# Exercises linear mixed modelling: linear effects

Stéphanie M. van den Berg

February 28, 2020

## 0.1 Exercises

Suppose you have a number of CEOs with smart watches and you have these smart watches log skin conductance. Skin conductance is a good measure for stress. These measurements are done at random intervals, for at most 4 times during one day. The experiment starts at 7am and stops at 7pm. The **time** variable measures how many hours have passed since 7am. Table 1 shows part of the data matrix.

Now you'd like to know if skin conductance in CEOs shows a general decrease during the day. Your null-hypothesis is therefore that there is no linear effect of time on skin conductance. Now, you have multiple measures for each CEO (repeated measures), and there might be individual differences in the average skin conductance that you would like to take into account. Therefore you perform a MIXED analysis in SPSS.

1. Look at the data plotted in Figure 1: do you think a linear effect is reasonable for this data set?
2. What would the SPSS syntax look like?
3. If you got the output as in Figure 2, what the predicted skin conductance be for a CEO at 15.00 hrs?
4. How much clustering is there for skin conductance across CEOs?
5. Would you say these individual differences are very important to take into account?
6. Is there a significant effect of time of day on skin conductance in CEOs?
7. What is the effect of time of day on skin conductance in CEOs? Also give the 95% confidence interval of this effect.
8. Write a short paragraph that describes the results in APA format.

Table 1: Skin conductance measures in CEOs.

| CEO | time | conductance |
|---|---|---|
| 001 | 2 | 80 |
| 001 | 3 | 65 |
| 001 | 10 | 60 |
| 001 | 11 | 60 |
| 002 | 4 | 34 |
| 002 | 6 | 25 |
| 002 | 9 | 30 |
| 002 | 12 | 30 |
| 003 | 3 | 23 |
| 003 | 4 | 15 |
| 003 | 5 | 20 |
| 003 | 8 | 20 |
| 004 | 0 | 90 |
| 004 | 3 | 70 |
| 004 | 4 | 65 |
| 004 | 11 | 65 |
| ... | ... | ... |

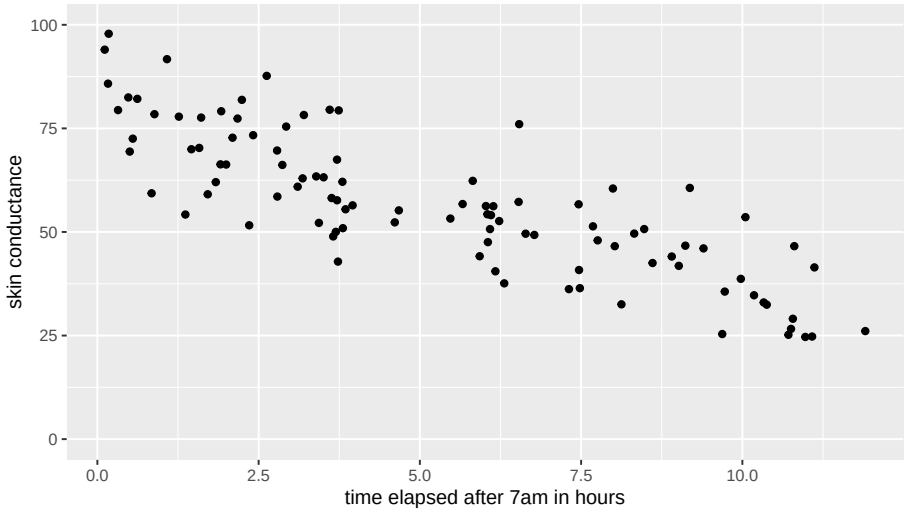


Figure 1: Skin conductance measured in CEOs.

**Fixed Effects**

**Type III Tests of Fixed Effects[a]**

| Source | Numerator df | Denominator df | F | Sig. |
|---|---|---|---|---|
| Intercept | 1 | 57.524 | 242.222 | .000 |
| time | 1 | 59.000 | 17.981 | .000 |

a. Dependent Variable: conductance.

**Estimates of Fixed Effects[a]**

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Intercept | 61.738462 | 3.966881 | 57.524 | 15.563 | .000 | 53.796487 | 69.680436 |
| time | -4.130769 | .974140 | 59.000 | -4.240 | .000 | -6.080020 | -2.181519 |

a. Dependent Variable: conductance.

**Covariance Parameters**

**Estimates of Covariance Parameters[a]**

| Parameter | | Estimate | Std. Error |
|---|---|---|---|
| Residual | | 246.726901 | 45.426105 |
| Intercept [subject = CEO] | Variance | 234.846972 | 84.637232 |

a. Dependent Variable: conductance.

Figure 2: Example output for the analysis of skin conductance in CEOs.

9. Suppose there is a new data set where every student's mood was tested at three points in time: During Christmas holidays (time point 1), during Easter holidays (time point 2) and at the start of the academic year, September 1 (time point 3). Look at the data plotted in Figure 3: do you think a linear effect is reasonable for this data set? Explain your answer.

10. Provide the syntax that you would use to analyze the problem of question 9.

## 0.2 Answers

1. Yes, a general linear downward trend is observed for the skin conductance.

2. 
```
MIXED conductance WITH time
  /FIXED=time
  /PRINT=DESCRIPTIVES  SOLUTION
  /RANDOM=intercept | SUBJECT(CEO) COVTYPE(VC).
```

3. 15 hrs is equal to 8 hours after 7am, so the expected skin conductance is equal to $62 - 4 \times 8 = 30$

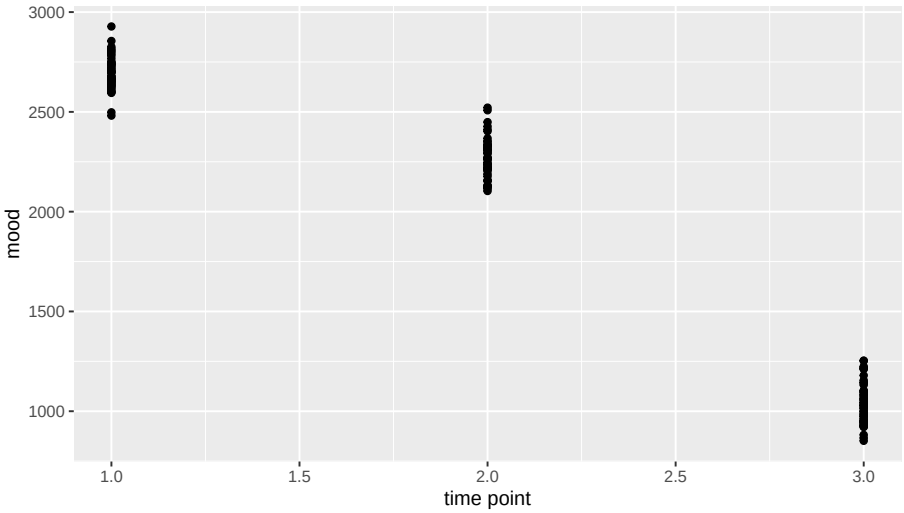


Figure 3: Data on mood at three different time points.

4. The intraclass correlation coefficient is equal to $\frac{235}{235+247} = 0.49$,

5. The correlation is quite different from 0, so there is certainly some clustering in the data and it is important to take these individual differences into account.

6. Yes, there is a signficant linear effect of time on skin conductance in CEOs, $t(59) = -4.24, p < 0.01$.

7. The linear effect of time of day on skin conductance in CEOs is around -4.13 points per hour after 7am (95 % CI: -6.08 – -2.18).

8. A linear mixed model was run with time as a quantitative predictor for skin conductance, including random effects for CEO. We found an effect of time of -4.13 points per hour which was significantly different from 0, $t(59) = -4.24, p < 0.001$. Therefore we conclude that time of day has an effect on skin conductance in the entire population of CEOs.

9. The relationship is not linear: you cannot draw a straight line through the means of the three measurements.

10. Because we have multiple measurements from the same students we should use a MIXED analysis. Furthermore, a qualitave analysis would be more

suitable, given the nonlinear relationship between time and mood. So we use the syntax:

```
MIXED mood BY time
  /FIXED=time
  /PRINT=DESCRIPTIVES  SOLUTION
  /RANDOM=intercept | SUBJECT(student) COVTYPE(VC).
```