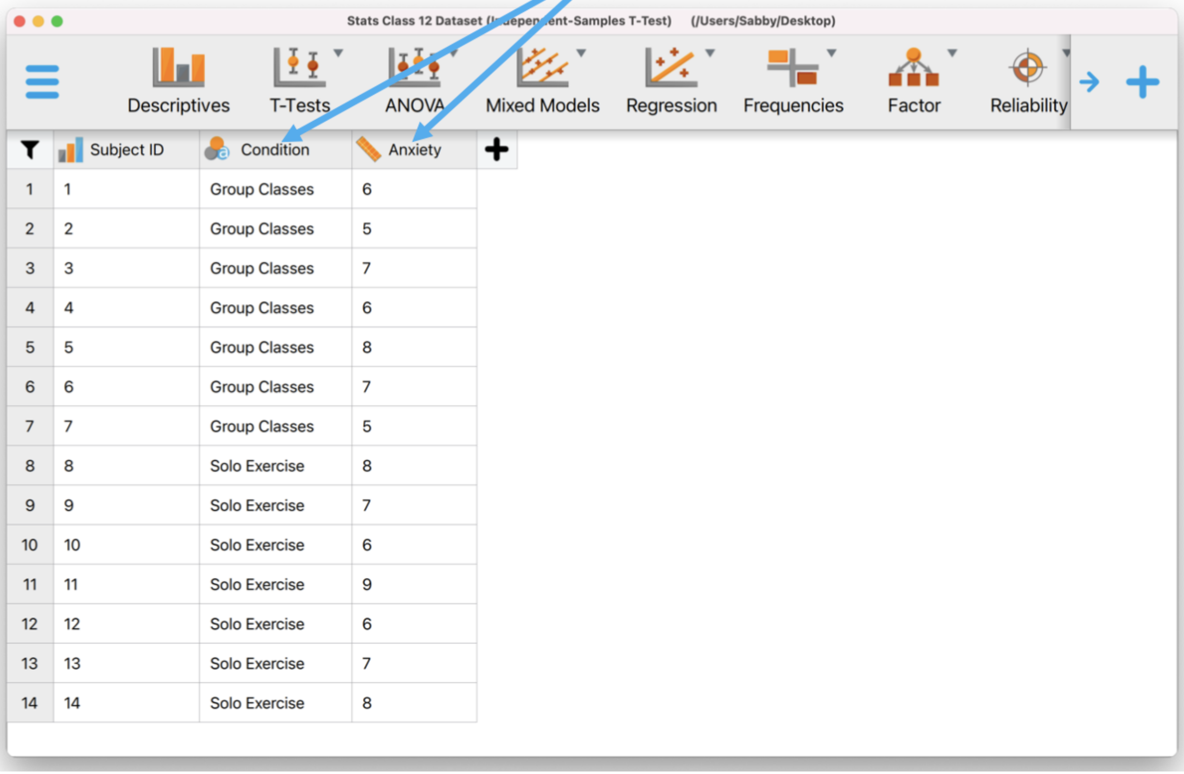
$\mu_{classes} \neq \mu_{solo}$

$\mu_1 \neq \mu_2$

There is a difference in anxiety levels when taking a group class compared to exercising alone

JASP

Notice that participants are now organized in rows, giving us one variable for Anxiety and one for Condition.

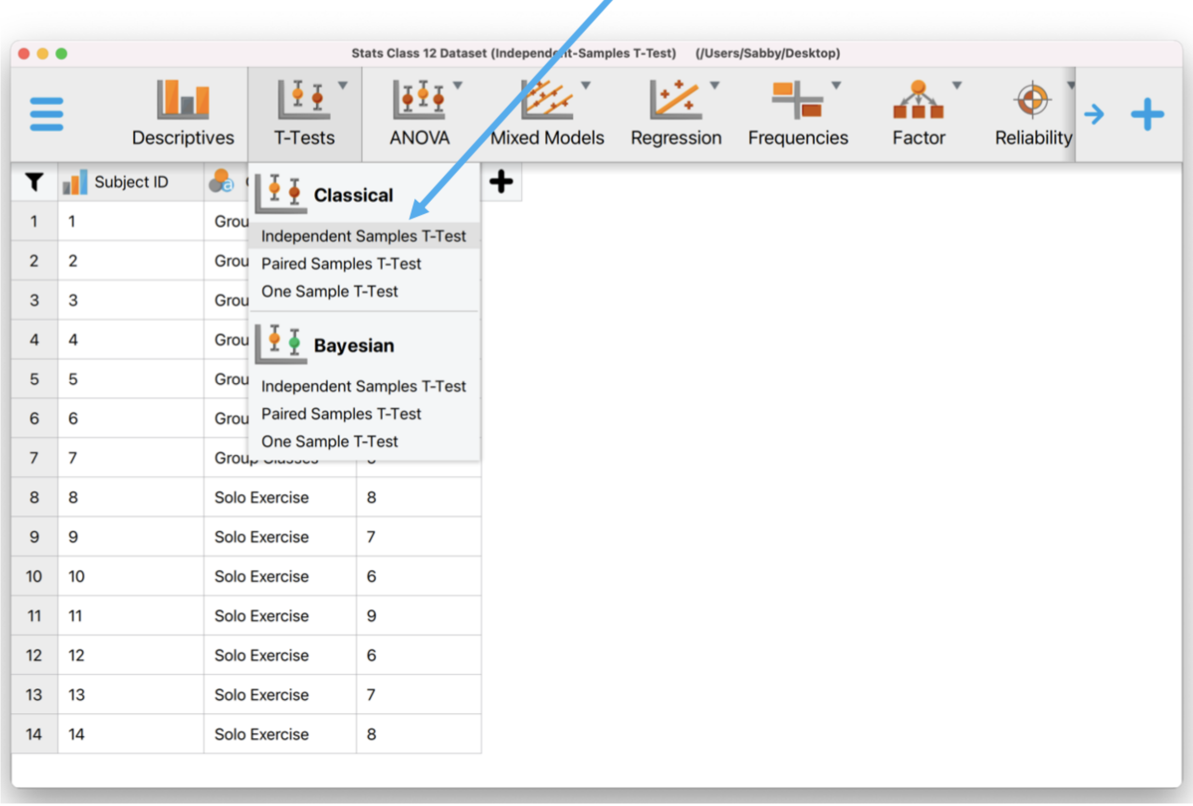


	Subject ID	Condition	Anxiety
1	1	Group Classes	6
2	2	Group Classes	5
3	3	Group Classes	7
4	4	Group Classes	6
5	5	Group Classes	8
6	6	Group Classes	7
7	7	Group Classes	5
8	8	Solo Exercise	8
9	9	Solo Exercise	7
10	10	Solo Exercise	6
11	11	Solo Exercise	9
12	12	Solo Exercise	6
13	13	Solo Exercise	7
14	14	Solo Exercise	8

1

JASP

Begin by clicking on “T-Tests” and selecting the “Independent Samples T-Test”



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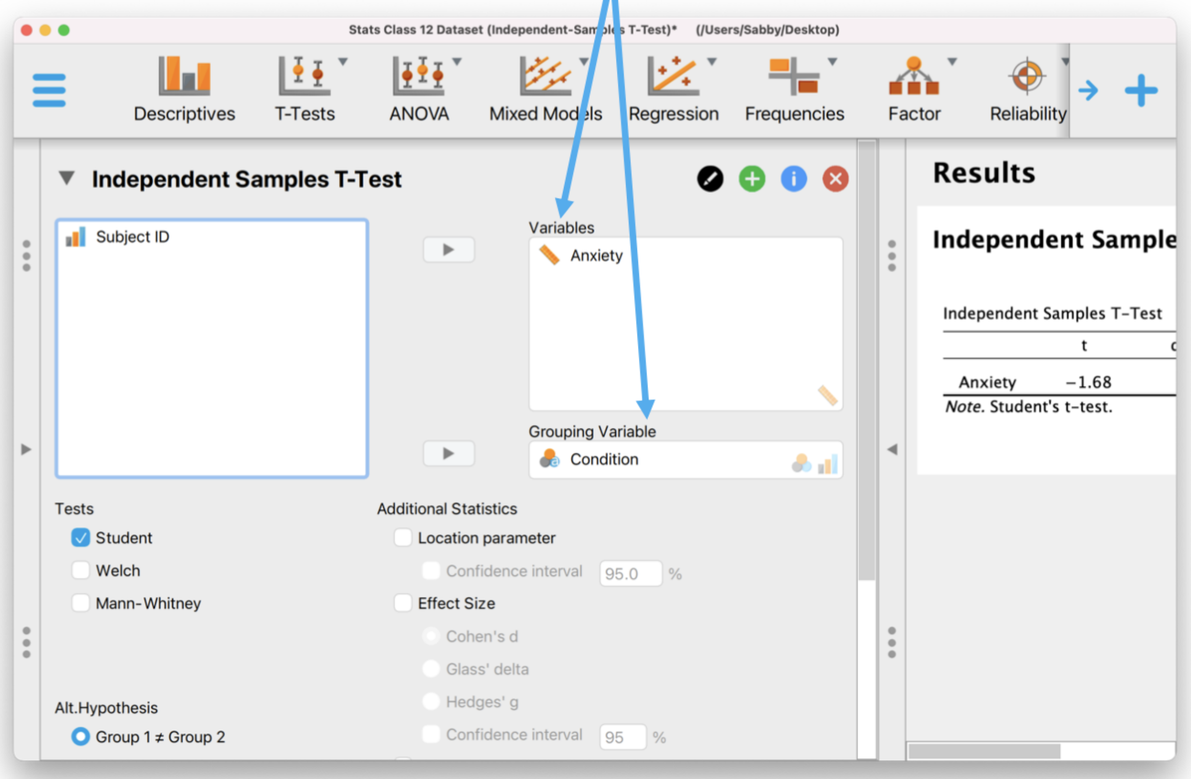
JASP

Put Anxiety (our y variable) in the "Variables" box and Condition (our x variable) in the "Grouping Variable" box



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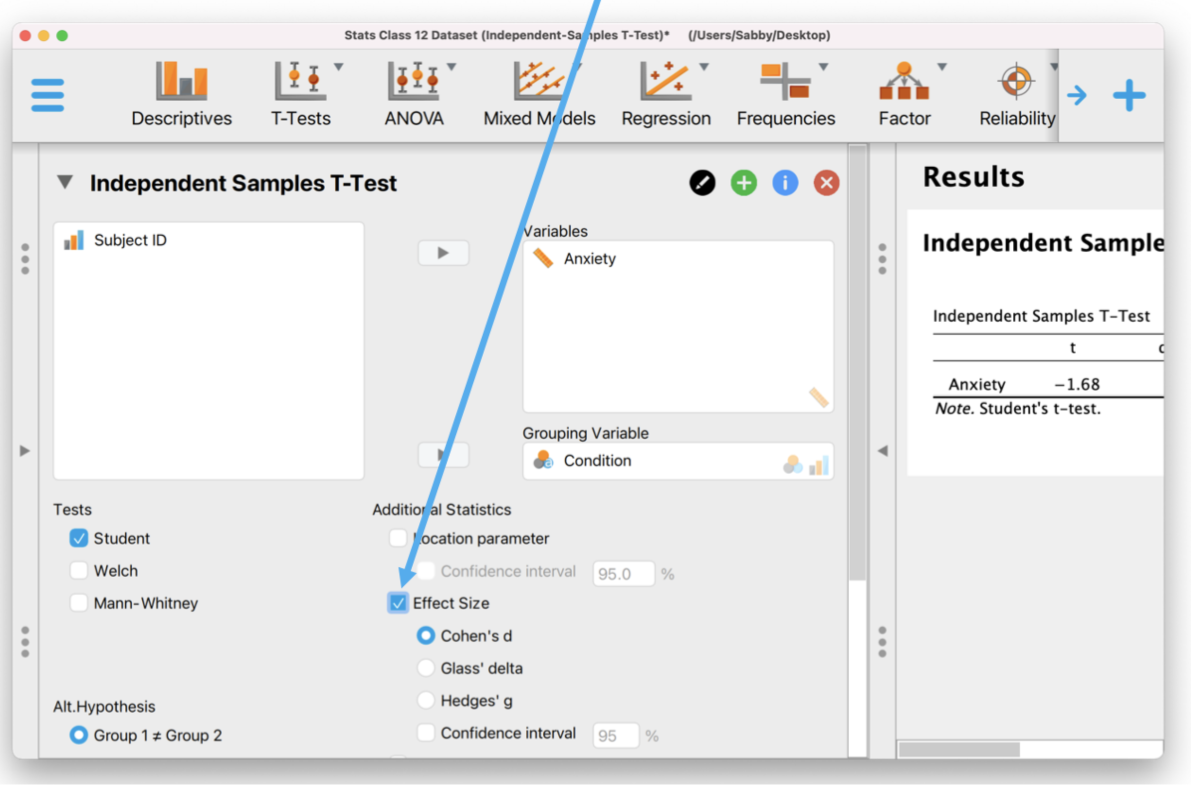
JASP

Finally, select “Effect Size” (set by default to Cohen’s d) to get the effect size for the independent-samples t-test



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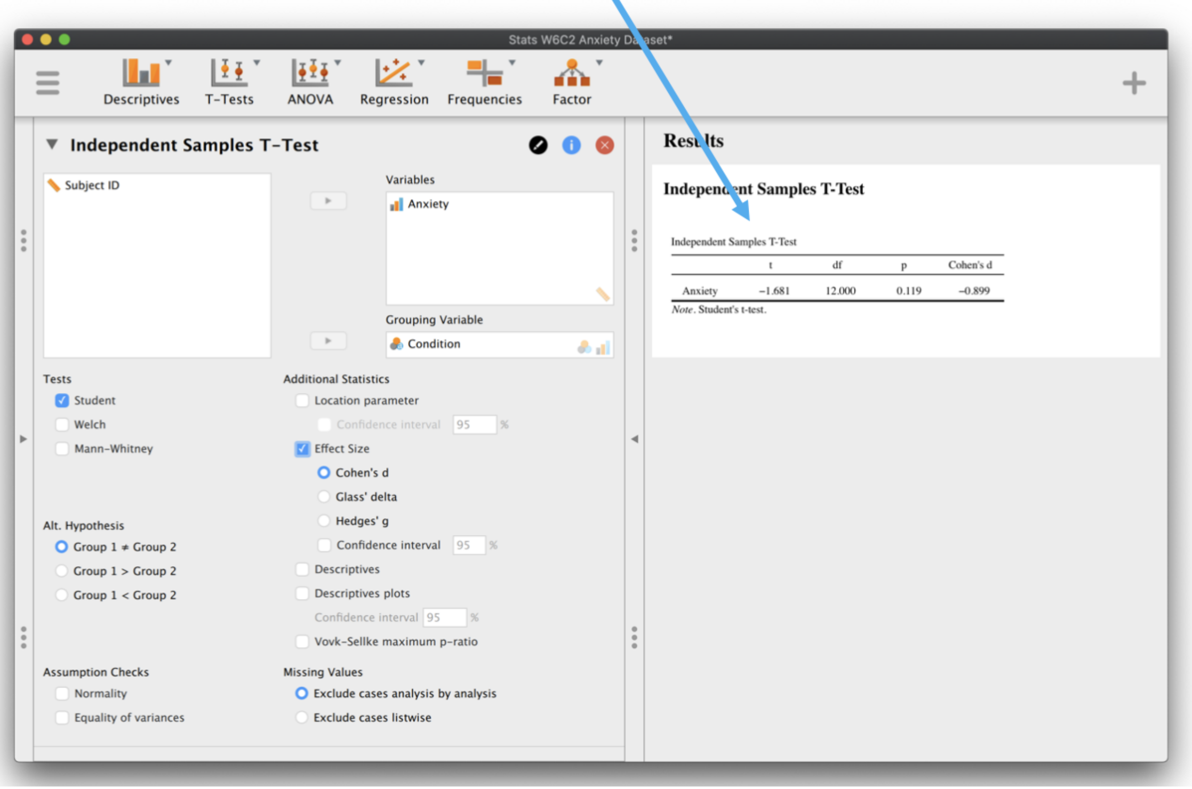
JASP

JASP now gives you the independent-samples t-test statistic, the *p*-value for this test, and the effect size. That's it! ☺



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Next time

Lecture

- Differences between two groups II

Reading

- Ch.11

Quiz 3

- Due tonight 2/9/22 11:59pm MT (Ch.9, 10)