

USING THE SAS MIXED PROCEDURE TO ANALYZE THE REPEATED MEASURES DATA

Hongsen Zhou, PhD
Statistician
Iowa Foundation for Medical Care
IAPRO.HZHOU@SDPS.ORG

INTRODUCTION

The measurement and analysis methodology plays a primary role in the fields of statistics. It would be difficult or impossible to provide a correct result if the measurement and analysis methodology were inappropriate. Consider a situation of remeasurement. The repeated measures data consist of multiple measurements obtained on the same experimental unit (i. e., subject). There are two sources of variability: within subjects and among subjects. The common mistake is that the variability within subjects is incorrectly assumed to represent the variability among subjects. The repeated measures data are not independent samples from the population of interest. They are repeated measurements on the same experiment unit. The response of a specific experiment unit at measurement can provide information about the response of the same experiment unit at remeasurement; therefore, the analysis of repeated measures data should consider the presence of correlation between the measurements obtained on the same subject and for possible nonconstant variability.

In order to deal efficiently with the problem above, SAS PROC MIXED is a powerful tool to analyze repeated measures data. PROC MIXED fits mixed linear models to data. The mixed model is a generalization of the standard linear model used in the General Linear Model (GLM) procedure; the generalization being that one can analyze data generated from several sources of variation instead of just one. The inferential statistics are essentially the same, but their scope is broader. The MIXED procedure is designed for easy accessibility to a wide variety of mixed models. The objective of this presentation is to demonstrate how to use SAS to analyze the repeated measures data.

PROCEDURE

Approach of Model

The mixed model extends the GLM by allowing a more general specification of the covariance matrix of $\mathbf{Y}$. The mixed model allows for random factors in the model and for random components of $\boldsymbol{\varepsilon}$ to be correlated. The model fit by the MIXED procedure is

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\boldsymbol{\gamma} + \boldsymbol{\varepsilon}$$

For the mixed model, assume $\boldsymbol{\gamma}$ and $\boldsymbol{\varepsilon}$ are normally distributed with

$$\mathbf{E} \begin{bmatrix} \boldsymbol{\gamma} \\ \boldsymbol{\varepsilon} \end{bmatrix} = \mathbf{0} \quad \text{and} \quad \mathbf{var} \begin{bmatrix} \boldsymbol{\gamma} \\ \boldsymbol{\varepsilon} \end{bmatrix} = \begin{bmatrix} \mathbf{G} & \mathbf{0} \\ \mathbf{0} & \mathbf{R} \end{bmatrix}$$

However, the independent and constant variance assumption of the GLM are not required. The GLM is a special case of the mixed model with $\mathbf{Z}=\mathbf{0}$ (which means $\mathbf{Z}\boldsymbol{\gamma}$ disappears from the model) and $\mathbf{R}=\boldsymbol{\sigma}^2\mathbf{I}$.

Comparing the MIXED and GLM procedures:

- Mixed is a generalization of GLM.
- They have similar syntax.

- They have the same parameterization but sometimes a different sorting of class levels.
- MIXED offers only Type I and III tests for fixed effects, whereas GLM offers Type I, II, III and IV tests.
- GLM has a MEANS and an LSMEANS statement, whereas MIXED only has an LSMEANS statement.
- The RANDOM and REPEATED statements are used differently.
- GLM uses method-of moments to estimate the variance components. MIXED uses Restricted/Residual Maximum-Likelihood (REML) or Maximum-Likelihood (ML).

MIXED Procedure

The general form of PROC MIXED is similar to PROC GLM, but there are some differences. The random statement is not included in the model statement and the use of the repeated statement is completely different. The MIXED procedure syntax is shown as following:

PROC MIXED options ;

```

CLASS variable-list;
MODEL dependent=fixed effects/ options;          /* required */
BY variable-list;
ID variable-list;
CONTRAST 'label' fixed-effect values|
           random-effect values/ options;
ESTIMATE 'label' fixed-effect values|
           random-effect values/ options;
LSMEANS fixed-effects / options;
MAKE 'table' OUT= SAS-data-set < options > ;
PARMS values... / options;
PRIOR < distribution > < / options >;
RANDOM random effects in G / options;
REPEATED random effects in R / options;
WEIGHT variable;

```

RUN;

PROC MIXED uses an experimental Output Delivery System (ODS) that has control over the tables that comprise the PROC MIXED output. The MAKE statement in PROC MIXED allows one to put these tables into SAS data sets.

To illustrate the procedures of repeated measures analysis using PROC MIXED, a Quality Improvement Project of Health Care is used as an example, a particular Quality Indicator (QI) of the project is used as a dependent variable, and hospital participation status (Yes or No) in the project and measurement periods (baseline, 9th month, 18th month and 28th month) are used as independent variables.

The procedure of analyzing repeated measures data with PROC MIXED generally consists of identifying the effects, selecting the appropriate within-subject covariance structure using Akaike's Information Criterion (AIC) and Schwarz's Bayesian Criterion (SBC) criteria or restricted likelihood ratio tests, and evaluating the significance and parameter estimates of the fixed effects.

Identify the Effects

For this example, the hospital is the subject. The participation status is a between-subject effect. The measurement period is a within-subject effect.

Determine the Appropriate Variance-Covariance Structure

PROC MIXED computes the least squares means that are averaged across the repeated measures and whose standard errors reflect the specified within-subject variance-covariance matrix. Before testing the significance of the fixed effects, an appropriate covariance structure must be selected correctly. The tests for the fixed effects can be invalid if the covariance structure is misspecified.

The Appendix contains a list and description of covariance structures available in PROC MIXED. To select an appropriate covariance structure, the following SAS macro program can be used to choose the best model by using various statistical measures, the AIC being used here to compare the models. However, these statistics are of opposite sign from those produced by PROC REG. Therefore, when PROC MIXED is used, models with the largest AIC are best.

```
%macro structur(z=, comment=, out=);
%let _print_=off;
proc mixed data=mwsuq.mwsug01 ;
  class HOSPITAL PARTICIP MEASURE;
  model &model;
  &z;
  make 'fitting' out=fitinfo;
run;
data fitinfo;
  length z $40;
  set fitinfo;
  z="&comment";
run;

proc append base=&out data=fitinfo;
run;

%let _print_=on;
%mend;

%let model=QI=PARTICIP MEASURE MEASURE*PARTICIP;

/****compound symmetry****/
%structur(z=repeated / type=cs subject=HOSPITAL,
  comment=cs, out=matrix);

/****Huynh Feldt****/
%structur(z=repeated / type=hf subject=HOSPITAL,
  comment=hf, out=matrix);

/****Heterogeneous Compound-Symmetry****/
%structur(z=repeated / type=csh subject=HOSPITAL,
  comment=csh, out=matrix);

/****Unstructure****/
%structur(z=repeated / type=un subject=HOSPITAL,
  comment=un, out=matrix);

/****Banded Main Diagonal****/
%structur(z=repeated / type=un(1) subject=HOSPITAL,
  comment=diag, out=matrix);

/****Variance Components****/
%structur(z=repeated / type=VC subject=HOSPITAL,
```

```
comment=VC, out=matrix);
```

```
proc sort data=matrix;  
  where descr= 'Akaike';  
  by descending value;  
run;
```

```
proc print data=matrix;  
run;
```

The Results Sorted by Fitting Criteria

OBS	Z	DESCR	VALUE
1	un	Akaike's Information Criterion	-230.175
2	csh	Akaike's Information Criterion	-242.670
3	hf	Akaike's Information Criterion	-249.532
4	cs	Akaike's Information Criterion	-250.117
5	diag	Akaike's Information Criterion	-288.901
6	vc	Akaike's Information Criterion	-288.927

In the above, the AIC indicates that an Unstructured Variance-Covariance (UN) provides the best fit.

Analyzing the Repeated Measures Data

The SAS code for analyzing the repeated measures data is shown below after the correct covariance structure has been found.

```
proc mixed data= mwsuq.mwsug01;  
  class HOSPITAL PARTICIP MEASURE;  
  model QI=PARTICIP MEASURE MEASURE*PARTICIP;  
  lsmeans PARTICIP MEASURE MEASURE*PARTICIP /cl pdiff adjust=tukey;  
  repeated / subject=HOSPITAL type=un;  
run;
```

The SAS output (see Appendix) shows that the likelihood ratio test indicates (p -value=0.000<0.01) that the unstructured variance-covariance structure fits better than the simple null model ($\sigma^2\mathbf{I}$).

With this covariance structure, the difference at a 5% significance level in the mean response QI of participation status, measurement periods and their interaction are detected because p -values (0.0195, 0.0000 and 0.0000, respectively) are less than 0.05. The quality improvement of the participating hospitals is significantly more than that of non-participating hospitals. The quality improvement significantly increases along with measurement periods. In addition, the interaction between participation status and measurement period also is detected to be significant. That indicates that the quality improvement of the participating hospitals is not parallel to that of non-participating hospitals along with measurement periods. The quality improvement of the participating hospitals is significantly faster than that of non-participating hospitals.

In order to test quality improvement within the groups (participating and non-participating groups) for each measure period, multiple comparisons are requested in the PROC MIXED procedure. For this example, the TUKEY adjustment is requested. There are also other adjustments such as BON, DUNNETT, SCHEFFE, SIDAK, SIMULATE and SMM available in PROC MIXED. The reason for selecting the TUKEY adjustment is that TUKEY test, sometimes call the “Honestly Significant Difference (HSD) test”, is more powerful than other tests. Some of the other tests are either conservative or produce a larger error compared to the TUKEY test.

The TUKEY test shows that the quality of health care of the participating hospitals has been significantly improved after each period except the period from baseline to 9th month. The quality improvement may be slow during the first few months. On the contrary, significant quality improvement of non-participating hospitals among each period is not detected at a 5% significance level. Therefore, all hospitals are encouraged to participate in the tracking quality improvement projects.

REFERENCE

1. Lloyd D. Fisher and Gerald Van Belle. Biostatistics: A Methodology for the Health Sciences, New York, 1993.
2. David J. Francis and Jack M. Fletcher. Analysis of Change: Modeling Individual Growth. Journal of Consulting and Clinical Psychology 1991. Vol. 59, No. 1, 27-37.
3. SAS/STAT User Guide Volume 1 and 2, Version 6, 4th ed., 1990.
4. SAS Course notes: Making Business Decisions Using ANOVA and Regression Techniques.

APPENDIX

AVAILABLE COVARIANCE STRUCTURES IN SAS MIXED PROCEDURE

Variance Component

Variance Components Models (TYPE=VC)

$$\begin{bmatrix} \sigma_1^2 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix}$$

Unstructured

All Variance and Covariances May be Unequal (TYPE=UN)

$$\begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} & \sigma_{34} \\ \sigma_{14} & \sigma_{24} & \sigma_{34} & \sigma_{44} \end{bmatrix}$$

Banded

Covariance Are Zero for Higher Lages (TYPE=UN(q))

$$\begin{bmatrix} \sigma_1 & \sigma_5 & 0 & 0 \\ \sigma_5 & \sigma_2 & \sigma_6 & 0 \\ 0 & \sigma_6 & \sigma_3 & \sigma_7 \\ 0 & 0 & \sigma_7 & \sigma_4 \end{bmatrix}$$

Toeplitz

Time Series Data with Equal Spacing(TYPE=TOEP(q))
And Arbitrary Correlations for Each Lag

$$\begin{bmatrix} \sigma_1 & \sigma_2 & \sigma_3 & \sigma_4 \\ \sigma_2 & \sigma_1 & \sigma_2 & \sigma_3 \\ \sigma_3 & \sigma_2 & \sigma_1 & \sigma_2 \\ \sigma_4 & \sigma_3 & \sigma_2 & \sigma_1 \end{bmatrix}$$

Compound Symmetry

Equal Covariances Plus Diagonal (TYPE=CS)

$$\begin{bmatrix} (\sigma^2 + \sigma_1) & \sigma_1 & \sigma_1 & \sigma_1 \\ \sigma_1 & (\sigma^2 + \sigma_1) & \sigma_1 & \sigma_1 \\ \sigma_1 & \sigma_1 & (\sigma^2 + \sigma_1) & \sigma_1 \\ \sigma_1 & \sigma_1 & \sigma_1 & (\sigma^2 + \sigma_1) \end{bmatrix}$$

Heterogeneous Compound-Symmetry

Different Variance Parameters for Each Diagonal Element and
Square Roots of These Parameters in the Off-Diagonal Elements (TYPE=CSH)

$$\begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2\rho & \sigma_1\sigma_3\rho & \sigma_1\sigma_4\rho \\ \sigma_2\sigma_1\rho & \sigma_2^2 & \sigma_2\sigma_3\rho & \sigma_2\sigma_4\rho \\ \sigma_3\sigma_1\rho & \sigma_3\sigma_2\rho & \sigma_3^2 & \sigma_3\sigma_4\rho \\ \sigma_4\sigma_1\rho & \sigma_4\sigma_2\rho & \sigma_4\sigma_3\rho & \sigma_4^2 \end{bmatrix}$$

Heterogeneous First-Order Autoregressive

Time Series Data with Unequal Covariances and Variances (TYPE=ARH(1))

$$\begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2\rho & \sigma_1\sigma_3\rho^2 & \sigma_1\sigma_4\rho^4 \\ \sigma_2\sigma_1\rho & \sigma_2^2 & \sigma_2\sigma_3\rho & \sigma_2\sigma_4\rho^2 \\ \sigma_3\sigma_1\rho^2 & \sigma_3\sigma_2\rho & \sigma_3^2 & \sigma_3\sigma_4\rho \\ \sigma_4\sigma_1\rho^3 & \sigma_4\sigma_2\rho^2 & \sigma_4\sigma_3\rho & \sigma_4^2 \end{bmatrix}$$

First-Order Autoregressive Moving Avarage

Time Series Data with Autoregressive Parameter ρ and Moving Average Component γ (TYPE=ARMA(1,1))

$$\begin{bmatrix} 1 & \gamma & \gamma\rho & \gamma\rho^2 \\ \gamma & 1 & \gamma & \gamma\rho \\ \gamma\rho & \gamma & 1 & \gamma \\ \gamma\rho^2 & \gamma\rho & \gamma & 1 \end{bmatrix}$$

First-Order Autoregressive

Time Series Data with Equal Spacing (TYPE=AR(1)) and Exponentially Declining Correlations

$$\begin{bmatrix} \sigma^2 & \sigma^2\rho & \sigma^2\rho^2 & \sigma^2\rho^3 \\ \sigma^2\rho & \sigma^2 & \sigma^2\rho & \sigma^2\rho^2 \\ \sigma^2\rho^2 & \sigma^2\rho & \sigma^2 & \sigma^2\rho \\ \sigma^2\rho^3 & \sigma^2\rho^2 & \sigma^2\rho & \sigma^2 \end{bmatrix}$$

Heterogeneous Compound-Symmetry

Different Variance Parameters for Each Diagonal Element and
Square Roots of These Parameters in the Off-Diagonal Elements (TYPE=CSH)

$$\begin{bmatrix} \sigma_1^2 & \frac{\sigma_1^2 + \sigma_2^2}{2 - \lambda} & \frac{\sigma_1^2 + \sigma_3^2}{2 - \lambda} & \frac{\sigma_1^2 + \sigma_4^2}{2 - \lambda} \\ \frac{\sigma_2^2 + \sigma_1^2}{2 - \lambda} & \sigma_2^2 & \frac{\sigma_2^2 + \sigma_3^2}{2 - \lambda} & \frac{\sigma_2^2 + \sigma_4^2}{2 - \lambda} \\ \frac{\sigma_3^2 + \sigma_1^2}{2 - \lambda} & \frac{\sigma_3^2 + \sigma_2^2}{2 - \lambda} & \sigma_3^2 & \frac{\sigma_3^2 + \sigma_4^2}{2 - \lambda} \\ \frac{\sigma_4^2 + \sigma_1^2}{2 - \lambda} & \frac{\sigma_4^2 + \sigma_2^2}{2 - \lambda} & \frac{\sigma_4^2 + \sigma_3^2}{2 - \lambda} & \sigma_4^2 \end{bmatrix}$$

SAS OUTPUT

The SAS System The MIXED Procedure Class Level Information

Class	Levels	Values
HOSPITAL	24	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
PARTICIP	2	NO YES
MEASURE	4	BASELINE MONTH_9 MONTH_18 MONTH_28

REML Estimation Iteration History

Iteration	Evaluations	Objective	Criterion
0	1	414.12116192	
1	1	278.61599456	0.00000000

Convergence criteria met.

Covariance Parameter Estimates (REML)

Cov Parm	Subject	Estimate
UN(1,1)	HOSPITAL	20.93075758
UN(2,1)	HOSPITAL	21.19166667
UN(2,2)	HOSPITAL	23.14390152
UN(3,1)	HOSPITAL	21.94734848
UN(3,2)	HOSPITAL	22.69530303
UN(3,3)	HOSPITAL	32.96814394
UN(4,1)	HOSPITAL	24.82712121
UN(4,2)	HOSPITAL	26.66799242
UN(4,3)	HOSPITAL	38.68098485
UN(4,4)	HOSPITAL	52.79890152

Model Fitting Information for QI

Description	Value
Observations	96.0000
Res Log Likelihood	-220.175
Akaike's Information Criterion	-230.175
Schwarz's Bayesian Criterion	-242.561
-2 Res Log Likelihood	440.3492
Null Model LRT Chi-Square	135.5052
Null Model LRT DF	9.0000
Null Model LRT P-Value	0.0000

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
PARTICIP	1	22	6.35	0.0195
MEASURE	3	22	22.41	0.0001
PARTICIP*MEASURE	3	22	20.26	0.0001

Least Squares Means

Effect	PARTICIP	MEASURE	LSMEAN	Std Error	DF	t	Pr > t	Alpha	Lower	Upper
PARTICIP	NO		16.21	1.51	22	10.69	0.0001	0.05	13.06	19.35
PARTICIP	YES		21.61	1.51	22	14.25	0.0001	0.05	18.47	24.76
MEASURE		BASELINE	16.15	0.93	22	17.30	0.0001	0.05	14.22	18.09
MEASURE		MONTH_18	19.94	1.17	22	17.02	0.0001	0.05	17.51	22.37
MEASURE		MONTH_28	23.68	1.48	22	15.97	0.0001	0.05	20.61	26.76
MEASURE		MONTH_9	15.86	0.98	22	16.15	0.0001	0.05	13.82	17.89
PARTICIP*MEASURE	NO	BASELINE	16.45	1.32	22	12.46	0.0001	0.05	13.71	19.18
PARTICIP*MEASURE	NO	MONTH_18	16.37	1.65	22	9.88	0.0001	0.05	12.93	19.81
PARTICIP*MEASURE	NO	MONTH_28	16.23	2.09	22	7.74	0.0001	0.05	11.88	20.58
PARTICIP*MEASURE	NO	MONTH_9	15.78	1.38	22	11.37	0.0001	0.05	12.90	18.66
PARTICIP*MEASURE	YES	BASELINE	15.86	1.32	22	12.01	0.0001	0.05	13.12	18.60
PARTICIP*MEASURE	YES	MONTH_18	23.51	1.65	22	14.19	0.0001	0.05	20.07	26.95
PARTICIP*MEASURE	YES	MONTH_28	31.14	2.09	22	14.85	0.0001	0.05	26.79	35.49
PARTICIP*MEASURE	YES	MONTH_9	15.94	1.38	22	11.48	0.0001	0.05	13.06	18.82

Differences of Least Squares Means

Effect	PARTICIP	MEASURE	_PARTICI	_MEASURE	Diff	Std Err	DF	t	Pr > t	Adjust
PARTICIP	NO		YES		-5.40	2.14	22	- 2.52	0.0195	Tukey

MEASURE		BASELINE		MONTH_18	-3.78	0.64	22	-5.87	0.0001	Tukey
MEASURE		BASELINE		MONTH_28	-7.52	1.00	22	-7.52	0.0001	Tukey
MEASURE		BASELINE		MONTH_9	0.29	0.26	22	1.11	0.2771	Tukey
MEASURE		MONTH_18		MONTH_28	-3.74	0.59	22	-6.32	0.0001	Tukey
MEASURE		MONTH_18		MONTH_9	4.08	0.66	22	6.11	0.0001	Tukey
MEASURE		MONTH_28		MONTH_9	7.82	0.97	22	8.06	0.0001	Tukey
PARTICIP*MEASURE	NO	BASELINE	NO	MONTH_18	<u>0.07</u>	0.91	22	0.08	<u>0.9353</u>	Tukey
PARTICIP*MEASURE	NO	BASELINE	NO	MONTH_28	<u>0.21</u>	1.41	22	0.15	<u>0.8798</u>	Tukey
PARTICIP*MEASURE	NO	BASELINE	NO	MONTH_9	<u>0.66</u>	0.37	22	1.78	<u>0.0896</u>	Tukey
PARTICIP*MEASURE	NO	BASELINE	YES	BASELINE	0.58	1.86	22	0.31	0.7577	Tukey
PARTICIP*MEASURE	NO	BASELINE	YES	MONTH_18	-7.06	2.11	22	-3.33	0.0030	Tukey
PARTICIP*MEASURE	NO	BASELINE	YES	MONTH_28	-14.69	2.47	22	-5.93	0.0001	Tukey
PARTICIP*MEASURE	NO	BASELINE	YES	MONTH_9	0.50	1.91	22	0.27	0.7933	Tukey
PARTICIP*MEASURE	NO	MONTH_18	NO	MONTH_28	<u>0.14</u>	0.83	22	0.17	<u>0.8671</u>	Tukey
PARTICIP*MEASURE	NO	MONTH_18	NO	MONTH_9	<u>0.59</u>	0.94	22	0.63	<u>0.5378</u>	Tukey
PARTICIP*MEASURE	NO	MONTH_18	YES	BASELINE	0.50	2.11	22	0.24	0.8127	Tukey
PARTICIP*MEASURE	NO	MONTH_18	YES	MONTH_18	-7.14	2.34	22	-3.05	0.0059	Tukey
PARTICIP*MEASURE	NO	MONTH_18	YES	MONTH_28	-14.76	2.67	22	-5.52	0.0001	Tukey
PARTICIP*MEASURE	NO	MONTH_18	YES	MONTH_9	0.43	2.16	22	0.20	0.8430	Tukey
PARTICIP*MEASURE	NO	MONTH_28	NO	MONTH_9	<u>0.45</u>	1.37	22	0.33	<u>0.7461</u>	Tukey
PARTICIP*MEASURE	NO	MONTH_28	YES	BASELINE	0.36	2.47	22	0.15	0.8837	Tukey
PARTICIP*MEASURE	NO	MONTH_28	YES	MONTH_18	-7.28	2.67	22	-2.72	0.0124	Tukey
PARTICIP*MEASURE	NO	MONTH_28	YES	MONTH_28	-14.90	2.96	22	-5.03	0.0001	Tukey
PARTICIP*MEASURE	NO	MONTH_28	YES	MONTH_9	0.29	2.51	22	0.12	0.9088	Tukey
PARTICIP*MEASURE	NO	MONTH_9	YES	BASELINE	-0.08	1.91	22	-0.04	0.9657	Tukey
PARTICIP*MEASURE	NO	MONTH_9	YES	MONTH_18	-7.73	2.16	22	-3.58	0.0017	Tukey
PARTICIP*MEASURE	NO	MONTH_9	YES	MONTH_28	-15.35	2.51	22	-6.11	0.0001	Tukey
PARTICIP*MEASURE	NO	MONTH_9	YES	MONTH_9	-0.15	1.96	22	-0.08	0.9365	Tukey
PARTICIP*MEASURE	YES	BASELINE	YES	MONTH_18	<u>-7.65</u>	0.91	22	-8.38	<u>0.0001</u>	Tukey
PARTICIP*MEASURE	YES	BASELINE	YES	MONTH_28	<u>-15.27</u>	1.41	22	-10.78	<u>0.0001</u>	Tukey
PARTICIP*MEASURE	YES	BASELINE	YES	MONTH_9	<u>-0.07</u>	0.37	22	-0.20	<u>0.8435</u>	Tukey
PARTICIP*MEASURE	YES	MONTH_18	YES	MONTH_28	<u>-7.62</u>	0.83	22	-9.11	<u>0.0001</u>	Tukey
PARTICIP*MEASURE	YES	MONTH_18	YES	MONTH_9	<u>7.57</u>	0.94	22	8.01	<u>0.0001</u>	Tukey
PARTICIP*MEASURE	YES	MONTH_28	YES	MONTH_9	<u>15.20</u>	1.37	22	11.07	<u>0.0001</u>	Tukey