

## Chapter 15: GLM 4: Repeated-measures designs

### Labcoat Leni's Real Research

#### Are splattered cadavers distracting?

##### Problem

Perham, N., & Sykora, M. (2012). *Applied Cognitive Psychology*, 26(4), 550–555..



In Chapter 10, I used the example of whether listening to my favourite music would interfere with people's ability to write an essay. It turns out that Nick Perham has tested this hypothesis (sort of). He was interested in the effects of liked and disliked music (compared to quiet) on people's ability to remember things. Twenty-five participants were asked to remember lists of 8 letters. Perham and Sykora (2012) manipulated the background noise while each list was presented: it could be silence (the control), liked music or disliked music. They used music that they believed most participants would like (a popular song called 'From Paris to Berlin' by Infernal) and dislike (Repulsion's 'Acid Bath', 'Eaten Alive' and 'Splattered Cadavers' – in other words, the sort of thing I listen to, although I don't actually have any stuff by Repulsion). Participants were asked to recall each list of 8 letters, which enabled the authors to calculate the probability of correctly recalling a letter in each position in the list. There are two variables: position in the list (which letter in the sequence is being recalled, 1 to 8) and sound playing when the list is presented (quiet, liked, disliked). Run a two-way repeated-measures ANOVA to see whether recall is affected by the type of sound played while learning the sequences (**Perham & Sykora (2012).sav**).

##### Solution

To conduct an ANOVA using a repeated-measures design, activate the *define factors* dialog box by selecting **Analyze** **General Linear Model** **▶ Repeated Measures...**. In the *define factors* dialog box (Figure ) you are asked to supply a name for the first within-subject (repeated-measures)

variable. In this case the first repeated-measures variable was the position of the letter in the list, so replace the word *factor1* with the word *Position*. Next, you have to tell SPSS how many levels there were (i.e., how many experimental conditions there were). In this case, there were eight possible positions, so enter the number 8 into the box labelled *Number of Levels*. Click on **Add** to add this variable to the list of repeated-measures variables. This variable will now appear in the white box at the bottom of the dialog box as *Position(8)*. You now have to repeat this process for the second independent variable. Enter the word *Sound* into the space labelled *Within-Subject Factor Name* and then, because there were three levels of this variable, enter the number 3 into the space labelled *Number of Levels*. Click on **Add** to include this variable in the list of factors; it will appear as *Sound(3)*. The finished dialog box is shown in Figure . When you have entered both of the within-subject factors click on **Define** to go to the main dialog box.

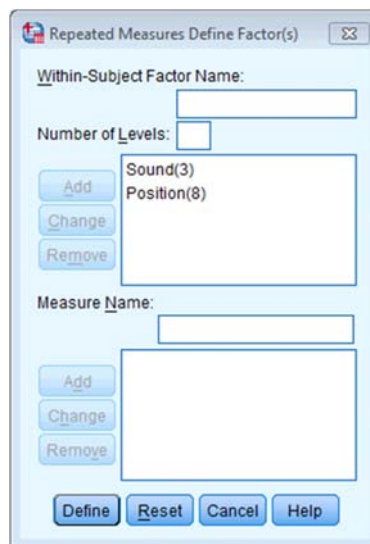


Figure 1

Once you are in the main dialog box (Figure ) you are required to replace the question marks with variables from the list on the left-hand side of the dialog box. In this design, if we look at the first variable, **Sound**, there were three conditions, *like*, *dislike* and *quiet*. The quiet condition is the control condition, therefore for this variable we might want to compare the like and dislike conditions with the quiet condition. In terms of conducting contrasts, it is therefore essential that the quiet condition be entered as either the first or last level of the independent variable **Sound** (because you can't specify the middle level as the reference category in a simple contrast). I have coded quiet = level 1, liked = level 2 and disliked = level 3. Now, let's think about the second factor **Position**. This variable doesn't have a control category and so it makes sense for us to just code level 1 as position 1, level 2 as position 2 and so on

for ease of interpretation. Coincidentally, this order is the order in which variables are listed in the data editor. Actually it's not a coincidence: I thought ahead about what contrasts would be done, and then entered variables in the appropriate order! (See Figure .)

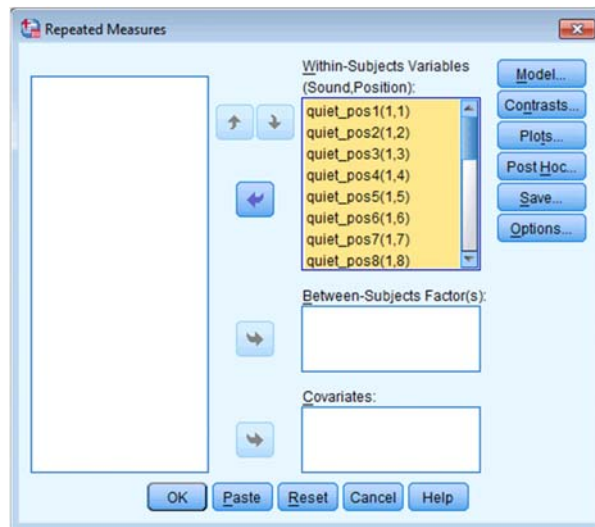



Figure 2

Clicking on **Options...** takes you to the dialog box in Figure . I recommend selecting some descriptive statistics. You might want to select some multiple comparisons by selecting all factors in the box labelled *Factor(s) and Factor Interactions* and dragging them to the box labelled *Display Means for*, or clicking on . Having selected these variables, you should select  **Compare main effects** and select an appropriate correction (I chose LSD(none)). These tests are interesting only if the interaction effect is not significant.

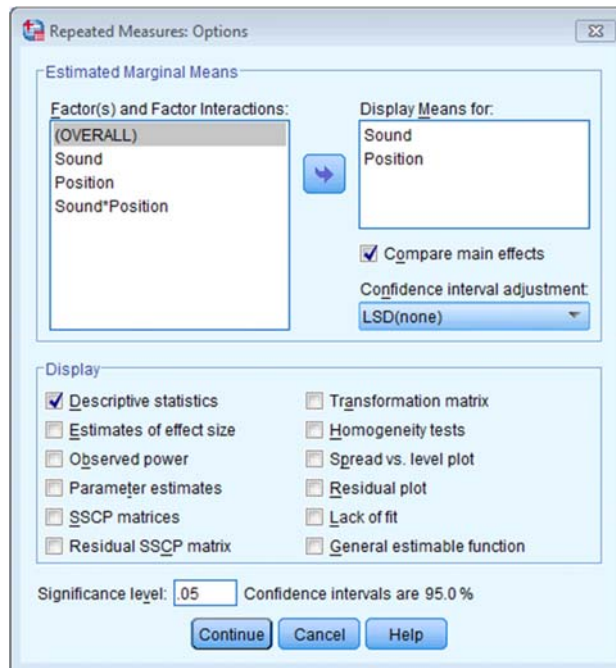


Figure 3

The *plots* dialog box is a convenient way to plot the means for each level of the factors (although really you should do some proper graphs before the analysis). To access this dialog box click on **Plots...**. Select **Position** from the variables list on the left-hand side of the dialog box and drag it to the space labelled *Horizontal Axis* or click on **→**. In the space labelled *Separate Lines* we need to place the remaining independent variable: **Sound**. As before, it is down to your discretion which way round the graph is plotted. When you have moved the two independent variables to the appropriate box, click on **Add** and this interaction graph will be added to the list at the bottom of the box (see Figure ). When you have finished specifying graphs, click on **Continue** to return to the main dialog box.

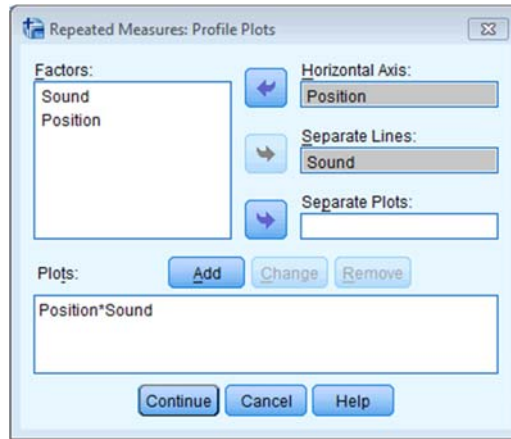


Figure 4

SPSS output

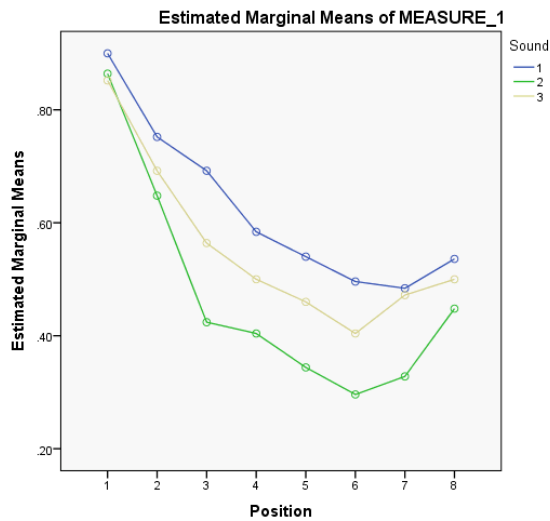


Figure 5

Figure displays the estimated marginal means of letters recalled in each of the positions of the lists when no music was played (blue line), when liked music was played (green line) and when disliked music was played (yellow line). The chart shows that the typical serial curve was elicited for all sound conditions (participants' memory was best for letters towards the

beginning of the list and at the end of the list, and poorest for letters in the middle of the list) and that performance was best in the quiet condition, poorer in the disliked music condition and poorest in the liked music condition.

**Mauchly's Test of Sphericity<sup>a</sup>**

Measure: MEASURE\_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon <sup>b</sup>		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Sound	.766	6.134	2	.047	.810	.861	.500
Position	.050	64.153	27	.000	.547	.664	.143
Sound * Position	.000	173.403	104	.000	.457	.640	.071

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

- a. Design: Intercept  
Within Subjects Design: Sound + Position + Sound \* Position
- 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.

**Output 1**

Output shows the results of Mauchly's test. The significance values are all below .05 and so the assumption of sphericity has been broken for both of the independent variables and also for the interaction.

**Tests of Within-Subjects Effects**

Measure: MEASURE\_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Sound	Sphericity Assumed	2.368	2	1.184	9.459	.000
	Greenhouse-Geisser	2.368	1.621	1.461	9.459	.001
	Huynh-Feldt	2.368	1.721	1.376	9.459	.001
	Lower-bound	2.368	1.000	2.368	9.459	.005
Error(Sound)	Sphericity Assumed	6.007	48	.125		
	Greenhouse-Geisser	6.007	38.895	.154		
	Huynh-Feldt	6.007	41.305	.145		
	Lower-bound	6.007	24.000	.250		
Position	Sphericity Assumed	13.474	7	1.925	41.432	.000
	Greenhouse-Geisser	13.474	3.830	3.518	41.432	.000
	Huynh-Feldt	13.474	4.648	2.899	41.432	.000
	Lower-bound	13.474	1.000	13.474	41.432	.000
Error(Position)	Sphericity Assumed	7.805	168	.046		
	Greenhouse-Geisser	7.805	91.923	.085		
	Huynh-Feldt	7.805	111.556	.070		
	Lower-bound	7.805	24.000	.325		
Sound * Position	Sphericity Assumed	.565	14	.040	1.435	.135
	Greenhouse-Geisser	.565	6.391	.088	1.435	.201
	Huynh-Feldt	.565	8.960	.063	1.435	.175
	Lower-bound	.565	1.000	.565	1.435	.243
Error(Sound*Position)	Sphericity Assumed	9.453	336	.028		
	Greenhouse-Geisser	9.453	153.389	.062		
	Huynh-Feldt	9.453	215.048	.044		
	Lower-bound	9.453	24.000	.394		

**Output 2**

Output 2 shows the main ANOVA summary table. We will look at the Greenhouse–Geisser corrected  $p$ -values for both **Sound** and **Position** and their interaction because the assumption of sphericity was broken. The main effect of sound is shown by the  $F$ -ratio in the row labelled **Sound**. The significance of this value is .001, which is well below the usual cut-off point of .05 and so we can conclude that sound had a significant effect on memory performance  $F(1.62, 48) = 9.46, p = .001$ . Looking at Figure , we can see that performance was best in the quiet condition, poorer in the disliked music condition and poorest in the liked music condition. However, we cannot tell where the significant differences lie without looking at some contrasts or *post hoc* tests. There was a significant main effect of position,  $F(3.83, 168) = 41.43, p < 0.001$ . Finally, there was no significant position by sound interaction,  $F(6.39, 153.39) = 41.43, p = 0.201$ .

#### Pairwise Comparisons

Measure: MEASURE\_1

(I) Sound	(J) Sound	Mean Difference (I-J)	Std. Error	Sig. <sup>b</sup>	95% Confidence Interval for Difference <sup>b</sup>	
					Lower Bound	Upper Bound
1	2	.154 <sup>*</sup>	.042	.001	.066	.241
	3	.068 <sup>*</sup>	.028	.022	.011	.124
2	1	-.154 <sup>*</sup>	.042	.001	-.241	-.066
	3	-.086 <sup>*</sup>	.035	.020	-.157	-.015
3	1	-.068 <sup>*</sup>	.028	.022	-.124	-.011
	2	.086 <sup>*</sup>	.035	.020	.015	.157

Based on estimated marginal means

\*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

#### Output 3

The main effect of position was significant because of the production of the typical serial curve, so *post hoc* analyses were not conducted. However, we did conduct some *post hoc* least significant difference (LSD) comparisons on the main effect of sound (see Output ). These *post hoc* tests revealed that performance in the quiet condition (level 1) was significantly better than both the liked condition (level 2),  $p = .001$ , and in the disliked condition (level 3),  $p = .022$ . Performance in the disliked condition (level 3) was significantly better than in the liked condition (level 2),  $p = 0.020$ . Finally, there was no significant position by sound interaction. We can conclude that liked music interferes more with performance on a memory task than disliked music.