

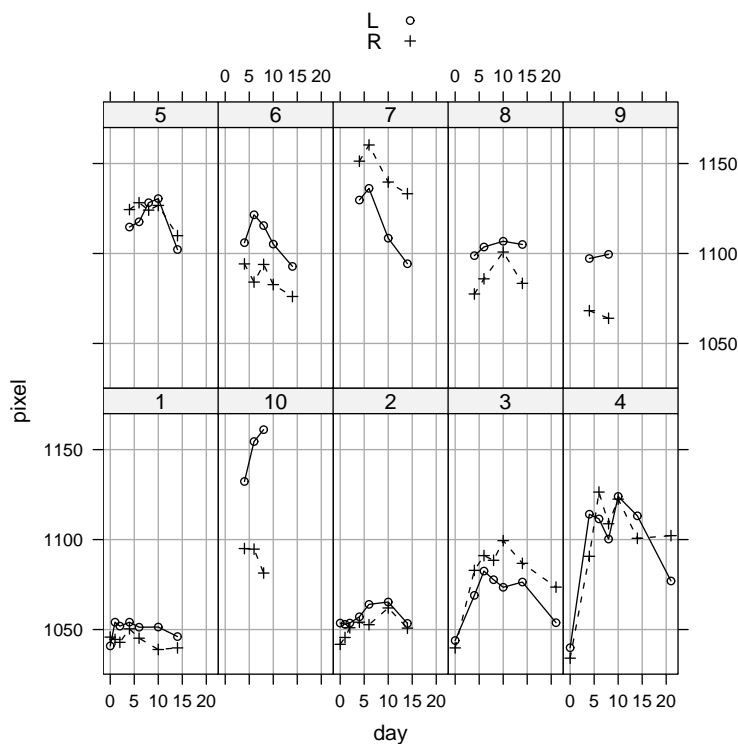
Stat 8311 – Nested classification

Each of ten dogs was injected with a dye, and then the mean pixel intensities were recoded for both the left and the right side of the dog, on several occasions up to 21 days post injection. The dogs are a random sample, and the sides of the dog, while expected to differ somewhat, are not expected to differ systematically, so, for example, it is not expected that the left side will always be higher than the right side. Sides of a dog are *nested* within the dog. The plot of the data suggests that intensity is not linear, and perhaps a quadratic curve might be appropriate.

```
> data(Pixel, package = "nlme")
> names(Pixel)
```

```
[1] "Dog" "Side" "day" "pixel"
```

```
> library(lattice)
> print(xyplot(pixel ~ day | Dog, groups = ~Side, type = c("g",
+ "p", "l"), layout = c(5, 2), data = Pixel, auto.key = T))
```



The first model fit has a quadratic effect of day (the use of $I(\text{day}^2)$ in place of day^2 is required). There is a two-level random effect. At the “Dog” level, there are potentially random intercept, linear and quadratic terms. Allowing for a general covariance matrix, there are six parameters in the between-dog variance to be estimated. At the second level or the “side” level, there is only one between side term that is the same for all dogs. The random effects have up to seven parameters.

```
> library(lme4)
> m1 <- lmer(pixel ~ day + I(day^2) + (1 | Dog), data = Pixel)
> m2 <- update(m1, ~. + (1 | with(Pixel, Dog:Side)))
> m3 <- update(m1, ~day + I(day^2) + (1 + day + I(day^2) |
```

```
+ Dog) + (1 | with(Pixel, Dog:Side)))
> anova(m3)
```

```
Analysis of Variance Table
      Df Sum Sq Mean Sq
day      1 3034.3  3034.3
I(day^2) 1 1889.5  1889.5
```

```
> print(m3, corr = FALSE)
```

Linear mixed-effects model fit by REML

Formula: pixel ~ day + I(day^2) + (1 + day + I(day^2) | Dog) + (1 | with(Pixel,

Dog:Side)

Data: Pixel

AIC	BIC	logLik	MLdeviance	REMLdeviance
837.4	863.6	-408.7	819.3	817.4

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
with(Pixel, Dog:Side)	(Intercept)	2.8742e+02	16.95332	
Dog	(Intercept)	1.1760e+03	34.29343	
	day	1.4804e+01	3.84764	-0.699
	I(day^2)	1.3249e-02	0.11510	0.698 -0.998
Residual		7.0823e+01	8.41567	

number of obs: 102, groups: with(Pixel, Dog:Side), 20; Dog, 10

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	1079.05723	11.93128	90.44
day	4.29749	1.40154	3.07
I(day^2)	-0.25024	0.04845	-5.17

```
> fixef(m3)
```

(Intercept)	day	I(day^2)
1079.0572350	4.2974859	-0.2502392

```
> (c1 <- coef(m3))
```

An object of class "lmer" [1]

[[1]]

	(Intercept)	day	I(day^2)
1:L	1073.026	4.297486	-0.2502392
1:R	1067.189	4.297486	-0.2502392
10:L	1111.063	4.297486	-0.2502392
10:R	1056.603	4.297486	-0.2502392
2:L	1075.045	4.297486	-0.2502392
2:R	1069.262	4.297486	-0.2502392
3:L	1071.215	4.297486	-0.2502392
3:R	1082.987	4.297486	-0.2502392
4:L	1081.859	4.297486	-0.2502392
4:R	1082.604	4.297486	-0.2502392

```

5:L      1082.071  4.297486 -0.2502392
5:R      1085.902  4.297486 -0.2502392
6:L      1089.910  4.297486 -0.2502392
6:R      1068.944  4.297486 -0.2502392
7:L      1072.305  4.297486 -0.2502392
7:R      1099.575  4.297486 -0.2502392
8:L      1087.280  4.297486 -0.2502392
8:R      1071.596  4.297486 -0.2502392
9:L      1090.712  4.297486 -0.2502392
9:R      1061.999  4.297486 -0.2502392

```

```
[[2]]
```

```

      (Intercept)      day  I(day^2)
1      1053.043    2.465509 -0.1955203
10     1096.886    4.641583 -0.2604199
2      1052.754    3.885074 -0.2381062
3      1048.189    7.936510 -0.3560359
4      1048.048   11.403537 -0.4631426
5      1107.888    2.979500 -0.2116230
6      1097.143    1.644044 -0.1716096
7      1141.789   -1.149355 -0.0882279
8      1069.505    6.085616 -0.3035897
9      1075.327    3.082839 -0.2141165

```

```
> ranef(m3)
```

```
An object of class "ranef.lmer"
```

```
[[1]]
```

```

      (Intercept)
1:L      -6.031308
1:R     -11.868677
10:L     32.005635
10:R    -22.454435
2:L      -4.012637
2:R     -9.794806
3:L      -7.842037
3:R      3.929301
4:L      2.801630
4:R      3.546826
5:L      3.013507
5:R      6.844695
6:L     10.853257
6:R    -10.113441
7:L      -6.752617
7:R     20.517443
8:L      8.222627
8:R     -7.461190
9:L     11.654319
9:R    -17.058093

```

[[2]]

	(Intercept)	day	I(day^2)
1	-26.014351	-1.8319766	0.05471885
10	17.828309	0.3440970	-0.01018070
2	-26.302809	-0.4124114	0.01213292
3	-30.867930	3.6390246	-0.10579675
4	-31.009232	7.1060514	-0.21290344
5	28.830686	-1.3179864	0.03861612
6	18.085287	-2.6534416	0.07862956
7	62.731711	-5.4468406	0.16201127
8	-9.551838	1.7881301	-0.05335054
9	-3.729833	-1.2146465	0.03612271