stcp-marshall-ANOVArepeatedS

The following resources are associated:

Checking normality in SPSS and the SPSS dataset 'Cholesterol.sav'

Repeated measures (within-subjects) ANOVA

Dependent variable: Continuous (scale)

Independent variable: Categorical e.g. time/ condition (within subjects factor)

Common Applications: Used when several measurements of the same dependent variable are taken at different time points or under different conditions. Repeated measures ANOVA analyses (1) changes in mean score over 3 or more time points or (2) differences in mean score under 3 or more conditions. This is the equivalent of a one-way ANOVA but for repeated samples and is an extension of a paired-samples t-test. Repeated measures ANOVA is also known as 'within-subjects' ANOVA.

Assumptions for repeated measures ANOVA

Assumptions	**How to check**	**What to do if the assumption is not met**
Normality of residuals by time point	In the **Save** menu, ask for the *standardised residuals*. A set of residuals will be produced for each time point and added to the data set. Use histograms/ Shapiro-Wilk tests to check they are approximately normally distributed.	If the residuals are **very** skewed, ANOVA is not reliable so use the non-parametric Friedman test instead
Sphericity: the variances of the differences between all combinations of the related conditions/ time points are equal (similar to the assumption of equal variances in ANOVA).	*Mauchly's test of Sphericity* is automatically given in the output. If $p > 0.05$, Sphericity can be assumed.	Use the p-value from the Greenhouse-Geisser correction row in the 'Tests of Within-Subjects Effects' ANOVA table

Data: Participants used Clora margarine for 8 weeks. Their cholesterol (in mmol/L) was measured before the special diet, after 4 weeks and after 8 weeks. Open the SPSS file 'Cholesterol.sav' and follow the instructions to see if the use of margarine has changed the mean cholesterol.

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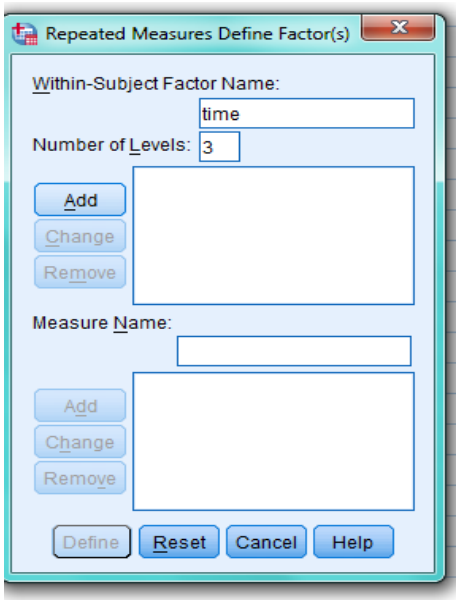
Steps in SPSS

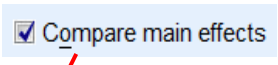
To carry out a repeated measures ANOVA, use *Analyse → General Linear Model → Repeated measures.*

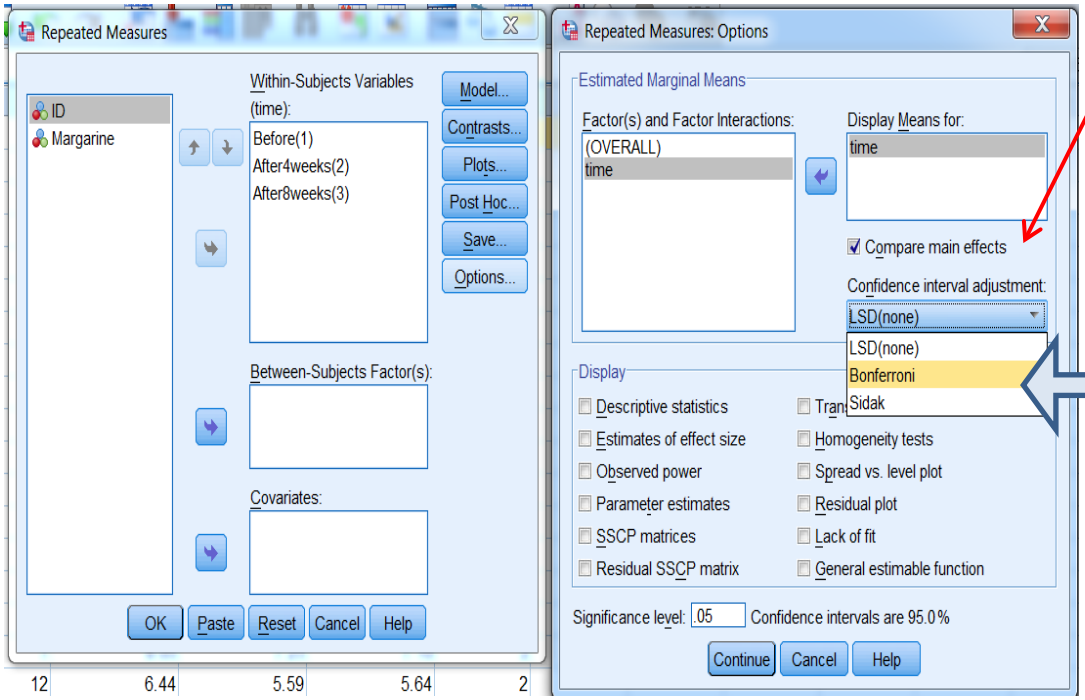


This screen comes up first. This is where we define the levels of our repeated measures factor which in our case is time. We need to name it using whatever name we like (we have used "time" in this case) and then state how many time points there are (which here is 3; before the experiment, after 4 weeks and after 8 weeks). Make sure in your data set there is one row per person and a separate column for each of the three time points or conditions.

Make sure you click on the **Add** button and then click on the **Define** button.

The next screen you see should be the one below. Move the three cholesterol variables across into the *Within-Subjects Variables* box. Post hoc tests for repeated measures are in the **Options** menu. Move time to the *Display Means for* box and select





***Choose** Bonferroni* from the *Confidence interval adjustment* menu

In the **Save** menu, ask for the *standardised residuals* to be added to the dataset (ZRE_1 – ZRE_3). These will be added to your dataset by SPSS when you run the analysis. They should then be checked for normality using histograms/ Shapiro-Wilk tests in *Analyze → Descriptive Statistics → Explore*.

ZRE_1	ZRE_2	ZRE_3
.01	-.01	-.03
.30	.32	.32
.13	-.01	-.06

The output

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig. (p-value)	Epsilon[b] Greenhouse-Geisser	Epsilon[b] Huynh-Feldt	Epsilon[b] Lower-bound
time	.381	15.440	2	.000	.618	.642	.500

The test above is significant ($p < 0.001$) so the assumption of Sphericity has not been met. If Sphericity can be assumed, use the top row of the '**Tests of Within-Subjects Effects**' below. If it cannot be assumed, use the Greenhouse-Geisser row (as shown below) which makes an adjustment to the degrees of freedom of the repeated measures ANOVA.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	4.320	2	2.160	212.321	.000
	Greenhouse-Geisser	4.320	1.235	3.497	212.321	.000
	Huynh-Feldt	4.320	1.284	3.365	212.321	.000
	Lower-bound	4.320	1.000	4.320	212.321	.000
Error(time)	Sphericity Assumed	.346	34	.010		
	Greenhouse-Geisser	.346	21.001	.016		
	Huynh-Feldt	.346	21.822	.016		
	Lower-bound	.346	17.000	.020		

As $p < 0.001$, there's a difference in cholesterol between at least 2 time points

Report the results of this table using [$F(df_{time}, df_{Error(time)})$= Test statistic F, p = …]. Here a Greenhouse-Geisser correction was applied to the degrees of freedom so use [F(1.235, 21.001)= 212.321, $p < 0.001$] when reporting the results. As the main ANOVA is significant, this means that there is a difference between at least two time points.

Pairwise Comparisons

Measure: MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	.566*	.037	.000	.469	.663
	3	.629*	.042	.000	.517	.741
2	1	-.566*	.037	.000	-.663	-.469
	3	.063*	.017	.004	.019	.107
3	1	-.629*	.042	.000	-.741	-.517
	2	-.063*	.017	.004	-.107	-.019

The **Pairwise comparisons** table contains multiple paired t-tests with a Bonferroni correction to keep the Type I error at 5% overall. There was a significant difference between each pair of time points. Cholesterol reduced by 0.566 mmol/L between baseline and 4 weeks ($p < 0.001$) and then reduced by an additional 0.063 mmol/L between 4 and 8 weeks ($p = 0.004$).

Finally, the standardised residuals need to be approximately normally distributed for the ANOVA to be reliable. Histograms of the standardised residuals at the three time points showed an approximate normal distribution.

Reporting ANOVA

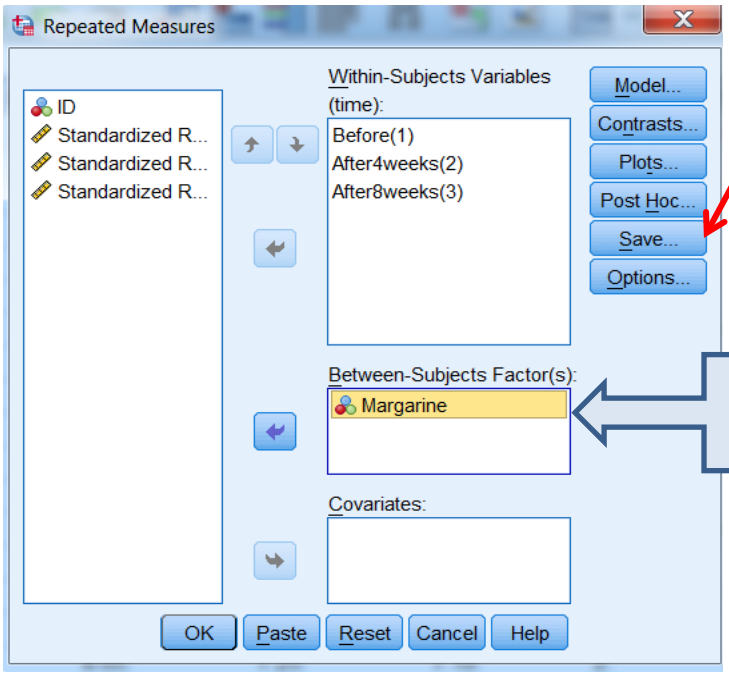
Participants used Clora margarine for 8 weeks. Their cholesterol was measured before the special diet, after 4 weeks and after 8 weeks. Normality checks were carried out on the residuals which were approximately normally distributed. A repeated measures ANOVA with a Greenhouse-Geisser correction showed that mean cholesterol differed significantly between time points [F(1.235, 21.001)= 212.321, p < 0.001]. Post hoc tests using the Bonferroni correction revealed that Cholesterol reduced by an average of 0.566 mmol/L after 4 weeks (p < 0.001) and then reduced by an additional 0.063 mmol/L between 4 and 8 weeks (p = 0.004).

Note: Does the change in mean cholesterol look meaningful?
To assess this, look at the starting mean. Cholesterol drops by approximately 9% after 4 weeks which is meaningful but only drops by approximately 1% between 4 and 8 weeks which seems less meaningful. The reason such a small change is significant is the small standard error for the differences (shown in the Pairwise Comparisons output).

	Mean	Standard Deviation
Before	6.41	1.19
After 4 weeks	5.84	1.12
After 8 weeks	5.78	1.10

ANOVA for more than one independent variable

Two way repeated measures ANOVA is also possible as well as 'Mixed ANOVA' with some between-subject and within-subject factors. For example, if participants were given either Margarine A or Margarine B, Margarine type would be a 'between groups' factor so a two-way 'Mixed ANOVA' would be used. If all participants had Margarine A for 8 weeks and Margarine B for a different 8 weeks (giving 6 columns of data), a two-way Repeated Measures ANOVA would be appropriate.



The **Post hoc** section is for between-subject factors when running a 'Mixed Model' with between-subject and within-subject factors.

For mixed ANOVA, add the between subject factor here e.g. type of margarine