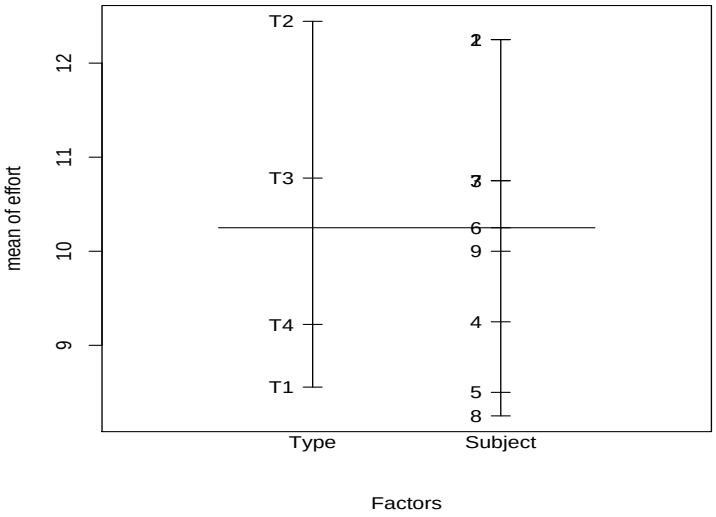
Stat 8311, Fall 2006, Randomized Block Design

This handout uses the ergoStool data from Pinhero and Bates. We first fit the usual way:

```
> library(nlme)
> data(ergoStool)
> xtabs(effort ~ Type + Subject, data = ergoStool)
```

```
    Subject
Type  8  5  4  9  6  3  7  1  2
  T1  7  8  7  9  9  7  8 12 10
  T2 11 11 11 13 11 14 12 15 14
  T3  8  8 10 10 11 13 12 12 13
  T4  7  7  9  8 10  9 11 10 12
```

```
> plot.design(ergoStool)
```



We use SAS parameterization to match SAS.

```
> ergoStool$subject <- factor(ergoStool$Subject, levels = 1:9,
+     ordered = FALSE)
> opt <- options(contrasts = c("contr.SAS", "contr.poly"),
+     digits = 8)
> (m1 <- lm(effort ~ 1 + subject + Type, data = ergoStool))
```

```
Call:
lm(formula = effort ~ 1 + subject + Type, data = ergoStool)

Coefficients:
(Intercept)     subject1     subject2     subject3     subject4
    8.97222      2.25000      2.25000      0.75000     -0.75000
   subject5     subject6     subject7     subject8       TypeT1
   -1.50000      0.25000      0.75000     -1.75000     -0.66667
     TypeT2       TypeT3
    3.22222      1.55556
```

```
> anova(m1)

Analysis of Variance Table

Response: effort
          Df  Sum Sq Mean Sq  F value     Pr(>F)
subject    8 66.5000  8.3125  6.86616 0.00010609
Type       3 81.1944 27.0648 22.35564 3.9346e-07
Residuals 24 29.0556  1.2106

> summary(m2 <- lme(effort ~ Type, random = ~1 | subject,
+     data = ergoStool, method = "ML"))

Linear mixed-effects model fit by maximum likelihood
 Data: ergoStool
        AIC       BIC     logLik
  134.14444 143.64555 -61.072219

Random effects:
 Formula: ~1 | subject
        (Intercept)  Residual
StdDev:   1.2562600 1.0373677

Fixed effects: effort ~ Type
                 Value  Std.Error DF    t-value p-value
(Intercept)  9.2222222 0.57601226 24 16.0104617  0.0000
TypeT1      -0.6666667 0.51868384 24 -1.2853045  0.2110
TypeT2       3.2222222 0.51868384 24  6.2123051  0.0000
TypeT3       1.5555556 0.51868384 24  2.9990438  0.0062
 Correlation:
       (Intr) TypeT1 TypeT2
TypeT1 -0.45
TypeT2 -0.45   0.50
TypeT3 -0.45   0.50   0.50

Standardized Within-Group Residuals:
         Min           Q1          Med           Q3          Max
-1.911313286 -0.682180462  0.061339198  0.743519659  1.730382787

Number of Observations: 36
Number of Groups: 9

> anova(m2)

            numDF denDF   F-value p-value
(Intercept)     1    24 455.00752  <.0001
Type            3    24  22.35564  <.0001

> (rm2 <- ranef(m2))
```

```
     (Intercept)
1  1.7087162e+00
2  1.7087162e+00
3  4.2717906e-01
4 -8.5435812e-01
5 -1.4951267e+00
6  7.8510488e-16
7  4.2717906e-01
8 -1.7087162e+00
9 -2.1358953e-01
```

```
> intervals(m2)

Approximate 95% confidence intervals

 Fixed effects:
                  lower        est.       upper
(Intercept)  8.10138172  9.22222222 10.34306272
TypeT1      -1.67595395 -0.66666667  0.34262062
TypeT2       2.21293494  3.22222222  4.23150951
TypeT3       0.54626827  1.55555556  2.56484284
attr(,"label")
[1] "Fixed effects:"

 Random Effects:
  Level: subject
                     lower      est.     upper
sd((Intercept)) 0.73015625 1.2562600 2.1614405

 Within-group standard error:
    lower      est.     upper
0.7944142 1.0373677 1.3546229
```

We next turn to lmer.

```
> library(lme4)

Loading required package: Matrix
Loading required package: lattice
Loading required package: lattice

> library(coda)
> summary(m3 <- lmer(effort ~ Type + (1 | subject), data = ergoStool,
+     method = "ML"))

Linear mixed-effects model fit by maximum likelihood
Formula: effort ~ Type + (1 | subject)
          Data: ergoStool
       AIC       BIC     logLik MLdeviance REMLdeviance
 132.14444 140.06203 -61.072219  122.14444    121.13079
```

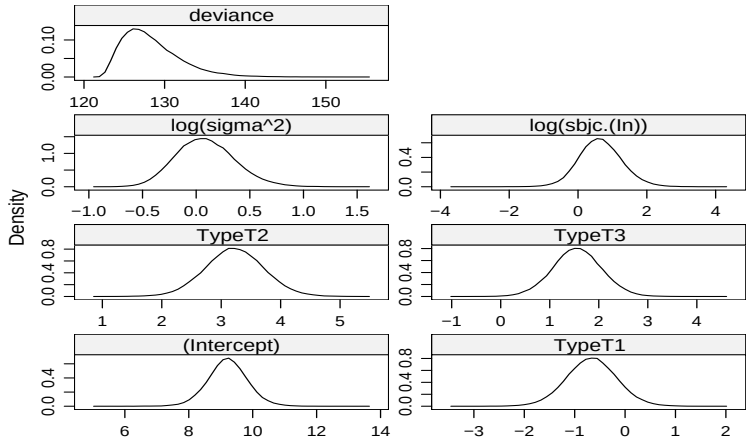
```
Random effects:
 Groups   Name        Variance Std.Dev.
 subject  (Intercept) 1.57818  1.25626
 Residual             1.07613  1.03737
number of obs: 36, groups: subject, 9

Fixed effects:
             Estimate Std. Error  t value
(Intercept)  9.222222   0.543069 16.98169
TypeT1      -0.666667   0.489020 -1.36327
TypeT2       3.222222   0.489020  6.58914
TypeT3       1.555556   0.489020  3.18096

Correlation of Fixed Effects:
       (Intr) TypeT1 TypeT2
TypeT1 -0.450
TypeT2 -0.450  0.500
TypeT3 -0.450  0.500  0.500
```

```
> anova(m3)

Analysis of Variance Table
     Df  Sum Sq Mean Sq
Type  3 81.1944 27.0648
```

```
> rm3 <- ranef(m3)
> cbind(rm2, rm3[[1]])

     (Intercept)    (Intercept)
1  1.7087162e+00  1.7087139e+00
2  1.7087162e+00  1.7087139e+00
3  4.2717906e-01  4.2717847e-01
4 -8.5435812e-01 -8.5435695e-01
5 -1.4951267e+00 -1.4951247e+00
6  7.8510488e-16 -2.3922170e-15
7  4.2717906e-01  4.2717847e-01
8 -1.7087162e+00 -1.7087139e+00
9 -2.1358953e-01 -2.1358924e-01
```

Unlike `lme`, `lmer` does not have an `intervals` method for getting interval estimates. Rather, it requires that you use a Markov Chain Monte Carlo to sample from the posterior distribution of the parameters given flat priors, including a flat prior on log variance, not the variances themselves, and make inference from these samples:

```
> ss1 <- mcmcsamp(m3, 50000)
> print(densityplot(ss1, plot.points = FALSE))
```



These look reasonably normal — so intervals are obtained as the highest posterior density intervals:

```
> HPDinterval(ss1)
```

```
                      lower        upper
(Intercept)      7.98254404  10.44998122
TypeT1          -1.67103627   0.30065321
TypeT2           2.21194515   4.20171565
TypeT3           0.55627155   2.55310830
log(sigma^2)    -0.43282681   0.66061604
log(sbjc.(In))  -0.55834254   1.92619840
deviance       122.72479363 135.47580615
attr(,"Probability")
[1] 0.95
```

SAS

```
proc mixed data=ergoStool method=ML cl=wald;
      class Type Subject;
      model effort = Type/ alpha=.05;
      random Subject/subject=Subject;
   run;
```

```
The SAS System                          12:14 Wednesday, November 22, 2006   2
The Mixed Procedure
                  Covariance Parameter Estimates
Cov Parm     Subject    Estimate     Alpha       Lower       Upper
Subject      Subject      1.5782      0.05      0.6740      7.0082
Residual                  1.0761      0.05      0.6727      1.9937

           Fit Statistics
-2 Log Likelihood               122.1
AIC (smaller is better)         134.1
AICC (smaller is better)        137.0
BIC (smaller is better)         135.3

                        Solution for Fixed Effects
                                  Standard
Effect      Type   Estimate       Error     DF   t Value   Pr > |t|    Alpha
Intercept           9.2222      0.5431      8     16.98     <.0001     0.05
Type        T1      -0.6667     0.4890     24     -1.36     0.1855     0.05
Type        T2       3.2222     0.4890     24      6.59     <.0001     0.05
Type        T3       1.5556     0.4890     24      3.18     0.0040     0.05
Type        T4            0          .      .       .         .          .

      Solution for Fixed Effects
Effect      Type       Lower       Upper
Intercept             7.9699     10.4745
Type        T1       -1.6760      0.3426
Type        T2        2.2129      4.2315
Type        T3        0.5463      2.5648
Type        T4             .           .

        Type 3 Tests of Fixed Effects
              Num     Den
Effect         DF      DF    F Value    Pr > F
Type            3      24      25.15    <.0001
```