REPEATED MEASURES ANOVA

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Flow of discussion for Repeated Measures ANOVA

- What is RM ANOVA?
- When to use?
- Typical examples
- Advantages
- Assumptions
- Type of data required
- Different designs and terms used
- Steps to follow
- How to analyze?
- Interpretation
- Presentation of results
- Recapping
- Hands-on exercise

What is Repeated Measures design?

- When the **same variable** is measured on **several occasions** for **each subject**
- Example: BP measurement on hypertensive patient for 4 successive weeks after the treatment

Two main conditions RM ANOVA is applicable

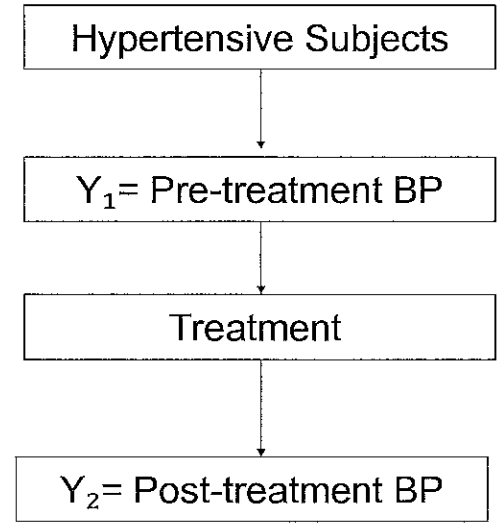
1) RM of same variable over time on a same group/groups of subject
   Example:
   RM of BP taken monthly over a period of 6 months

2) Exposing the same subject in a group/groups to several categories of treatment
   Example:
   Each migraine patient is treated sequentially with Imitrex, therapeutic touch, acupuncture and meditation

Simplest example

Research question :

Is there a significant change in blood pressure between pre-treatment and post-treatment measurements?

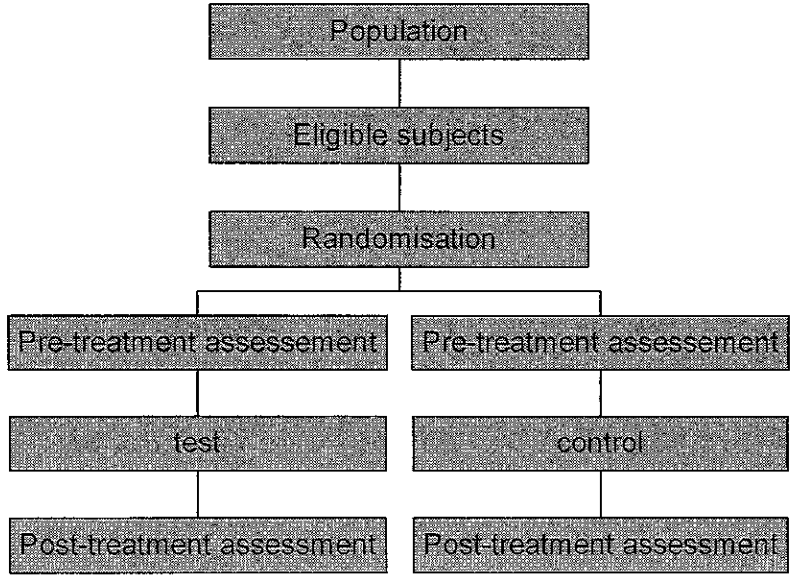


Examples:

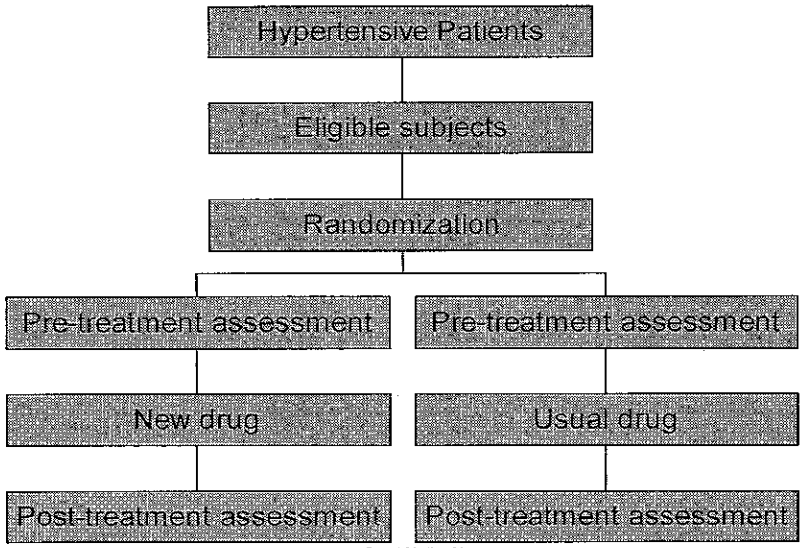
RD Randomised controlled trials

RQ Effectiveness of new antihypertensive drug

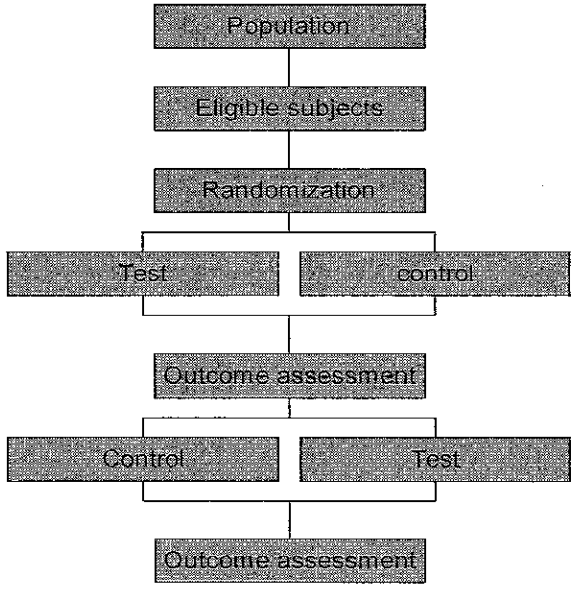
Parallel



Example



Cross-over



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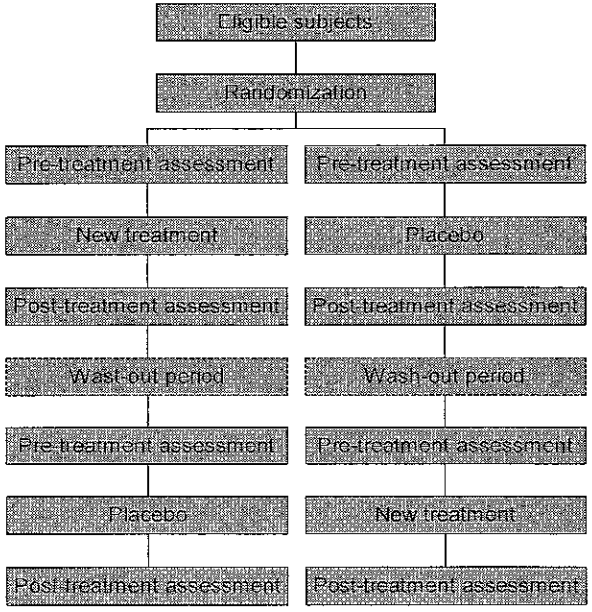


Advantages and disadvantages of using repeated measures design

Advantages

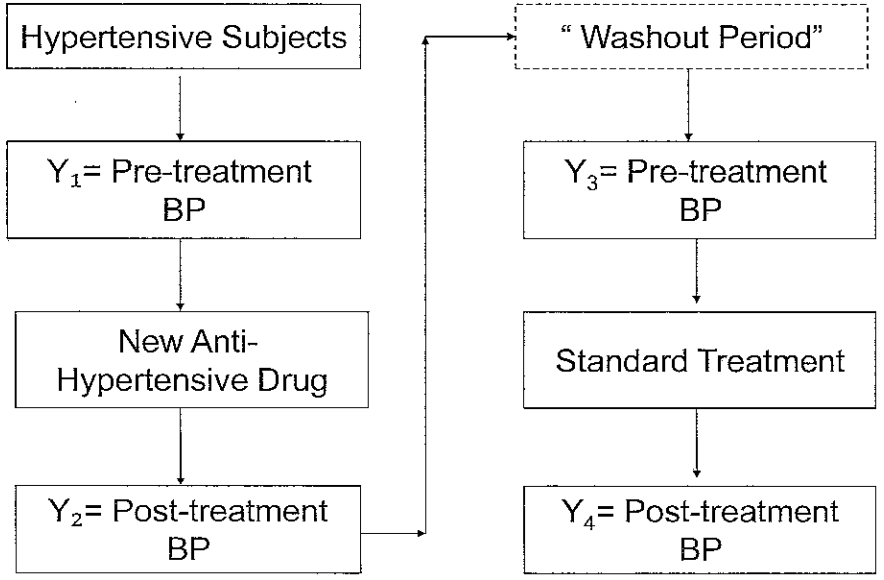
- Fewer subjects required
- Variability between subjects is eliminated (no inter- subject variability) as subjects provide their own control

Disadvantages

1. Carry-over effect

Would occur if the influence of the new drug is still present when another round of measurement starts

Solution : Include adequate "wash-out period"



Disadvantages

2. Latency effect

Would occur when one treatment activates the dormant effect of the previous treatment or interact with the previous treatment

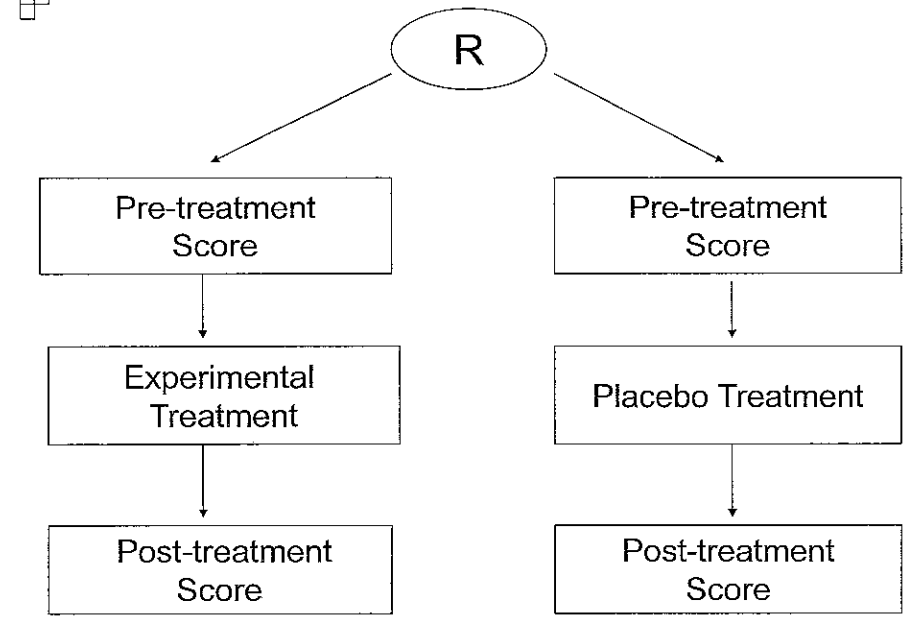
Solution : Do not use repeated measures design

Disadvantages

3. Learning effect

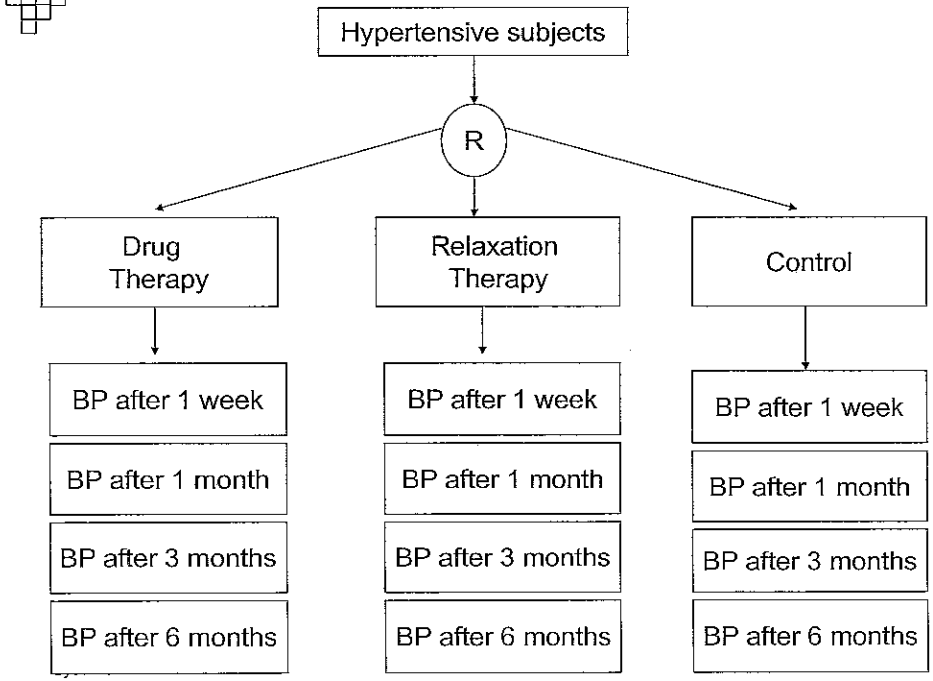
Would occur when the response may improve by repetition of an intervention. (example: visual field testing)

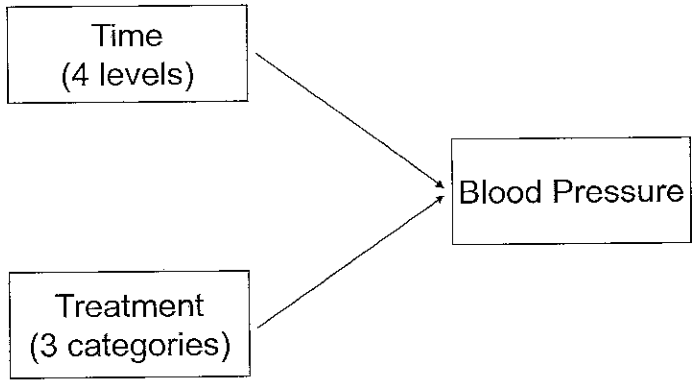
Solution : Include a control group that performs same task repeatedly without any treatment



Example for discussion

Randomized control trials in hypertensive patients





Treatment (3 categories) → **BP1 , BP2 , BP3 , BP4**

(One independent variable) **(Four dependent variables)**

Within group factor
(Time Effect)

*

Between group factor with regard to time
(Time*Treatment Interaction)

Between group factor regardless of time
(Treatment Effect) (Overall)

Note:
Interest in classical ANOVA is *between group* whereas interest in RM ANOVA may be either ***within or between group or both***

1) Is there any significant difference of mean blood pressure within group based on time?

Within group factor (Time effect)

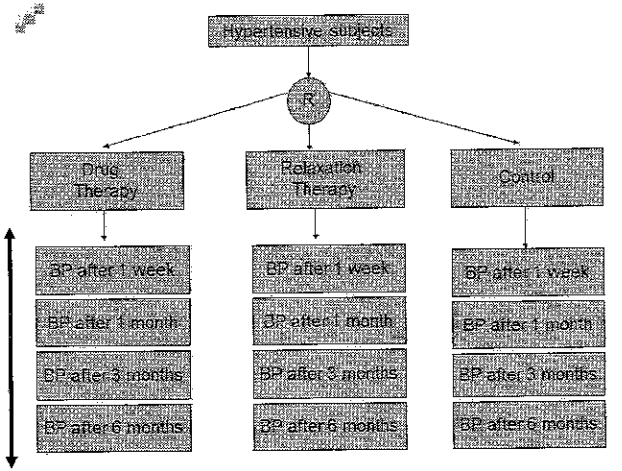
3) Is there any significant difference of mean blood pressure between or among group with regard to time?

Between group factor with regard to time (Time*Treatment interaction)

*

2) Is there any significant difference of mean blood pressure between or among group regardless of time?

Between group factor regardless of time (Treatment effect) (Overall)



Assumptions of RM ANOVA

I Normal distribution

II Homogeneity of variances (HOV)

III Compound symmetry

H_o: Correlation across all the measurement have constant (H_o: R12 = R23 = R34 ≠ 0)
H_A: Otherwise (at least one is not constant)
Example:
There are 4 measurements (M1, M2, M3, M4) at 4 different times (0, 1, 6, 12 months)

M1	0	R12
M2	1	R23
M3	6	R34
M4	12	

R is the correlation between the measurements

Types of data required & terms used

Within subject variable (continuous) – which is repeatedly measured	Blood pressure
Between subject variable (categorical)	Treatment groups

Different designs and terms used

Repeated measures design may be:	**Research question**
Within subject design (Time effect)	Difference of mean blood pressure within group based on time
Between subject design (Treatment effect)	Difference of mean blood pressure between/ among treatment groups regardless of time
Within-between design (Time effect, treatment effect, Time-treatment interaction)	Difference of mean blood pressure between/ among treatment groups based on time/ with regard to time

Types of data required & terms used

Within subject variable (continuous) – which is repeatedly measured	Blood pressure
Between subject variable (categorical)	Treatment groups
Covariates (continuous)	Age

Different designs and terms used

Repeated measures design may be:	Research question
Within subject design (Time effect)	Difference of mean blood pressure within group based on time
Between subject design (Treatment effect)	Difference of mean blood pressure between/ among treatment groups regardless of time
Within-between design (Time-treatment interaction)	Difference of mean blood pressure between/ among treatment groups based on time/ with regard to time
Within-between design with covariates	Difference of blood pressure between/ among treatment groups based on time when age is controlled

Steps in RM ANOVA

- Step 1: Data exploration and cleaning
- Step 2: Fit RM ANOVA model
- Step 3: Checking assumptions
  - ⇨Normality of residuals
  - ⇨Homogeneity of variances
  - ⇨Assumption of compound symmetry
- Step 4: Interpretation, conclusion and presentation

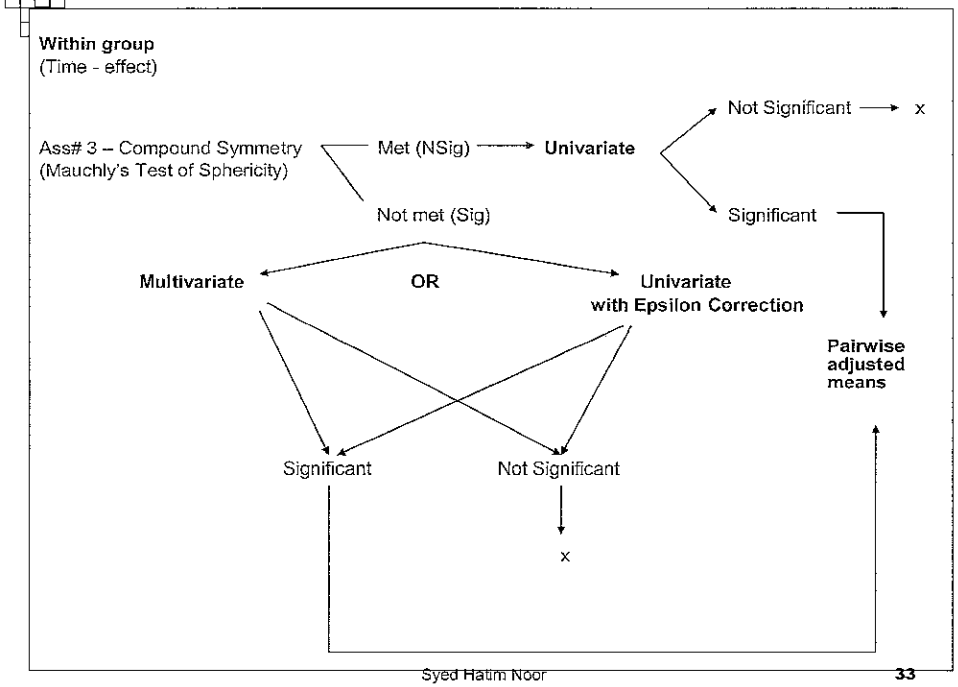
Step 2: Fit RM ANOVA model

How to analyze

Research question:

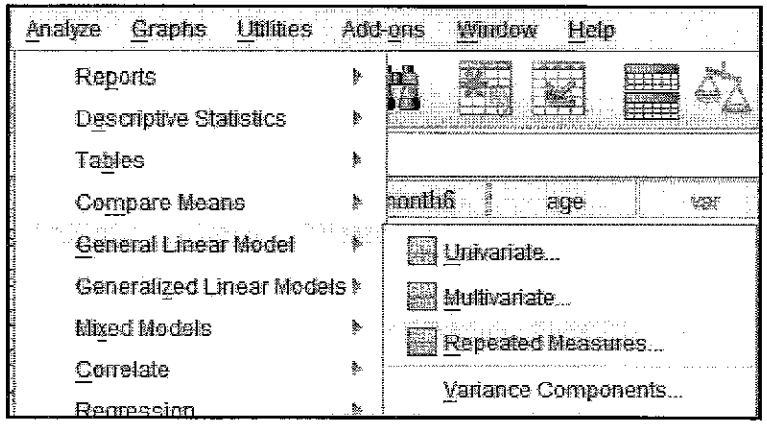
(1) Is there any significant difference of mean blood pressure within group based on time?

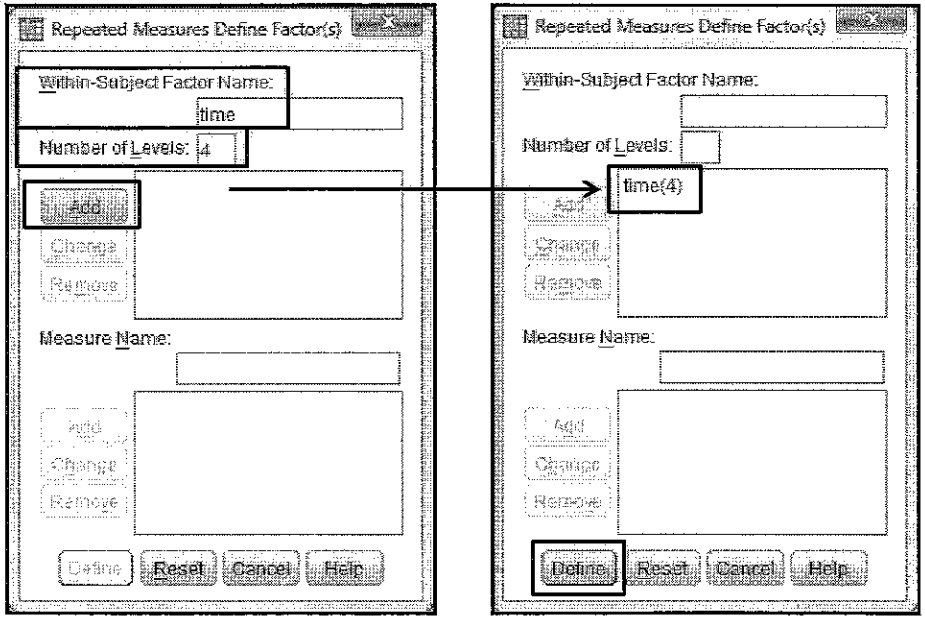
(within group factor) (time effect)

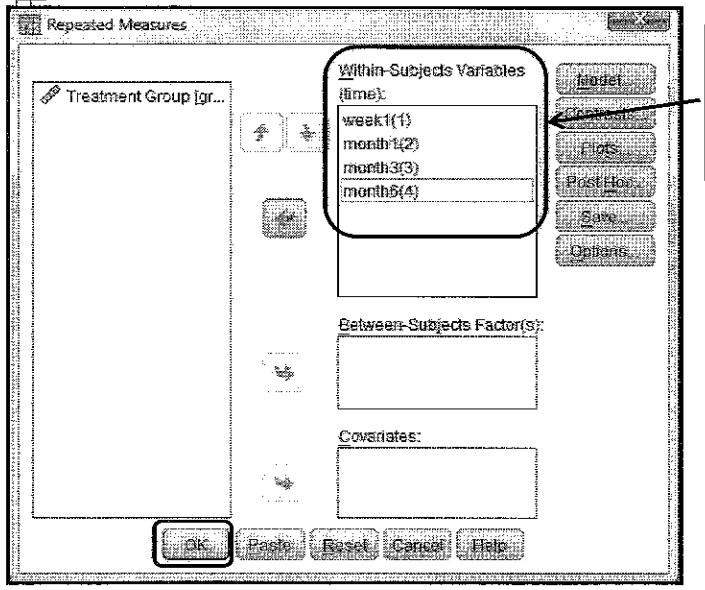


How to analyze

- An alyze > General Linear Model > Repeated Measures







Within-subject variables (continuous) which is repeatedly measures

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
time	.013	120.211	5	.000	.367	.370	.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 table.

b. Design: Intercept
Within Subjects Design: time

- Based on Mauchly's test of sphericity, the p-value <0.001 indicated that assumption of compound symmetry was not met
- Multivariate test statistics have been used when the data violated this assumption

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.350	4.852[a]	3.000	27.000	.008
	Wilks' Lambda	.650	4.852[a]	3.000	27.000	.008
	Hotelling's Trace	.539	4.852[a]	3.000	27.000	.008
	Roy's Largest Root	.539	4.852[a]	3.000	27.000	.008

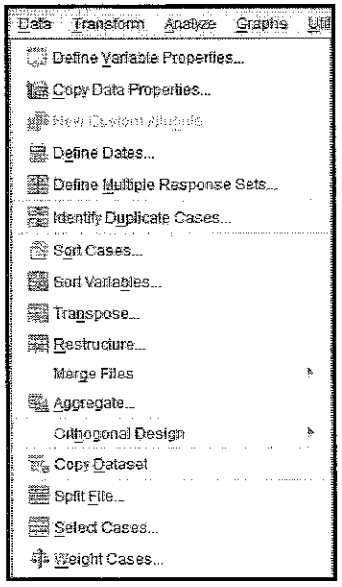
a. Exact statistic

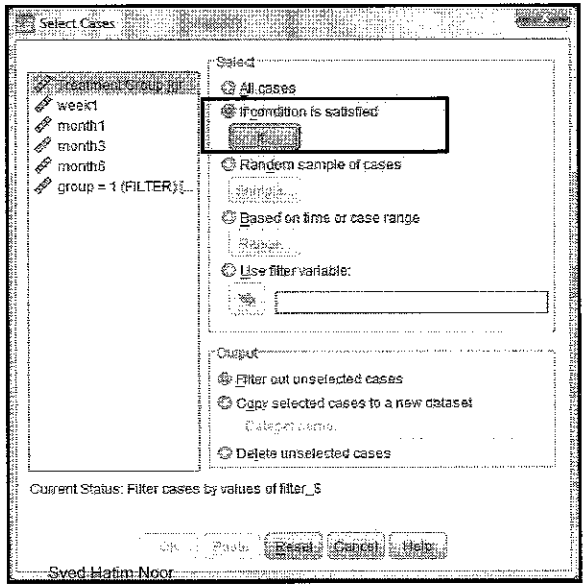
b. Design: Intercept
Within Subjects Design: time

There is significant difference of mean blood pressure within group based on time

P-value is significant, proceed with pairwise comparison with confidence interval adjustment

How to analyze





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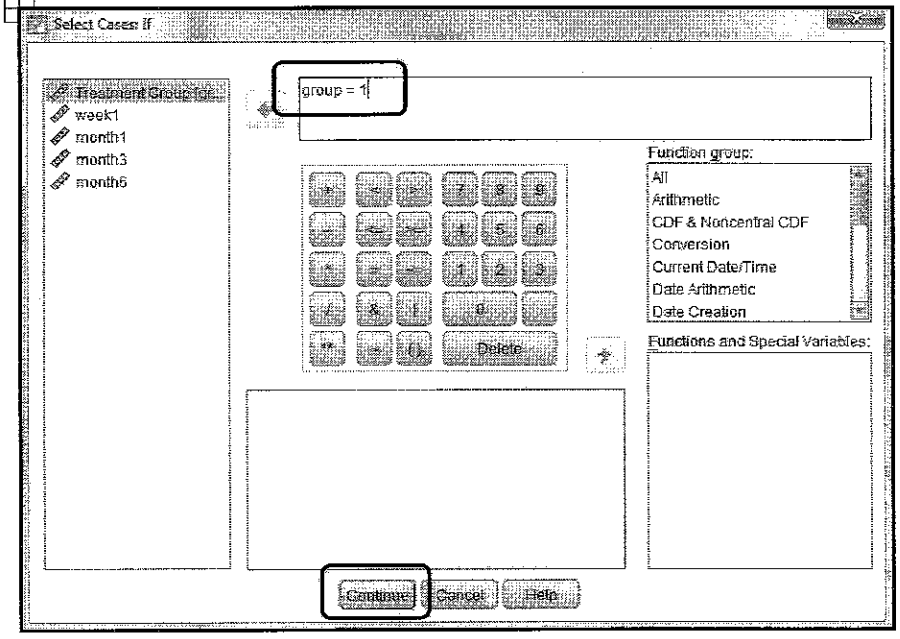
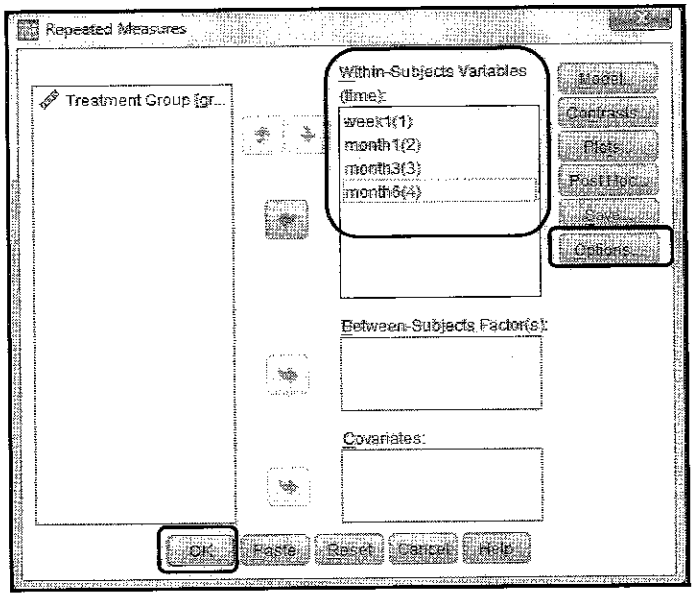
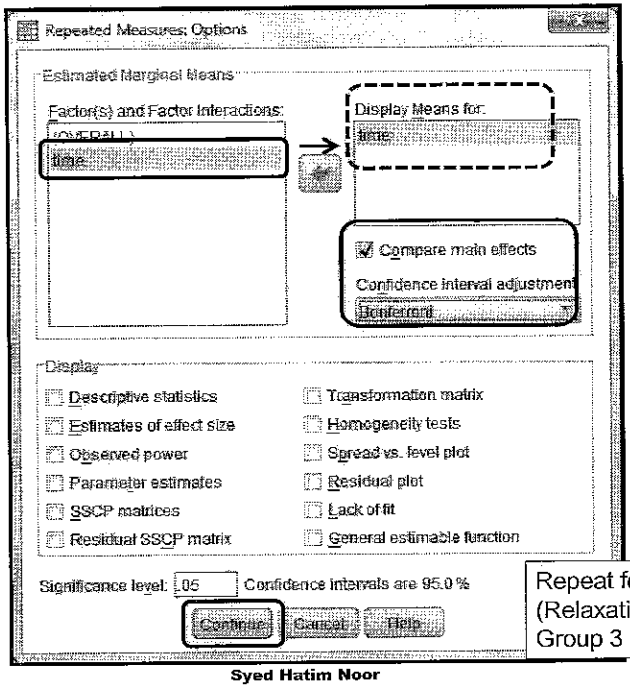


Pairwise comparison with confidence interval adjustment





Repeat for Group 2 (Relaxation) and Group 3 (Control)

Group 1 (Drug)

Pairwise Comparisons

Measure:MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	4.800*	.680	.000	2.513	7.087
	3	10.600*	1.368	.000	5.998	15.202
	4	15.600*	1.600	.000	10.217	20.983
2	1	-4.800*	.680	.000	-7.087	-2.513
	3	5.800*	1.209	.006	1.732	9.868
	4	10.800*	1.373	.000	6.182	15.418
3	1	-10.600*	1.368	.000	-15.202	-5.998
	2	-5.800*	1.209	.006	-9.868	-1.732
	4	5.000*	.803	.001	2.299	7.701
4	1	-15.600*	1.600	.000	-20.983	-10.217
	2	-10.800*	1.373	.000	-15.418	-6.182
	3	-5.000*	.803	.001	-7.701	-2.299

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

Group 1 (Drug)

- Week 1 vs. Month 1: p<0.001
- Week 1 vs. Month 3: p<0.001
- Week 1 vs. Month 6: p<0.001
- Month 1 vs. Month 3: p=0.006
- Month 1 vs. Month 6: p<0.001
- Month 3 vs. Month 6: p=0.001

- Significant differences were observed in all comparisons for Drug group

Group 2 (Relaxation)

Pairwise Comparisons

Measure:MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	3.800*	.757	.004	1.253	6.347
	3	8.800*	1.467	.001	3.866	13.734
	4	14.200*	2.118	.001	7.076	21.324
2	1	-3.800*	.757	.004	-6.347	-1.253
	3	5.000*	.803	.001	2.299	7.701
	4	10.400*	1.514	.000	5.305	15.495
3	1	-8.800*	1.467	.001	-13.734	-3.866
	2	-5.000*	.803	.001	-7.701	-2.299
	4	5.400*	1.077	.004	1.777	9.023
4	1	-14.200*	2.118	.001	-21.324	-7.076
	2	-10.400*	1.514	.000	-15.495	-5.305
	3	-5.400*	1.077	.004	-9.023	-1.777

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

Group 2 (Relaxation)

- Week 1 vs. Month 1: p=0.004
- Week 1 vs. Month 3: p=0.001
- Week 1 vs. Month 6: p=0.001
- Month 1 vs. Month 3: p=0.001
- Month 1 vs. Month 6: p<0.001
- Month 3 vs. Month 6: p=0.004

- Significant differences were observed in all comparisons for Relaxation group

Group 3 (Control)

Pairwise Comparisons

Measure:MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-2.400*	.653	.031	-4.597	-.203
	3	-4.200	1.281	.057	-8.508	.108
	4	-8.400*	1.424	.009	-11.189	-1.611
2	1	2.400*	.653	.031	.203	4.597
	3	-1.800	.814	.326	-4.538	.938
	4	-4.000*	.989	.017	-7.327	-.673
3	1	4.200	1.281	.057	-.108	8.508
	2	1.800	.814	.326	-.938	4.538
	4	-2.200*	.359	.001	-3.408	-.992
4	1	6.400*	1.424	.009	1.611	11.189
	2	4.000*	.989	.017	.673	7.327
	3	2.200*	.359	.001	.992	3.408

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

Group 3 (Control)

- Week 1 vs. Month 1: p=0.031
- Week 1 vs. Month 3: p=0.057
- Week 1 vs. Month 6: p=0.009
- Month 1 vs. Month 3: p=0.326
- Month 1 vs. Month 6: p=0.017
- Month 3 vs. Month 6: p=0.001

- Significant differences were observed between Week 1 and Month1, Week 1 and Month 6, Month 1 and Month 6, Month 3 and Month 6 for Control group

How to analyze

Research question:

(2) Is there any significant difference of mean blood pressure among groups regardless of time?

(Between group factor regardless of time)

(Treatment effect) (Overall)

Between group overall
(Treatment effect
regardless of time)

Between group result

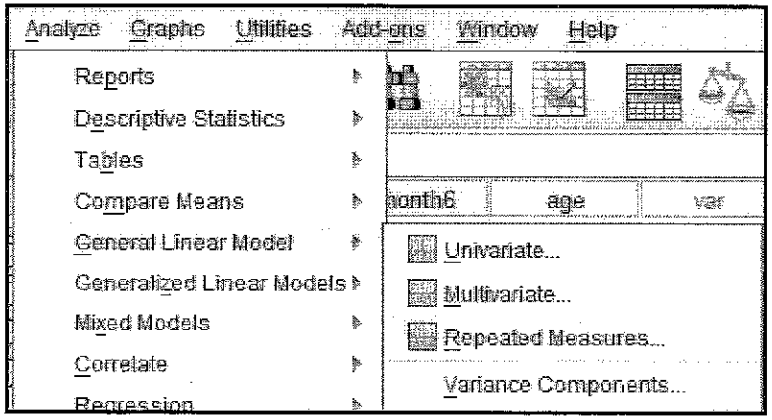
F Test

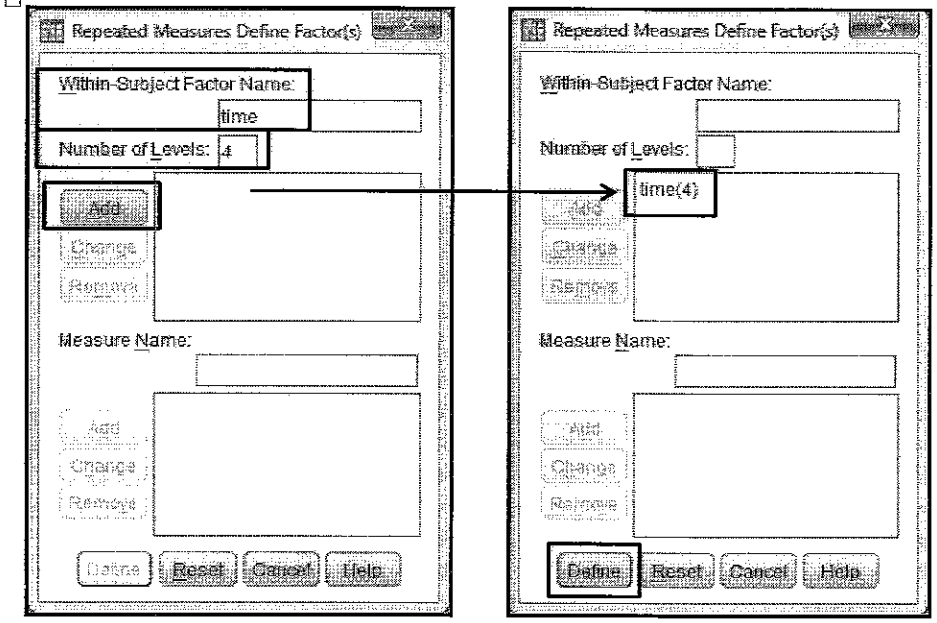
Significant → **Post Hoc Multiple Comparison**
(For significant difference between pairs of treatment groups)

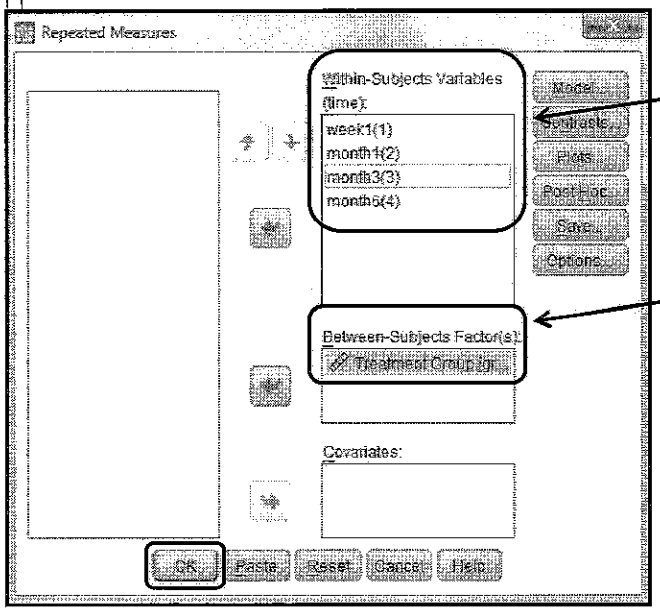
Not Significant → ×

How to analyze

- An alyze > General Linear Model > Repeated Measures







Within-subject variables (continuous) which is repeatedly measures

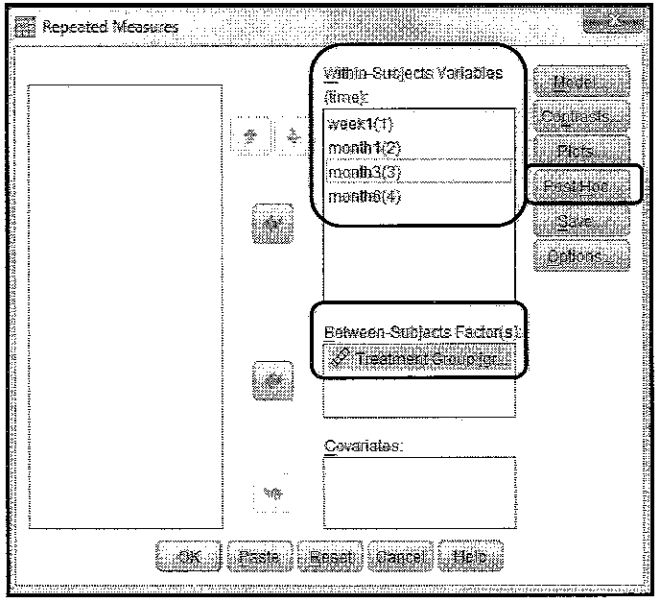
Between-subject variable (categorical)

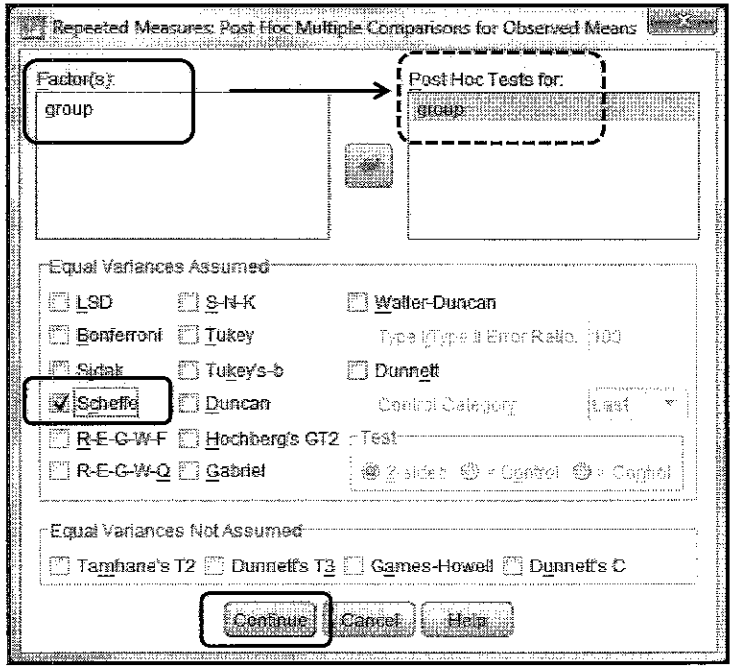
Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1250112.533	1	1250112.533	4734.611	.000
group	2642.467	2	1321.233	5.004	.014
Error	7129.000	27	264.037		

P value for F test is significant → Post hoc multiple comparison





Multiple Comparisons

MEASURE_1
Scheffe

(I) Treatment Group	(J) Treatment Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Drug	Relaxation	-1.45	3.633	.924	-10.86	7.96
	Control	-10.60*	3.633	.025	-20.01	-1.19
Relaxation	Drug	1.45	3.633	.924	-7.96	10.86
	Control	-9.15	3.633	.058	-18.56	.26
Control	Drug	10.60*	3.633	.025	1.19	20.01
	Relaxation	9.15	3.633	.058	-.26	18.56

Based on observed means.
The error term is Mean Square(Error) = 66.009.

*. The mean difference is significant at the .05 level.

Homogeneous Subsets

MEASURE_1

Scheffe[a,b,c]

Treatment Group	N	Subset 1	Subset 2
Drug	10	98.05	
Relaxation	10	99.50	99.50
Control	10		108.65
Sig.		.924	.058

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 66.009.

a. Uses Harmonic Mean Sample Size = 10.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

- If there is more than one subset → there is at least one pair that is significant
- There is no significant difference between groups if the groups fall under the same subset
- There is a significant difference between groups if the groups fall under different subset

Post hoc multiple comparison

- Drug vs. relaxation: p=0.924
- Drug vs. control: p=0.025
- Relaxation vs. control: p=0.058

- Significant difference was reported between drug and control groups

How to analyze

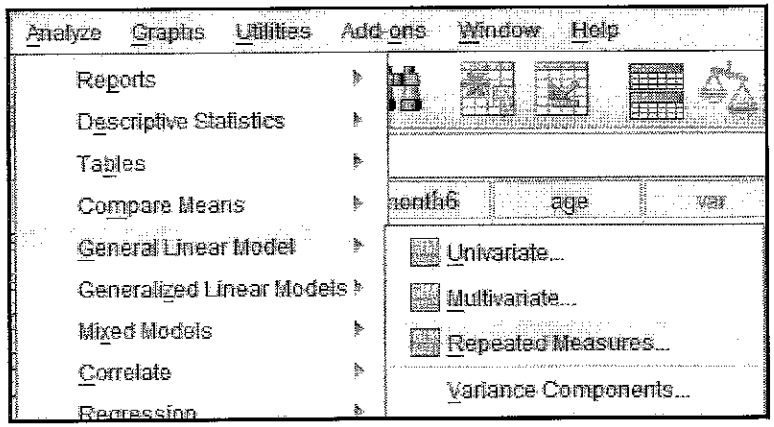
Research question:

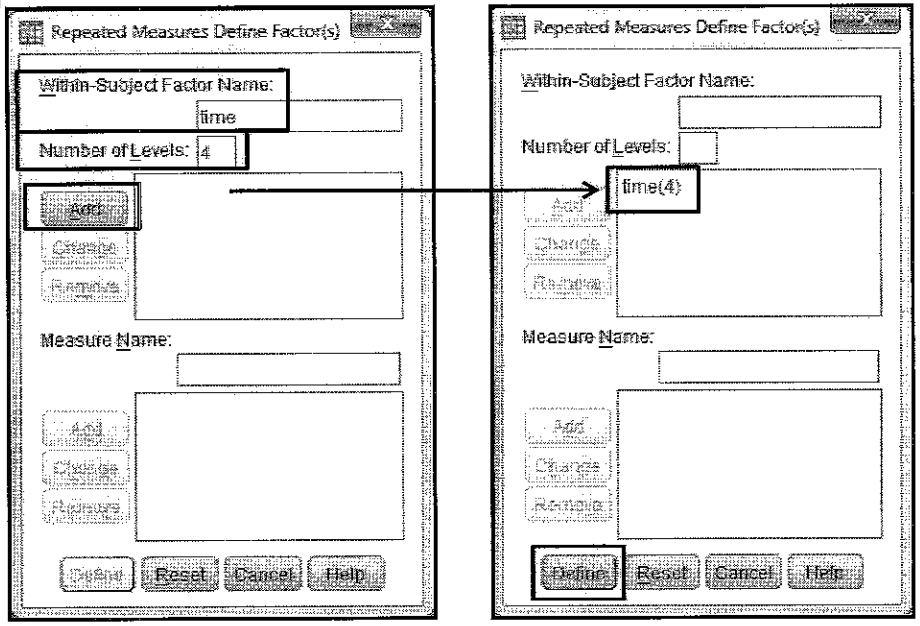
(3) Is there any significant difference of mean blood pressure among groups with regard to time?

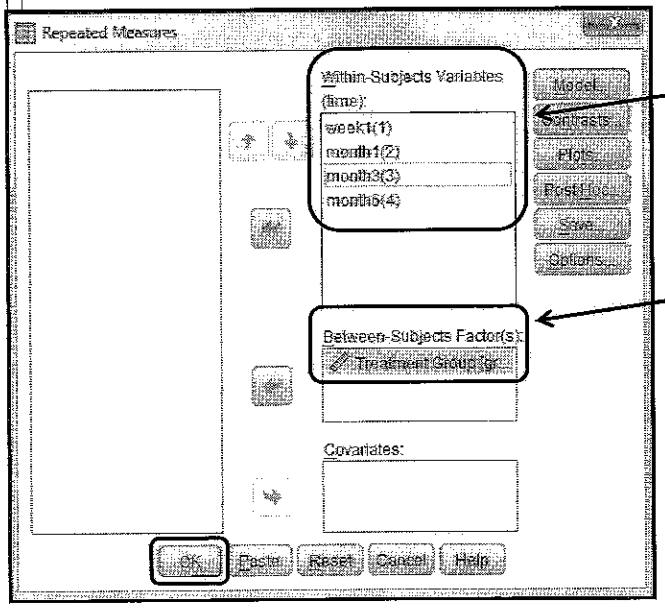
(Time*treatment interaction)

How to analyze

- An alyze > General Linear Model > Repeated Measures







Within-subject variables (continuous) which is repeatedly measures

Between-subject variable (categorical)

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.697	19.182[a]	3.000	25.000	.000
	Wilks' Lambda	.303	19.182[a]	3.000	25.000	.000
	Hotelling's Trace	2.302	19.182[a]	3.000	25.000	.000
	Roy's Largest Root	2.302	19.182[a]	3.000	25.000	.000
time * group	Pillai's Trace	.840	6.279	6.000	52.000	.000
	Wilks' Lambda	.197	10.461[a]	6.000	50.000	.000
	Hotelling's Trace	3.899	15.597	6.000	48.000	.000
	Roy's Largest Root	3.851	33.373[b]	3.000	26.000	.000

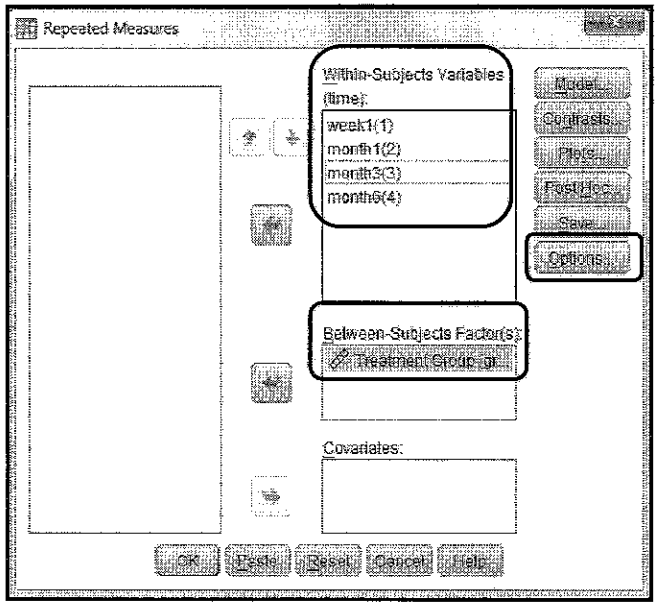
a. Exact statistic

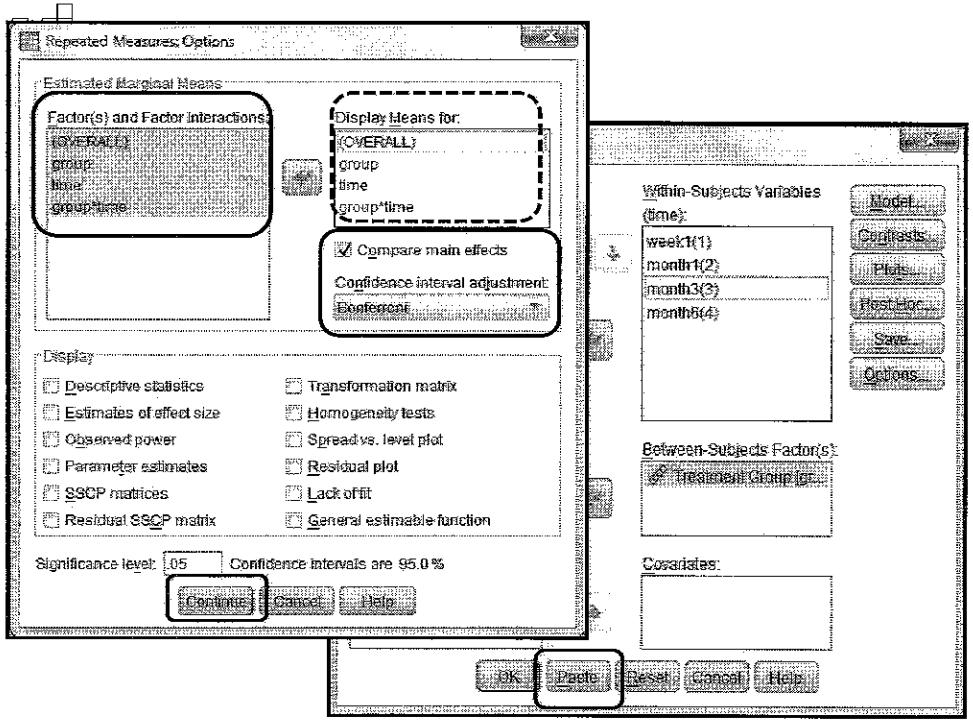
b. The statistic is an upper bound on F that yields a lower bound on the significance level.

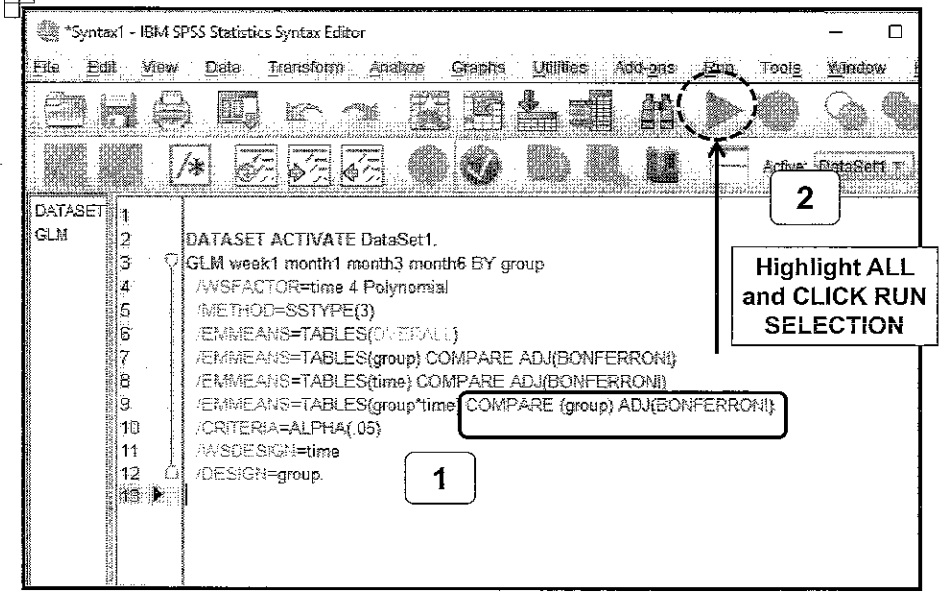
c. Design: Intercept + group
Within Subjects Design: time

When the p-value for time-treatment interaction results based on F-test is significant (less than 0.05), the analysis is followed by producing adjusted means (estimated marginal means) with its confidence interval

Analyze > General Linear Model > Repeated Measures > Options







4. Treatment Group * time

Estimates

Measure: MEASURE_1

Treatment Group	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Drug	1	105.800	2.849	99.954	111.646
	2	101.000	2.708	95.444	106.556
	3	95.200	2.667	89.728	100.672
	4	90.200	2.452	85.169	95.231
Relaxation	1	106.200	2.849	100.354	112.046
	2	102.400	2.708	96.844	107.956
	3	97.400	2.667	91.928	102.872
	4	92.000	2.452	86.969	97.031
Control	1	105.400	2.849	99.554	111.246
	2	107.800	2.708	102.244	113.356
	3	109.600	2.667	104.128	115.072
	4	111.900	2.452	106.769	116.831

Pairwise Comparisons

Measure: MEASURE_1

time	(I) Treatment Group	(J) Treatment Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	Drug	Relaxation	-.400	4.029	1.000	-10.684	9.884
		Control	.400	4.029	1.000	-9.884	10.684
	Relaxation	Drug	.400	4.029	1.000	-9.884	10.684
		Control	.800	4.029	1.000	-9.484	11.084
	Control	Drug	-.400	4.029	1.000	-10.684	9.884
		Relaxation	-.800	4.029	1.000	-11.084	9.484
2	Drug	Relaxation	-1.400	3.830	1.000	-11.175	8.375
		Control	-6.800	3.830	.261	-16.575	2.975
	Relaxation	Drug	1.400	3.830	1.000	-8.375	11.175
		Control	-5.400	3.830	.510	-15.175	4.375
	Control	Drug	6.800	3.830	.261	-2.975	16.575
		Relaxation	5.400	3.830	.510	-4.375	15.175
3	Drug	Relaxation	-2.200	3.772	1.000	-11.827	7.427
		Control	-14.400*	3.772	.002	-24.027	-4.773
	Relaxation	Drug	2.200	3.772	1.000	-7.427	11.827
		Control	-12.200*	3.772	.010	-21.827	-2.573
	Control	Drug	14.400*	3.772	.002	4.773	24.027
		Relaxation	12.200*	3.772	.010	2.573	21.827
4	Drug	Relaxation	-1.800	3.468	1.000	-10.651	7.051
		Control	-21.600*	3.468	.000	-30.451	-12.749
	Relaxation	Drug	1.800	3.468	1.000	-7.051	10.651
		Control	-19.800*	3.468	.000	-28.651	-10.949
	Control	Drug	21.600*	3.468	.000	12.749	30.451
		Relaxation	19.800*	3.468	.000	10.949	28.651

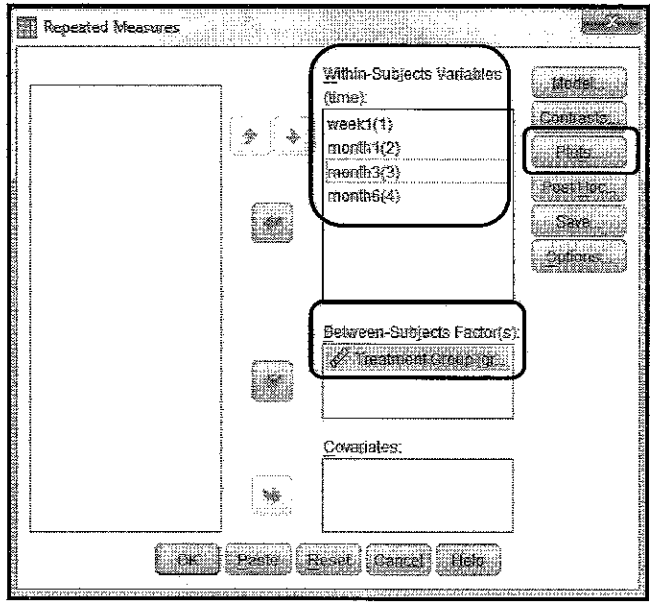
Based on estimated marginal means

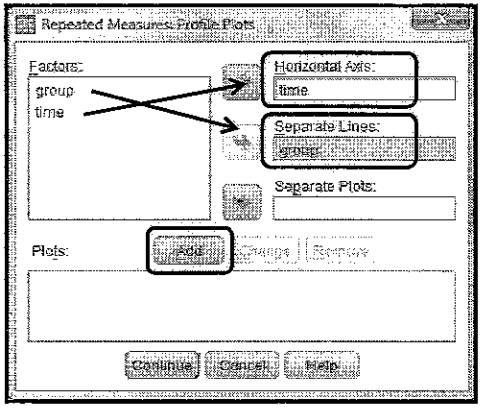
*. The mean difference is significant at the .05 level.

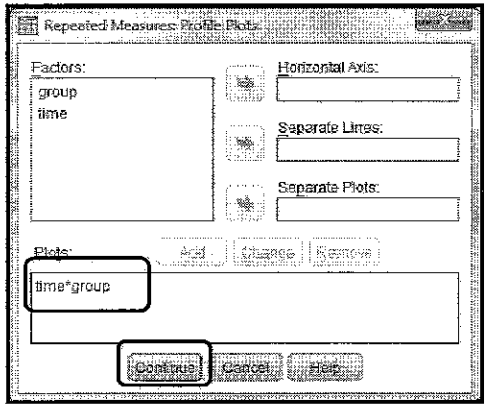
b. Adjustment for multiple comparisons: Bonferroni.

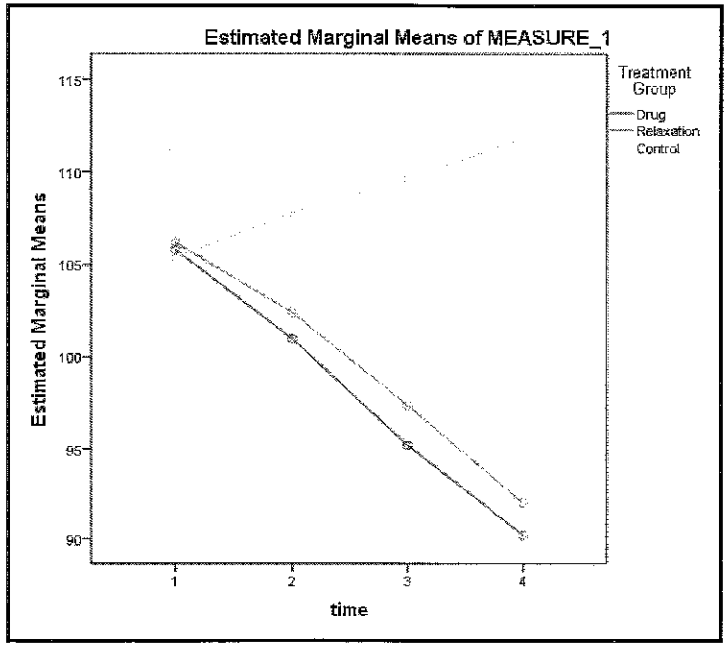
Profile plot

Analyze > General Linear Model > Repeated Measures > Plots





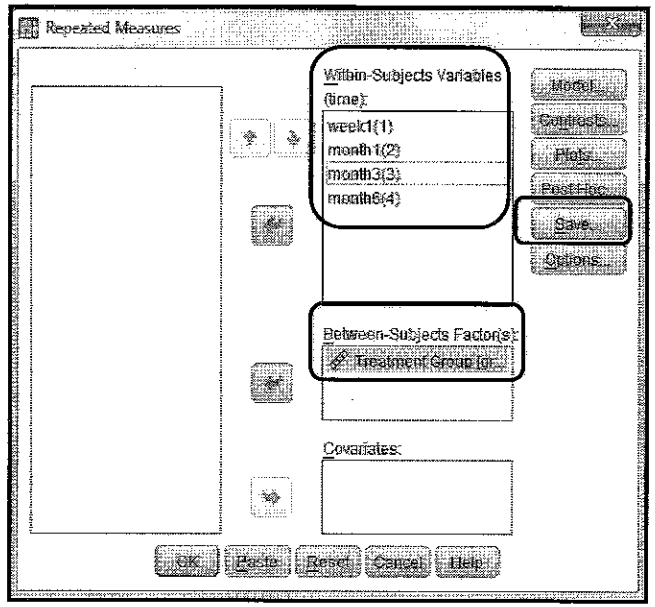


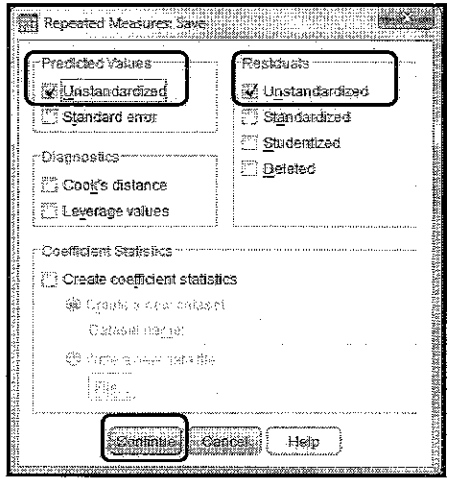


Step 3: Checking Assumptions

Normality of the residuals	Histogram with overlaid normal curve of residuals Box and whisker plot of residuals
Homogeneity of variance H_o : Variances are equal H_A : Variances are unequal	Levene's test Scatter plot between residuals and predicted values (XP-YR)
Assumption of compound symmetry H_o : Correlation across all measurement have constant (R12 = R23 = R34 ≠ 0) H_A : Otherwise (at least one is not constant)	Mauchly's test of sphericity

Residuals and predicted values



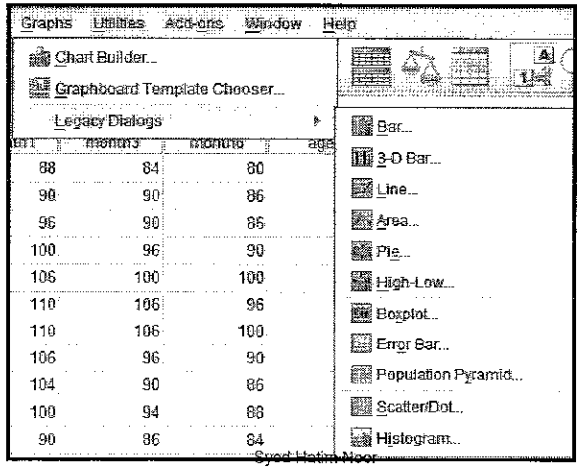


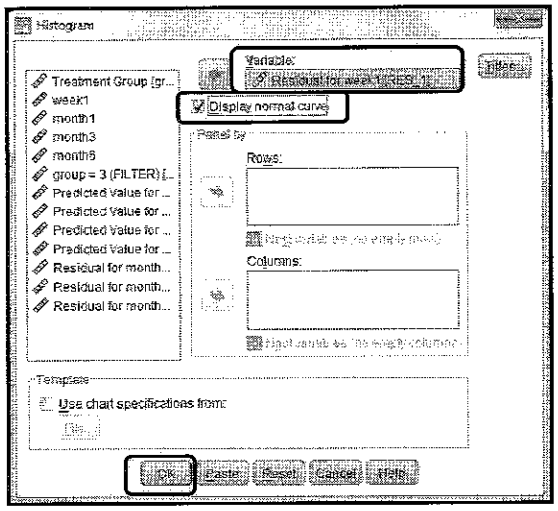
PRE_1	PRE_2	PRE_3	PRE_4	RES_1	RES_2	RES_3	RES_4
105.80	101.00	95.20	90.20	-15.80	-13.00	-11.20	-10.20
105.80	101.00	95.20	90.20	-11.80	-11.00	-5.20	-4.20
105.80	101.00	95.20	90.20	-5.80	-5.00	-5.20	-4.20
105.80	101.00	95.20	90.20	.20	-1.00	.80	-.20
105.80	101.00	95.20	90.20	4.20	5.00	4.80	9.80
105.80	101.00	95.20	90.20	6.20	9.00	10.80	5.80

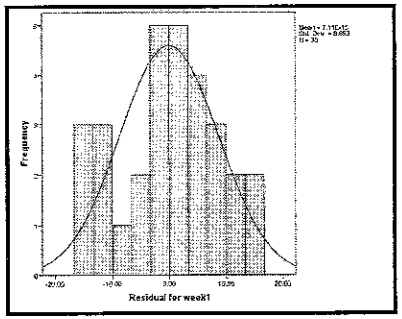
Normality of residuals

- Histogram with overlaid normal curve

  Graphs > Legacy Dialogs > Histogram





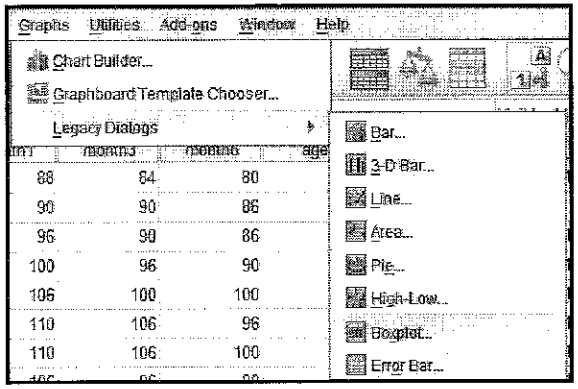


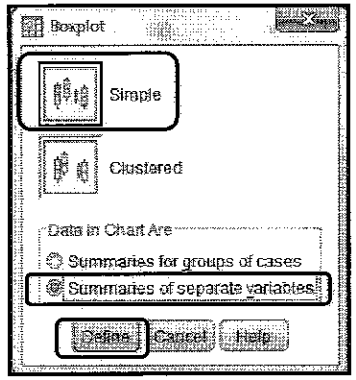
Repeat for other residuals
-Residual for month1
-Residual for month3
-Residual for month6

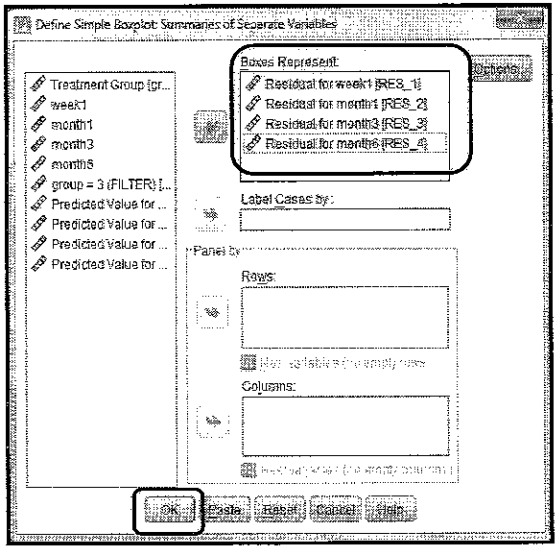
Normality of residuals

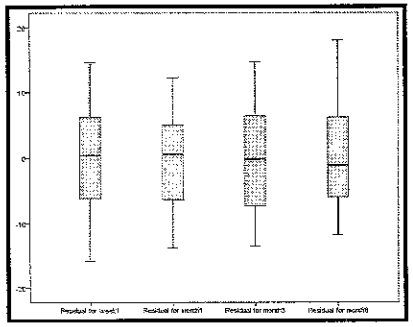
- Bo x and whisker plot

  Graphs > Legacy Dialogs > Boxplot

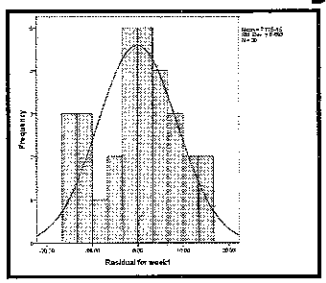


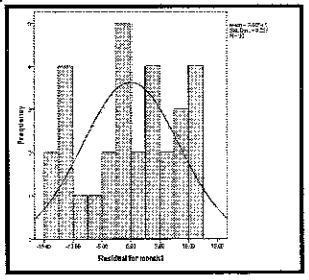


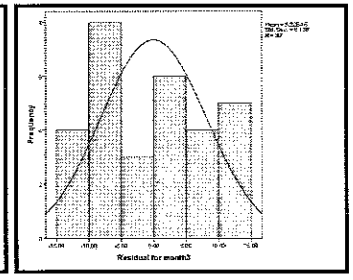


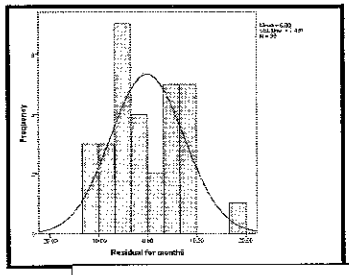


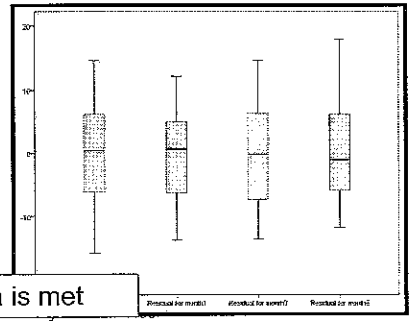
Normality of residuals







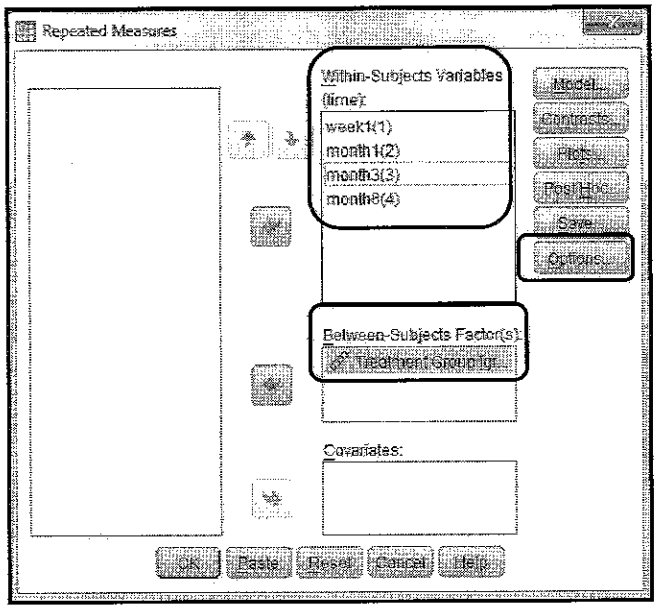


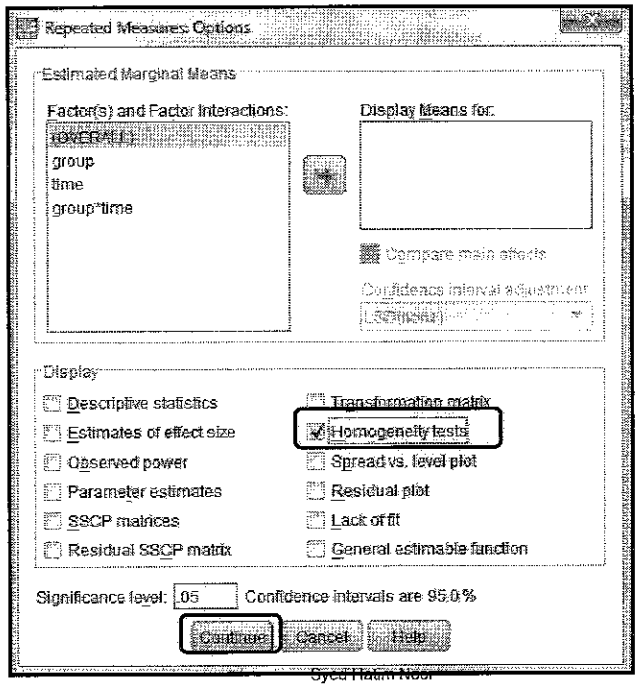


Normality assumption is met

Homogeneity of variances

- Levene's test





Homogeneity of variances

- H_o: Variances are equal

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
week1	.021	2	27	.979
month1	.240	2	27	.788
month3	1.020	2	27	.374
month6	.758	2	27	.478

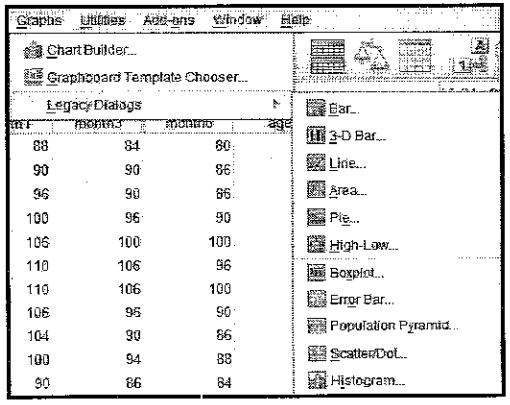
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

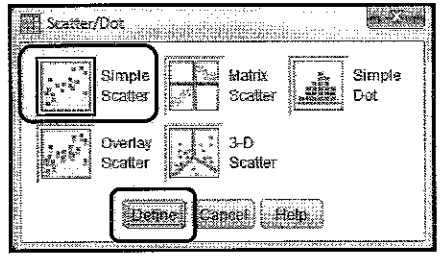
a. Design: Intercept + group
Within Subjects Design: time

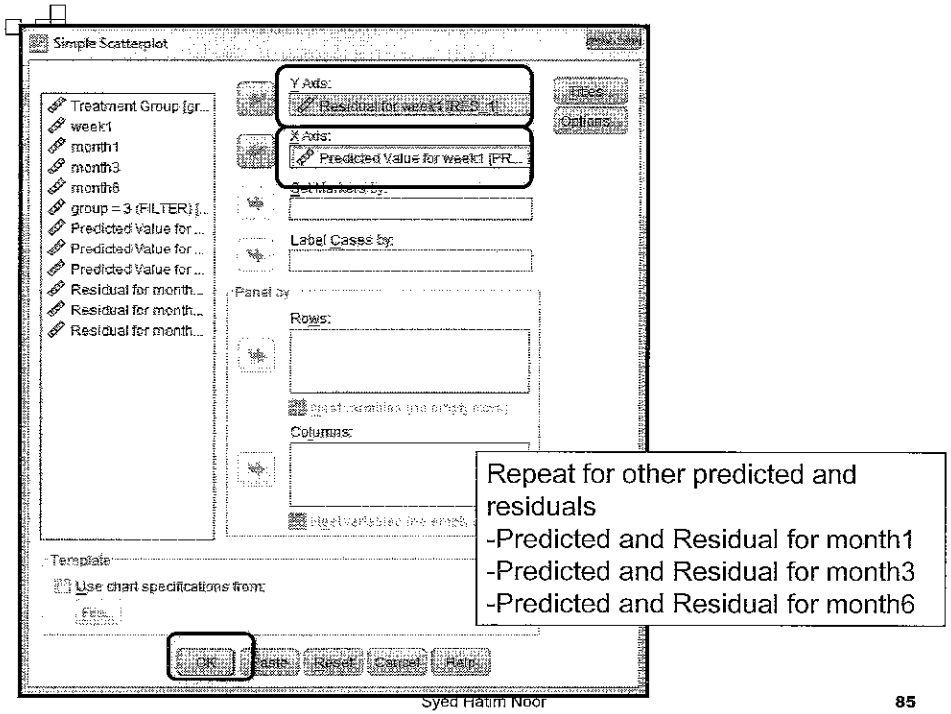
Assumption for homogeneity of variances is met

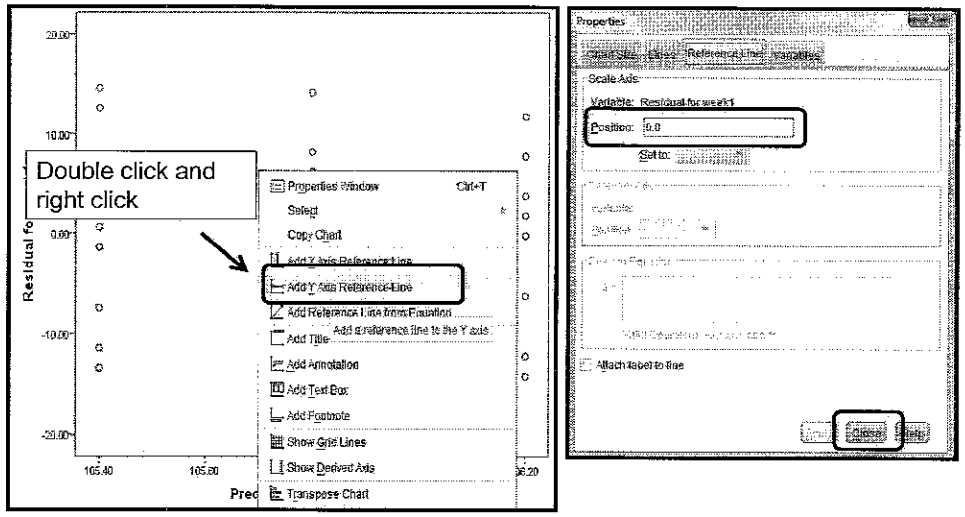
Homogeneity of variances

- Scatter plot between residuals and predicted values (XP-YR)

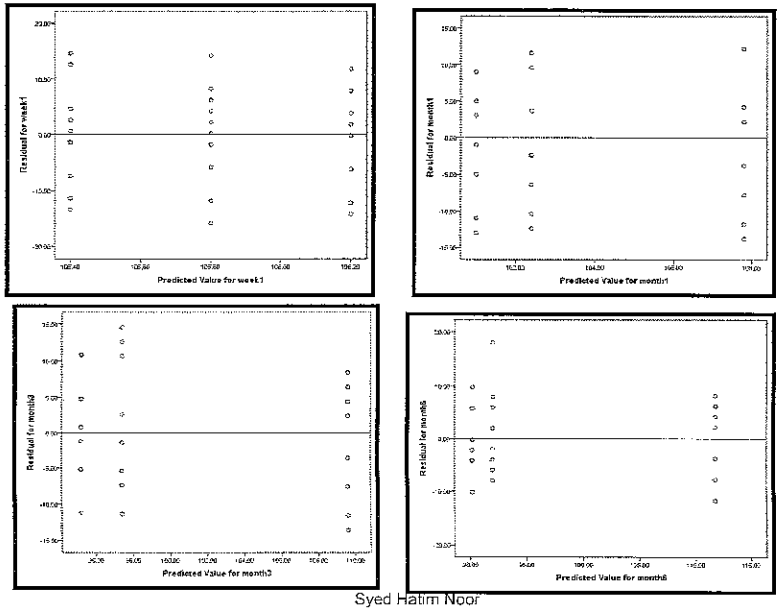




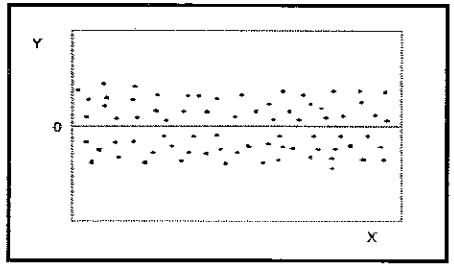


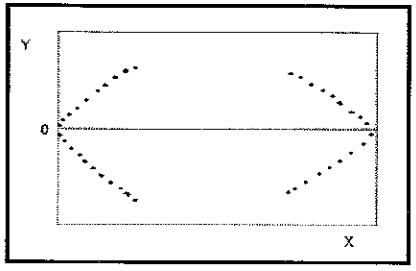


Homogeneity of variances



Homogeneity of variances





Observations along the line

Divergent

Convergent

Homogeneity of variances

- The residuals should scatter randomly about a horizontal line of 0 if the assumption is met
- There is no peculiar shape of divergence or convergence or a megaphone or a fan-shape of fitted observations
- The assumption of homogeneity of variances is met

Assumption of compound symmetry

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
time	.152	48.529	5	.000	.475	.531	.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 table.

b. Design: Intercept + group
Within Subjects Design: time

- Based on Mauchly's test of sphericity, the p-value <0.001 indicated that assumption of compound symmetry was not met
- Multivariate test statistics have been used when the data violated this assumption

Step 4: Interpretation, conclusion and presentation

- Interpre tation should be based on the primary research question
- With in group / between groups / within-between groups design
- Pre sentation of results should also be based on the primary research question

Presentation of the result

- **Within groups**
  Results of pairwise comparison with confidence interval adjustment should be presented
- **Between groups and within-between groups**
  - Comparison of mean and confidence intervals of parameter between groups at each time point should be presented in a table as well as a graph
  - Some researchers prefers to present only the overall difference of parameter

Table(1) Comparison of blood pressure within each treatment groups based on time (Time effect)

Comparison	Drug		Relaxation		Control	
	MD(95% CI)	p-value	MD(95% CI)	p-value	MD(95% CI)	p-value
Week1-Month1	4.80(2.51, 7.09)	<0.001	3.80(1.25, 6.35)	0.004	-2.40(-4.60, -0.20)	0.031
Week1-Month3	10.60(6.00, 15.20)	<0.001	8.80(3.87, 13.73)	0.001	-4.20(-8.51, 0.11)	0.057
Week1-Month6	15.60(10.22, 20.98)	<0.001	14.20(7.08, 21.32)	0.001	-6.40(-11.20, -1.61)	0.009
Month1-Month3	5.80(1.73, 9.87)	0.006	5.00(2.30, 7.70)	0.001	-1.80(-4.54, 0.94)	0.350
Month1-Month6	10.80(6.18, 15.42)	<0.001	10.40(5.31, 15.50)	<0.001	-4.00(-7.33, -0.67)	0.017
Month3-Month6	5.00(2.30, 7.70)	0.001	5.40(1.78, 9.02)	0.004	-2.20(-3.41, -0.99)	0.001

Repeated measures ANOVA within group analysis was applied followed by pairwise comparison with 95% confidence interval adjustment by Bonferroni correction
MD = mean difference

Table (2): Overall mean difference of blood pressure among three treatment groups (Treatment effect)

Comparison	Mean difference (95% CI)	p-value
Drug-Relaxation	-1.45 (-10.86, 7.96)	0.924
Drug-Control	-10.60 (-20.01, -1.19)	0.025
Relaxation-Control	-9.15 (-18.56, 0.26)	0.058

Repeated measures ANOVA between group analysis was applied followed by post-hoc multiple comparisons using Scheffe method
F-stat (df) = 5.00(2), p-value = 0.014

Table (3) Comparison of mean blood pressure among three different treatment groups based on time (Time-treatment interaction)

	Comparison	Mean difference (95% CI)	p-value
Week 1	Drug-Relaxation	-0.40 (-10.68, 9.88)	>0.950
	Drug-Control	0.40 (-9.88, 10.68)	>0.950
	Relaxation-Control	0.80 (-9.48, 11.08)	>0.950
Month 1	Drug-Relaxation	-1.40 (-11.18, 8.38)	>0.950
	Drug-Control	-6.80 (-16.58, 2.98)	0.261
	Relaxation-Control	-5.40 (-15.18, 4.38)	0.510
Month 3	Drug-Relaxation	-2.20 (-11.83, 7.43)	>0.950
	Drug-Control	-14.40 (-24.03, -4.77)	0.002
	Relaxation-Control	-12.20 (-21.83, -2.57)	0.010
Month 6	Drug-Relaxation	-1.80 (-10.65, 7.05)	>0.950
	Drug-Control	-21.60 (-30.45, -12.75)	<0.001
	Relaxation-Control	-19.80 (-28.65, -10.95)	<0.001

Repeated measures ANOVA between group analysis with regard to time was applied followed by pairwise comparison with 95% confidence interval adjustment by Bonferroni correction
Assumptions of normality, homogeneity of variances and compound symmetry were checked and were fulfilled

Recapping

- Regular ANOVA is meant for between subject analysis as measurements are made on different subjects (independent assumption)
- RM ANOVA is not reasonable to assume independence as repeated measures are made on the same individuals
- Benefit of requirement of fewer subjects if design can be made to overcome pitfalls
- Analysis and interpretation is made according to the primary research question (within / between/ within-between) of the study