

## Chapter 20: Multilevel Linear Models

### Labcoat Leni's Real Research

#### A fertile gesture

##### Problem

Miller, G., Tybur, J. M., & Jordan, D. B. (2007). *Evolution and Human Behavior*, 28, 375–381.




Most female mammals experience a phase of 'estrus' during which they are more sexually receptive, proceptive, selective and attractive. As such, the evolutionary benefit to this phase is believed to be to attract mates of superior genetic stock. However, some people have argued that this important phase became uniquely lost or hidden in human females. Geoffrey Miller and his colleagues reasoned that if the 'hidden-estrus' theory is incorrect then men should find women most attractive during the fertile phase of their menstrual cycle compared to the pre-fertile (menstrual) and post-fertile (luteal) phase.

To measure how attractive men found women in an ecologically valid way, they came up with the ingenious idea of collecting data from women working at lap-dancing clubs. These women maximize their tips from male visitors by attracting more dances. In effect the men 'try out' several dancers before choosing a dancer for a prolonged dance. For each dance the male pays a 'tip', therefore the more men that choose a particular woman, the more her earnings will be. As such, each dancer's earnings are a good index of how attractive the male customers have found her. If the 'hidden-estrus' theory is incorrect then men will find the lap dancers more attractive during their estrus phase therefore they will earn more money. This study is a brilliant example of using a real-world phenomenon to address an important scientific question in an ecologically valid way.

The data for this study are in the file **Miller et al. (2007).sav**. The researchers collected data via a website from several dancers (**ID**), who provided data for multiple lap-dancing shifts (so for each person there are several rows of data). They also measured what phase of the menstrual cycle the women were in at a given shift (**Cyclephase**), and whether they were using hormonal contraceptives (**Contraceptive**), because this would affect their cycle. The outcome was their earnings on a given shift in dollars (**Tips**). The data are unbalanced: the women differed in the number of shifts for which they provided data (the range was 9 to 29 shifts).

Labcoat Leni wants you to carry out a multilevel model to see whether **Tips** can be predicted from **Cyclephase**, **Contraceptive** and their interaction. Is the 'estrus-hidden' hypothesis supported?

## Solution

First, select **Analyze Mixed Models** > **Linear...**; in this initial dialog box (Figure 1) we need to set up the level 2 variable. In this example, multiple scores or shifts are nested within each dancer. Therefore, the level 2 variable is the participant (the lap dancer) and this variable is represented by the variable labelled **ID**. Select this variable and drag it to the box labelled **Subjects** (or click on ). Click on **Continue** to access the main dialog box.

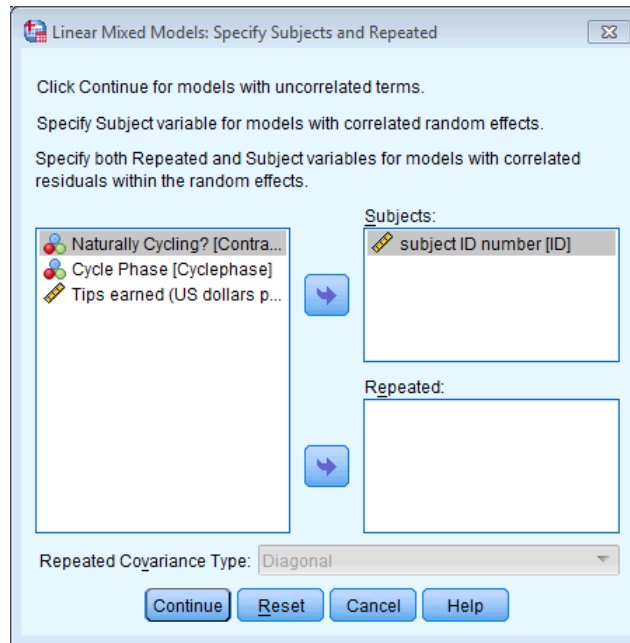




Figure 1

In the main dialog box (Figure 2) we need to set up our predictors and outcome. The outcome was the value of tips earned, so select **Tips** and drag it to the box labelled **Dependent variable** (or click on ). We also have two predictors: **Cyclephase** and **Contraceptive**. Select both of these (click on one and then while holding down *Ctrl* click on the other) and then drag them to the box labelled **Factor(s)**, or click on . We use the *Factor(s)* box because both variables are categorical.

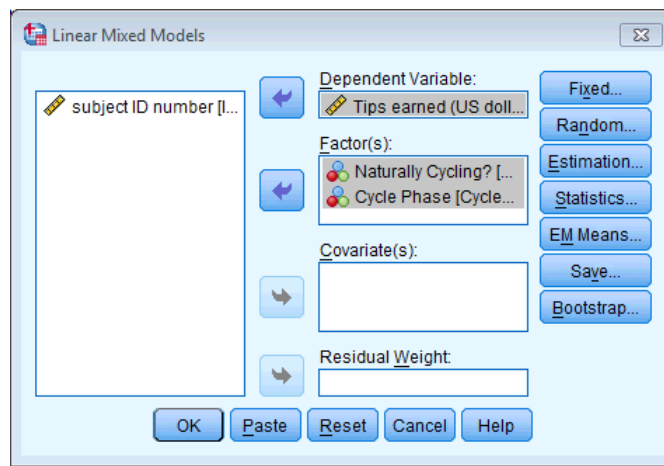


Figure 2

We need to add these fixed effects to our model, so click on **Fixed...** to bring up the *fixed effects* dialog box (Figure 3). To specify both main effects and the interaction term, select both predictors (click on **Cyclephase** and then, while holding down *Ctrl*, click on **Contraceptive**), then select **Factorial**, and then click on **Add**. With **Factorial** selected you should find that both main effects and the interaction term are transferred to the *Model*. Click on **Continue** to return to the main dialog box.

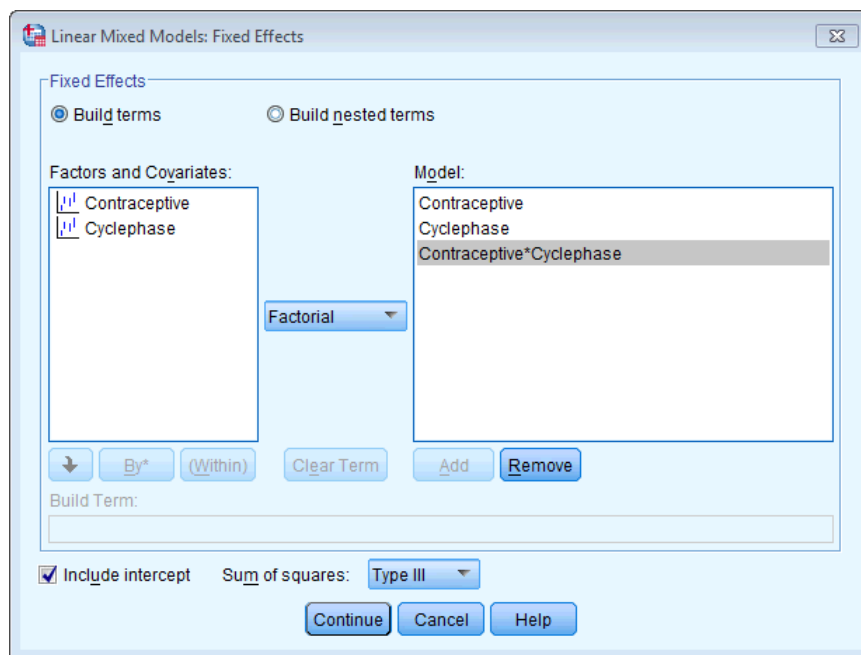



Figure 3

In the model that Miller et al. fitted, they did not assume that there would be random slopes (i.e., the relationship between each predictor and tips was not assumed to vary within lap dancers). This decision is appropriate for **Contraceptive** because this variable didn't vary at level 2 (the lap dancer was either taking contraceptives or not, so this could not be set up as a random effect because it doesn't vary over our level 2 variable of participant). Also, because

**Cyclephase** is a categorical variable with three unordered categories we could not expect a linear relationship with tips: we expect tips to vary over categories but the categories themselves have no meaningful order. However, we might expect tips to vary over participants (some lap dancers will naturally get more money than others) and we can factor this variability in by allowing the intercept to be random. As such, we're fitting a random intercept model to the data.

To do this, click on **Random...** in the main dialog box to access the dialog box in Figure 4. The first thing we need to do is to specify our contextual variable. We do this by selecting it from the list of contextual variables that we have told SPSS about already. These appear in the section labelled **Subjects**. Because we only specified one variable, there is only one variable in the list, **ID**. Select this variable and drag it to the area labelled **Combinations** (or click on ). We want to specify only that the intercept is random, and we do this by selecting  **Include intercept**. Notice that this dialog box includes a drop-down list used to specify the type of covariance (**Variance Components**). For a random intercept model this default option is fine. Click on **Continue** to return to the main dialog box.

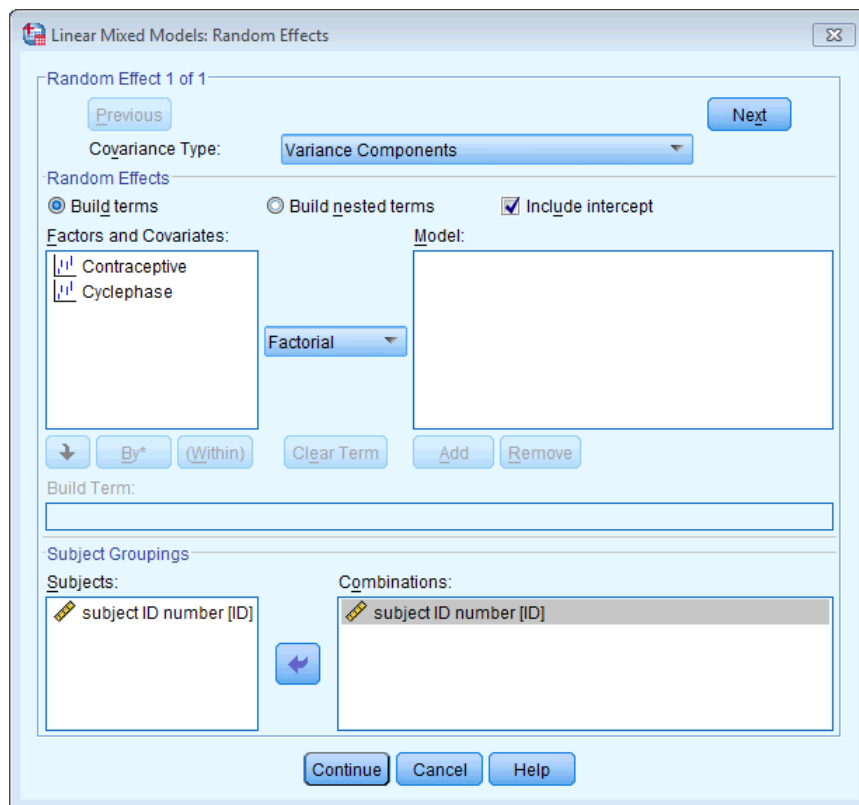


Figure 4

The authors report in the paper that they used restricted maximum-likelihood estimation (REML), so click on **Estimation...** and select this option. Finally, click on **Statistics...** and select *Parameter estimates* and *Tests for covariance parameters*. Click on **Continue** to return to the main dialog box. To run the analysis, click on **OK**.

Type III Tests of Fixed Effects<sup>a</sup>

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	16.673	198.395	.000
Contraceptive	1	16.673	6.756	.019
Cyclephase	2	235.940	27.461	.000
Contraceptive * Cyclephase	2	235.940	5.319	.005

a. Dependent Variable: Tips earned (US dollars per shift).

## Output 1

Output 1 tells us our fixed effects. As you can see they are all significant. Miller et al. reported these results as follows: 'Main effects of cycle phase [ $F(2, 236)=27.46, p < .001$ ] and contraception use [ $F(1, 17)=6.76, p < .05$ ] were moderated by an interaction between cycle phase and pill use [ $F(2, 236)=5.32, p < .01$ ]' (p. 378). Hopefully you can see where these values come from in the table (they rounded the *df* off to whole numbers).

Basically this shows that the phase of the dancer's cycle significantly predicted tip income, and this interacted with whether or not the dancer was having natural cycles or was on the contraceptive pill. However, we don't know which groups differed. We can use the parameter estimates to tell us (Output 2).

Estimates of Fixed Effects<sup>b</sup>

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	356.653831	21.108117	21.093	16.897	.000	312.768908	400.538754
[Contraceptive=0]	-141.624036	35.299199	24.887	-4.012	.000	-214.340803	-68.907268
[Contraceptive=1]	0 <sup>a</sup>	0	.	.	.	.	.
[Cyclephase=0]	-100.408861	16.422344	235.211	-6.114	.000	-132.762537	-68.055186
[Cyclephase=1]	-170.856199	17.366234	234.920	-9.838	.000	-205.069651	-136.642747
[Cyclephase=2]	0 <sup>a</sup>	0	.	.	.	.	.
[Contraceptive=0] * [Cyclephase=0]	86.086114	30.053055	237.000	2.864	.005	26.880874	145.291353
[Contraceptive=0] * [Cyclephase=1]	89.936462	34.143956	238.804	2.634	.009	22.671763	157.201161
[Contraceptive=0] * [Cyclephase=2]	0 <sup>a</sup>	0	.	.	.	.	.
[Contraceptive=1] * [Cyclephase=0]	0 <sup>a</sup>	0	.	.	.	.	.
[Contraceptive=1] * [Cyclephase=1]	0 <sup>a</sup>	0	.	.	.	.	.
[Contraceptive=1] * [Cyclephase=2]	0 <sup>a</sup>	0	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

b. Dependent Variable: Tips earned (US dollars per shift).

## Output 2

I coded **Cyclephase** in a way that would be most useful for interpretation, which was to code the group of interest (fertile period) as the last category (2), and the other phases as 1 (Menstrual) and 0 (Luteal). The parameter estimates for this variable, therefore, compare each category against the last category, and because I made the last category the fertile phase this means we get a comparison of the fertile phase against the other two. Therefore, we could say (because the *b* is negative) that tips were significantly higher in the fertile phase than in the luteal phase,  $b = -100.41, t(235.21) = -6.11, p < .001$ , and in the menstrual phase,  $b = -170.86, t(234.92) = -9.84, p < .001$ . The beta, as in regression, tells us the change in tips as we shift from one group to another, so during the fertile phase, dancers earned about \$100 more than during the luteal phase, and \$170 more than the menstrual phase.

These effects don't factor in the contraceptive use. To look at this we need to look at the contrasts for the interaction term. The first of these tells us the following: if we worked out the relative difference in tips between the fertile phase and the luteal phase, how much more do those in their natural cycle earn compared to those on contraceptive pills? The answer is about \$86. In other words, there is a combined effect of being in a natural cycle (relative to being on the pill) and being in the fertile phase (relative to the luteal phase), and this is significant,  $b = 86.09$ ,  $t(237) = 2.86$ ,  $p < .01$ . The second contrast tells us the following: if we worked out the relative difference in tips between the fertile phase and the menstrual phase, how much more do those in their natural cycle earn compared to those on contraceptive pills? The answer is about \$90 (the  $b$ ). In other words, there is a combined effect of being in a natural cycle and being in the fertile phase compared to the menstrual phase, and this is significant,  $b = 89.94$ ,  $t(236.80) = 2.63$ ,  $p < .01$ .

Estimates of Covariance Parameters<sup>a</sup>

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	8631.057451	799.985654	10.789	.000	7197.286738	1.035045E4
Intercept [subject = ID] Variance	3571.117214	1507.797905	2.368	.018	1561.024071	8169.558939

a. Dependent Variable: Tips earned (US dollars per shift).

## Output 3

The final table (Output 3) is not central to the hypotheses, but it does tell us about the random intercept. In other words, it tells us whether tips (in general) varied from dancer to dancer. The variance in tips across dancers was 3571.12, and this is significant,  $z = 2.37$ ,  $p < .05$ . In other words, the average tip per dancer varied significantly. This confirms that we were justified in treating the intercept as a random variable.

To conclude, then, this study showed that the 'estrus-hidden' hypothesis is wrong: men did find women more attractive (as indexed by how many lap dances a woman performed and therefore how much she earned) during the fertile phase of their cycle compared to the other phases.