

STAT 222

Sleepstudy (Bates)

①

```
R version 2.10.1 (2009-12-14)
> library(lme4) # the "new" random effects (vs nlme) see Bates book 2010
Loading required package: Matrix Loading required package: lattice
> data(sleepstudy) # sleep deprivation 3hrs/night truckers
> dim(sleepstudy) [1] 180 3
> head(sleepstudy)
```

data source lme4 package

```
Reaction Days Subject
1 249.5600 0 308
2 258.7047 1 308
3 250.8006 2 308
4 321.4398 3 308
5 356.8519 4 308
6 414.6901 5 308
```

10 obs, 18 subjects

```
> attach(sleepstudy) > table(Subject) # "balanced data"
Subject
```

```
308 309 310 330 331 332 333 334 335 337 349 350 351 352 369 370 371 372
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
```

```
> #yes 18 subjects (3hrs sleep) 10 observations on each, page 64 of bates ch4
```

SFYS

```
#lmList has the old nlme syntax, even in lme4 #Start "Smart First Year Student" description
```

lmList

```
> sleepplmList = lmList(Reaction ~ Days | Subject, data = sleepstudy)
> sleepplmList Call: lmList(formula = Reaction ~ Days | Subject, data = sleepstudy)
```

```
Coefficients:
(Intercept) Days
308 244.1927 21.764702
309 205.0549 2.261785
310 203.4842 6.114899
330 289.6851 3.008073
331 285.7390 5.266019
332 264.2516 9.566768
333 275.0191 9.142045
334 240.1629 12.253141
335 263.0347 -2.881034
337 290.1041 19.025974
349 215.1118 13.493933
350 225.8346 19.504017
351 261.1470 6.433498
352 276.3721 13.566549
369 254.9681 11.348109
370 210.4491 18.056151
371 253.6360 9.188445
372 267.0448 11.298073
```

[show data and fit plots linked]

```
Degrees of freedom: 180 total; 144 residual
Residual standard error: 25.59182 # note this matches Bates lmer Residual (random eff)
```

```
> mean(coef(sleepplmList)[,1]) [1] 251.4051
> mean(coef(sleepplmList)[,2]) [1] 10.46729
> #mean int and slope match lmer Fixed effects results p.67 ✓
> var(coef(sleepplmList)[,1]) [1] 838.3423
> var(coef(sleepplmList)[,2]) [1] 43.01034
> #these are too big as they should be, compare with variance random effects p.67
> # mle subtracts off wobble in estimated indiv regressions Y on t
> # - SSR/SST
```

```
> quantile(coef(sleepplmList)[,1])
0% 25% 50% 75% 100%
203.4842 229.4167 258.0576 273.0255 290.1041
> quantile(coef(sleepplmList)[,2])
0% 25% 50% 75% 100%
-2.881034 6.194548 10.432421 13.548395 21.764702
```

level (day 0) fit

rate

```
> stem(coef(sleepplmList)[,2])
The decimal point is 1 digit(s) to the right of the |
-0 | 3
0 | 23
0 | 56699
1 | 011234
1 | 89
2 | 02
```

rate

Mixed effects

Level 1
 $R = \alpha_0 + \alpha_1 D + \epsilon$

$$\alpha_0 = \gamma_{00} + u_0$$

$$\alpha_1 = \gamma_{10} + u_1$$

fixed effects

```
# series of (redundent) lmer analyses for expository
# first 2 do REML, second pair match Bates p.67 in doing MLE (REML FALSE)
> sleepplmer = lmer(Reaction ~ Days + (1 + Days|Subject), sleepstudy)
> summary(sleepplmer)
Linear mixed model fit by REML
Formula: Reaction ~ Days + (1 + Days | Subject) Data: sleepstudy
AIC BIC logLik deviance REMLdev
1756 1775 -871.8 1752 1744
```

growth curve

lmer replaces lme in nlme

level 2

2

```

Random effects:
Groups Name Variance Std.Dev. Corr
Subject (Intercept) 612.092 24.7405
Days 35.072 5.9221 0.066
Residual 654.941 25.5918

```

random: varies over units (subj)

```

Number of obs: 180, groups: Subject, 18
Fixed effects:

```

Fixed: constant over units (subj)

```

Estimate Std. Error t value
(Intercept) 251.405 6.825 36.84
Days 10.467 1.546 6.77

```

means from SFYS

```

Correlation of Fixed Effects:
(Intr)

```

Days -0.138

```
> cor(coef(sleepmlList)[,1],coef(sleepmlList)[,2]) [1] -0.1375534
```

```
> sleepmlmer2 = lmer(Reaction ~ 1 + Days + (1 + Days|Subject), sleepstudy)
> summary(sleepmlmer2) #same as above, intercept implicit (else set to 0)
```

same model

Linear mixed model fit by REML

```
Formula: Reaction ~ 1 + Days + (1 + Days | Subject) Data: sleepstudy
```

```
AIC BIC logLik deviance REMLdev
1756 1775 -871.8 1752 1744
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Random effects:

```

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Subject (Intercept) 612.092 24.7405
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```

Correlation of Fixed Effects:
(Intr)

```

Days -0.138

Laird-wave do REML

```
> sleepmlmer3 = lmer(Reaction ~ 1 + Days + (1 + Days|Subject), sleepstudy, REML = FALSE)
```

```
> summary(sleepmlmer3) #mle results a little different than REML, as it should
```

Linear mixed model fit by maximum likelihood

```
Formula: Reaction ~ 1 + Days + (1 + Days | Subject) Data: sleepstudy
```

```
AIC BIC logLik deviance REMLdev
1764 1783 -876 1752 1744
```

Random effects:

```

Groups Name Variance Std.Dev. Corr
Subject (Intercept) 565.518 23.7806
Days 32.682 5.7168 0.081
Residual 654.941 25.5918

```

```
Number of obs: 180, groups: Subject, 18
```

Fixed effects:

```

Estimate Std. Error t value
(Intercept) 251.405 6.632 37.91
Days 10.467 1.502 6.97

```

```

Correlation of Fixed Effects:
(Intr)

```

Days -0.138

mle versions in Bates recedents

```
> sleepmlmer4 = lmer(Reaction ~ Days + (1 + Days|Subject), sleepstudy, REML = FALSE)
```

```
> summary(sleepmlmer4)
```

Linear mixed model fit by maximum likelihood

```
Formula: Reaction ~ Days + (1 + Days | Subject) Data: sleepstudy
```

```
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1764 1783 -876 1752 1744
```

Random effects:

```

Groups Name Variance Std.Dev. Corr
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```

Correlation of Fixed Effects:
(Intr)

```

Days -0.138