

One-Way Repeated Measures Analysis of Variance

(Within-Subjects ANOVA)

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SPSS for Windows® Intermediate & Advanced Applied Statistics

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Introduction

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- The topic of this module is also One-Way ANOVA. Much of what was covered in the previous module on One-Way ANOVA is applicable to this lesson.
- We previously introduced the **between groups** independent samples ANOVA
- In the present module, we will discuss **within subjects** correlated samples ANOVA also known as one-way repeated measures ANOVA

Introduction

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- A One-Way within subjects design involves repeated measures on the same participants (multiple observations overtime, or under experimental different conditions).
- The simplest example of one-way repeated measures ANOVA is measuring before and after scores for participants who have been exposed to some experiment (**before-after** design).
- Example: An employer measures employees knowledge before a workshop and two weeks after the workshop.

Introduction

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- One-way repeated measure ANOVA and **paired-samples t-test** are both appropriate for comparing scores in **before and after designs** for the same participants.
- Repeated-measures designs are considered an extension of the **paired-samples t-test** when comparisons between *more than two repeated measures are needed*.

Introduction

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- Usually, repeated measures ANOVA are used when more than two measures are taken (3 or more). Example:
 - Taking a self-esteem measure before, after, and following-up a psychological intervention), and/or
 - A measure taken over time to measure change such as a motivation score upon entry to a new program, 6 months into the program, 1 year into the program, and at the exit of the program.
 - A measure repeated across multiple **conditions** such as a measure of experimental condition A, condition B, and condition C, and
 - Several related, comparable measures (e.g., sub-scales of an IQ test).

Hypotheses

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- SPSS conducts 3 types of tests **if the within-subject factor has more than 2 levels:**
 - The standard univariate F within subjects
 - Alternative univariate tests, and
 - Multivariate tests
- All three types of repeated measures ANOVA tests evaluate the same hypothesis:
 - The population means are equal for all levels of a factor.
 - $H_0: \mu_1 = \mu_2 = \mu_3 \dots$
 - H_A : At least one treatment or observation mean (μ) is different from the others.

Sources of Variability

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- In repeated measure ANOVA, there are three potential sources of variability:
 - Treatment variability: **between columns**,
 - Within subjects variability: **between rows**, and
 - random variability: **residual** (chance factor or experimental error beyond the control of a researcher) .

- A repeated measure design is powerful, as it controls for all potential sources of variability.

F Test Structure

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- The test statistic for the repeated measures ANOVA has the following structure:

variance between treatments

- $F = \frac{\text{variance between treatments}}{\text{variance within subjects + variance expected by chance/error}}$

variance within subjects + variance expected by chance/error

- The logic of Repeated measures ANOVA: Any differences that are found between treatments can be explained by only two factors:
 - 1. Treatment effect.
 - 2. Error or Chance
- This formula leaves only differences due to treatment/observation effects.
- A large F value indicates that the differences between treatments/observations are greater than would be expected by chance or error alone.

Univariate Assumptions

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- **1. Normality Assumption: Robust**
 - The dependent variable is normally distributed in the population for each level of the within-subject factor.
 - ✦ With a moderate or large sample sizes the test may still yield accurate p values even if the normality assumption is violated except in thick tailed and heavily skewed distributions.
 - ✦ A commonly accepted value for a moderate sample size is 30 subjects.

Univariate Assumptions

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- **2. Sphericity Assumption: Non-Robust**

- The population variance of difference scores computed between any two levels of a within subject factor is the same.
- The sphericity assumption (also known as the homogeneity of variance of differences assumption) is meaningful only if there are more than two levels of a within subjects factor.
 - ✦ If this assumption is violated the resulting p value should not be trusted.
 - ✦ Sphericity can be tested using the Mauchly's Sphericity Test. If the Chi-Square value obtained is significant, it means that the assumption was violated.
 - ✦ If the sphericity assumption is not met, some procedures can be used to correct the univariate results (see next). These tests make adjustments to the degrees of freedom in the denominator and numerator.

Univariate Assumptions

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2. Sphericity Assumption (continued):

- SPSS, computes alternative test which are all robust to violations of the sphericity assumption as they adjust the degrees of freedom to account for any violations of this assumption. These tests include:
 - univariate tests
 - ✦ Greenhouse-Geisser Epsilon,
 - ✦ Huynh-Feldt Epsilon, and
 - ✦ Lower-bound Epsilon)
 - And multivariate tests
 - ✦ Pillai's Trace,
 - ✦ Wilk's Lambda,
 - ✦ Hotelling's Trace, and
 - ✦ Roy's Largest Root

Univariate Assumptions

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- **3. Independence Assumption: Non-Robust**
 - The cases represent a random sample from the population and there is no dependency in the scores between participants.
 - Dependency can exist only across scores for individuals.
 - Results should be not trusted if this assumption is violated.

Multivariate Assumptions

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- 1. Normality Assumption: Non-Robust
 - The difference scores are multivariately normally distributed in the population.
 - ✦ To the extent that population distributions are not normal and the sample sizes are small, especially in thick tailed or heavily skewed distributions, the p values are invalid.

- 2. Independence Assumption: Non-Robust
 - The difference scores for any one subject are independent from the scores for any other subjects.
 - ✦ The test should not be used if the independence assumption is violated.

Conducting A One-Way Repeated Measures ANOVA

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- There are three steps in conducting the one-way repeated measures ANOVA:
 - 1. Conducting the omnibus test
 - Conducting polynomial contrasts (compares the linear effect, quadratic effect, and cubic effect).
 - Conducting pairwise comparisons.

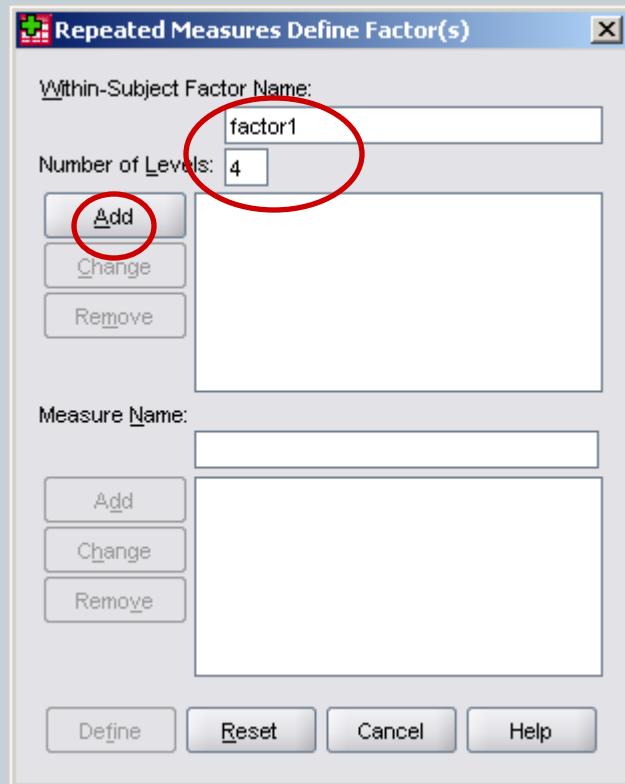
How to obtain a One-way repeated measure ANOVA (omnibus)

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The screenshot shows the SPSS Data Editor interface. The 'Analyze' menu is open, and the path 'General Linear Model' > 'Repeated Measures...' is highlighted. A red circle is drawn around this menu path. The data view shows a table with columns 'subject', 'trial1', 'trial2', 'trial3', 'trial4', and three 'var' columns. The status bar at the bottom indicates 'Repeated Measures...' and 'SPSS Processor is ready'.

subject	trial1	trial2	trial3	trial4	var	var	var
1	10	11	12	6			
2	10	11	8	4			
3	10	11	6	2			
4	10	11	10	4			
5	12	8	6	2			
6	18	10	5	1			
7	16	10	8	4			
8	18	8	4	1			
9	16	12	6	2			
10	19	16	10	8			
11	16	14	10	9			
12	16	12	8	8			

- Enter the number of levels
- Press add



The image shows a screenshot of the "Repeated Measures Define Factor(s)" dialog box in SPSS. The dialog box has a title bar with a plus sign icon and the text "Repeated Measures Define Factor(s)". Inside the dialog, there are two main sections: "Within-Subject Factor Name:" and "Measure Name:". In the "Within-Subject Factor Name:" section, the text "factor1" is entered in the text box, and the "Number of Levels:" is set to "4". The "Add" button is circled in red. Below the "Within-Subject Factor Name:" section are three buttons: "Add", "Change", and "Remove". In the "Measure Name:" section, there is an empty text box and three buttons: "Add", "Change", and "Remove". At the bottom of the dialog are four buttons: "Define", "Reset", "Cancel", and "Help".

- Press define

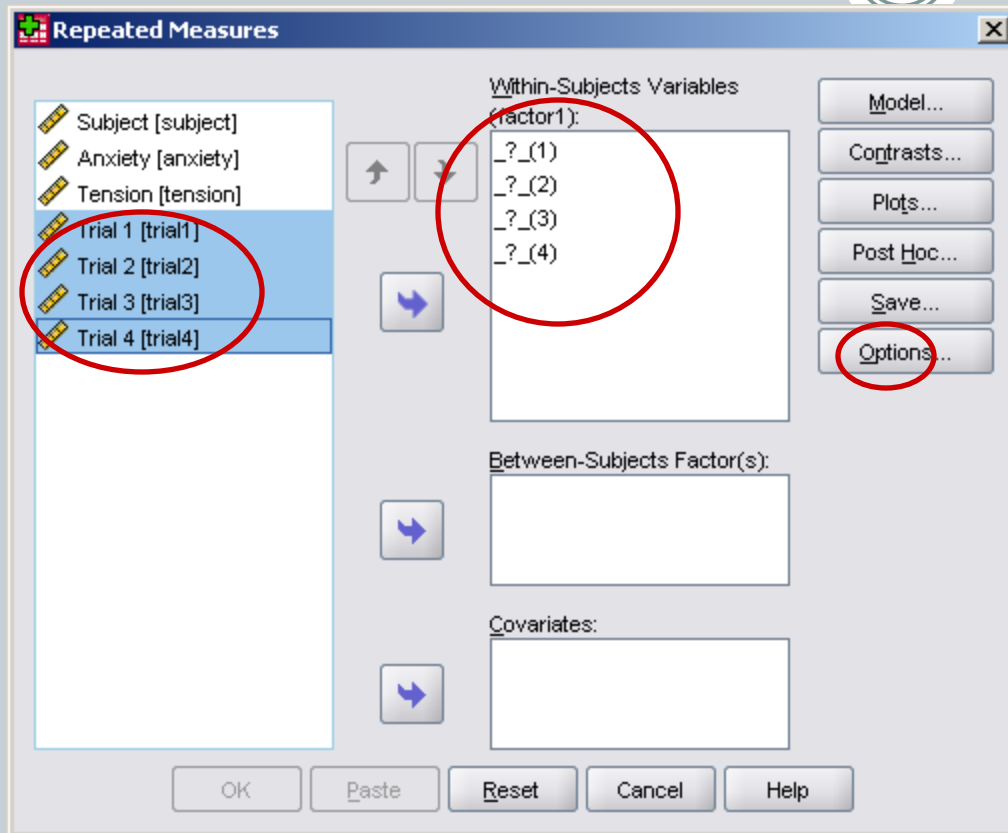
Repeated Measures Define Factor(s)

Within-Subject Factor Name:

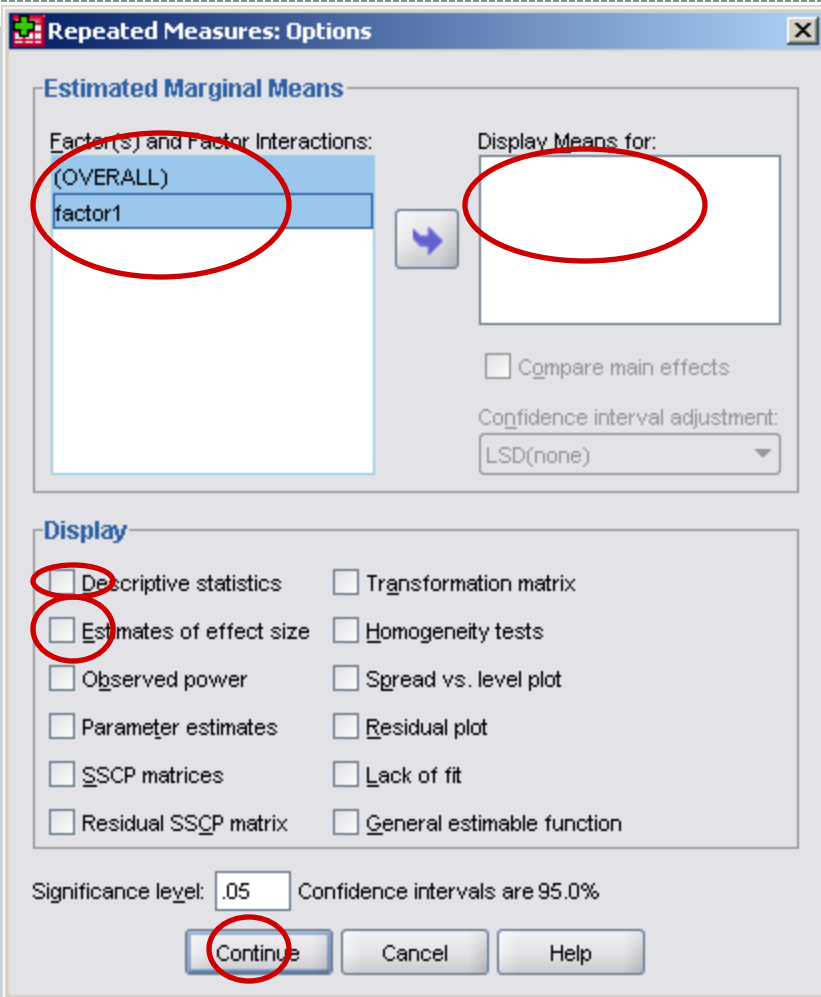
Number of Levels:

factor1(4)

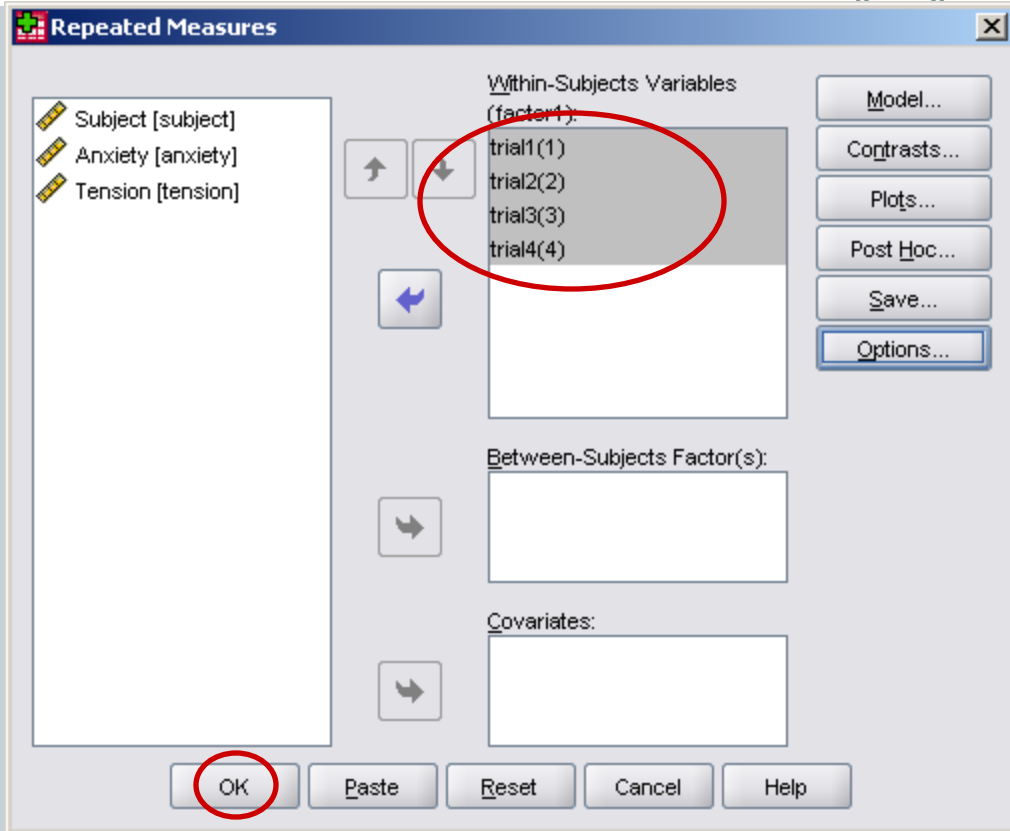
Measure Name:



- Move the needed variables to the within subject box.
- Then Press Options



- In Options, move the variables to the Display means for.
- Choose descriptive statistics and estimates of effect size.
- Press continue



- Now press OK.

*Output1 [Document1] - SPSS Viewer

File Edit View Data Transform Insert Format Analyze Graphs Utilities Add-ons Window Help

Output

- General Linear Model
 - Title
 - Notes
 - Within-Subjects Factors
 - Descriptive Statistics
 - Multivariate Tests
 - Mauchly's Test of Sphericity
 - Tests of Within-Subjects Effects
 - Tests of Between-Subjects Effects
 - Estimated Marginal Means
 - Title
 - 1. Grand Mean
 - 2. factor1

Multivariate Tests^b

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
factor1	Pillai's Trace	.958	1.883E3	3.000	249.000	.000	.958
	Wilks' Lambda	.042	1.883E3	3.000	249.000	.000	.958
	Hotelling's Trace	22.684	1.883E3	3.000	249.000	.000	.958
	Roy's Largest Root	22.684	1.883E3	3.000	249.000	.000	.958

a. Exact statistic
b. Design: Intercept
Within Subjects Design: factor1

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^a		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
factor1	.398	230.066	5	.000	.622	.626	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects.
b. Design: Intercept
Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
factor1	Sphericity Assumed	20821.500	3	6940.500	2910.719	.000	.921
	Greenhouse-Geisser	20821.500	1.865	11165.895	2910.719	.000	.921
	Huynh-Feldt	20821.500	1.878	11086.145	2910.719	.000	.921
	Lower-bound	20821.500	1.000	20821.500	2910.719	.000	.921
Error(factor1)	Sphericity Assumed	1735.500	249	6.970			

- ANOVA is interpreted using the multivariate test typically reporting values for Wilks Lambda or,
- Reporting the within subjects effects under sphericity assumed.

Multiple Comparisons/Post-Hoc Tests

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- If the overall ANOVA yields a significant result, pair-wise comparisons should be conducted to assess which means differ from each other.

Alternate tests

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- The Friedman analysis of variance by ranks is an alternative to one-way repeated measures ANOVA if the dependent variable is not normally distributed.
- When using the Friedman test it is important to use a sample size of at least 12 participants to obtain accurate p values.
- The **Friedman test** is a non-parametric statistical test used to detect differences in treatments across multiple test attempts.

Degrees of freedom

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- Degrees of Freedom
 - The df for the repeated measures are identical to those in the independent measures ANOVA
 - $df \text{ total} = N - 1$
 - $df \text{ between treatments} = k - 1$
 - $df \text{ within treatments} = N - k$

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