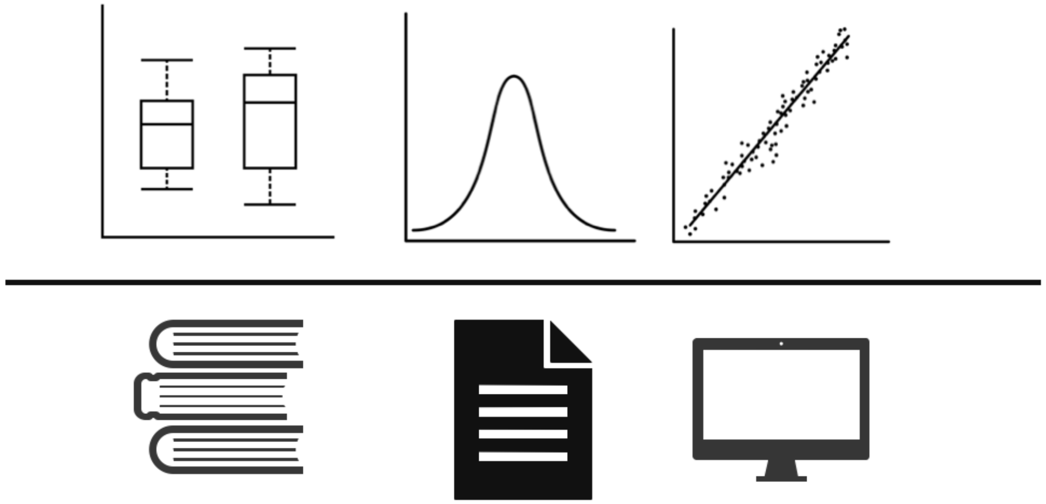
PSYC 2300

Introduction to Statistics



Lecture 11: Differences Between Two Groups (Part II)

Outline for today

- Review parts of last class
- The Dependent samples *t*-test
- Effect size for the Dependent samples *t*-test
- Dependent Samples *t*-tests in JASP
  - Download `Stats Class 13 Dataset (Dependent-Samples T-Test).jasp`

Review

Review: One-sample *t*-test

One-sample *t*-test statistic

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

Estimated standard error

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

- Used when we **don't know the true standard deviation** in the population
- We can use the estimated standard error, $s_{\bar{x}}$, in place of the true standard error, $\sigma_{\bar{x}}$

Review: one sample *t*-test

As the name implies, we have ***one* sample** to compare to the population mean under the null hypothesis, H_0. For example:

Does lie detection accuracy differ significantly from chance?

- We collect $n = 40$ students, they watch videos of liars and truth-tellers, and we compute their accuracy performance as $\bar{x} = 0.56$ and $s = 0.12$
  - The null hypothesis is $H_0 : \mu = 0.50$ which would represent chance performance
  - The alternative hypothesis is $H_a : \mu \neq 0.50$

One sample *t*-test: $t_{\bar{x}} = \frac{0.56 - 0.50}{\frac{0.12}{\sqrt{40}}} = \frac{0.06}{.01897367} = 3.16$

$p = .0003 < \alpha$ so we reject the null hypothesis

Review: Independent samples *t*-test

Used when we have two independent samples

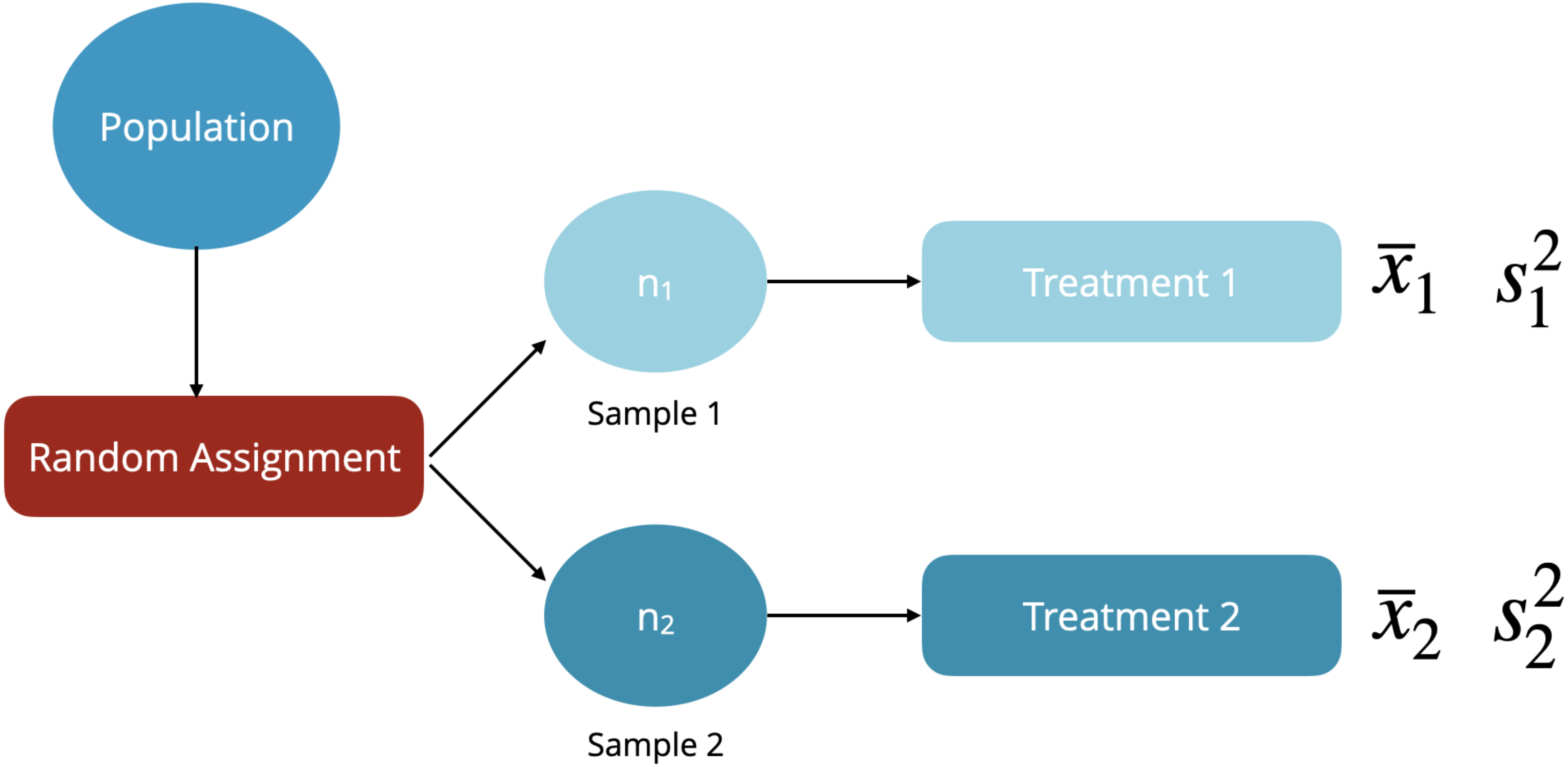
Independent samples *t*-test

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

Estimated standard error of the mean difference

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

Independent Samples



Review: Independent samples *t*-test

As the name implies, we have ***independent* samples**, specifically two samples, to compare to their respective populations.

Does getting bumped (vs. not getting bumped) in the hallway decrease compassion?

No hallway bump

$$n_1 = 10$$

$$\bar{x}_1 = 5.5$$

$$s_1^2 = 2.5$$

Hallway bump

$$n_2 = 10$$

$$\bar{x}_2 = 8.5$$

$$s_2^2 = 3$$

$$H_0 : \mu_1 = \mu_2$$
$$H_a : \mu_1 \neq \mu_2$$

$$t_{(\bar{x}_1 - \bar{x}_2)} = \frac{5.5 - 8.5}{0.74} = -4.054$$

$$p = 0.0008 < \alpha$$

Reject the null hypothesis

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**

Dependent samples *t*-test

Independent vs. Dependent

- **Independent-samples** (called *between-subjects*) compare two *different* or unrelated groups of people
- **Dependent-samples** (called *within-subjects*) compare the *same* group of people to themselves

Put another way:

- A *t*-test for independent means indicates that two groups of different participants are being studied under two separate conditions
- A *t*-test for dependent means indicates that a single group of the same participants is being studied under two conditions

Goal: Dependent samples *t*-test

- To investigate whether some treatment made an effect compared to a baseline within the same individual(s)
- The dependent-samples *t*-test asks whether the mean difference between each subject's pair of observed values is significantly different from 0

Put another way:

- Did *pre-treatment* scores differ from *post-treatment* scores?

Example Experiment

Research question

Does watching a TED Talk by Carol Dweck affect students' perceived self-efficacy?

Self-efficacy is an individual's belief or confidence in their ability to achieve goals

Example Experiment

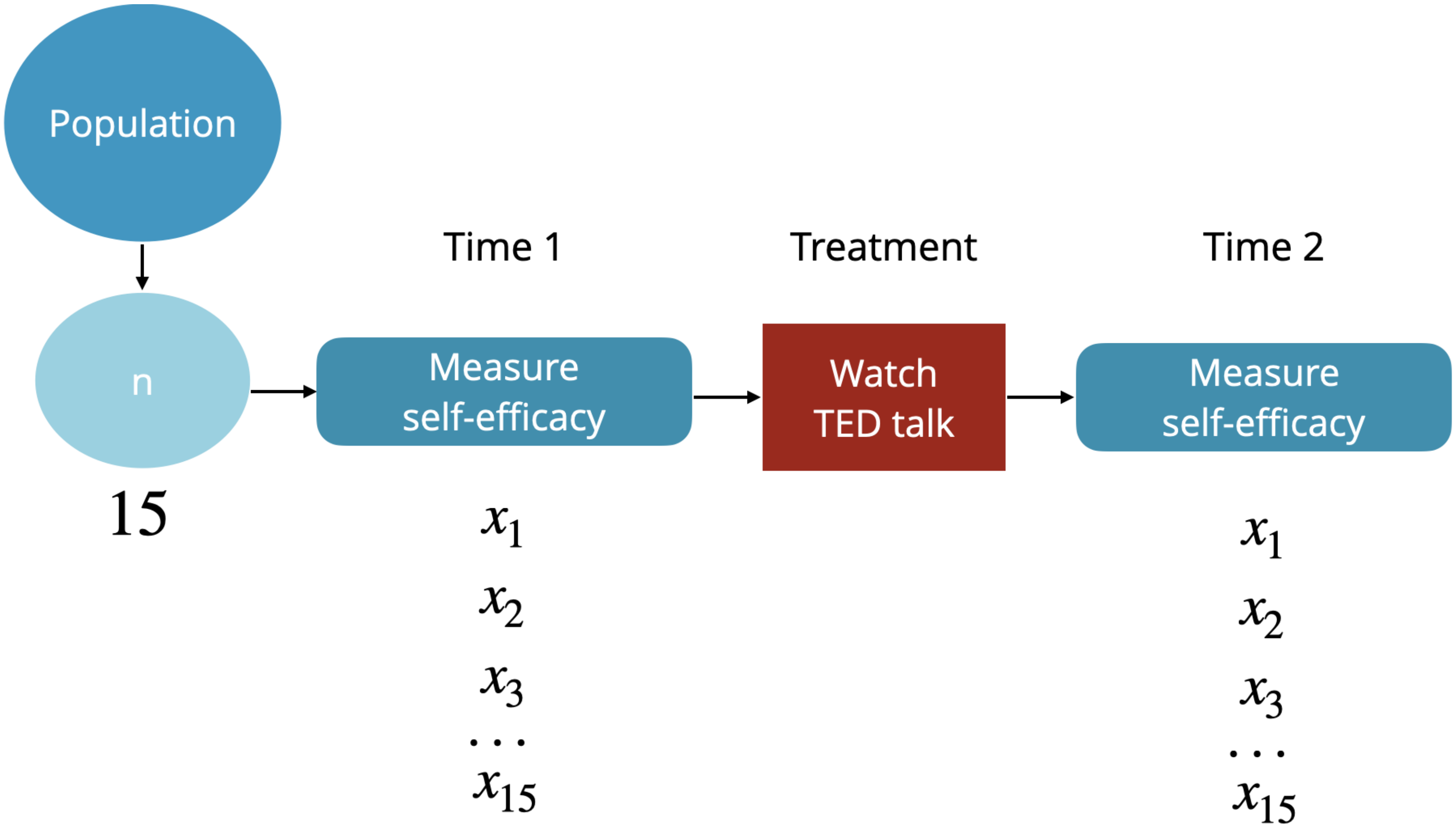
Self-Efficacy Scale

"Please rate the following on a scale of 1 (strongly disagree) to 14 (strongly agree)"

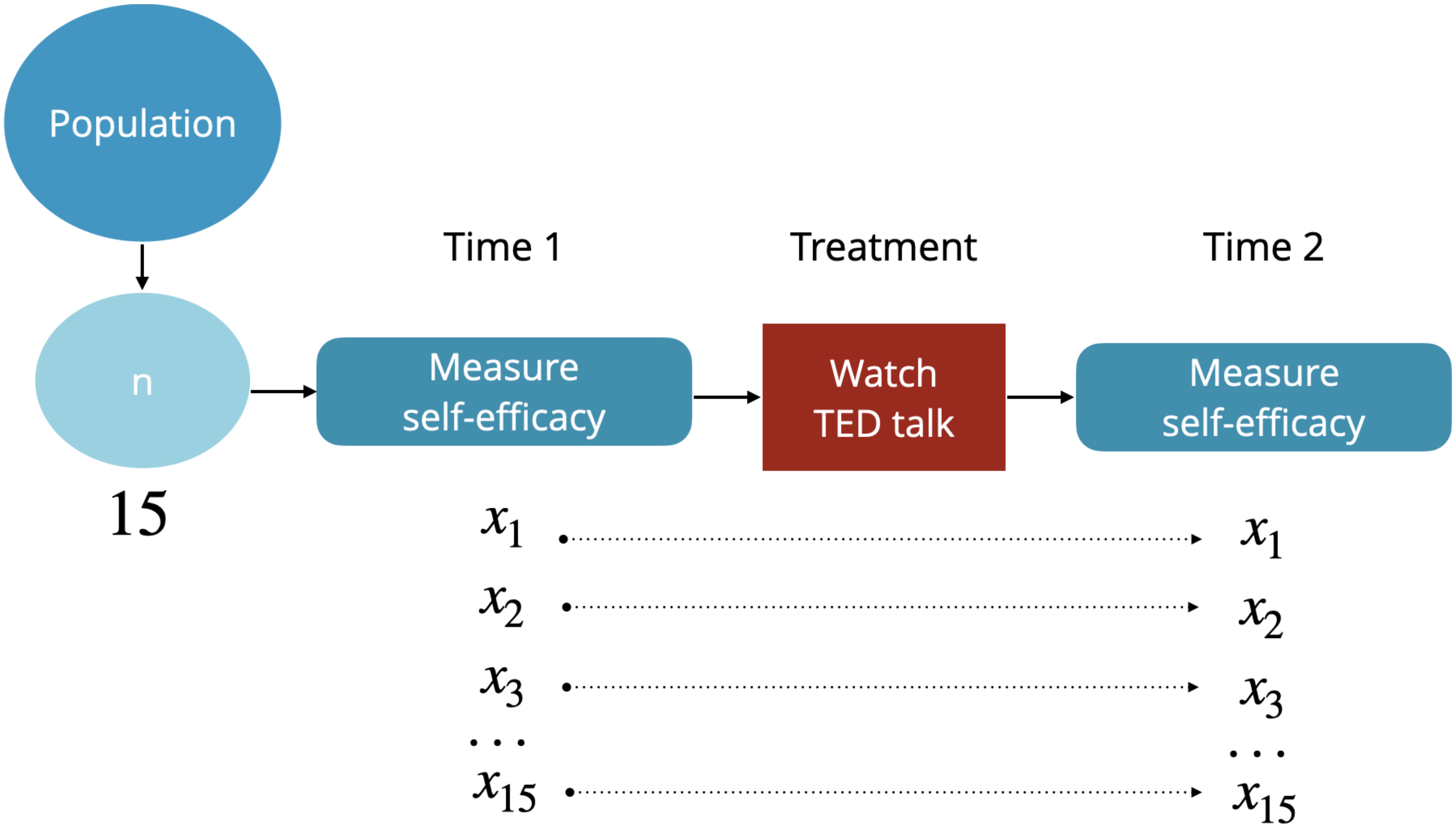
1. If I can’t do a job the first time, I keep trying until I can.
2. When I have something unpleasant to do, I stick to it until I finish it.
3. Failure just makes me try harder.
4. I am a self-reliant person.

Sherer et al. (1982)

Within-subjects designs



Within-subjects designs



Within-subjects designs

Time 1		Time 2		
Baseline self-efficacy		Post-treatment self-efficacy		Difference score
x_1	$-$	x_1	$=$	x_{d_1}

$$\begin{array}{cc} x_2 & x_2 \\ x_3 & x_3 \\ \cdots & \cdots \\ x_{15} & x_{15} \end{array}$$

Within-subjects designs

Time 1		Time 2		
Baseline self-efficacy		Post-treatment self-efficacy		Difference score
x_1	$-$	x_1	$=$	x_{d_1}
x_2	$-$	x_2	$=$	x_{d_2}

x_3 x_3

$\dots$ $\dots$

x_{15} x_{15}

Within-subjects designs

Time 1		Time 2		
Baseline self-efficacy		Post-treatment self-efficacy		Difference score
x_1	$-$	x_1	$=$	x_{d_1}
x_2	$-$	x_2	$=$	x_{d_2}
x_3	$-$	x_3	$=$	x_{d_3}
$\dots$	$-$	$\dots$	$=$	$\dots$
x_{15}	$-$	x_{15}	$=$	$x_{d_{15}}$

Statistical Hypotheses

Null hypothesis H_0

$$\mu_d = 0$$

There is no difference

Alternative hypothesis H_a

$$\mu_d \neq 0$$

There is a difference

Building the *t*-test statistic

General form of t-test statistics

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

Building the *t*-test statistic

General form of dependent samples t-test

$$t = \frac{sample\ difference\ score\ mean - population\ difference\ score\ mean}{estimated\ standard\ error\ of\ statistic}$$

$\bar{x}_1 - \bar{x}_2 =$ sample difference score mean

$\mu_1 - \mu_2 =$ population difference score mean

Note:
$\bar{x}_1$ is the same as $\bar{x}_{pre-treatment}$
$\bar{x}_2$ is the same as $\bar{x}_{post-treatment}$

Building our t-test statistic

General form of dependent samples t-test

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

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

$$\mu_1 - \mu_2 = \mu_d$$

Building our t-test statistic

General form of dependent samples t-test

$$t = \frac{\bar{x}_d - \mu_d}{estimated\, standard\, error\, of statistic}$$

Under the null hypothesis, H_0, $\mu_d = 0$

Building our t-test statistic

General form of dependent samples t-test

$$t = \frac{\bar{x}_d}{estimated\ standard\ error\ of statistic}$$

Dependent samples *t*-test

Dependent samples *t*-test

$$t_{\bar{x}_d} = \frac{\bar{x}_d}{s_{\bar{x}_d}}$$

$\bar{x}_d$ is the mean of the difference scores

$s_{\bar{x}_d}$ is the standard error of the mean difference

Dependent samples *t*-test

Estimated standard error of the difference scores

$$s_{\bar{x}_d} = \sqrt{\frac{s_d^2}{n}}$$

s_d^2 is the variance of the difference scores

n is the size of the sample (the number of difference scores)

Dependent samples *t*-test

Dependent samples *t*-test

$$t_{\bar{x}_d} = \frac{\bar{x}_d}{s_{\bar{x}_d}}$$

Standard error of the difference scores

$$s_{\bar{x}_d} = \sqrt{\frac{s_d^2}{n}}$$

Practice Activity

Research question: Does cognitive behavioral therapy reduce symptoms of depression?

participant	pre_treatment	post_treatment
1	5	2
2	3	3
3	6	2
4	9	4

Dependent samples *t*-test

$$t_{\bar{x}_d} = \frac{\bar{x}_d}{s_{\bar{x}_d}}$$

Standard error of the difference scores

$$s_{\bar{x}_d} = \sqrt{\frac{s_d^2}{n}}$$

Practice Activity

participant	pre_treatment	post_treatment	difference_score
1	5	2	3
2	3	3	0
3	6	2	4
4	9	4	5

$\bar{x}_d = 3$ mean of the difference scores

$s_d^2 = 4.67$ variance of the difference scores

Practice Activity

$$t_{\bar{x}_d} = \frac{\bar{x}_d}{s_{\bar{x}_d}}$$

$$t_{\bar{x}_d} = \frac{3}{\sqrt{\frac{s_d^2}{n}}}$$

$$t_{\bar{x}_d} = \frac{3}{\sqrt{\frac{4.67}{4}}} = \frac{3}{1.080509} = 2.78$$

Effect size for dependent samples *t*-test

Effect size for dependent samples *t*-test

Effect size for dependent samples *t*-test

$$d_{\bar{x}_d} = \frac{\bar{x}_d}{s_d}$$

$\bar{x}_d$ is the mean of the difference scores

s_d is the standard deviation of the difference scores (**NOT** standard error)

Dependent samples *t*-test in JASP

Example Experiment

Research question: Does watching a TED Talk by Carol Dweck affect students' perceived self-efficacy?

Null hypothesis H_0

$\mu_d = \mu_1 - \mu_2 = 0$

There is no difference

Students' perceived self-efficacy *before* watching the TED talk **will not differ** from their self-efficacy *after* watching the TED talk.

Alternative hypothesis H_a

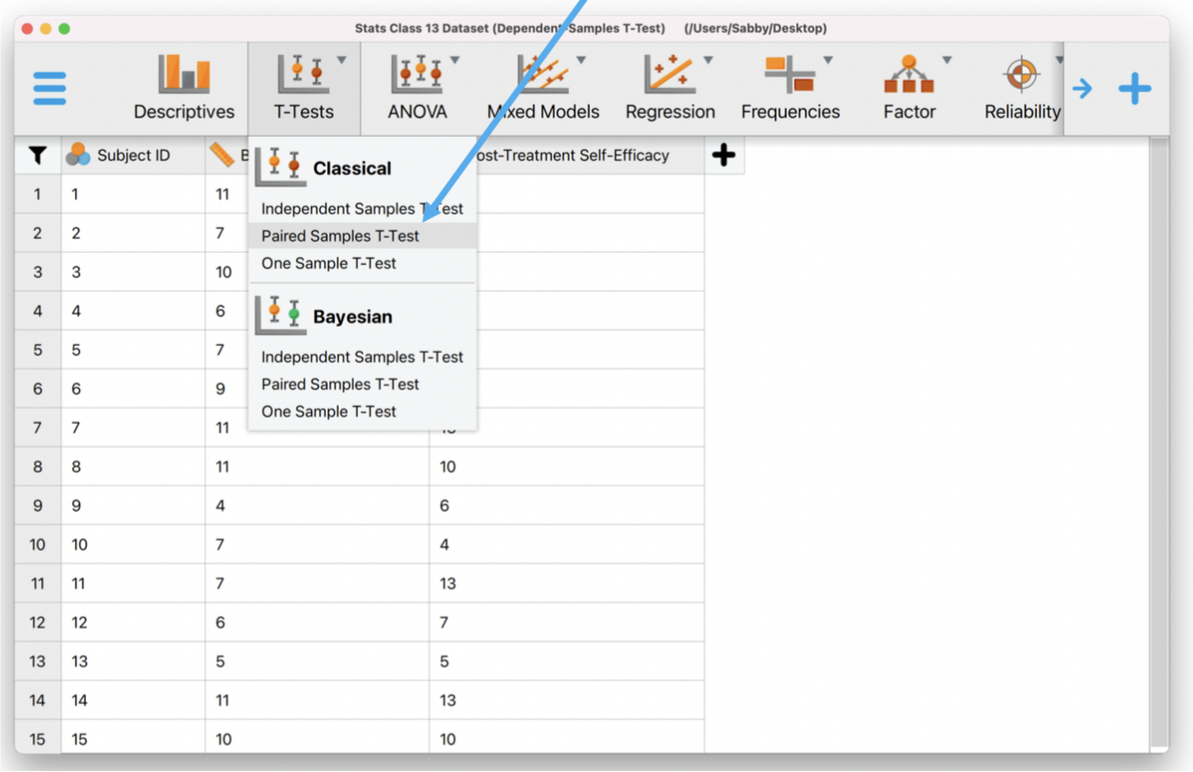
$\mu_d = \mu_1 - \mu_2 \neq 0$

There is a difference

Students' perceived self-efficacy *before* watching the TED talk **will differ** from their self-efficacy *after* watching the TED talk.

JASP: dependent samples *t*-test

The dependent-samples t-test is also called the "paired samples" t-test, so let's select that option under the "T-Tests" menu



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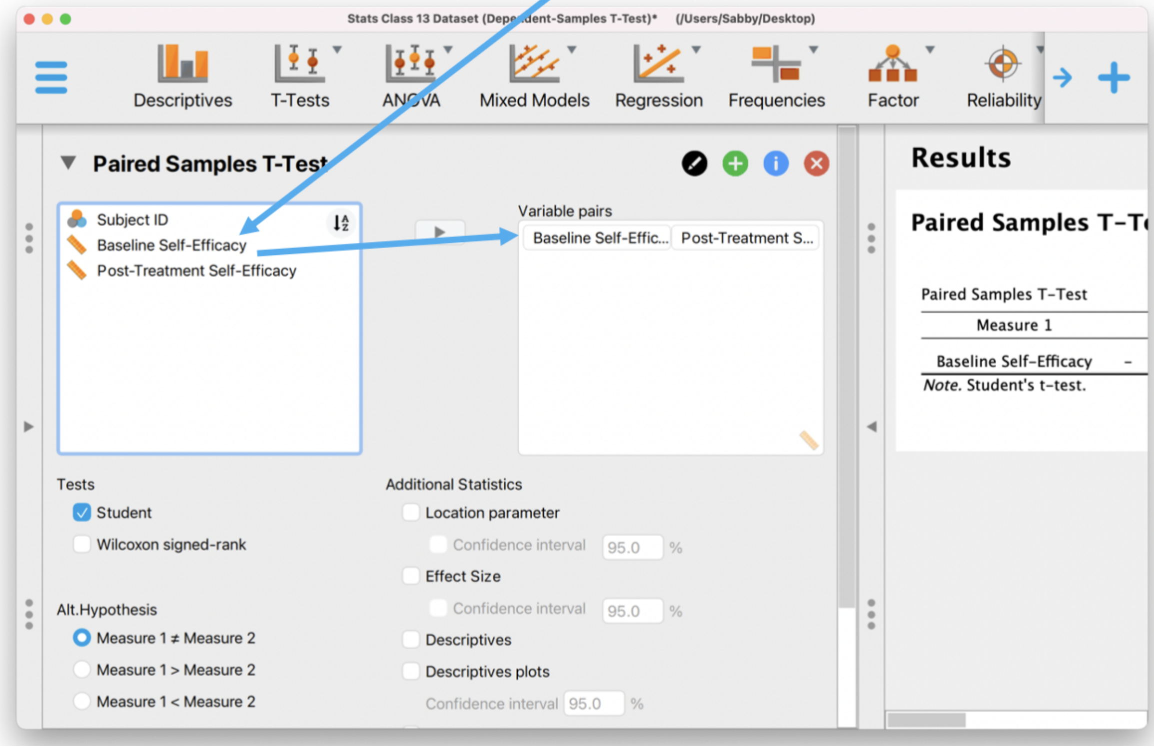
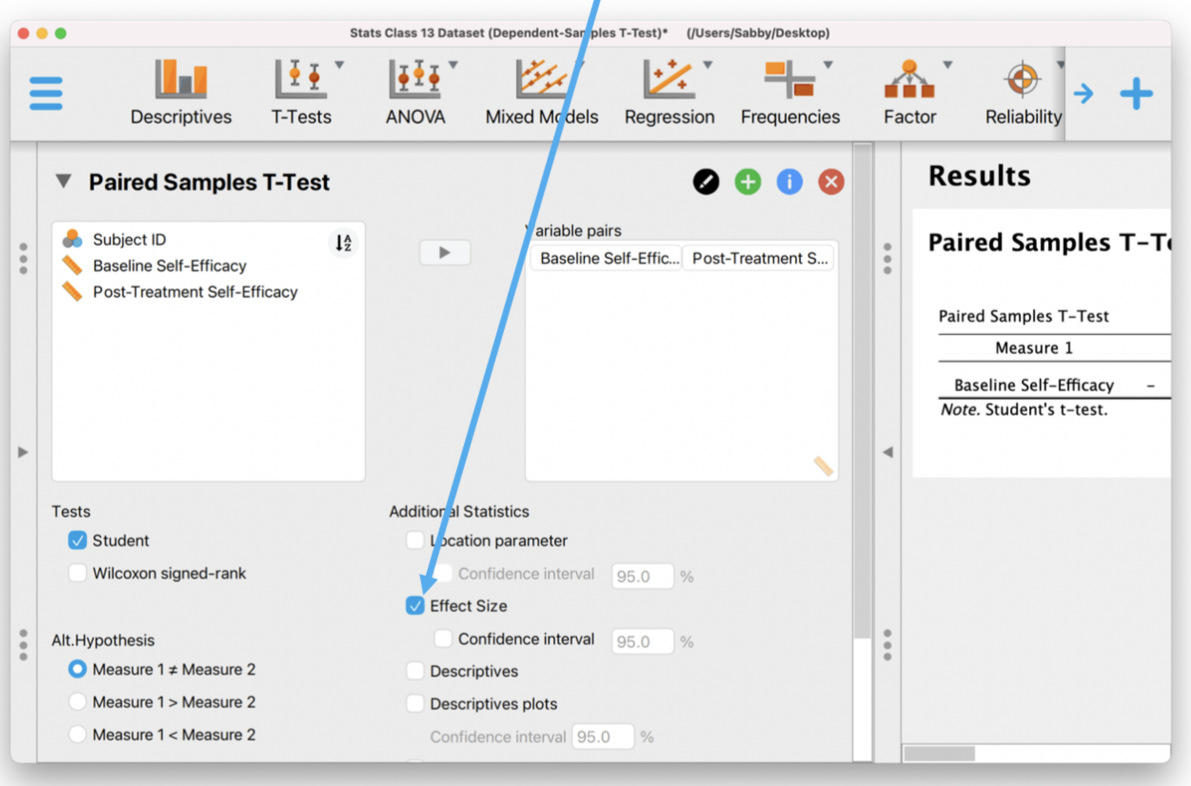
JASP: dependent samples *t*-test

Select the "before" and "after" variables into the "Variable pairs" box; JASP will automatically assume these are pairs of observed values



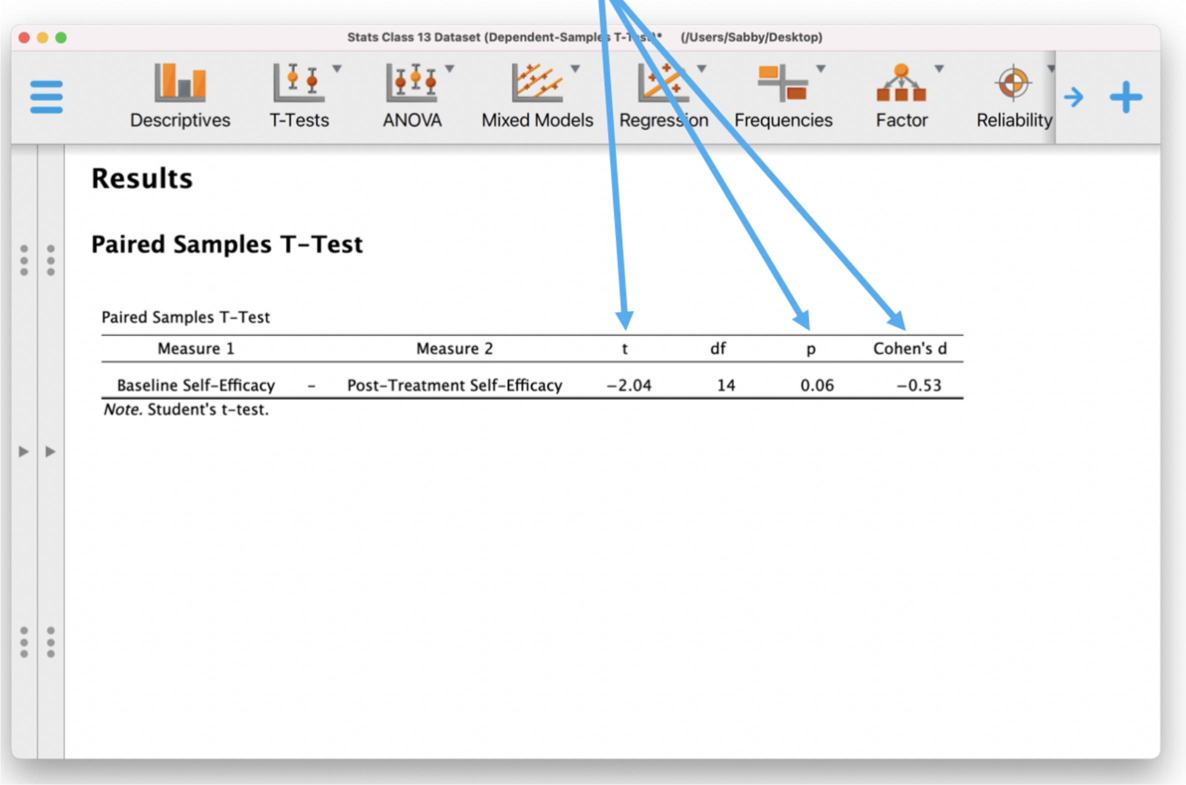
JASP: dependent samples *t*-test

Click on "Effect Size" to have JASP calculate your Cohen's *d* effect size as well.



JASP: dependent samples *t*-test

JASP gives you the dependent-samples t-test statistic, the p-value associated with this test, and the Cohen's d effect size



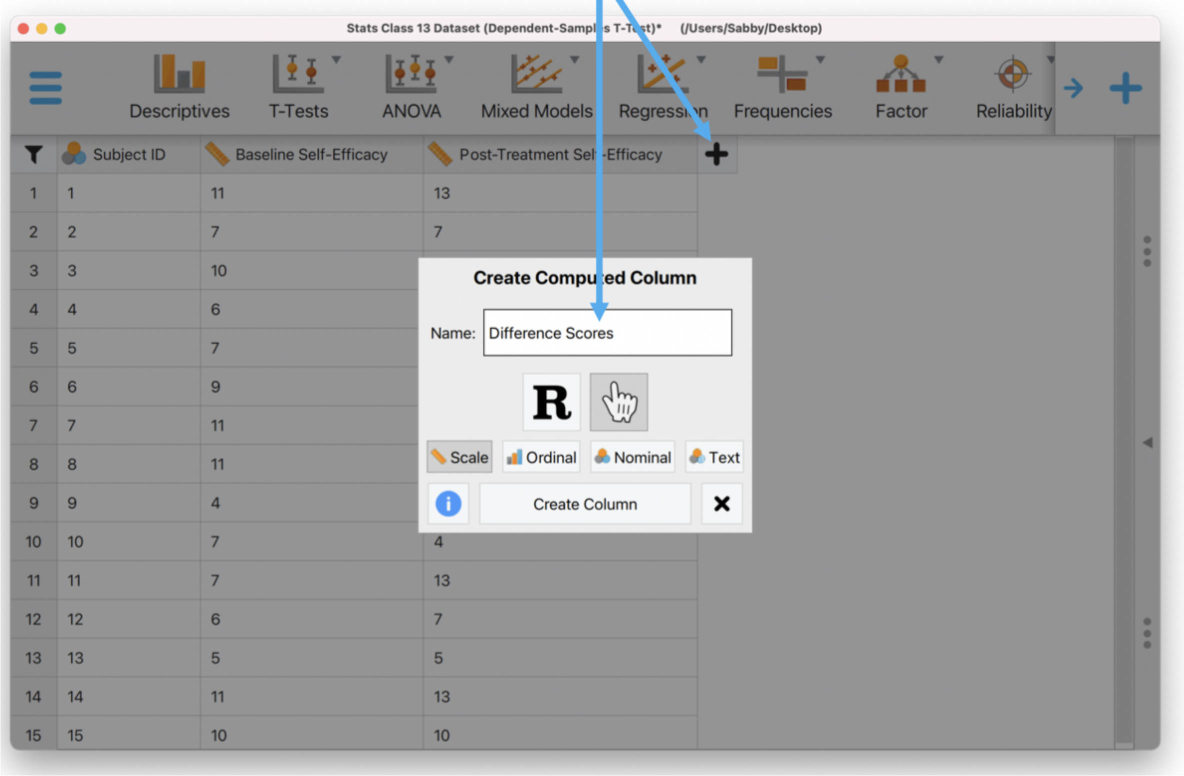
Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Cohen's d
Baseline Self-Efficacy	-	Post-Treatment Self-Efficacy	−2.04	14	0.06	−0.53

Note. Student's t-test.

JASP: dependent samples *t*-test

A dependent-samples t-test is the same as a one-sample t-test of difference scores against 0. Let's see another way to do this!



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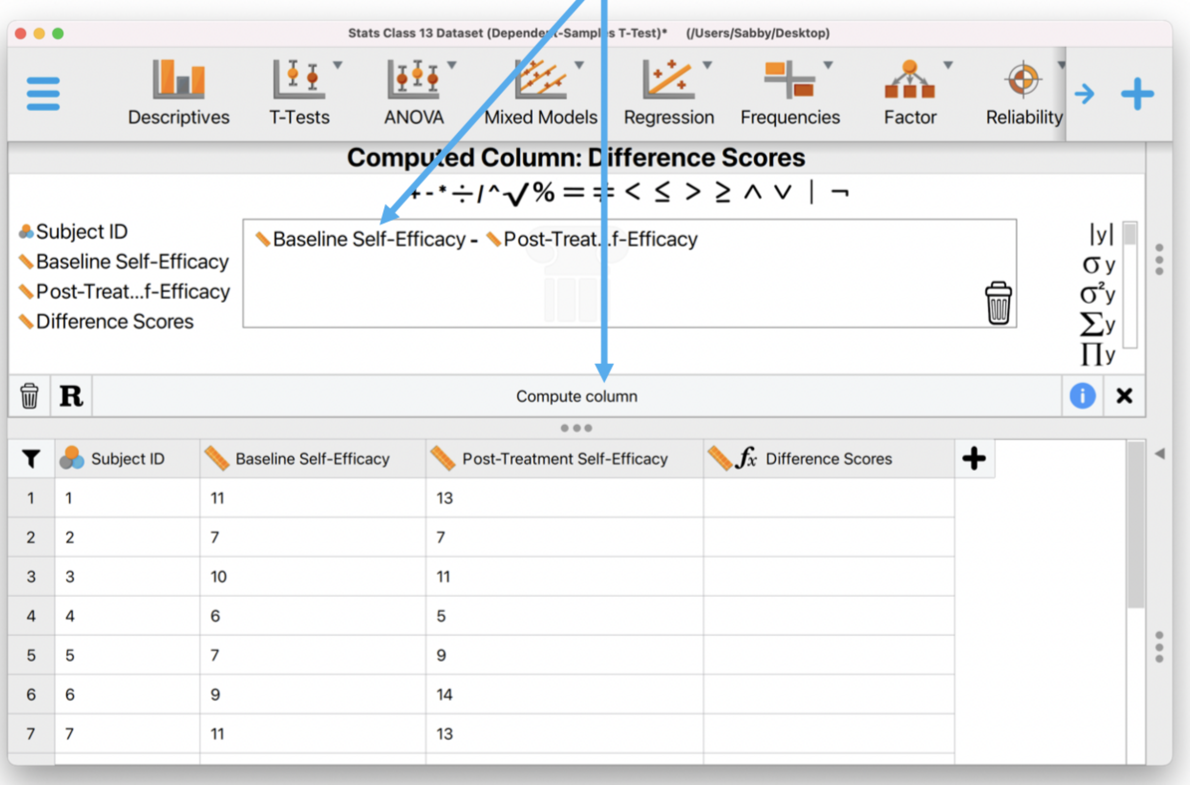
JASP: dependent samples *t*-test

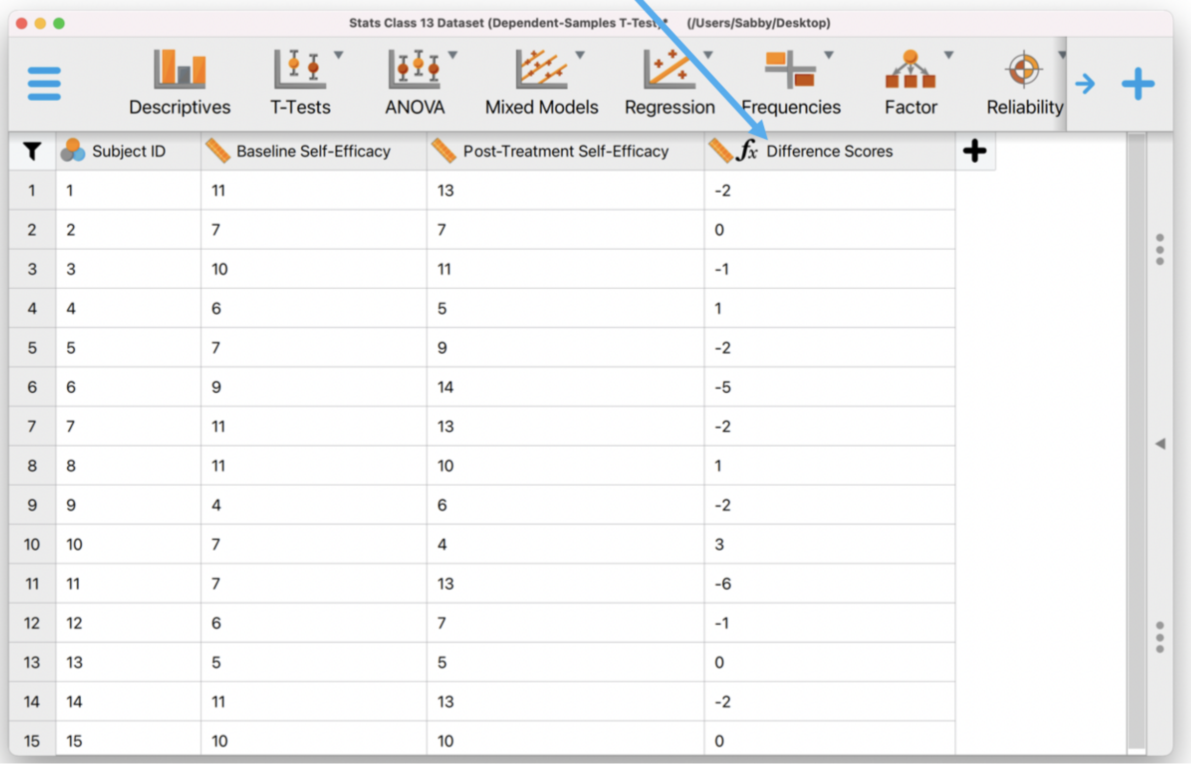
Subtract the post- and pre-scores from one another to create a “Difference Scores” variable. Then click “Compute column.”



	Subject ID	Baseline Self-Efficacy	Post-Treatment Self-Efficacy	Difference Scores
1	1	11	13	
2	2	7	7	
3	3	10	11	
4	4	6	5	
5	5	7	9	
6	6	9	14	
7	7	11	13	

JASP: dependent samples *t*-test

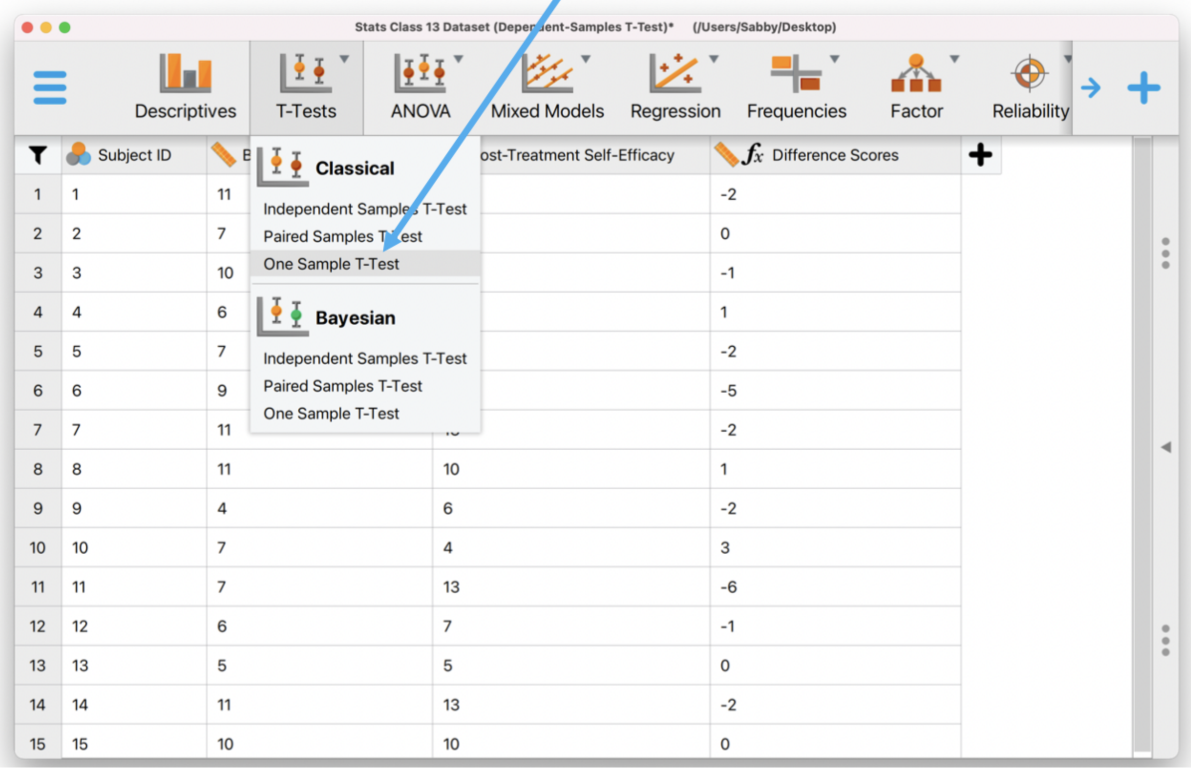
Now we have a column of Difference Scores, which we can test against 0 to see if the average difference was different from 0.



	Subject ID	Baseline Self-Efficacy	Post-Treatment Self-Efficacy	Difference Scores
1	1	11	13	-2
2	2	7	7	0
3	3	10	11	-1
4	4	6	5	1
5	5	7	9	-2
6	6	9	14	-5
7	7	11	13	-2
8	8	11	10	1
9	9	4	6	-2
10	10	7	4	3
11	11	7	13	-6
12	12	6	7	-1
13	13	5	5	0
14	14	11	13	-2
15	15	10	10	0

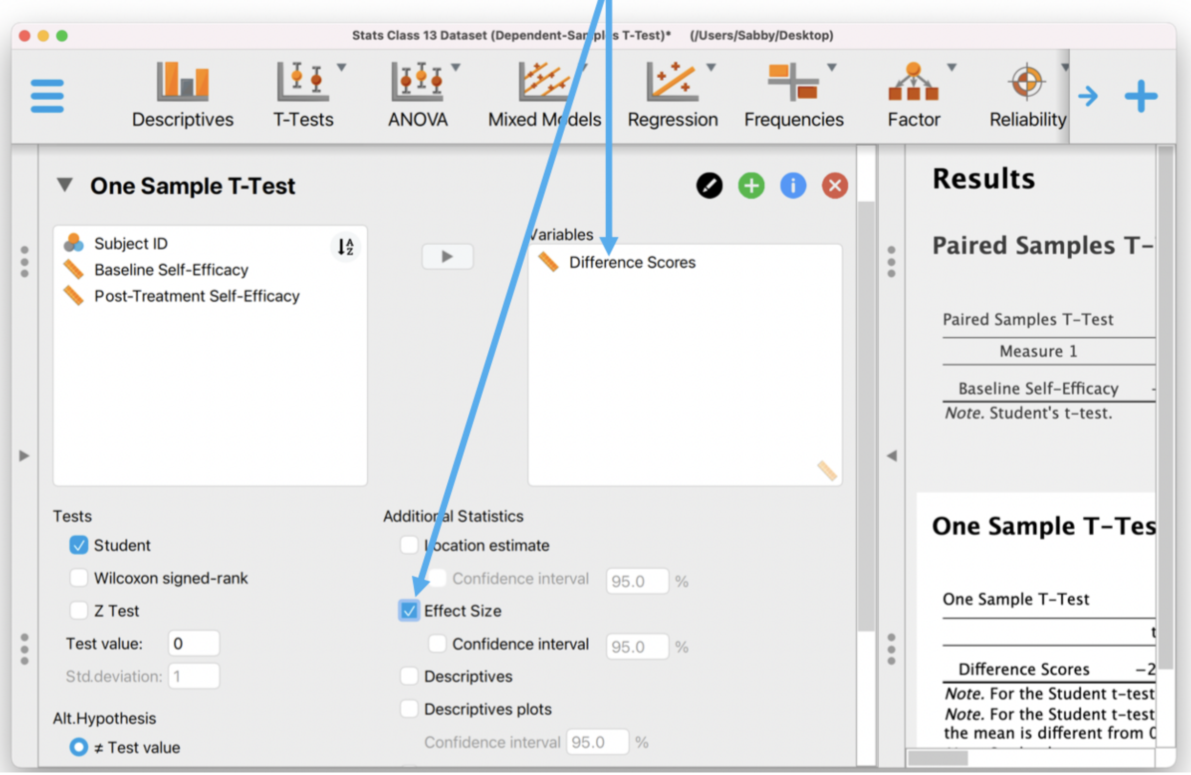
JASP: dependent samples *t*-test

Select the one-sample t-test under the “T-Tests” menu.



JASP: dependent samples *t*-test

Place the Difference Scores in the "Variables" box, and click on "Effect Size" to show the Cohen's d effect size.



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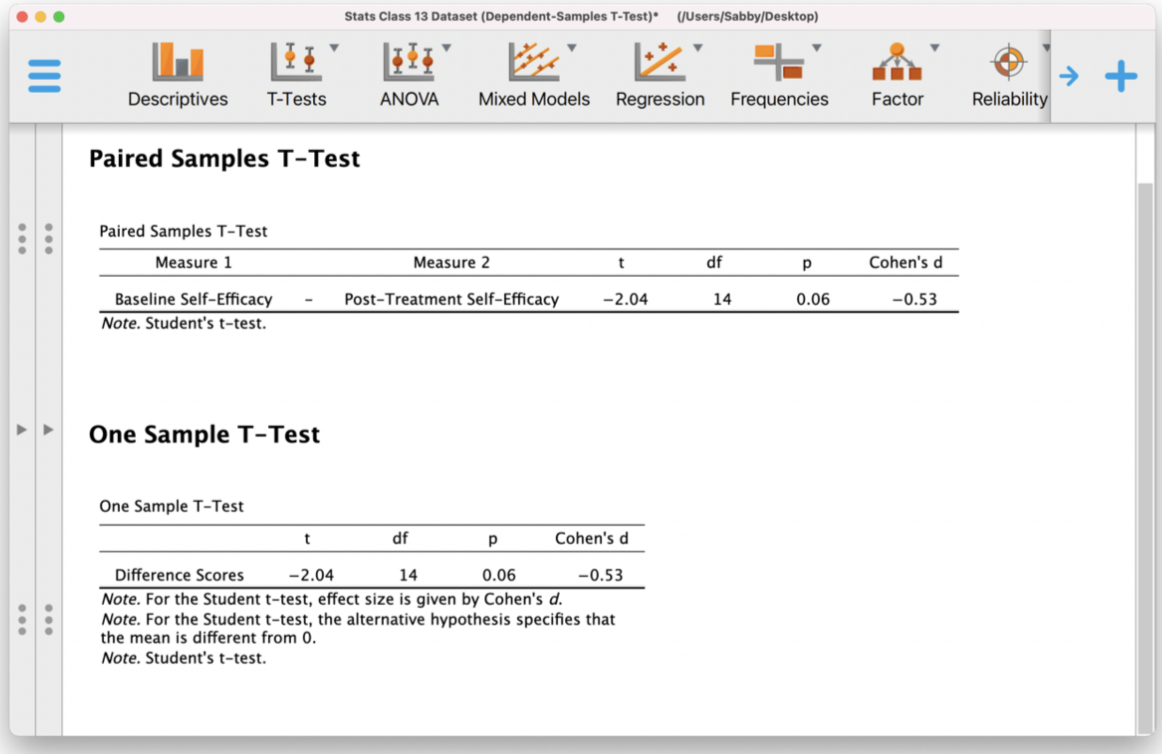
JASP: dependent samples *t*-test

Notice that the results (e.g., the t-test statistic, the p-value, and the Cohen's d effect size) are identical for the two analyses!



Next time

Lecture

- Difference between many groups

Reading

- Chapter 12

Quiz 4

- Due Wednesday 2/16/2022 11:59pm MT
  - Covers Ch.11-12