Sample *30584:* Analyzing Repeated Measures in JMP Software

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Analyzing Repeated Measures Data in JMP® Software

Often in an experiment, more than one measure is taken on the same subject or experimental unit. This means that a repeated measures analysis of the data may be necessary to make valid inferences and to draw meaningful conclusions.

JMP offers two methods to analyze repeated measures: a univariate split-plot approach and a multivariate repeated-measures approach. These two types of analyses are compared in the following discussion. The example uses the DOGS (dogs.jmp) sample data table, which is the result of a study with repeated measures.

Figure A shows selected columns from the DOGS table. This data table contains information on sixteen dogs assigned to groups defined by the independent variable *drug* with values "morphine" and "trimeth." The blood concentration of histamine is recorded before drug injection and again at one and three minutes after injection. Also, there is an additional *ID* column, declared Nominal, which will be used to account for the within-subject variability in a univariate analysis of repeated-measures data.

Figure A: Arrangement of Data Table, Multivariate Approach.

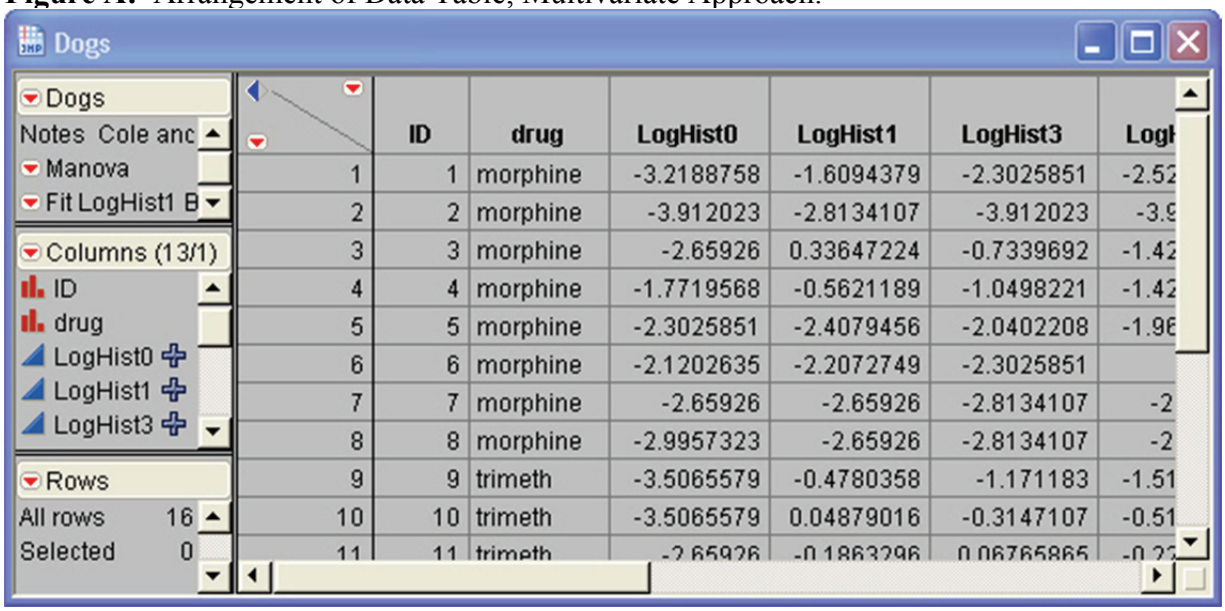
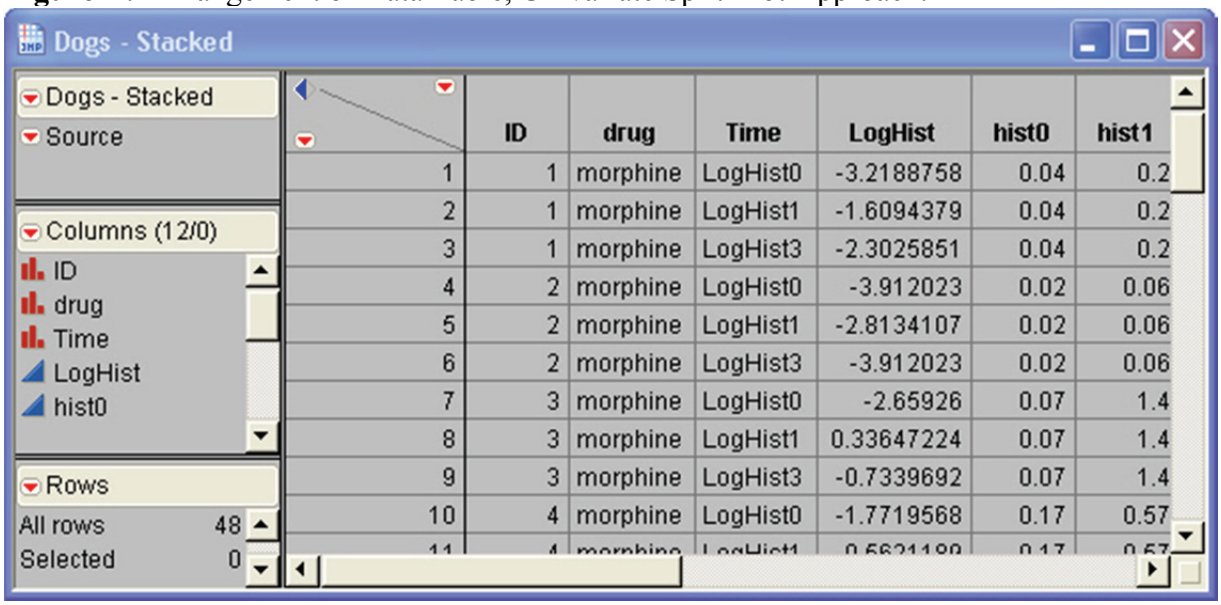


Figure B shows selected columns from the restructured DOGS table where the *LogHist* columns have been stacked into a single response column.

Figure B: Arrangement of Data Table, Univariate Split-Plot Approach.



	ID	drug	Time	LogHist	hist0	hist1
1	1	morphine	LogHist0	-3.2188758	0.04	0.2
2	1	morphine	LogHist1	-1.6094379	0.04	0.2
3	1	morphine	LogHist3	-2.3025851	0.04	0.2
4	2	morphine	LogHist0	-3.912023	0.02	0.06
5	2	morphine	LogHist1	-2.8134107	0.02	0.06
6	2	morphine	LogHist3	-3.912023	0.02	0.06
7	3	morphine	LogHist0	-2.65926	0.07	1.4
8	3	morphine	LogHist1	0.33647224	0.07	1.4
9	3	morphine	LogHist3	-0.7339692	0.07	1.4
10	4	morphine	LogHist0	-1.7719568	0.17	0.57

A Multivariate Approach

The original DOGS table with multiple response columns is in the form needed for a multivariate analysis that tests the same effects–nothing needs to be changed.

With this data table active, again choose Fit Model from the Analyze Menu. Specify *LogHist0*, *LogHist1* and *LogHist3* as Y variables. Change the Fitting Personality to Manova. Assign *drug* as the model effect and run the model.

When there are multiple Y variables, JMP automatically performs a multivariate analysis. When you first run the model, the multivariate control panel appears. To test the effect of *drug* over time, select "Repeated Measures" as the response design from the popup menu on the control panel. In the repeated-measures dialog that appears, use the default effect name Time but check "Univariate Tests Also" to obtain univariate and adjusted univariate tests. This option includes a test of sphericity (not shown here), which checks whether the unadjusted univariate F tests are appropriate. If the sphericity chi-square test is not significant, you can use the unadjusted univariate F tests. However, if the sphericity test chi-square is significant, then the criterion is rejected and the multivariate F tests or the adjusted univariate F tests should be used. JMP gives both the Greenhouse-Geisser (G-G), and the Huynh-Feldt (H-F) adjusted F tests.

A Univariate Approach

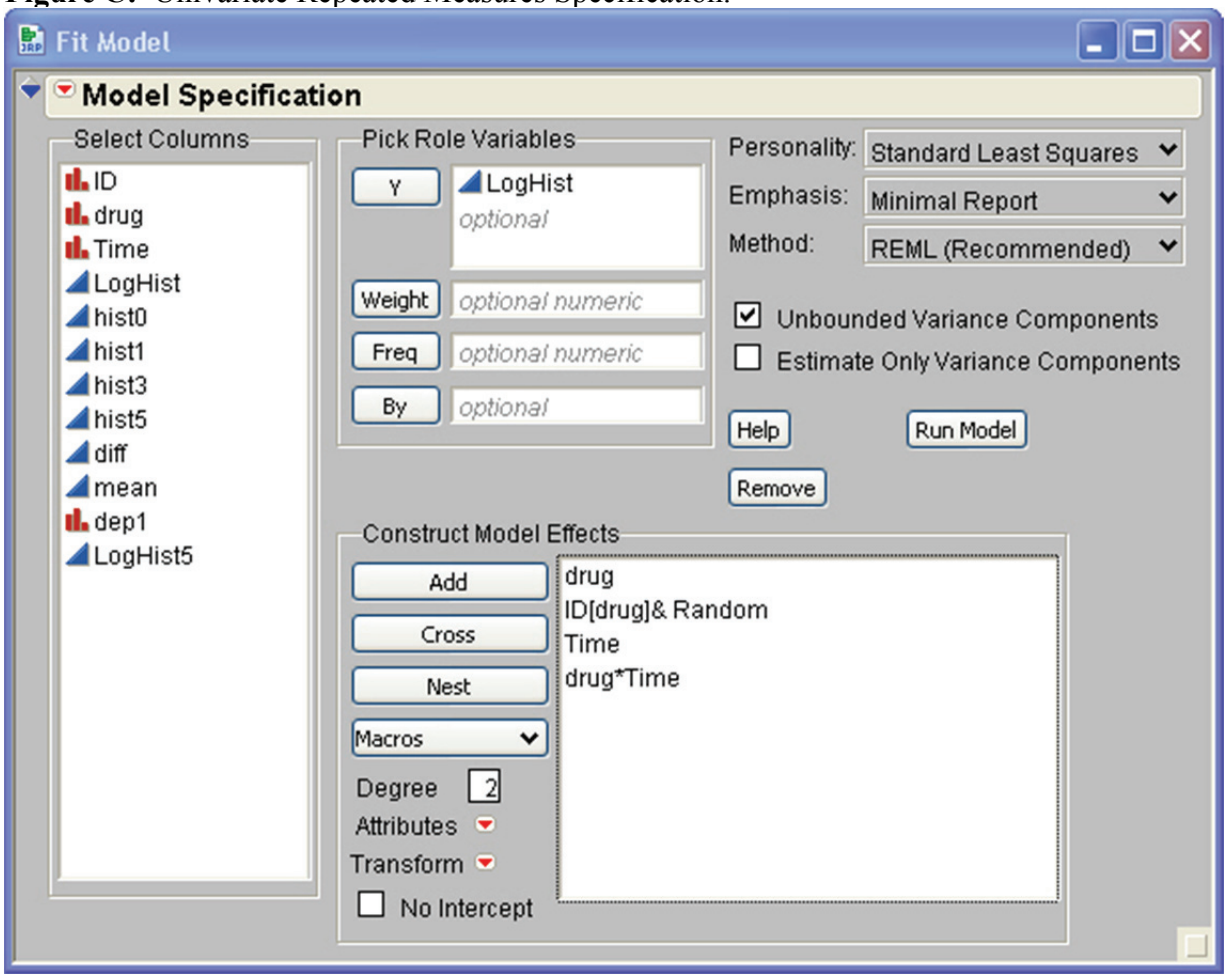
A univariate model has a single response. Each source of variation (between-subjects and within-subjects) is included as an effect in the model.

The univariate analysis requires that the response measurements be in a single column. Using the Stack command in the Tables menu, you can stack the *LogHist0*, *LogHist1*, and *LogHist3*

columns to create a new response column, as shown in **Figure B**. The new response, *LogHist*, and also the new classification variable, *Time*, were created by the Stack command.

With the data table correctly set up, choose Fit Model from the Analyze Menu. Select *LogHist* as Y, and add the Effects in Model as shown in **Figure C**.

Figure C: Univariate Repeated Measures Specification.



To create the model shown to the left, which has a random effect for testing the between-subjects effect in the model, click the following variables and buttons:

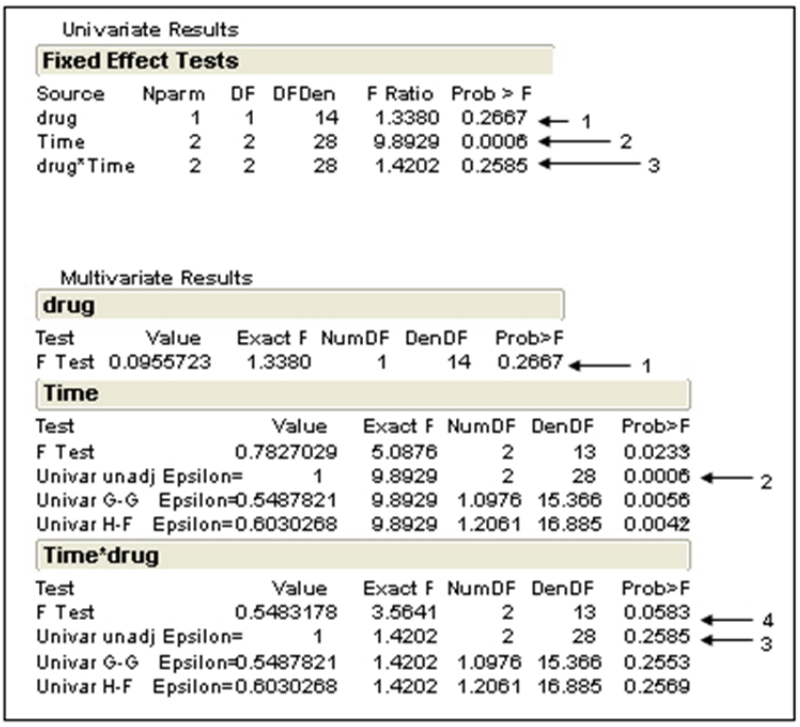
- ***drug*** in the variable selection list, then **Add**
- ***ID*** in the variable selection list, then **Add**
- ***drug*** in the variable selection list, and
- ***ID*** in the Effects in Model list, then **Nest**
- ***ID[drug]*** in the Effects in Model list, then select **Random** from the Effect Attributes pop-up menu giving ***ID[drug]& Random*** in the Effects in Model list
- ***Time*** in the variable selection list, then **Add**
- ***drug*** in the variable selection list and
- ***Time*** in the variable selection list, then **Cross**

The between-subject effect, *drug* is the whole plot effect of a split-plot design. The *Subject* effect is nested within *drug*. This *Subject(drug)* effect is the appropriate error term for the between-subject effect. Therefore, it is specified as a random effect using the Random selection from the Effect Attributes pop-up menu. JMP uses a random effect as the error term to test appropriate terms in the Effects in Model list.

The within-subject effects, *Time* and *drug*Time* will be tested with the residual error term.

After running this model you can examine the significance of the model effects seen in the "Tests wrt Random Effects" table shown in **Figure D**.

Figure D: Comparison of Univariate and Multivariate Results.



Univariate Results

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F	
drug	1	1	14	1.3380	0.2667	← 1
Time	2	2	28	9.8929	0.0006	← 2
drug*Time	2	2	28	1.4202	0.2585	← 3

Multivariate Results

drug

Test	Value	Exact F	NumDF	DenDF	Prob>F	
F Test	0.0955723	1.3380	1	14	0.2667	← 1

Time

Test	Value	Exact F	NumDF	DenDF	Prob>F	
F Test	0.7827029	5.0876	2	13	0.0233	
Univar unadj Epsilon=	1	9.8929	2	28	0.0006	← 2
Univar G-G Epsilon=	0.5487821	9.8929	1.0976	15.366	0.0056	
Univar H-F Epsilon=	0.6030268	9.8929	1.2061	16.885	0.0042	

Time*drug

Test	Value	Exact F	NumDF	DenDF	Prob>F	
F Test	0.5483178	3.5641	2	13	0.0583	← 4
Univar unadj Epsilon=	1	1.4202	2	28	0.2585	← 3
Univar G-G Epsilon=	0.5487821	1.4202	1.0976	15.366	0.2553	
Univar H-F Epsilon=	0.6030268	1.4202	1.2061	16.885	0.2569	

Comparing the Two Methods

A comparison of analysis results is shown in Figure C. By examining each analysis, you can see the relationship between the univariate and multivariate effects tests:

1. For between-subject effects (*drug*), the multivariate approach gives the same results as the univariate approach when there are no missing values. If there are missing values, a univariate analysis uses all nonmissing data values but the multivariate analysis excludes any subject with any missing values.

2. If there are no missing values, the within-subjects *Time* variable in the univariate model is the same as the unadjusted Time effect in a multivariate model having a "Repeated

Measures" response design. However, these tests are appropriate only if the sphericity test criterion (mentioned previously) is met. Otherwise, the multivariate tests or the adjusted univariate tests should be used.

3. Often in a repeated-measures study the most important effect is the within-subject by between-subject interaction– the hypothesis of interest is whether the study treatment has an effect over time. In the univariate analysis, the *drug*Time* interaction appears insignificant.

4. In this example the more powerful multivariate approach shows the *drug*Time* interaction effect to have marginal significance.

In summary, if you have repeated-measures data, JMP can analyze the data as either a univariate split-plot model or a multivariate model. Each type of analysis has its advantages and disadvantages:

- The multivariate analysis is easy and intuitive to specify in JMP. Its tests are usually more powerful. From a computing standpoint, this method is most efficient. However, if a subject is missing a value, all information for that subject is lost to the analysis.

- The univariate analysis can use all the data–only a subject's missing measurement is lost to the analysis. However, the univariate analysis can be very computationally intensive, particularly if there are many subjects.

Also, the univariate tests for within-subject effects and interactions involving these effects require assumptions about the covariance matrix in order for the probabilities provided by the ordinary F tests to be correct. If these assumptions are not met (if the sphericity test is rejected), then probabilities for adjusted Figure C: Comparison of Univariate and Multivariate Results univariate F tests (given in the multivariate report) or the multivariate F tests should be used. Because of these assumptions, the univariate approach should be considered only when the Sphericity condition is met. For more information see the discussion on this test in the *JMP Statistics and Graphics Guide*, in the Multivariate Model Fitting chapter.

Cole and Grizzle, J.E. (1966), "Sixteen Dogs," Biometrics, 22:810