

## ANOVA mixed

### *An alternative medical example for the same mixed design*

A study is designed to compare the effectiveness of top-of-the-range analogue and digital hearing aids in a wide range of acoustic environments for adults with mild to moderately severe sensorineural hearing loss. Nine adults aged between 50 and 60 years are recruited, three in the mid-range of each of three levels of hearing loss, based on the pure tone average of hearing thresholds at 500, 1000 and 2000 Hz. The three levels of hearing loss are defined as, 60-65 dB (moderately severe), 45-50 dB (moderate) and 30-35 dB (mild). None of the participants has used a hearing aid before. Participants use either an analogue or digital hearing aid, customized to their requirements, for a period of two months before its effectiveness is assessed. They then use the other type of hearing aid, again customised to their requirements, for two months before its effectiveness is assessed. The order of use of type of hearing aid is balanced across participants. Level of hearing loss is a between-subjects factor and type of hearing aid is a within-subjects factor. The DV is a hearing difficulty score on the assessment test. The test involves the presentation of 30 samples of speech recorded in environments ranging from quiet to extremely noisy and the participant reports 'difficulty' or 'no difficulty' in understanding each sample. The hearing difficulty score is the total number of samples for which difficulty is reported. The data appear in Table 2.7. Once again, we remind you that, for a real experiment, the sample size should be justified by reference to a power analysis.

Table 2.7

*Data from a mixed design (LOSS between-subjects and hearing aid TYPE within-subjects) (med.anova.mixed.sav)*

participant	loss	type	
		difficulty (analogue)	difficulty (digital)

1	high	15	14
2	high	18	12
3	high	12	11
4	medium	14	10
5	medium	12	8
6	medium	15	12
7	low	13	6
8	low	11	9
9	low	14	5

### *A mixed design: setting it up in SPSS*

To set up the ANOVA in SPSS we need, as usual, a row of the datasheet for each participant. We shall need one column for the between-subjects variable, LOSS, and two columns for the within-subjects variable, TYPE, one for each level of that variable (i.e., analogue and digital). Notice that the DV, the score on difficulty (DIFFIC), must be recorded as a variable for each level of the TYPE variable, which is the one that is within-subjects, so that each participant occupies one row of the datasheet. The SPSS datasheet is set out just like Table 2.7, except that we don't need the first column giving the participant number, nor do we need the heading TYPE, so we have 9 rows and 3 columns of data, and we have called the variables LOSS, DIFFIC1 and DIFFIC2 in the datasheet. The levels of LOSS could be coded 1, 2 and 3 and labels assigned similarly to the example in SPSS Dialog Box 2.1.

### *A mixed design: requesting the analysis in SPSS*

Once the datasheet is ready, from the menu bar select **Analyze, General Linear Model and Repeated Measures** to get a dialog box like SPSS Dialog Box 2.8. First we must define the within-subject factor. Type the factor name, TYPE in our example, in the **Within-Subject Factor Name** box. Then type 2 in the **Number of Levels** box and click **Add**. We have no more within-subject factors. The **Measure Name** is the DV, in our case DIFFIC, so type this into the box and click Add. Click **Define** to move on to a dialog box like SPSS Dialog Box 2.9.

Now use the arrow to put first DIFFIC1 and then DIFFIC2 into the **Within-Subjects Variables** box. The first variable that we enter becomes the value of the DV DIFFIC at level 1 of the within-subject factor TYPE, and the next becomes the value at level 2. The small up and down arrows can be used to reverse the positions of the two levels of TYPE if necessary. Use the arrow to put LOSS in the **Between-Subjects Factors** box.

Clicking the **Model** button gives us a dialog box like SPSS Dialog Box 2.6. This time there are separate boxes for **Within** and **Between-Subjects** factors, and as we have only one of each we may as well accept the default **Full factorial** model. We could click the **Custom** radio button as we did in the between-subjects design, but all we can do is put TYPE in the **Within-Subjects Model** box and LOSS in the **Between-Subjects Model** box. We could specify the interactions to include if we had more than one variable in a category, but the interactions between within-subjects and between-subjects variables to be included will be determined by the mixed nature of the design. The default sum of squares, Type III, is the one usually needed. If your design is balanced then all the different types give the same answer. For Type I, the sums of squares are found sequentially allowing for variables already in the model so that the order of the variables in the model matters. For Type II, the sums of squares for a main effect is not adjusted for any interactions containing it. Type III gives the reduction in the residual sums assuming that the effect was the last one entered into a model containing all the other variables. Type IV is a variation of Type III developed for designs with a combination of factor levels with no observations. So click **Continue** to return to the main dialog box.

The **Plots** button gives us a dialog box just like SPSS Dialog Box 2.7. This time, we request a plot with TYPE on the horizontal axis and separate lines for LOSS. Remember to click **Add** and then **Continue**. In the **Options** dialog box, once again request **Estimates of effect size, Observed power, Homogeneity tests** and **Residual plot**. Then press **Continue** and **OK** to get the analysis.

#### *A mixed design: understanding the output*

First in the output come two tables (not shown here) summarizing the levels of the within-subjects factor and showing the number of observations at each level of the between-subjects factor. This summary is followed by the tables of multivariate tests. In this case we have just one within-subjects factor and it has only two levels. In these circumstances the multivariate and univariate tests are equivalent and we just show the within-subjects analysis (we discuss the multivariate tests in the next chapter, on MANOVA). In SPSS Output 2.13 we see the ANOVA table for the within-subjects effects. We see that TYPE is judged significant ( $F(1,6) = 21.06, p = 0.004, < 0.01$ ) with sphericity assumed and also with all of the three adjusted types (which will also be discussed in the next chapter), and with an effect size of partial  $\eta^2 = 0.78$  and power = 0.97. The interaction of TYPE with LOSS is not significant ( $F(2,6)=1.22, p > 0.05$ ).

Since TYPE has only two levels, only the linear contrast is possible, and the table of within-subjects contrasts which follows the ANOVA table just repeats the information that TYPE is significant and its interaction with LOSS is not.

Next is the test we requested to check the homogeneity of variance assumption, here done separately for the DIFFIC scores at the two levels of TYPE. Both probabilities in

the Sig column are well above 0.05 so we need have no concern about this assumption. The ANOVA table for the between-subjects factor follows and we see that the main effect of LOSS is significant at the 5% level ( $F(2,6) = 5.35, p = 0.046$ ), with an effect size of partial  $\eta^2 = 0.64$  and power = 0.61. These results are all shown in SPSS Output 2.13.

**Tests of Within-Subjects Effects**

Measure:diffic									
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power <sup>a</sup>
type	Sphericity Assumed	76.056	1	76.056	21.062	.004	.778	21.062	.966
	Greenhouse-Geisser	76.056	1.000	76.056	21.062	.004	.778	21.062	.966
	Huynh-Feldt	76.056	1.000	76.056	21.062	.004	.778	21.062	.966
	Lower-bound	76.056	1.000	76.056	21.062	.004	.778	21.062	.966
type * loss	Sphericity Assumed	8.778	2	4.389	1.215	.360	.288	2.431	.178
	Greenhouse-Geisser	8.778	2.000	4.389	1.215	.360	.288	2.431	.178
	Huynh-Feldt	8.778	2.000	4.389	1.215	.360	.288	2.431	.178
	Lower-bound	8.778	2.000	4.389	1.215	.360	.288	2.431	.178
Error(type)	Sphericity Assumed	21.667	6	3.611					
	Greenhouse-Geisser	21.667	6.000	3.611					
	Huynh-Feldt	21.667	6.000	3.611					
	Lower-bound	21.667	6.000	3.611					

a. Computed using alpha = .05

**Tests of Within-Subjects Contrasts**

Measure:diffic									
Source	type	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power <sup>a</sup>
type	Linear	76.056	1	76.056	21.062	.004	.778	21.062	.966
type * loss	Linear	8.778	2	4.389	1.215	.360	.288	2.431	.178
Error(type)	Linear	21.667	6	3.611					

a. Computed using alpha = .05

**Levene's Test of Equality of Error Variances<sup>a</sup>**

	F	df1	df2	Sig.
diffic1	.598	2	6	.580
diffic2	.176	2	6	.842

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

a. Design: Intercept + loss  
Within Subjects Design: type

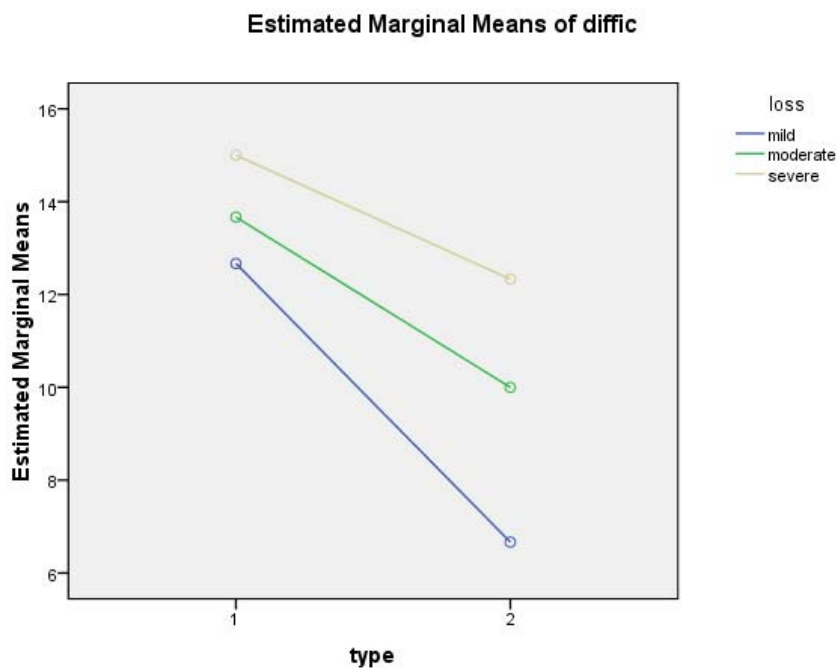
**Tests of Between-Subjects Effects**

Measure:diffic Transformed Variable:Average									
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power <sup>a</sup>
Intercept		2473.389	1	2473.389	549.642	.000	.989	549.642	1.000
loss		48.111	2	24.056	5.346	.046	.641	10.691	.609
Error		27.000	6	4.500					

a. Computed using alpha = .05

*SPSS Output 2.13. ANOVA table for within-subjects factors, test for homogeneity of variance, and ANOVA table for the between subjects factor*

Right at the end of the output is our plot (SPSS Output 2.14), where we see these results illustrated. The severe LOSS group has the highest difficulty scores with both types of hearing aid, followed by the moderate LOSS and then the mild LOSS groups. For all LOSS groups, DIFFIC scores were higher using the analogue TYPE. The differences among the group means were a little greater when the digital TYPE was used (but this difference wasn't great enough to cause a significant interaction effect).



*SPSS Output 2.14. Plot showing mean DIFFIC scores for three LOSS groups for each of two types of hearing aid, analogue (TYPE 1) and digital (TYPE 2)*

Finally, the residual plots (one for DIFFIC scores at each level of TYPE) are not very informative in this analysis (because there are so few points in each) and we do not reproduce them here.