Mixed Models ANOVA

While the term “mixed models ANOVA” can be used to describe the inclusion of a variety of different combinations of independent variables, we will use it to imply a repeated measures model that also includes a factor variable. To distinguish the different roles of the variables, the repeated measures factor is referred to as a “within-subjects” factor, while the factor comparing groups or categories is the “between-subjects” factor.

Specifically, our analysis will look at how a between-subjects factor affects, or interacts with, the within-subjects factor (the repeated measures factor). Our goal in this analysis is to test and interpret a model which focuses on the interaction between the between-subjects factor and the repeated measures factor. Our research hypothesis is that there is a significant interaction effect, and the subjects have a different pattern of change over time depending on which category of the between-subjects factor they are associated with.

We will use the Omaha.sav data base which contains data on the feelings and attitudes of victims of domestic. We will look at how these feelings and attitudes change over time, and whether or not the pattern is different for victims who are employed compare to those who are not employed. These analyses could test a theory that employment changes the responses to domestic violence. Victims who have a job have a broader social network whose support offsets the loss of self-esteem, the tenuous feelings of control, and the fears experienced of victims. (PLEASE NOTE: I am making this theory up to fit the data that is available; I do not know enough about domestic violence to know whether or not the “theory” would be supported by experts.)

If the presence of an interaction between the repeated measures factor and the repeated measures factor is supported by our analysis, we will refine our interpretation by using the syntax features of SPSS to force it to do the Bonferroni post hoc test for the interaction effect. The interpretation of the interaction will be similar to the statements we made about interactions in the two-factor ANOVA problems, bolstered by a test of significance.

If the interaction effect between the repeated measures factor and the between-subjects factor is not significant, we revert to the interpretation of the repeated measures, as we did for the repeated measures problems without any additional factor. While we could also interpret the main effect for the between subjects factor, we will not because it complicates our interpretation without providing additional useful information. Interpreting the employment factor would be answering questions of whether or not victims differed at a specific time, rather than testing whether or not they experienced a different pattern over time.

In combining repeated measures ANOVA and factorial ANOVA, we will be required to satisfy the requirements and assumptions of both:

- Mixed models analysis of variance requires that the repeated measure variables be interval level and the between-subject factor be any level that defines groups (dichotomous, nominal, ordinal, or grouped interval)
- There is a minimum sample size both for the total number of subjects (10 + the number of time periods making up the within-subjects factor) and the minimum number in each cell (5)
- The assumption of normality for the repeated measures
- The assumption of sphericity for the within-subjects factor for the repeated measures
- The assumption of homogeneity of variance for the between-subjects factor
Solving Mixed Models Problems in SPSS

Statements about requirements and assumptions

The introductory statement identifies the variables for the analysis and the significance levels to use. The repeated measures and the factor are listed in the problem statement.

Note that we use a more conservative alpha (.01) for diagnostic statistics than we do for the statistics that answer our research.

The first block of statements addresses level of measurement, sample size, and assumptions required for the use of the statistic.
Statements about the interaction effect

The next block of statements is about the presence and interpretation of the interaction effect. If there is an interaction effect, we will mark the first check box, and the check boxes below it that are the correct interpretation of the interaction.

If there is a significant interaction effect, we will not do a separate interpretation of the main effect of change over time.

Statements about the main effect of change over time

The final block of questions interprets the main effect for change over time when the interaction effect is not significant. We mark the first check box if there is a significant main effect for the repeated measures, and any post hoc effects that are statistically significant.
Mixed-model analysis of variance requires that the repeated measure variables be interval level and the between-subjects factor be any level that defines groups (dichotomous, nominal, ordinal, or grouped interval).

The variables "At times I fear for my life (1 week)" [fear1_4], "At times I fear for my life (6 months)" [fear6_4] or "At times I fear for my life (12 months)" [fear12_4] are ordinal level. However, we will follow the common convention of treating ordinal variables as interval level. We should consider including the use of this convention as a limitation of the analysis.

"The victim's employment status" [employed] is dichotomous satisfying the requirement for the factor.

The Sample Size Requirement

To check sample size requirements, we run the univariate general linear model procedure. This procedure will give us the total number of cases and the correct number of cases in each cell, removing any missing data for the three time period variables and the between-subjects factor.

The minimum sample size requirement that we will use for mixed models ANOVA is 10 + the number of dependent variables, adapted from Tabachnick and Fidell. We will also require that the smallest cell have 5 or more cases.
Select General Linear Model > Repeated Measures from the Analyze menu.

First, change the name of the Within-Subject Factor Name from the default of factor1 to time. We can select any name that is meaningful to us.

Second, enter the number of levels in the text box. In this example, we have measures at 1 week, 6 months, and 12 months so we enter 3.

Third, click on the Add button to add this factor to the list.
First, highlight the time(3) factor in the list box.

Second, click on the Define button to tell SPSS what variables make up the time factor.

First, select the variable for the first time period, fear1_4.

Second, click on the right arrow button to move the variable to the first time slot.

The variables must be added in the correct sequence, since SPSS will assume that the order entered is correct.
First, select the variable for the second time period, fear6_4.

Second, click on the right arrow button to move the variable to the second time slot.

First, select the variable for the third time period, fear12_4.

Second, click on the right arrow button to move the variable to the third time slot.
We have now specified the variables for the three time periods and for the between-subject factor.

We have now requested the statistical output.

First, select the variable employed as the between-subjects factor.

Second, click on the right arrow button to move the variable to Between-Subjects Factors list box.

Click on the Options button to request additional output.
First, copy the list from Factors and Factor Interactions to the Display Means for list box.

Second, mark the check box Compare main effects. This will compute the post hoc tests for the main effects.

Third, select Bonferroni from the Confidence interval adjustment drop down men. This will hold the error rate for our multiple comparisons to the specified alpha error rate.

Next, mark the check boxes for:
- Descriptive statistics,
- Estimates of effect size,
- Observed power, and
- Homogeneity tests

Finally, click on the Continue button to close the dialog box.
To support the interpretation of the pattern of change, click on the **Plots** button to request a line chart.

First, move the time factor to the **Horizontal Axis** text box.

Second, move the between subjects factor to the **Separate Lines** text box.

Third, click on the **Add** button to add this entry to the list of **Plots**.
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Click on the Paste button (not the OK button) to paste the SPSS command into a syntax window.

Click on the Continue button to close the Profile Plots dialog.

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We need to manually add the post hoc test for the interaction effect to the SPSS command.

Click on the Paste button (not the OK button) to paste the SPSS command into a syntax window.
This is the text specification for the commands that we just requested through the menus and dialog boxes. Syntax commands are text that we can edit.

Add the highlighted text `COMPARE(time) ADJ(BONFERRONI)` to the end of the line `/EMMEANS = TABLES(employed*time)` as shown in the screen shot.

Be sure to leave spaces at the beginning of the line and between the old and new text.
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Evaluating the Sample Size

Click on the Run Current button to produce the SPSS output from the syntax window.

When we have produced the output, we can close or save the syntax window. If we save it, we can modify it for future analyses.

The number of cases available for the analysis was 416. Since this number is greater than $10 + \text{the number of levels in the repeated factor}$, the minimum total sample size requirement is satisfied.

In addition, the smallest cell in the analysis had 206 cases, so the requirement of 5 or more cases per cell is satisfied.
Since we satisfied both the level of measurement and the sample size requirements for analysis of covariance, we mark the first check box for the problem.

The next statement in the problem focuses on the assumption of normality, using the skewness and kurtosis criteria that both statistical values should be between -1.0 and +1.0.
Skewness and kurtosis are calculated in several procedures. We will use Descriptive Statistics.

Select Descriptive Statistics > Descriptives from the Analyze menu.

First, move the variables for the three time periods to the Variable(s) list box.

Second, click on the Options button to specify the statistics we want computed.
Computing Skewness and Kurtosis to Test for Normality - 3

First, mark the check boxes for Kurtosis and Skewness. Second, click on the Continue button to close the dialog box.

Click on the OK button to obtain the output.
"At times I fear for my life (1 week)" [fear1_4] did not satisfy the criteria for a normal distribution. The skewness of the distribution (.122) was between -1.0 and +1.0, but the kurtosis of the distribution (-1.299) fell outside the range from -1.0 to +1.0. Though analysis of variance is robust to violations of the assumption normality, we should consider including the violation as a limitation of the analysis.

"At times I fear for my life (6 months)" [fear6_4] satisfied the criteria for a normal distribution. The skewness of the distribution (.577) was between -1.0 and +1.0 and the kurtosis of the distribution (-.838) was between -1.0 and +1.0.

"At times I fear for my life (12 months)" [fear12_4] satisfied the criteria for a normal distribution. The skewness of the distribution (.751) was between -1.0 and +1.0 and the kurtosis of the distribution (-.648) was between -1.0 and +1.0.
Since the skewness and kurtosis did not satisfy the assumption for "At times I fear for my life (1 week)" [fear1_4], we do not mark the check box.

The next statement ask about homogeneity of variance for the between subjects factor. The Levene test is part of the output from the Univariate General Linear Model procedure.
For the variable "At times I fear for my life (1 week)" [fear1_4], the probability associated with Levene's test for equality of variances (F(1, 414) = 0.17, p = .678) is greater than the alpha for diagnostic tests (0.01). The assumption of equal variances is satisfied.

For the variable "At times I fear for my life (6 months)" [fear6_4], the probability associated with Levene's test for equality of variances (F(1, 414) = 0.96, p = .327) is greater than the alpha for diagnostic tests (0.01). The assumption of equal variances is satisfied.

For the variable "At times I fear for my life (12 months)" [fear12_4], the probability associated with Levene's test for equality of variances (F(1, 414) = 0.80, p = .372) is greater than the alpha for diagnostic tests (0.01). The assumption of equal variances is satisfied.

Satisfying the assumption of homogeneity means that variance for each of the time periods is the homogenous for the categories of the employment variable.
Marking the Assumption of Homogeneity of Variance for the Between-Subjects Factor

Since we satisfied the assumption of homogeneity of variance, we mark the check box.

The next statement in the problem focuses on the assumption of sphericity, which is part of the output for GLM.

The Assumption of Sphericity for the Within-Subjects Factor

Had we violated the assumption of homogeneity of variance, we would have computed the ratio of the largest to the smallest variance to see whether we could continue with the analysis, similar to what we did with other ANOVA problems.
Since we did not satisfy the assumption of sphericity, we do not mark the check box.
Interpretation of the interaction effect

Since we did not satisfy the assumption of sphericity, we will interpret the output on rows labeled “Greenhouse-Geisser.”

The next statement indicates that there is an interaction effect, i.e. the pattern of responses is different for those who are employed compared to those who are not employed.
The interaction effect between the repeated measures factor "time" and "the victim's employment status" [employed] was statistically significant ($F(1.93, 800.83) = 7.10, p = .001$, partial eta squared = .02). The null hypothesis that the pattern of change in the repeated measure "At times I fear for my life" was the same for the different categories of the victim's employment status was rejected. There is a significant interaction effect.

Since there was a significant interaction effect, we mark the check box.
The next four statements are possible interpretations of the pattern of change over time for the employed and not employed. One of these statements will be correct for victims who were employed and one will be correct for victims who were not employed.

To identify the correct statements, we look to the Bonferroni pairwise comparisons for the combinations of the repeated measure and the between-subjects factor.

For victims who were employed, the difference between the first and second time period was statistically significant (p<.001) and would be characterized as substantial. The difference between time period 2 and time period 3 is not significant (p>.99) and would be characterized as a minimal difference. The difference between time periods 1 and 3 is also statistically significant (p<.001), but that information is not used in the problem.
For both employed victims and victims who were not employed, the average fear for their life decreased from the first to the second period, and further from the second to the third period. However, there was a substantial change from the first to the second time period for those who were employed, but no comparable change for those who were not employed.
The blue line in the profile plot supports the interpretation of a substantial decrease from time 1 to time 2 for the employed, followed by a minimal decrease from time 2 to 3.

The green line supports the interpretation of minimal decreases from both time 1 to time 2 and from time 2 to time 3 for the unemployed group.

The significant interaction is linked to the different patterns of change from time 1 to time 2 for the two groups. One change was substantial (blue) and the other was minimal (green).

Based on our evaluation of post hoc results, the first statement for employed victims and the second statement for unemployed victims match up with our interpretation of the post hoc tests.

Since we had a significant interaction effect, we do not interpret the main effect for change over time.
When this assignment was submitted, BlackBoard indicated that all marked answers were correct, and we received full credit for the question.
Logic Diagram for Mixed Models ANOVA Problems - 1

SPSS Univariate General Linear Model for Repeated Measures

Measurement & sample size ok? (cells = 5+) (> 10 + number of dv's)

Yes → Mark check box for correct answer

No → Do not mark check box

Mark: Inappropriate application of the statistic

Stop

Ordinal dv's?

Yes → Mention convention in discussion of findings

SPSS Descriptives to get skewness and kurtosis for the repeated measures

Assumption of normality satisfied? (skewness, kurtosis between +/-1)

Yes → Mark check box for correct answer

No → Do not mark check box

Mention violation in discussion of findings

Assumption of homogeneity of variance ok? (Levene Sig > diagnostic alpha)

Yes → Mark check box for correct answer

No → Do not mark check box
Logic Diagram for Mixed Models ANOVA Problems - 2

1. **Assumption of sphericity satisfied?** (Mauchly’s W Sig > diagnostic alpha)
   - Yes → Interpret Sphericity Assumed Output
   - No → Do not mark check box

2. **Ratio of largest group variance to smallest group variance ≤ 3**
   - Yes → Interpret Greenhouse-Geisser Output
   - No → Mention violation in discussion of findings

3. **Mark: Inappropriate application of the statistic**
   - Stop

4. **Interaction effect statistically significant?** (Sig < alpha)
   - Yes → Mark check box for correct answer
   - No → Do not mark check box

5. **Compare patterns of change for factor on pair wise comparisons and means to interpretative statements**

6. **Statement matches pair wise comparison?**
   - Yes → Mark check box
   - No → Do not mark check box
Main effect statistically significant? (Sig < alpha)

Yes

Compare pattern of change over time based on pair wise comparisons and means to interpretative statements

Statement matches pair wise comparison?

Yes

Mark check box for statement

No

Do not mark check box for statement

No

Do not interpret pair wise comparisons

Stop

No

Do not mark check box

Stop

Yes

Do not interpret main effects

Stop