Producing the examples in chapters 4 and 5

1 Example 4.1

```
mlb0 <- lmer(langPOST ~  (1|schoolnr), data = mlbook_red,
             REML = FALSE)
summary(mlb0)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: langPOST ~ (1 | schoolnr)
##    Data: mlbook_red
##
##      AIC      BIC   logLik deviance df.resid
##  26601.3  26620.0 -13297.6  26595.3     3755
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1848 -0.6416  0.0909  0.7227  2.5277
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  schoolnr (Intercept) 18.13    4.257
##  Residual             62.85    7.928
## Number of obs: 3758, groups:  schoolnr, 211
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  41.0046     0.3249   126.2
```

2 Example 4.3, Table 4.4

```
mlb44 <- lmer(langPOST ~ IQ_verb + sch_iqv
                       + (1|schoolnr), data = mlbook_red,
                       REML = FALSE)
summary(mlb44)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: langPOST ~ IQ_verb + sch_iqv + (1 | schoolnr)
##    Data: mlbook_red
##
##      AIC      BIC   logLik deviance df.resid
##  24898.0  24929.2 -12444.0  24888.0     3753
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2220 -0.6411  0.0634  0.7059  3.2190
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  schoolnr (Intercept)  8.68    2.946
##  Residual             40.43    6.358
```

```
## Number of obs: 3758, groups:  schoolnr, 211
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) 41.11378    0.23181  177.36
## IQ_verb      2.45361    0.05549   44.22
## sch_iqv      1.31242    0.26160    5.02
##
## Correlation of Fixed Effects:
##         (Intr) IQ_vrb
## IQ_verb -0.007
## sch_iqv  0.043 -0.210
```

2.1 The parameters of the random part of the model are in

```
VarCorr(mlb44)
```

```
##  Groups   Name        Std.Dev.
##  schoolnr (Intercept) 2.9461
##  Residual             6.3584
```

2.2 the estimated intercept variance is

```
VarCorr(mlb44)$schoolnr[1,1]
```

```
## [1] 8.679719
```

2.3 For other methods for the objects produced by lmer, see

```
methods(class="merMod")
```

```
##  [1] anova        as.function  coef         confint      deviance
##  [6] df.residual  drop1        extractAIC   family       fitted
## [11] fixef        formula      fortify      getL         getME
## [16] hatvalues    isGLMM       isLMM        isNLMM       isREML
## [21] logLik       model.frame  model.matrix ngrps        nobs
## [26] plot         predict      print        profile      ranef
## [31] refit        refitML      residuals    show         sigma
## [36] simulate     summary      terms        update       VarCorr
## [41] vcov         weights
## see '?methods' for accessing help and source code
```

3 Section 4.8.

3.1 The posterior means are obtained as follows: the word ranef stands for "random effects"

```
re.mlb44 <- ranef(mlb44, condVar=TRUE, standard=TRUE)
tbl_df(re.mlb44$schoolnr) %>% glimpse
```

```
## Observations: 211
## Variables: 1
## $ (Intercept) <dbl> 0.7854736, -3.9600743, 0.6766074, 0.6581958, -2.87...
```

3.2 The condVar parameter will also give the posterior variances. What is the structure of this object?

```
str(re.mlb44)
```

```
## List of 1
##  $ schoolnr:'data.frame':    211 obs. of  1 variable:
##   ..$ (Intercept): num [1:211] 0.785 -3.96 0.677 0.658 -2.878 ...
##   ..- attr(*, "postVar")= num [1, 1, 1:211] 1.36 3.47 3.19 2.58 4.19 ...
##  - attr(*, "class")= chr "ranef.mer"
```

3.3 The posterior means are

```
postmean <- re.mlb44$schoolnr[,1]
str(postmean)
```

```
##  num [1:211] 0.785 -3.96 0.677 0.658 -2.878 ...
```

3.4 and the posterior variances are

```
postvar <-  attr(re.mlb44$schoolnr,'postVar')[1,1,]
head(postvar)
```

```
## [1] 1.363199 3.467994 3.194016 2.582055 4.186157 1.957101
```

3.5 These are also the comparative variances. The diagnostic variance is calculated using (4.18):

```
diagvar <- VarCorr(mlb44)$schoolnr[1,1] - postvar
diagvar[1:5]
```

```
## [1] 7.316520 5.211725 5.485703 6.097663 4.493562
```

4 Comparative standard deviations

```
compsd <- sqrt(postvar)
compsd[1:5]
```

```
## [1] 1.167561 1.862255 1.787181 1.606878 2.046010
```

5 Bounds of comparative intervals

```
lower <- postmean - 1.39*compsd
upper <- postmean + 1.39*compsd
lower[1:5]
```

```
## [1] -0.8374365 -6.5486087 -1.8075742 -1.5753640 -5.7216451
```

```
upper[1:5]
```

```
## [1]  2.40838377 -1.37153986  3.16078909  2.89175558 -0.03373715
```

5.1 Order

```
perm <- order(postmean, lower, upper)
pm_sort <- postmean[perm]
upper_sort <- upper[perm]
lower_sort <- lower[perm]
pm_sort[1:5]
```

```
## [1] -6.717241 -6.469771 -5.887817 -5.760691 -5.316493
```

```
upper_sort[1:5]
```

```
## [1] -4.972407 -4.818789 -4.291595 -3.861553 -2.832311
```

```
pm_sort[1:5]
```

```
## [1] -6.717241 -6.469771 -5.887817 -5.760691 -5.316493
```

5.2 A caterpillar plot like Fig. 4.4 can be produced as follows.

```
library(Hmisc)
errbar(1:211, pm_sort, upper_sort, lower_sort)
```

6 Example 5.4

```r
form <- langPOST ~
  1 +
  IQ_verb +
  ses +
  sch_iqv +
  sch_ses +
  IQ_verb:ses +
  sch_iqv:sch_ses +
  (1 + IQ_verb|schoolnr)

mlb54sh <- lmer(form, data = mlbook_red,
                        REML = FALSE)

summary(mlb54sh)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: langPOST ~ 1 + IQ_verb + ses + sch_iqv + sch_ses + IQ_verb:ses +
##     sch_iqv:sch_ses + (1 + IQ_verb | schoolnr)
##    Data: mlbook_red
##
##      AIC      BIC   logLik deviance df.resid
##  24648.8  24717.4 -12313.4  24626.8     3747
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2688 -0.6295  0.0783  0.7036  2.8697
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  schoolnr (Intercept)  8.3685  2.8928
##           IQ_verb      0.1643  0.4054   -0.79
##  Residual             37.3779  6.1137
## Number of obs: 3758, groups:  schoolnr, 211
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)     41.612180   0.247479  168.14
## IQ_verb          2.231092   0.063344   35.22
## ses              0.174436   0.011660   14.96
## sch_iqv          0.760180   0.295794    2.57
## sch_ses         -0.088609   0.042280   -2.10
## IQ_verb:ses     -0.017341   0.004901   -3.54
## sch_iqv:sch_ses -0.119716   0.033260   -3.60
##
## Correlation of Fixed Effects:
##             (Intr) IQ_vrb ses    sch_qv sch_ss IQ_vr:
## IQ_verb     -0.305
## ses          0.009 -0.251
## sch_iqv     -0.092 -0.167  0.061
## sch_ses      0.051  0.054 -0.269 -0.496
## IQ_verb:ses -0.099  0.076 -0.123 -0.014 -0.140
## sch_qv:sch_ -0.374 -0.010  0.024  0.181 -0.017 -0.126
```

```
mlb54 <- lmer(langPOST ~ IQ_verb*ses + sch_iqv*sch_ses
                       + (IQ_verb|schoolnr), data = mlbook_red,
                       REML = FALSE)
summary(mlb54)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula:
## langPOST ~ IQ_verb * ses + sch_iqv * sch_ses + (IQ_verb | schoolnr)
##    Data: mlbook_red
##
##      AIC      BIC   logLik deviance df.resid
##  24648.8  24717.4 -12313.4  24626.8     3747
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2688 -0.6295  0.0783  0.7036  2.8697
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  schoolnr (Intercept)  8.3685  2.8928
##           IQ_verb      0.1643  0.4054   -0.79
##  Residual             37.3779  6.1137
## Number of obs: 3758, groups:  schoolnr, 211
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)     41.612180   0.247479  168.14
## IQ_verb          2.231092   0.063344   35.22
## ses              0.174436   0.011660   14.96
## sch_iqv          0.760180   0.295794    2.57
## sch_ses         -0.088609   0.042280   -2.10
## IQ_verb:ses     -0.017341   0.004901   -3.54
## sch_iqv:sch_ses -0.119716   0.033260   -3.60
##
## Correlation of Fixed Effects:
##             (Intr) IQ_vrb ses    sch_qv sch_ss IQ_vr:
## IQ_verb     -0.305
## ses          0.009 -0.251
## sch_iqv     -0.092 -0.167  0.061
## sch_ses      0.051  0.054 -0.269 -0.496
## IQ_verb:ses -0.099  0.076 -0.123 -0.014 -0.140
## sch_qv:sch_ -0.374 -0.010  0.024  0.181 -0.017 -0.126
```

```
mlb54 <- lmer(langPOST ~ IQ_verb*ses + sch_iqv*sch_ses
                       + (IQ_verb|schoolnr), data = mlbook_red,
                       REML = TRUE)
summary(mlb54)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## langPOST ~ IQ_verb * ses + sch_iqv * sch_ses + (IQ_verb | schoolnr)
##    Data: mlbook_red
##
## REML criterion at convergence: 24658.2
##
```

```
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2662 -0.6285  0.0765  0.7014  2.8700
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  schoolnr (Intercept)  8.5527  2.9245
##           IQ_verb      0.1707  0.4131   -0.78
##  Residual             37.3946  6.1151
## Number of obs: 3758, groups:  schoolnr, 211
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)     41.611567   0.249637  166.69
## IQ_verb          2.231943   0.063655   35.06
## ses              0.174412   0.011665   14.95
## sch_iqv          0.762673   0.298530    2.55
## sch_ses         -0.088785   0.042640   -2.08
## IQ_verb:ses     -0.017302   0.004912   -3.52
## sch_iqv:sch_ses -0.119733   0.033548   -3.57
##
## Correlation of Fixed Effects:
##             (Intr) IQ_vrb ses    sch_qv sch_ss IQ_vr:
## IQ_verb     -0.304
## ses          0.009 -0.250
## sch_iqv     -0.092 -0.165  0.060
## sch_ses      0.051  0.054 -0.267 -0.497
## IQ_verb:ses -0.098  0.076 -0.123 -0.014 -0.139
## sch_qv:sch_ -0.375 -0.009  0.024  0.183 -0.017 -0.124
```

```
library("R2MLwiN")
```

```
## Loading required package: stats4
```

```
## Loading required package: lattice
```

```
## Loading required package: memisc
```

```
## Loading required package: MASS
```

```
##
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:dplyr':
##
##     select
```

```
##
## Attaching package: 'memisc'
```

```
## The following object is masked from 'package:Matrix':
##
##     as.array
```

```
## The following objects are masked from 'package:dplyr':
##
##     collect, query, recode, rename
```

```
## The following objects are masked from 'package:stats':
```

```
##
##     contr.sum, contr.treatment, contrasts

## The following object is masked from 'package:base':
##
##     as.array

## Loading required package: coda

## The MLwiN_path option is currently set to C:/Program Files (x86)/MLwiN v2.36/
## To change this use: options(MLwiN_path="<path to MLwiN>")
```

```
library("doBy")
options(MLwiN_path = "C:/Program Files (x86)/MLwiN trial/i386/")

form <- langPOST ~
  1 +
  IQ_verb +
  ses +
  sch_iqv +
  sch_ses +
  IQ_verb:ses +
  sch_iqv:sch_ses +
  (1 + IQ_verb|schoolnr)

(mymodel1 <- runMLwiN(form, data = mlbook_red))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Normal)
## Estimation algorithm:  IGLS        Elapsed time : 6.68s
## Number of obs:  3758 (from total 3758)        The model converged after 4 iterations.
## Log likelihood:      -12482.4
## Deviance statistic:  24964.8
## ---------------------------------------------------------------------------------------------------
## The model formula:
## langPOST ~ 1 + IQ_verb + ses + sch_iqv + sch_ses + IQ_verb:ses +
##     sch_iqv:sch_ses + (1 + IQ_verb | schoolnr)
## Level 1: schoolnr
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                      Coef.   Std. Err.         z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept         41.73600     0.12250    340.70           0   ***     41.49591    41.97610
## IQ_verb            2.12585     0.05774     36.82   1.04e-296   ***      2.01268     2.23903
## ses                0.17885     0.01280     13.97   2.247e-44   ***      0.15376     0.20393
## sch_iqv            0.89485     0.16525      5.42   6.121e-08   ***      0.57097     1.21873
## sch_ses           -0.09691     0.02386     -4.06   4.864e-05   ***     -0.14367    -0.05015
## IQ_verb:ses       -0.02063     0.00471     -4.38   1.173e-05   ***     -0.02985    -0.01140
## sch_iqv:sch_ses   -0.11705     0.01913     -6.12   9.402e-10   ***     -0.15453    -0.07956
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the schoolnr level:
##                            Coef.   Std. Err.
## var_Intercept           46.65785     1.19486
## cov_Intercept_IQ_verb   -2.29677     0.26798
## var_IQ_verb             -0.11155     0.13368
```

-*-