Chapter 4
Models for Longitudinal Data

Longitudinal data consist of repeated measurements on the same subject (or some other “experimental unit”) taken over time. Generally we wish to characterize the time trends within subjects and between subjects. The data will always include the re4 -11vn(c)27(h)(c)241(re)1ame s1(ud(t)1(re)1(nd)re)c t561(i)1(i1.955(

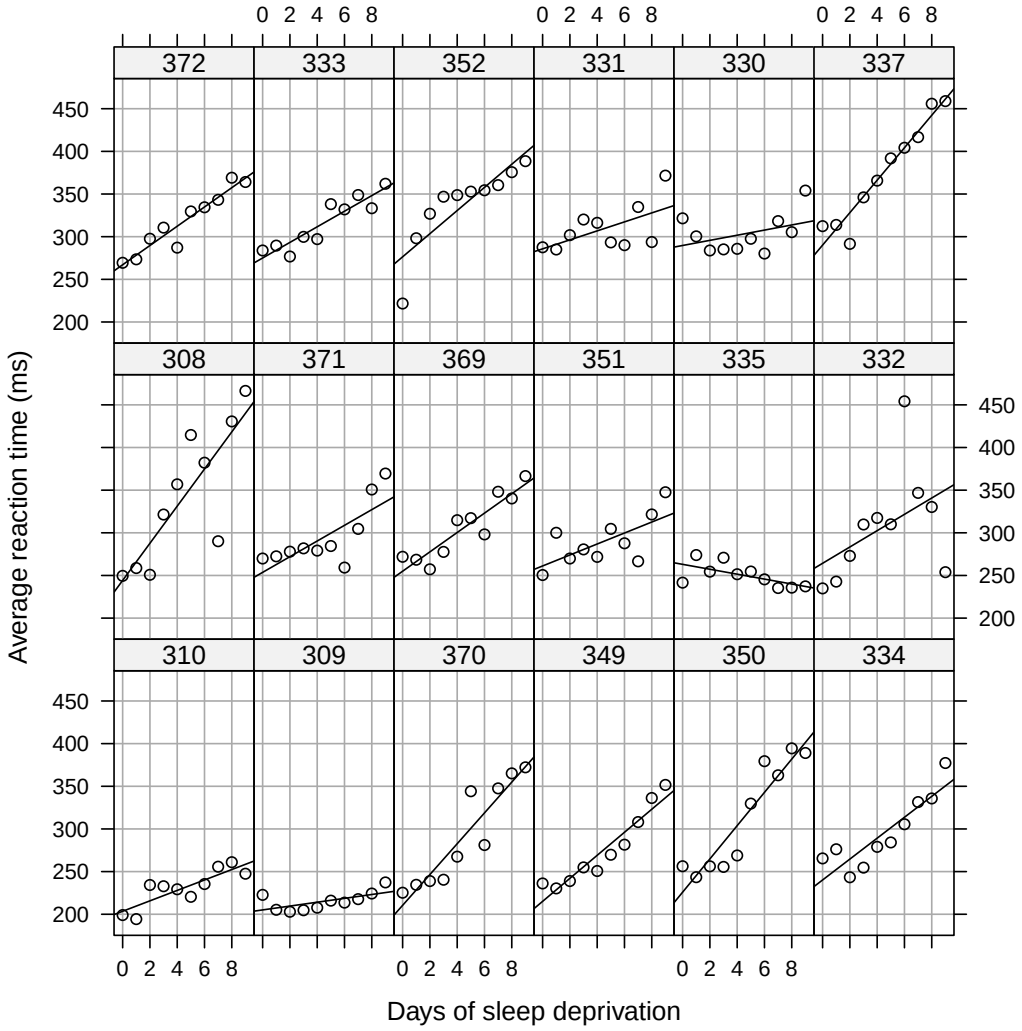
372
333
352
331
330
337
308
371
369
351
335
332
310
309
370
349
350
334
Average reaction time (ms)
Days of sleep deprivation
0 2 4 6 8
200
250
300
350
400
450

Fig. 4.1

```
331 1 1 1 1 1 1 1 1 1 1
332 1 1 1 1 1 1 1 1 1 1
333 1 1 1 1 1 1 1 1 1 1
334 1 1 1 1 1 1 1 1 1 1
335 1 1 1 1 1 1 1 1 1 1
337 1 1 1 1 1 1 1 1 1 1
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369 1 1 1 1 1 1 1 1 1 1
370 1 1 1 1 1 1 1 1 1 1
371 1 1 1 1 1 1 1 1 1 1
372 1 1 1 1 1 1 1 1 1 1
```

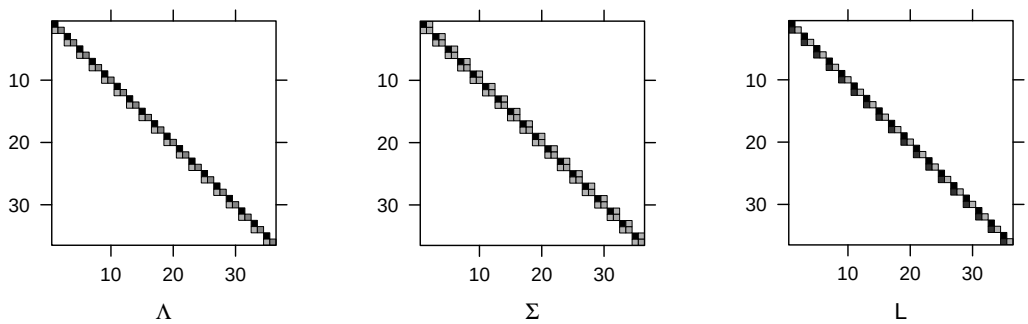


Fig. 4.2 Images of Λ, Σ and L for model `fm8`

18 triangular blocks of size 2 along the diagonal, generating 18 square, symmetric blocks of size 2 along the diagonal of Σ. The 18 symmetric blocks on the diagonal of Σ are identical. Overall we estimate two standard deviations and a correlation for a vector-valued random e□ect of size 2, as shown in the model summary.

surprised by intercepts as low as 200 ms. or as high as 300 ms. This range is consistent with the reference lines shown in Figure 4.1.

Similarly, the estimated subject-to-subject variation in the slope corre-

```
Linear mixed model fit by maximum likelihood
```

interaction between a single covariate and the grouping factor to generating an “interaction” of a model matrix and the levels of the grouping factor. In other words, we begin with the two columns of the model matrix for the expression

```
Yield ~ 1 | Batch
```

although omitting the parentheses around a random-effects term is risky. Because of operator precedence, the vertical bar operator, `|`, takes essentially everything in the expression to the left of it as its first operand. It is advisable always to enclose such terms in parentheses so the scope of the operands to the `|` operator is clearly defined.

op

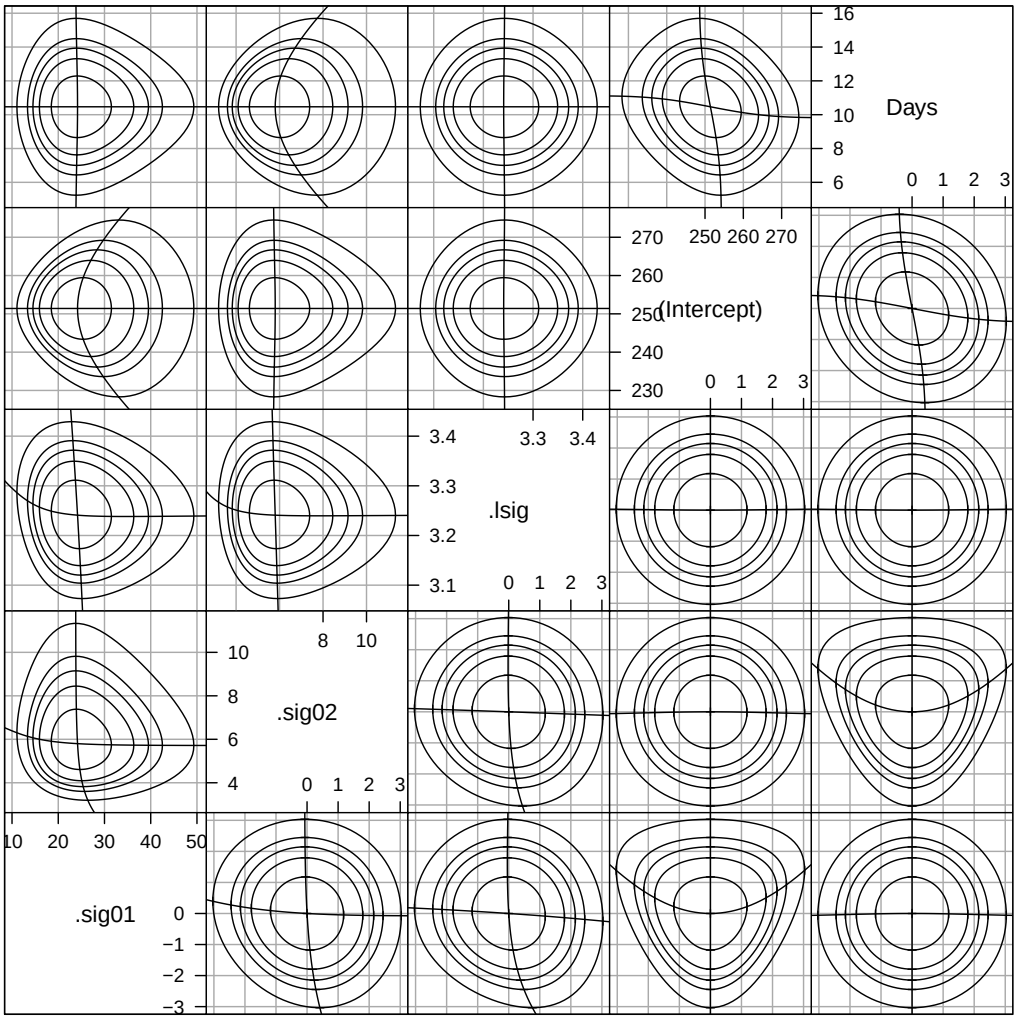
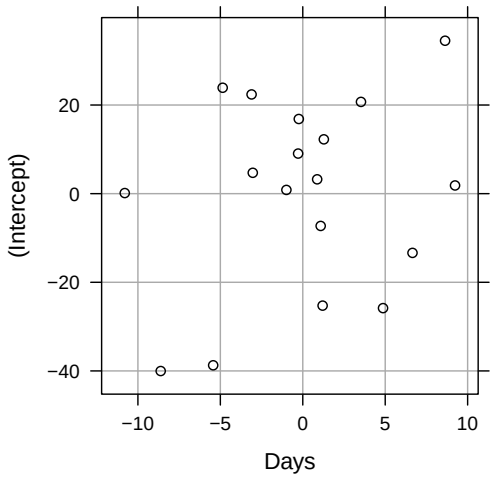
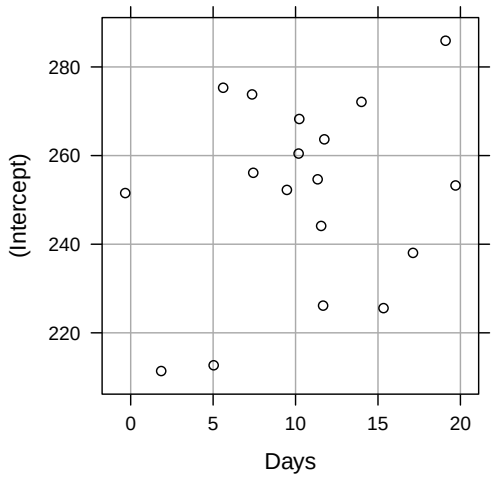


Fig. 4.6 Profile pairs plot for the parameters in model `fm9`. The contour lines correspond to marginal 50%, 80%, 90%, 95% and 99% confidence regions based on the likelihood ratio. Panels below the diagonal represent the ($\zeta\zeta$

the other fixed e□ect, which makes sense although the perfect orthogonality


(Intercept)
20
0
−20
−40
−10
−5
0
5
10
Days


(Intercept)
280
260
240
220
0
5
10
15
20
Days