Concepts of multilevel, longitudinal, and mixed models: Group 3

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1 Introduction

The data set results from a longitudinal observational study, the aim of which is to study the post-operative evolution of the cognitive status of elderly hipfracture patients and their pre-operative cognitive status, and to study the effects of housing situation and age on these evolutions. The physical ability is measured using the MMSE (Mini Mental State Examination) score, with values between 0 and 30, where low values correspond to a bad cognitive condition, while high scores correspond to high cognitive condition of the patient. The pre-operative cognitive status is measured through the so-called 'neuro-status' which is a binary indicator for being neuro-psychiatric.

- id: patient identification number
- age: age of the patient at entry
- neuro: neuro-psychiatric status of the patient (1: neuro-psychiatric, 0: not neuro-psychiatric)
- mmse: MMSE score
- time: day after operation at which the MMSE score has been measured (1, 3, 5, 8, or 12)
- housing: the housing situation prior to the hip fracture (1: alone, 2: with family or partner, 3: nursing home)

2 Data exploration

Considering the completeness of the data, it can be observed that 5 persons' housing situation is unknown. Additionally, there was some dropout over time as show in Table 1. The column "Nb" shows the number of respondent at each time instance. The column "Return" shows the number of respondents that participated at time t while they did not participate at time $t-1$; there is, for instance, one respondent that did not participate at $time = 1$ while he did participate at $time = 3$. The column "Dropout" shows the number of respondents that did not participate at time t while they did participate at time $t-1$. It can be seen than many drop out at $time = 12$. The other columns show how the patient characteristics change over time as patients are added or lost from the study. Overall, there is not much variation which might indicate that

Table 1: Dropout and patient characteristics over time.

Time	Nb	Return	Dropout	Mean age	% neuro-psychiatric	%alone	%family/ partner	%nursing home	%NA
						Housing			
1	58	0	0	78.71	31.03	29.31	39.66	22.41	8.62
3	57	1	2	78.18	33.33	29.82	38.60	22.81	8.77
5	59	2	0	78.59	32.20	28.81	38.98	23.73	8.47
8	52	0	7	77.88	30.77	28.85	36.54	25.00	9.62
12	38	0	14	77.82	28.95	31.58	34.21	23.68	10.53

the dropout of patients is not related to MMSE or patient characteristics. We will thus assume dropout is completely random.

Figure 1 shows the average evolution of MMSE over time (Loess curves) for groups of patients with different housing and/or neuro-psychiatric status. Patients that are not neuro-psychiatric seem to have higherMMSE that stays reasonably constant over time (except for nursing home patients). MMSE seems to go up over time for nursing home patients (but they are the smallest group), and down for neuro-spychiatric patients that live with their family or partner (or unknown housing). MMSE for neuro-psychiatric patients that live alone might have a quadratic evolution over time.

Figure 2 shows all patient profiles. There is quite a lot of variation between the patients' evolution. The non-psychiatric patients are also under-represented (except in the nursing home group).

The last variable that is explored, is the age. The loess curves in Figure 3 show that age might be negatively correlated with MMSE.

2.1 Variance analysis and correlation structure

Figure 4 shows that the variance is larger for the neuro-psychiatric patients (the smallest group).

Figure **??** shows that there seems to be an inverse relationship between the mean mmse and the variance for patients with either neuro-psychiatric status.

2.2 Conclusion exploratory analysis

The exploratory analysis has shows that the pattern of mmse over time is likely not constant or even linear. One might attempt quadratic, cubic, or logarithmic transformations of time to accommodate this. Both the level (intercept) of mmse differs quite a lot, depending on neuro-psychiatric status, housing and age.

There seems to be high intraclass correlation???

3 Methodology and results

This section, gradually develops a statistical model that seems to fit the data best. It starts with a simple model where only limited covariates are included in 3.1

3.1 A simple model

This first, simple model will assume a linear relationship between mmse and $log(time)$ for each patient. The model allows for subject-specific intercepts and slopes and the neuro-psychiatric status is the only additional explanatory variable that is taken into account.
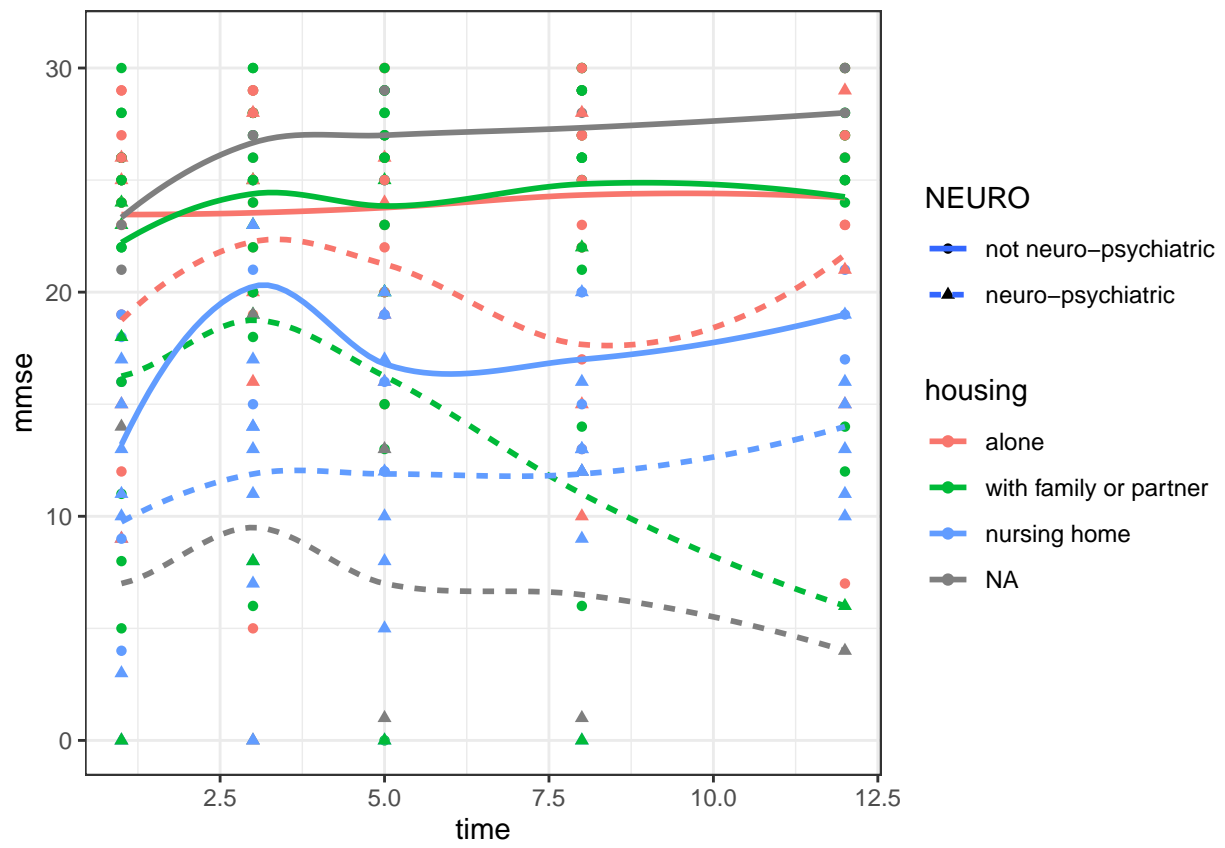
```
## [1] FALSE
```

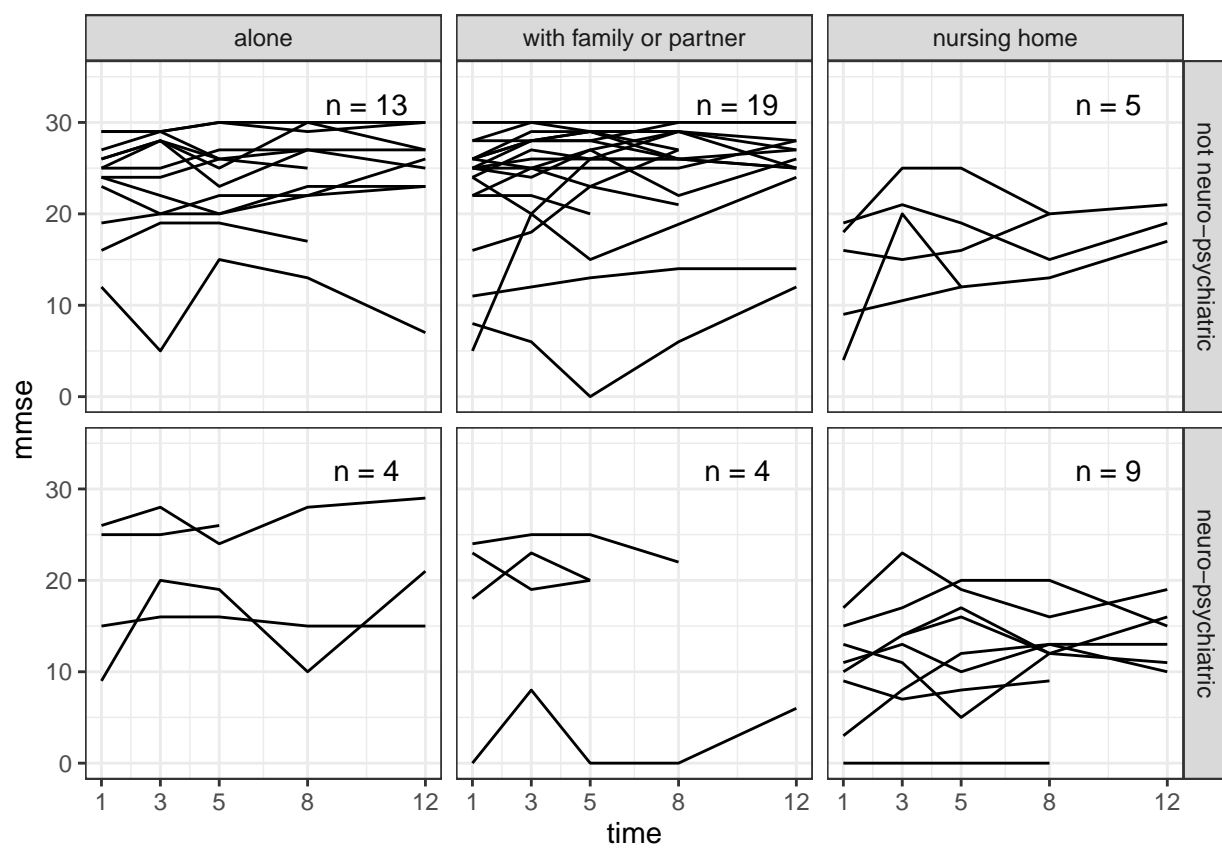Figure 1: MMSE over time for all patient profiles, including smoothed curves.

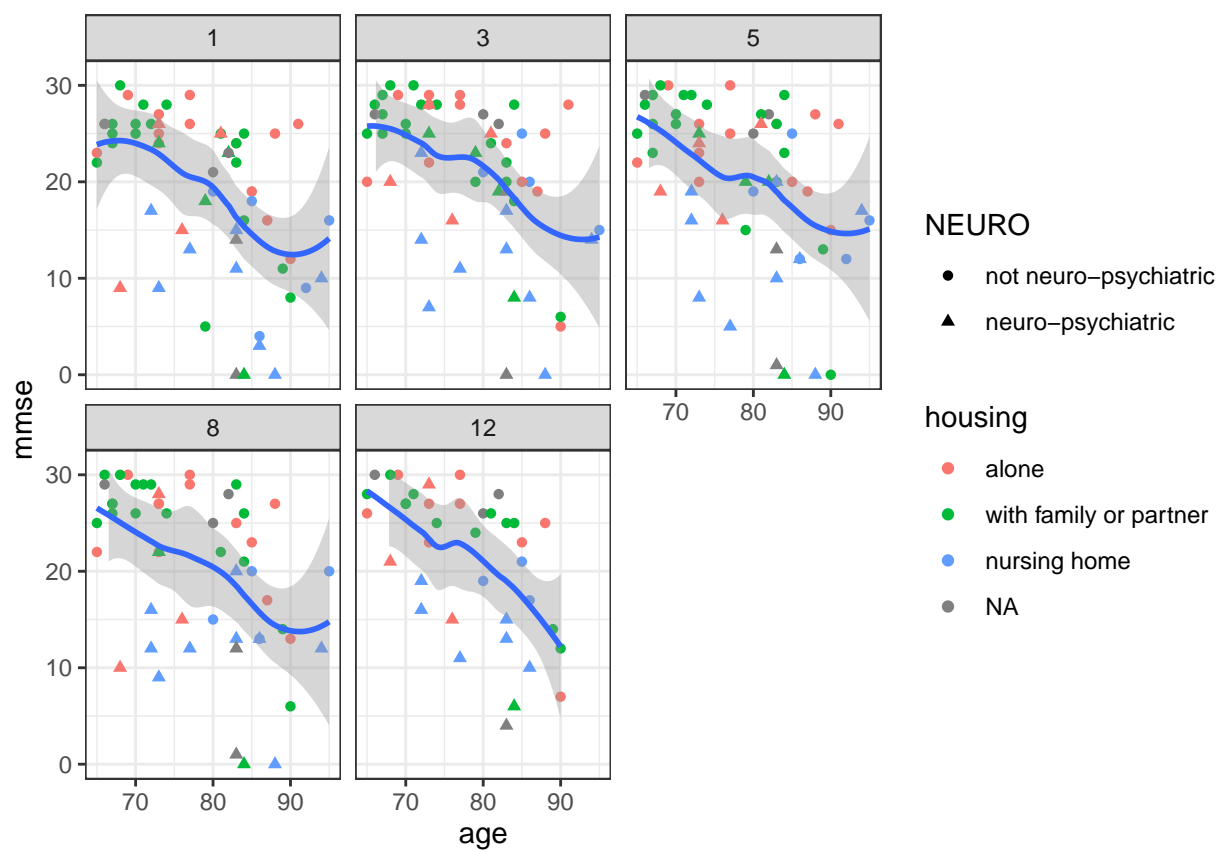Figure 2: Patient profiles of MMSE over time.

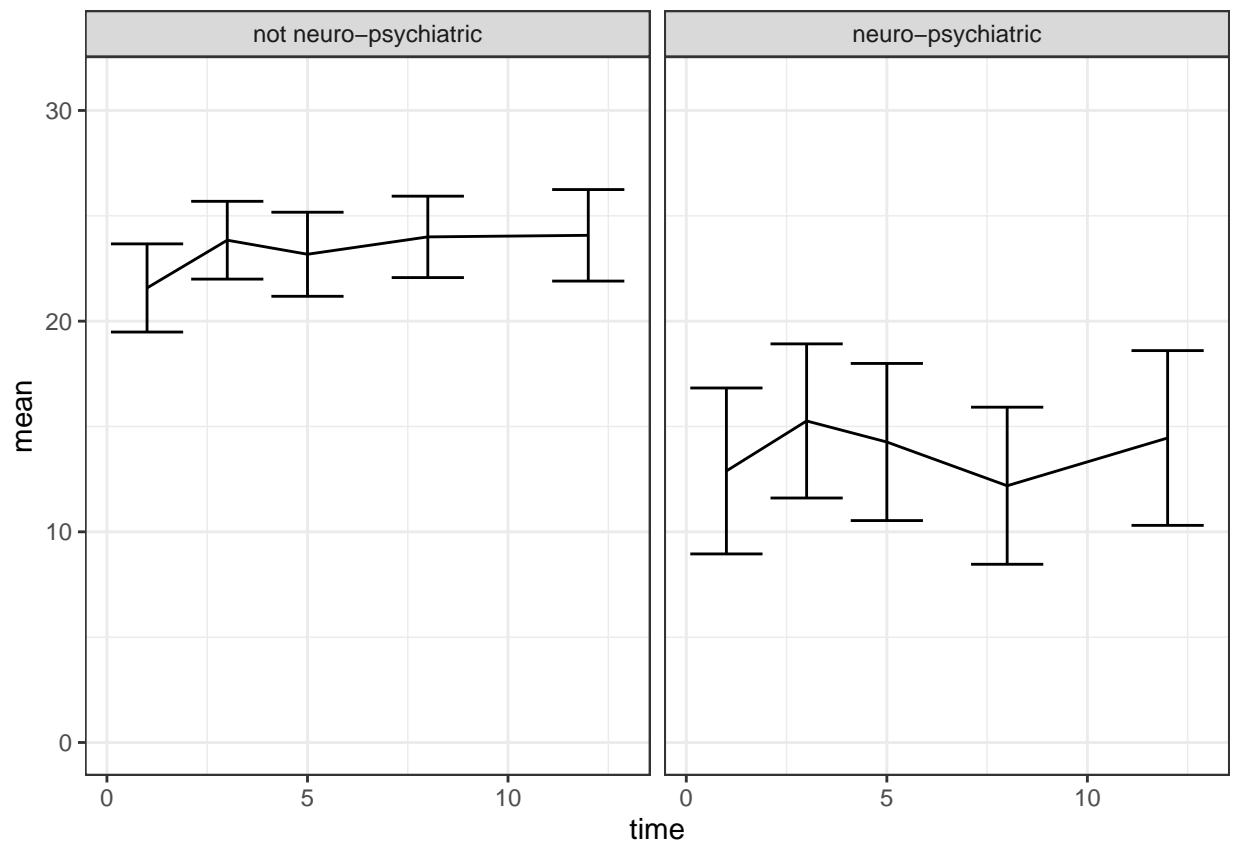Figure 3: MMSE versus age. Facets show the time instances.

Figure 4: Error bars with 95% confidence intervals.

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: mmse ~ logtime + NEURO + NEURO * logtime + (1 + logtime | id)
##    Data: data
##
## REML criterion at convergence: 1420.1
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.6721 -0.4208  0.0266  0.4702  2.9375
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  id       (Intercept) 47.3833  6.884
##           logtime      0.2034  0.451    -0.76
##  Residual              5.9571  2.441
## Number of obs: 264, groups:  id, 59
##
## Fixed effects:
##                            Estimate Std. Error t value
## (Intercept)                 21.7624     1.1415  19.065
## logtime                      0.9530     0.2272   4.194
## NEUROneuro-psychiatric      -8.3806     2.0156  -4.158
## logtime:NEUROneuro-psychiatric -0.3268  0.4147  -0.788
##
## Correlation of Fixed Effects:
##             (Intr) logtim NEURO-
## logtime     -0.470
## NEUROnr-psy -0.566  0.266
## lgtm:NEURO-  0.258 -0.548 -0.469
```
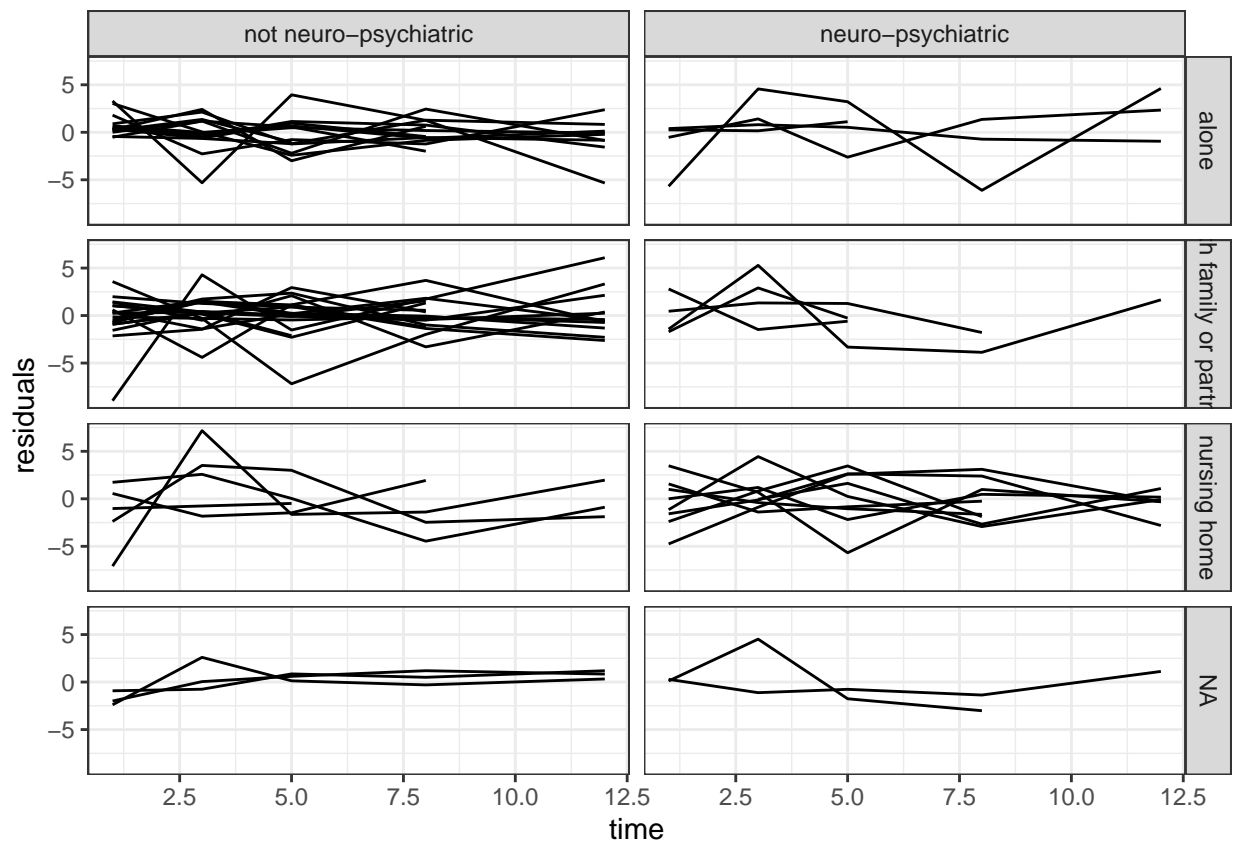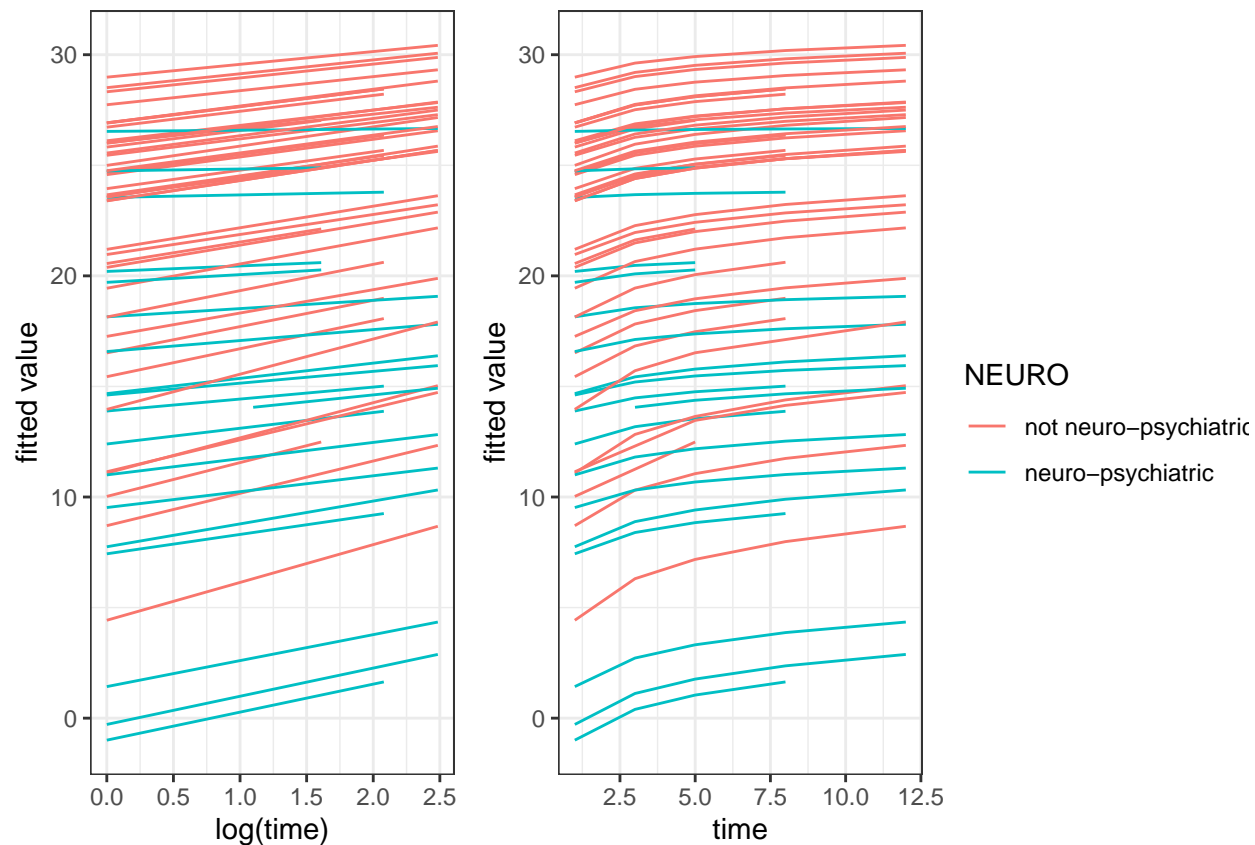
2.Fit a linear mixed model assuming a linear evolution for the response of every subject, on a log-scale for time (i.e., use log(t) as 'time scale'). Allow for subject-specific intercepts as well as slopes. Compare the average evolution of the two neuro groups. Interpret all estimated parameters. 3. Estimate the random effects, and produce a scatterplot of the estimated slopes versus the estimated intercepts. 4.

4   Conclusion