Example of a Mixed Factorial ANOVA updated 11/25/20

A 3 × 3 (Lecture Type × Time) mixed between and within factorial analysis of vocabulary scores

Syntax

```plaintext
COMPUTE vocab=mean(baseline,twowks,fourwks).
MEANS VARS=vocab BY lecture.
MEANS VARS=baseline twowks fourwks by lecture.

GLM baseline twowks fourwks BY lecture
  /WSFACTOR=time 3
  /WSDESIGN=time
  /DESIGN=lecture
  /PRINT=DESCRIPTIVE ETASQ
  /EMMEANS=TABLES(time*lecture)
  /EMMEANS=TABLES(time*lecture)
  /PLOT=PROFILE(time*lecture).
```

Menus

Analyze → General Linear Model → Repeated Measures

Enter number of levels of within-subjects factor and name it. Click Add. Click the Define button. Drag over the variables for the within-subjects factor (here, baseline, twowks, and fourwks). Move over Between-Subjects Factor.

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1 * This numeric example is adapted from Keppel, G., & Zedeck S. (1989). *Data analysis for research designs*. New York: Freeman. Explanation of the mixed factorial using this example is in the handout “Factorial ANOVA for Mixed Designs Example: SPSS and R” for this class.
### Mauchly’s Test of Sphericity

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly’s W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>.691</td>
<td>2.952</td>
<td>2</td>
<td>.229</td>
<td>.764</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

- **Design:** Intercept + lecture
- **Within Subjects Design:** time

- **b.** 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.

### Multivariate Tests

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.963</td>
<td>104.309</td>
<td>2.000</td>
<td>8.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Wilks’ Lambda</td>
<td>.037</td>
<td>104.309</td>
<td>2.000</td>
<td>8.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Hotelling’s Trace</td>
<td>26.077</td>
<td>104.309</td>
<td>2.000</td>
<td>8.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Roy’s Largest Root</td>
<td>26.077</td>
<td>104.309</td>
<td>2.000</td>
<td>8.000</td>
<td>.000</td>
</tr>
<tr>
<td>time * lecture</td>
<td>Pillai’s Trace</td>
<td>.683</td>
<td>2.335</td>
<td>4.000</td>
<td>18.000</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td>Wilks’ Lambda</td>
<td>.332</td>
<td>2.942</td>
<td>4.000</td>
<td>16.000</td>
<td>.053</td>
</tr>
<tr>
<td></td>
<td>Hotelling’s Trace</td>
<td>1.966</td>
<td>3.441</td>
<td>4.000</td>
<td>14.000</td>
<td>.037</td>
</tr>
<tr>
<td></td>
<td>Roy’s Largest Root</td>
<td>1.942</td>
<td>8.741</td>
<td>2.000</td>
<td>9.000</td>
<td>.008</td>
</tr>
</tbody>
</table>

- **a.** Design: Intercept + lecture
- **Within Subjects Design:** time
- **b.** Exact statistic
- **c.** The statistic is an upper bound on F that yields a lower bound on the significance level.

### Tests of Within-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>Sphericity Assumed</td>
<td>2974.500</td>
<td>2</td>
<td>1487.250</td>
<td>52.184</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>2974.500</td>
<td>1.528</td>
<td>1946.128</td>
<td>52.184</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>2974.500</td>
<td>2.000</td>
<td>1487.250</td>
<td>52.184</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>2974.500</td>
<td>1.000</td>
<td>2974.500</td>
<td>52.184</td>
<td>.000</td>
</tr>
<tr>
<td>time * lecture</td>
<td>Sphericity Assumed</td>
<td>320.500</td>
<td>4</td>
<td>80.125</td>
<td>2.811</td>
<td>.057</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>320.500</td>
<td>3.057</td>
<td>104.847</td>
<td>2.811</td>
<td>.078</td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>320.500</td>
<td>4.000</td>
<td>80.125</td>
<td>2.811</td>
<td>.057</td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>320.500</td>
<td>2.000</td>
<td>160.250</td>
<td>2.811</td>
<td>.113</td>
</tr>
<tr>
<td>Error(time)</td>
<td>Sphericity Assumed</td>
<td>513.000</td>
<td>18</td>
<td>28.500</td>
<td>28.500</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>513.000</td>
<td>13.756</td>
<td>37.293</td>
<td>37.293</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>513.000</td>
<td>18.000</td>
<td>28.500</td>
<td>28.500</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>513.000</td>
<td>9.000</td>
<td>57.000</td>
<td>57.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

### Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>40401.000</td>
<td>1</td>
<td>40401.000</td>
<td>459.693</td>
<td>.000</td>
<td>.981</td>
</tr>
<tr>
<td>lecture</td>
<td>1194.000</td>
<td>2</td>
<td>597.000</td>
<td>6.793</td>
<td>.016</td>
<td>.602</td>
</tr>
<tr>
<td>Error</td>
<td>791.000</td>
<td>9</td>
<td>87.899</td>
<td>87.899</td>
<td>.000</td>
<td>.811</td>
</tr>
</tbody>
</table>
$R$

```r
rm(d)
rm(longdata)

library(haven)
d = read_sav("c:/jason/spsswin/uvclass/tabl17-5.sav")

library(reshape2)
longdata <- melt(d,
               measure.vars = c("BASELINE", "TWOWKS", "FOURWKS"),
               variable.name = "TIME", #old variables
               value.name = "SCORE")     #name a new variable for the values

library('ez')
mymodel = ezANOVA(data = longdata,
                  dv = SCORE,            #dependent variable
                  wid = id,              #id variable
                  within = TIME,         #within-subjects factor
                  between = LECTURE,     #between-subjects factor
                  detailed = TRUE)       #print some extra details
print(mymodel)

$ANOVA
Effect DFn DFd     SSn SSd          F                 p p<.05       ges
1  (Intercept)   1   9 40401.0 791 459.682680 0.000000004913104     * 0.9687328
2      LECTURE   2   9  1194.0 791   6.792668 0.015917390678695     * 0.4779824
3         TIME   2  18  2974.5 513  52.184211 0.000000032242473     * 0.6952203
4 LECTURE:TIME   4  18   320.5 513   2.811404 0.056533989865637       0.1972915

`Mauchly's Test for Sphericity`
Effect         W         p p<.05
3         TIME 0.6914584 0.2285937
4 LECTURE:TIME 0.6914584 0.2285937

`Sphericity Corrections`
3         TIME 0.7642096 0.000001009711         * 0.8889813 0.0000001627447         *
4 LECTURE:TIME 0.7642096 0.077784352860 0.8889813 0.0656228251801

#Get cell means
descrip = ezStats(data = longdata,
                  dv = SCORE,            #dependent variable scores
                  wid = id,              #id variable
                  within = TIME,         #within-subjects factor
                  between = LECTURE)     #between-subjects factor
print(descrip)

LECTURE     TIME N  Mean        SD     FLSD
1 physical science BASELINE 4 47.75  4.573474 7.930807
2 physical science TWOWKS  4 44.25  7.410578 7.930807
3 physical science FOURWKS 4 28.00  7.438638 7.930807
4 social science BASELINE 4 41.25  4.349329 7.930807
5 social science TWOWKS  4 26.00 13.832329 7.930807
6 social science FOURWKS 4 10.75  4.112988 7.930807
7          history BASELINE 4 40.00  3.915780 7.930807
8          history   TWOWKS 4 38.50  5.802298 7.930807
9          history  FOURWKS 4 25.00  5.228129 7.930807

#plot the data
#ezplot requires factor rather than double precision (continuous) used by havenl
library(lessR)  #lessR transform function
longdata <- Transform(TIME = as.factor(TIME), data=longdata)
longdata <- Transform(LECTURE = as.factor(LECTURE), data=longdata)

mixplot = ezPlot(data = longdata,
                 dv = SCORE,            #dependent variable scores
                 wid = id,              #id variable
                 x = TIME,              #x-axis variable
                 split = LECTURE,      #separate lines
                 within = TIME,        #within factor
                 between = LECTURE)    #between factor
print(mixplot)
```
Example Write-Up
A 3 (physical science, social science, history) × 3 (baseline, two weeks, four weeks) mixed factorial ANOVA, with one between-subjects factor and one within-subjects factor, was conducted to investigate whether changes in vocabulary over time differed by lecture type. The univariate repeated-measures tests and their sphericity corrections were examined to determine significance because of the small sample size (Algina & Kesselman, 1997). There was a significant main effect for lecture type, $F(2,9) = 6.79, p = .057$, partial $\eta^2 = .60$, with the highest vocabulary scores in physical science $M = 40, SD = 5.24$, followed by history ($M = 34.50, SD = 3.16$), and social science ($M = 26.00, SD = 7.11$). A significant main effect for time, $F(2,18) = 52.18, p < .001$ (for sphericity assumed and corrections), partial $\eta^2 = .85$, indicated that there was a decline in vocabulary scores over time (baseline $M = 43.00, SD = 5.26$, two weeks $36.25, SD = 11.42$, four weeks $M = 21.25, SD = 9.42$). The interaction was only marginally significant, based on the sphericity assumed results $F(4,18) = 2.81, p = .057$, the Greenhouse-Geisser ($p = .08$), and the Huynh-Feldt corrections ($p = .06$), partial $\eta^2 = .39$, showing that there was a tendency for vocabulary scores to decline at different rates across lecture types.

Several follow-up tests might be conducted following these analyses, which might explore the main effects for lecture or time by conducting main effect contrasts. For example, it might of interest to know whether there was a significant difference between baseline and two-week vocabulary scores overall or whether history and social science vocabulary scores differed significantly overall. Because the interaction effect was marginally significant, some authors might choose to conduct simple effect tests, such as exploring whether baseline scores differed among the three lecture types (using one-way ANOVA) or social science scores changed significantly over time (within-subjects ANOVA). Those simple effect tests might be followed by simple contrasts, such as examining whether social science scores differed between baseline and two weeks (paired $t$ test) or whether social and physical science scores differed at four weeks (one-way ANOVA planned contrast).