Parametric Methods

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Parametric vs. Non-Parametric

- Parametric methods. Parametric methods usually involved data expressed in absolute numbers (as opposed to ranks for example).
  - Meet the assumption of normality.
  - Parametric statistics are based on assumptions about the distribution of population from which the sample was taken.
- Non-parametric statistics are not based on assumptions, that is, the data can be collected from a sample that does not follow a specific distribution.
  - Upcoming workshop!

| INDEPENDENT VARIABLE	CATEGORICAL		DEPENDENT VARIABLE (CONTINUOUS)	
			Non-Parametric	Parametric
		1 Variable 2 Categories	Mann-Whitney U Test	Independent Samples t-test
		1 Variable 2 Categories	Wilcoxon Signed Rank Test	Paired t-test
		1 Variable > 2 Categories	Kruskal-Wallis H Test	One-Way ANOVA
		1 Variable > 2 Categories	Friedman Test	Repeated Measures
		1 Variable	Spearman rho	Pearson's r

Why `jamovi` ?

- Free and open source software.
  - Free as in freedom.
  - Open source.
- Available in the virtual desktop (one.uttyler.edu)
- Download: jamovi.com
- Resources:
  - Videos: https://www.youtube.com/c/datalabcc
  - Textbook: https://sites.google.com/brookes.ac.uk/learning-stats-with-jamovi

# Independent vs. Dependent Samples

- When testing the difference between two means, we must first determine if the samples are independent or dependent.
- Independent samples
  - Two samples are independent when the subjects selected for the first sample in no way influence how the subjects are selected for the second sample.
  - There is no relationship between the subjects in each sample
  - Undergraduates vs Graduates
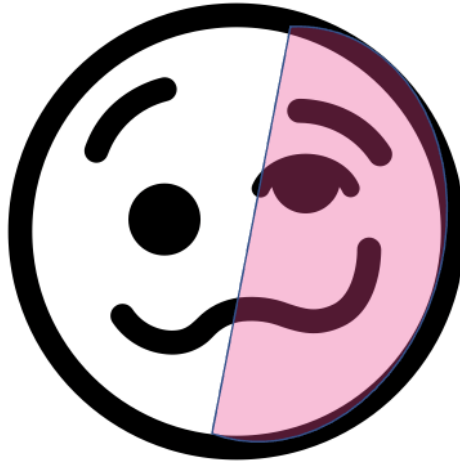 - Residents of Texas vs New Mexico

Independent Samples
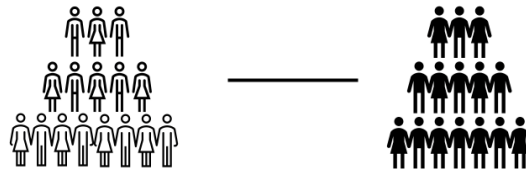
Dependent Samples

- Dependent samples
  - Each subject in one sample has a corresponding matched subject in the other sample
  - E.g., before & after, pre-test vs. post-test
  - Statistics knowledge
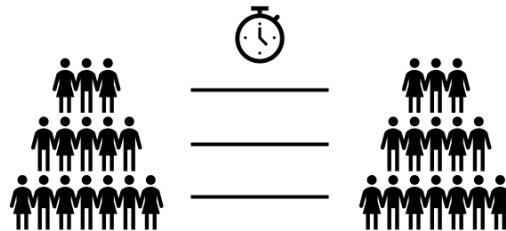
Assumptions

Normality

It is assumed that the data are normally distributed. Specifically, we assume that both groups are normally distributed. We check this with a test called Shapiro Wilk
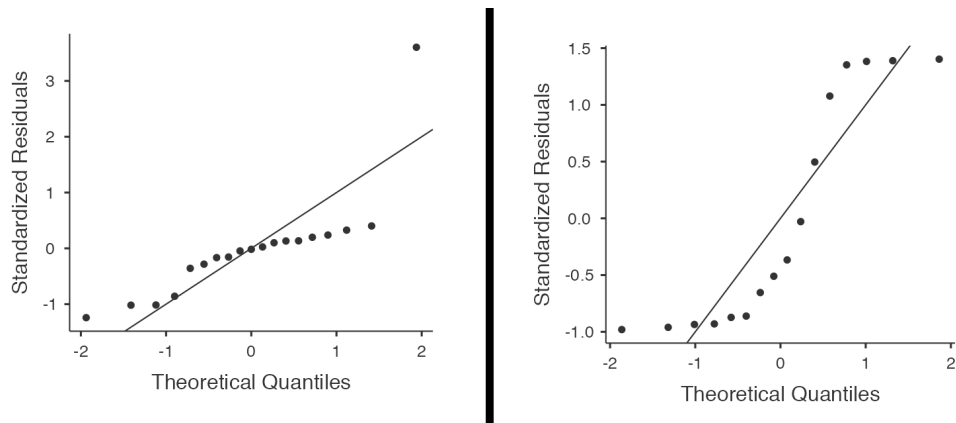
Shapiro Wilk

- Shapiro-Wilk is a test of normality (there are many others!).
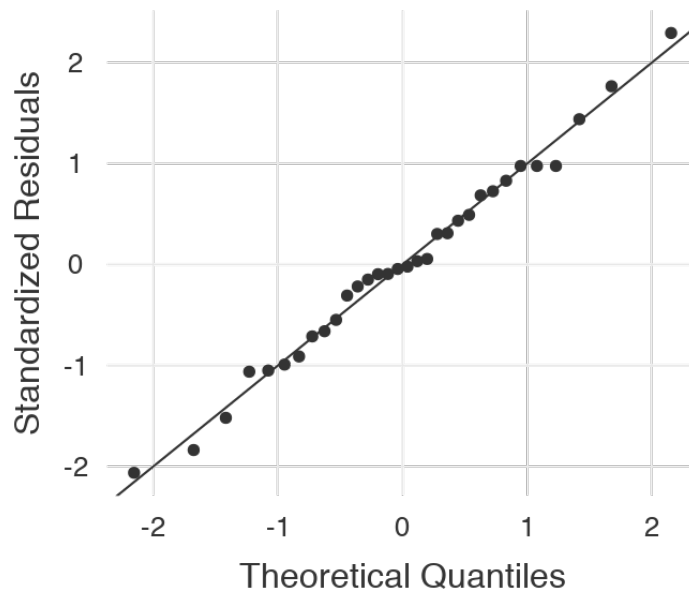
The hypotheses:

- Ho: The data are normally distributed

- Ha: The data are not normally distributed

QQ Plots

Examples of QQ-Plots when the assumption of normality is violated

Example of QQ-Plot when the normality assumption is met

Assumption-shumptions!

- What happens if I don't meet the normality assumption?
- In the case where you don't have continuous data, you have ranked data, you can use the Mann-Whitney Test.

Independence

It is assumed that the observations are independently sampled. Firstly, we assume that the observations within each sample are independent of one another (exactly the same as for the one-sample test). However, we also assume that there are no cross-sample dependencies.

- Some researchers use the intra-class correlation coefficient (ICC) to determine independence.
- Available as an "add on" in `jamovi`

Equality of variance

- Homogeneity of variance (also called "homoscedasticity") or simply equality of variance.
- One of the assumptions of parametric statistical tests is that the samples you are comparing should have fairly homogeneous variances.

Levene's Test for Equality of Variances

You can test this assumption using the Levene test. You want it to NOT be significant, if it is not significant you should use Welch's t-test (a non-parametric test).

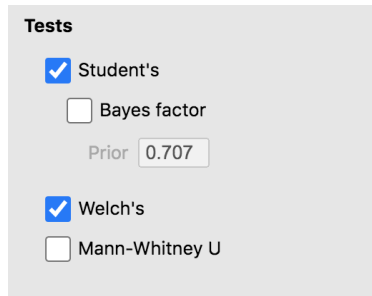- The hypotheses for Levene's Test

Ho: The variances are equal
Ha: The variances are not equal

Assumption-shumptions!

- What happens if I don't meet the assumption of equal variance?
- Welch's test!

Resources for Assumptions

- Nimon (2012)

Independent Samples T-Test

- We use this test when we want to compare the mean of two independent samples

Independent Samples t-test in `jamovi`

People who witness a crime may recall it differently when they are hypnotized. Researchers select two samples who watch a videotape of a supposed robbery Later one group will be hypnotized and then answer 30 questions about the event. The other group will answer the questions without being hypnotized. The IV is the presence of hypnosis and the DV is the amount of information correctly recalled. Use α=0.05 (Heiman, 2014).

In the `Analysis` tab, navigate to `T-tests` and select `Independent Samples t-test`
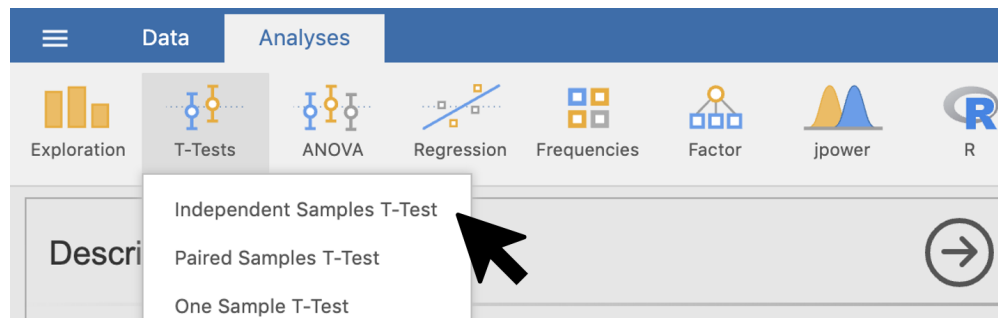
Drag the `Hypnosis Score` into the `Dependent Variable` box, and `Hypnosis Condition` into the grouping variable condition

Check Assumptions

To obtain the assumptions you simply check the options under the `Assumptions Check` option. Let's begin with Shapiro Wilk.

Shapiro Wilk

Test of Normality (Shapiro-Wilk)
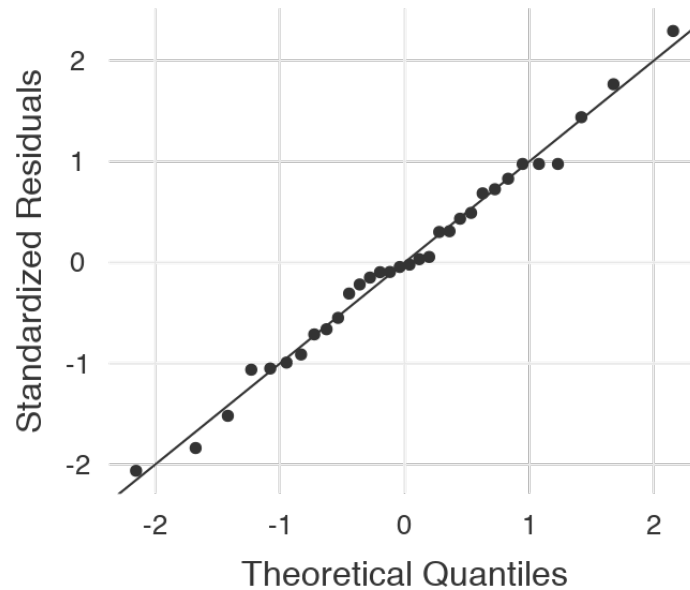
	W	p
Hypnosis Score	0.990	0.989

Note. A low p-value suggests a violation of the assumption of normality

Interpretation > A Shapiro Wilk test showed no departures from normality W = .990, p > .05 >

QQ Plots for Normality

Interpretation

Points on the Normal QQ plot provide an indication of univariate normality of the dataset. If the data is normally distributed, the points will fall on the 45-degree reference line. If the data is not normally distributed, the points will deviate from the reference line.

Levene's Test

Test of Equality of Variances (Levene's)

	F	df	df2	p
Hypnosis Score	1.48	1	30	0.234

Note. A low p-value suggests a violation of the assumption of equal variances

We again do not reject the null hypothesis for this test, this tells us, we can go ahead an interpret the t-test output.

Interpretation

To test for equality of variance Levene's test was performed which was non-significant ($F(1,30) = 1.48$, $p > .05$)

The output. . .

Independent Samples T-Test

Independent Samples T-Test

		statistic	df	p
Hypnosis Score	Student's t	1.46	30.0	0.154

Group Descriptives

	Group	N	Mean	Median	SD	SE
Hypnosis Score	Hypnosis	17	23.5	23.1	3.80	0.921
	No hypnosis	15	21.2	21.3	5.22	1.35

The results indicate that there was no significant difference in performance between the hypnosis and no hypnosis groups, $t(30) = 1.46$, $p = .154$. That is, the average performance for the hypnosis group ($M = 23.5$, $SD = 3.80$) was not significantly different from that of the no hypnosis group ($M = 21.3$, $SD = 5.22$).
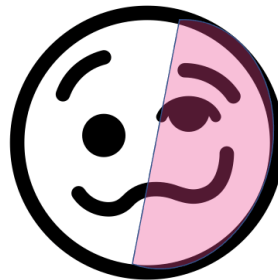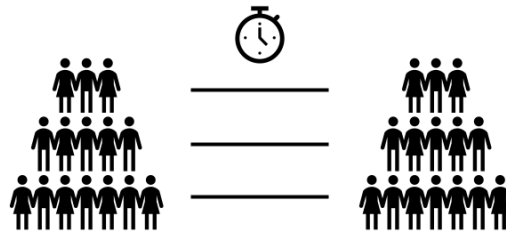
Dependent Samples T-Test

- Also known as paired samples, matched samples, repeated measures t-test etc
- No longer comparing independent samples of people, but looking at differences in scores within people
- When would you want to use this kind of test?*
  - Repeated measures research designs (looking at changes performance before and after an intervention)
  - Longitudinal designs (another type of repeated measures)

Independent Samples
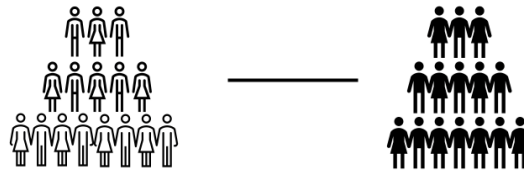
**Dependent Samples**

Example: Dependent Samples t-test

A dietitian wishes to see if a person's cholesterol level will change if the diet is supplemented by a certain mineral. N = 13 randomly selected subjects were pretested, and then they took the mineral supplement for a 6-week period. (Cholesterol level is measured in milligrams per deciliter.) Can it be concluded that the cholesterol level has been changed at $\alpha = 0.05$?

Dependent Samples t-test in jamovi

In the `Analysis` tab, navigate to `T-tests` and select `Paired Samples t-test`
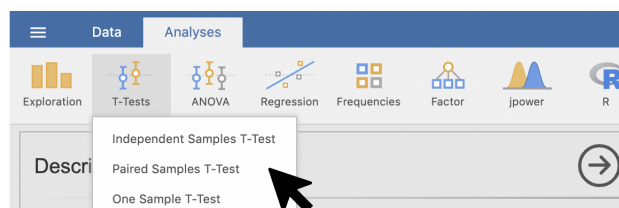

Drag the paired variables, for our example, we can drag `before` first, and then `after`.
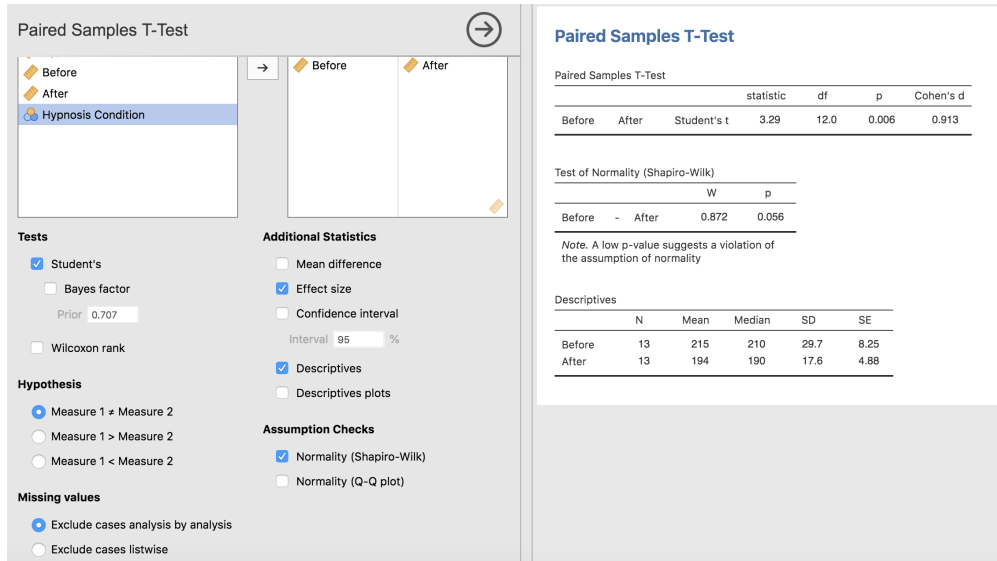
Interpretation

The results from the pre-test before the mineral supplement ($M = 215$, $SD = 29.7$) and after the six week period of taking the mineral supplement (M = 194, SD = 17.6) indicate that the participants' cholesterol level changed when the diet was supplemented by a certain mineral, t(12) = 3.29, p < .05.

Decision Tree
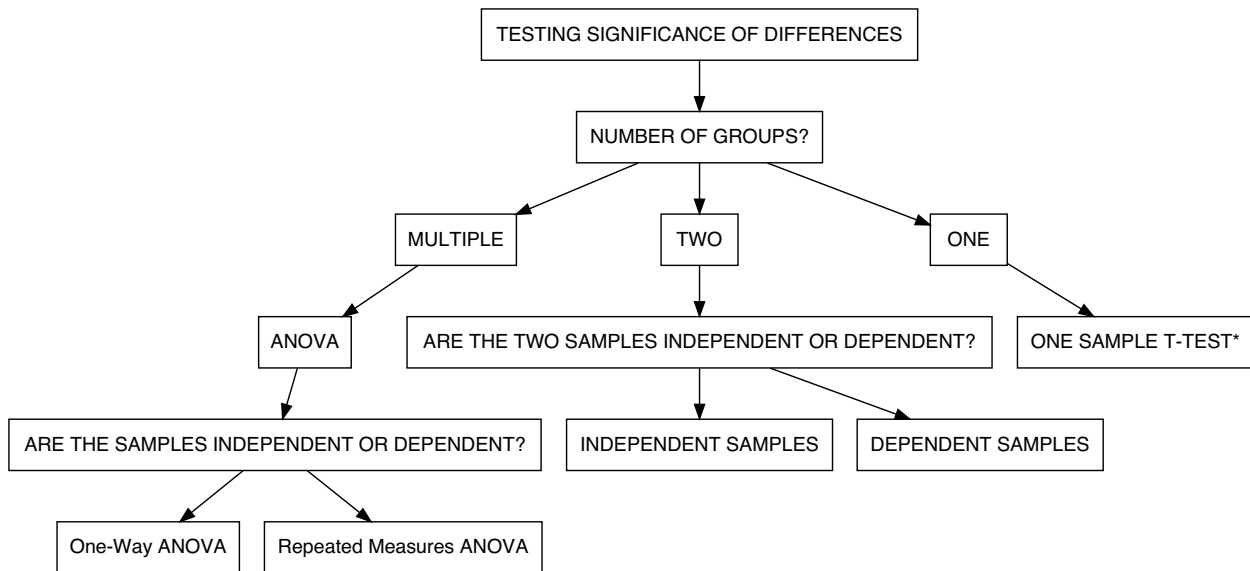
ANOVA

Assumptions: One-Way ANOVA

- Independence of Observations

- Normality
- Homogeneity of Variance

Data Example: One-Way ANOVA

A researcher wishes to try three different techniques to lower the blood pressure of individuals diagnosed with high blood pressure. The subjects are randomly assigned to three groups; the first group takes medication, the second group exercises, and the third group follows a special diet. After four weeks, the reduction in each person's blood pressure is recorded. At $\alpha = 0.05$, test the claim that there is no difference among the means. The data are shown.

`jamovi` Using the ANOVA option

In the `Analysis` tab, navigate to `ANOVA` in the menu select `ANOVA`
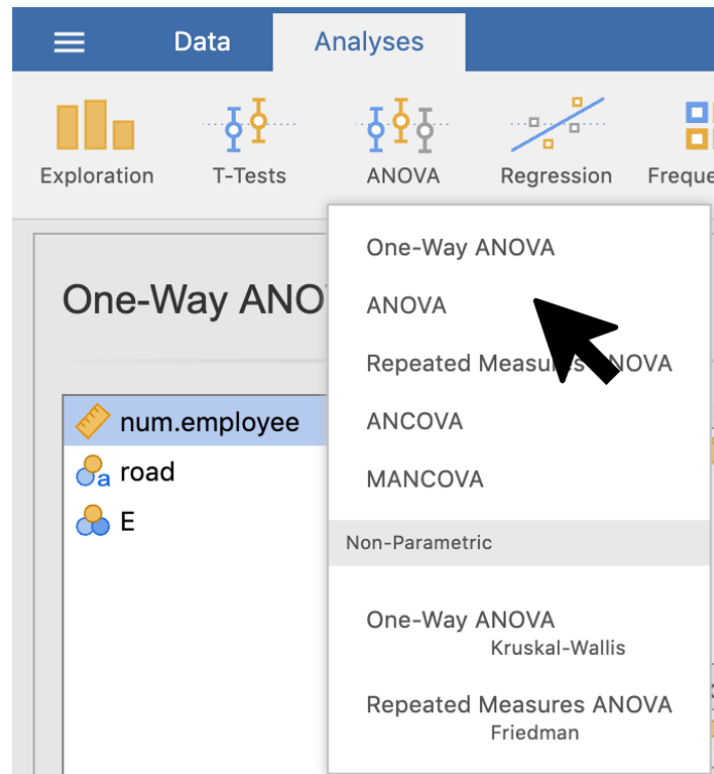

Figure 1: ANOVA menu

Assumption Checks

Under the `ANOVA` menu, you can navigate to the `Assumptions` sub-menu, and check the options.

Drag the dependent variable (Blood pressure) `BP` into the dependent variable box and the variable with the conditions `Condition` in the `Fixed Factors` box. To find the assumptions we use the assumptions submenu.

ANOVA

The output:

ANOVA

ANOVA - BP

	Sum of Squares	df	Mean Square	F	p
Condition	160	2	80.07	9.17	0.004
Residuals	105	12	8.73		

[3]

Assumption Checks

Homogeneity of Variances Test (Levene's)

F	df1	df2	p
0.384	2	12	0.689

[3]

Normality Test (Shapiro-Wilk)
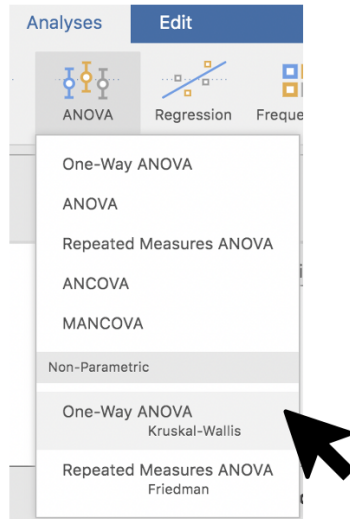
Statistic	p
0.945	0.444

The assumption of normality is met according to the Shapiro-Wilk test ($W = .945$, p > .05)

The assumption of equality of variance is met according to Levene's test ($F(2,13) = .384$, p > .05)

Assumption-shumptions!

- What happens if I don't meet the normality assumption?
- The option when violating an assumption would be Kruskal-Wallis

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Repeated Measures Analysis of Variance

- In certain kinds of experimental research, it is common to obtain repeated measurements of a variable from the same individual at several different points in time.
- Usually it is unrealistic to assume that these repeated observations are uncorrelated, and it is very desirable to build their intercorrelations into the statistical model.

- In Repeated Measures ANOVA an individual (in some combination of experimental conditions) is measured under essentially the same conditions at several different points in time.
- Time is a within-subjects factor, because each subject contributes data at more than one value of the IV "time."
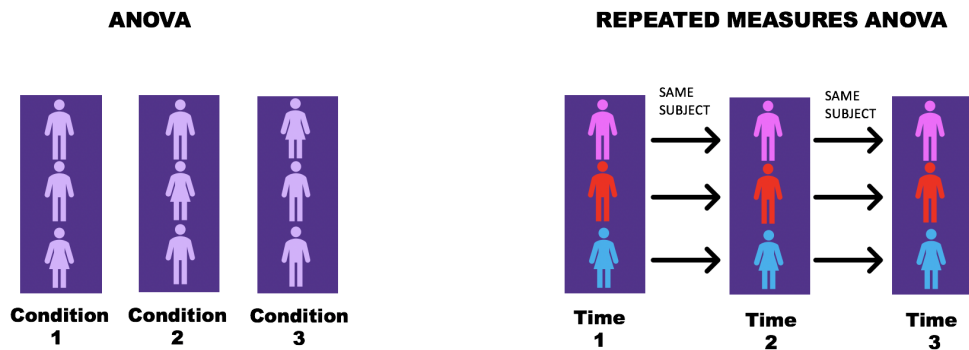- If a subject experiences only one value of an IV, it is called a between subjects factor.

Figure 2: ANOVA vs Repeated Measures ANOVA

Example

The data consists of people who were randomly assigned to two different diets: low-fat and not low-fat and three different types of exercise: at rest, walking leisurely and running. Their pulse rate was measured at three different time points during their assigned exercise: at 1 day, 15 days and 30 days.

`jamovi:` **Repeated Measures ANOVA**

In the `Analysis` tab, navigate to `ANOVA` in the menu select `Repeated Measures ANOVA`
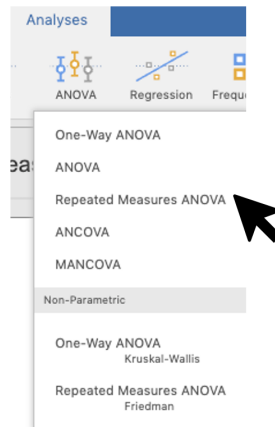

Figure 3: Menu

Next, add a third level in the Repeated Measures Factors text box, as there are three levels representing the three tasks: `Time 1`, `Time 2`, `Time 3` Change the labels of the levels accordingly.

In the `Repeated Measures Cells` drag the variables that were measured multiple times, in this case `1 Day`, `15 Day`, and `30 Day`.

Drag the variable `Diet` into the `Between Subjects Factors` box.

Assumptions

Test of Sphericity

Ho: Sphericity assumption met
Ha: Sphericity assumption not met

First let's check the assumptions:

Interpretation & Reporting

> Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, (W = .839 , p = .094).
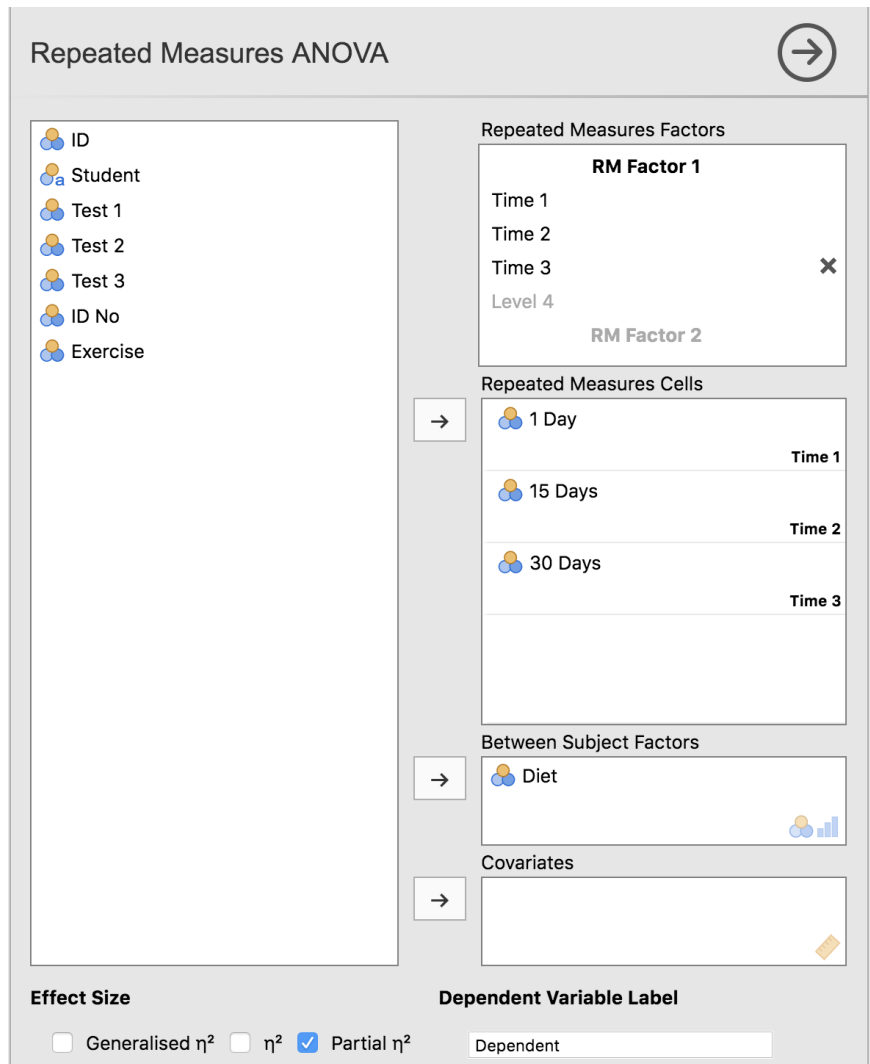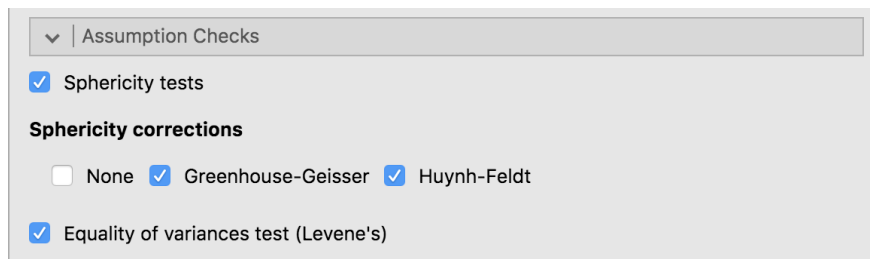
Figure 4: Repeated Measures Menu

Figure 5: Assumption Checks Menu

Assumptions

Tests of Sphericity

	Mauchly's W	p	Greenhouse-Geisser ε	Huynh-Feldt ε
RM Factor 1	0.839	0.094	0.862	0.913

Equality of variances test (Levene's)

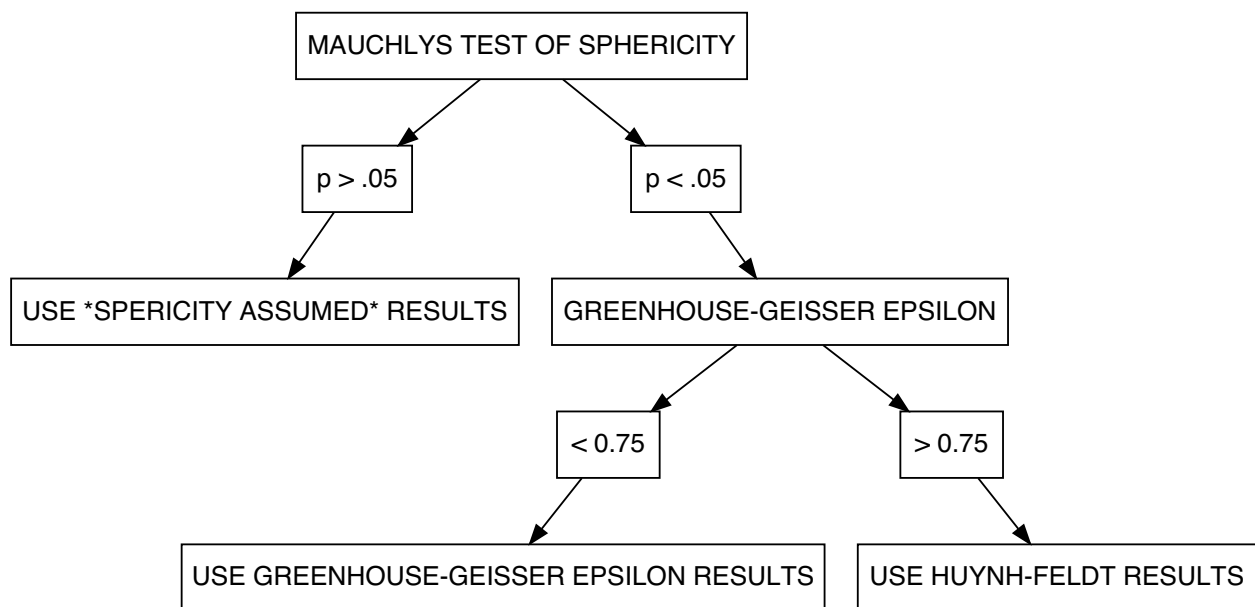|	F	df1	df2	p
1 Day	0.957	1	28	0.336
15 Days	2.518	1	28	0.124
30 Days	2.663	1	28	0.114

✓ Ho: Sphericity is met

✗ Ha: Sphericity is not met

✓ Ho: Variances are equal

✗ Ha: Variances not equal

Figure 6: Assumption Output

Repeated Measures Decision Tree

Rules of thumb from Field (2013)

Data Analysis

Interpretation & Reporting

The results show that there was a significant effect in the pulse scores across time, $F(2, 56) = 4.46$, $p = .016$ $\eta_p^2 = .137$.

Assumption-shumptions!

⚠

- What happens when I don't meet the assumptions of the RM ANOVA?

Repeated Measures ANOVA

Within Subjects Effects

	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η²ₚ
Time	Greenhouse-Geisser	1158	1.72	672	4.462	0.021	0.137
	Huynh-Feldt	1158	1.83	634	4.462	0.019	0.137
Time ✻ Diet	Greenhouse-Geisser	193	1.72	112	0.743	0.462	0.026
	Huynh-Feldt	193	1.83	106	0.743	0.469	0.026
Residual	Greenhouse-Geisser	7267	48.24	151			
	Huynh-Feldt	7267	51.11	142			

Note. Type 3 Sums of Squares

Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²ₚ
Diet	1262	1	1262	4.27	0.048	0.132
Residual	8276	28	296			

Note. Type 3 Sums of Squares

If you need to correct for sphericity, you select the appropriate correction in this output and report it

Figure 7: Output
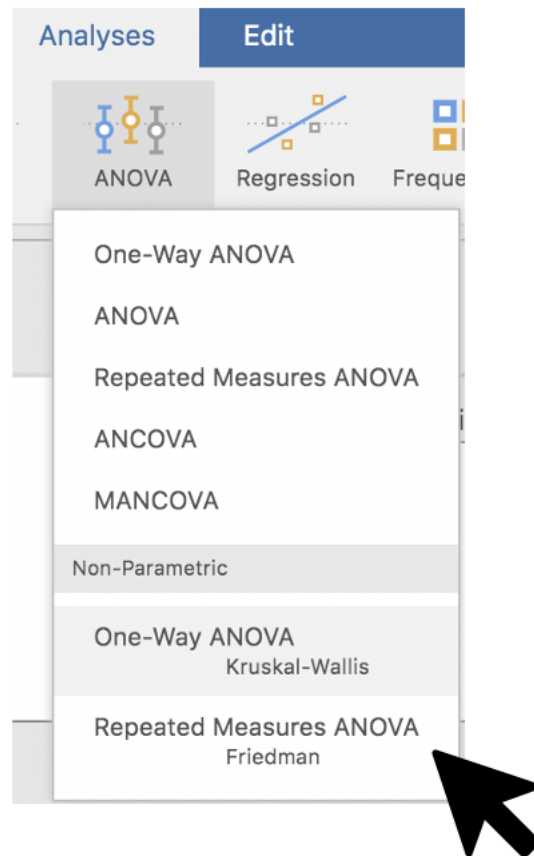
Other `jamovi` functions

- Show in `jamovi`*

Resources

- Research Design & Data Analysis Lab: https://www.uttyler.edu/research/ors-research-design-data-analysis-lab/
- Schedule a consultant appointment with me: https://www.uttyler.edu/research/ors-research-design-data-analysis-lab/ors-research-design-data-analysis-lab-consultants/
- Check out Lab Resources (including recording of this webinar): https://www.uttyler.edu/research/ors-research-design-data-analysis-lab/resources/

References

Field, A. (2013). *Discovering statistics using ibm spss statistics.* Sage.

Heiman, G. (2014). *Basic statistics for the behavioral sciences.* Cengage Learning.

Nimon, K. F. (2012). Statistical assumptions of substantive analyses across the general linear model: A mini-review. *Frontiers in Psychology*, *3*, 322.