

Discovering Associations - Gaussian model selection

Gaussian data of flower width.

Gaussian outcome data. We received data from 180 flowers. This was distributed as 12 flowers for each compound for each of the 15 compounds. In each of those groups, there were 6 flowers per species and 6 grown in each garden. There were also 18 different subplots. The number of subplots is greater than the number of number of flowers per group.

For each of the 18 flowers, we have measurements of the width of the flower over the course of 21 days. All measurements for all flowers were taken by a single rater.

Below I transform the data so that there is a row for each measurement of each flower on each day resulting in 3780 rows.

```
g <- fread('gaussian_data_G6.csv')
#summary(g) #there is only one rater, drop it
g<-g %>% dplyr::select(-Rater)

colnames(g)<-c("flowerID",0:20,"compound","type","garden","subplot")

dataG_long <- gather(g, days, width, "0":"20", factor_key=TRUE) %>%
  mutate(garden=as.factor(garden),
         type=as.factor(type),
         compound=as.factor(compound),
         subplot=as.factor(subplot),
         days=as.numeric(days),
         flowerID=as.factor(flowerID))

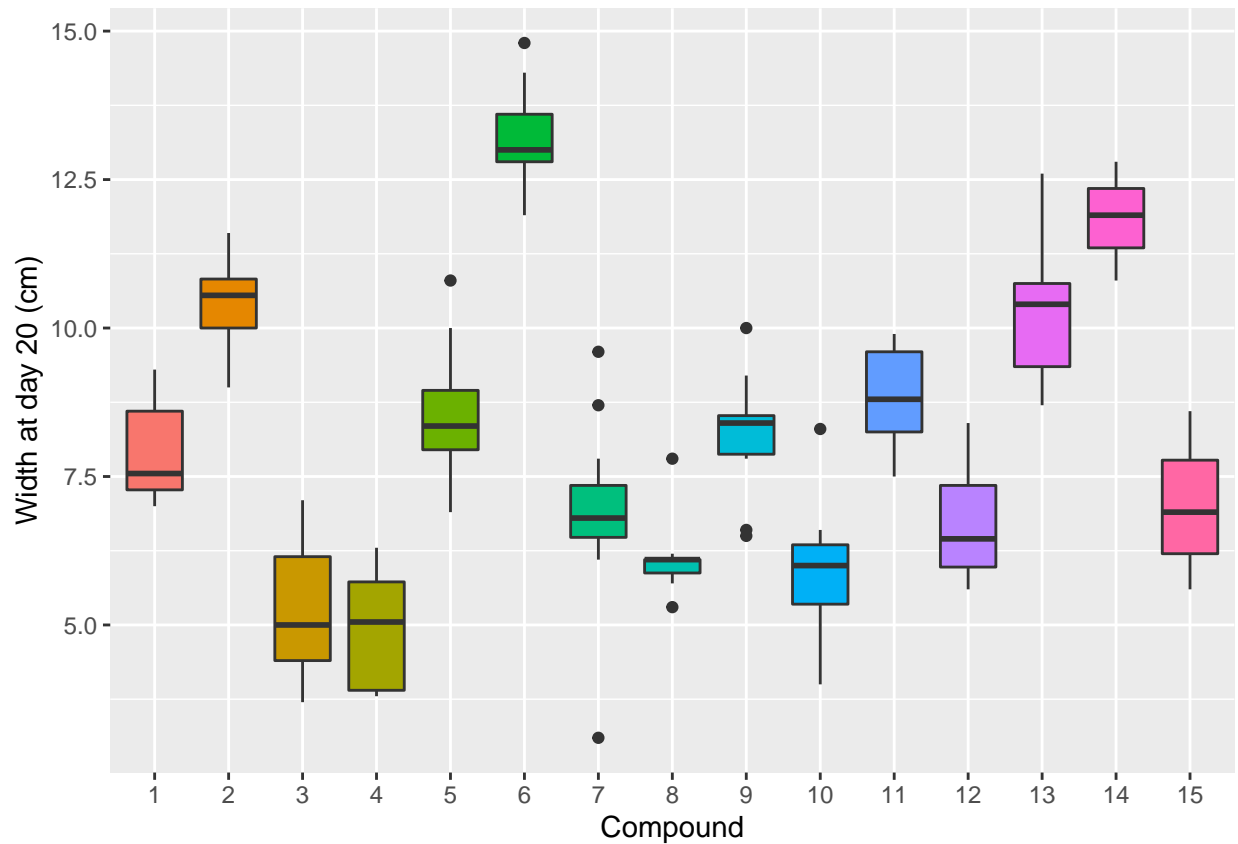
head(dataG_long)
```

##	flowerID	compound	type	garden	subplot	days	width
## 1	18075	1	1	1	1	1	2.9
## 2	18767	1	1	1	2	1	2.6
## 3	18028	1	1	1	3	1	5.2
## 4	18326	1	1	2	4	1	6.5
## 5	18017	1	1	2	5	1	4.2
## 6	18718	1	1	2	6	1	5.7

I also added a column showing the change in the width of the flower so that we can see the change in width per day. It is worth noting that the width of the flower does not uniformly increase, instead it does fluctuate from day to day, decreasing occasionally. Also, there are quite a few missing measurements, we probably should have accounted for this in our sample size calculation?

```
ggplot(dataG_combo[dataG_combo$days==20,], aes(x=compound,y=width, fill=compound))+geom_boxplot()+theme(
  labs(y = "Width at day 20 (cm)", x= "Compound")
```

```
## Warning: Removed 10 rows containing non-finite values (stat_boxplot).
```



Below I plotted the individual flower width evolution (per compound) and the evolution of the mean flower width by compound.

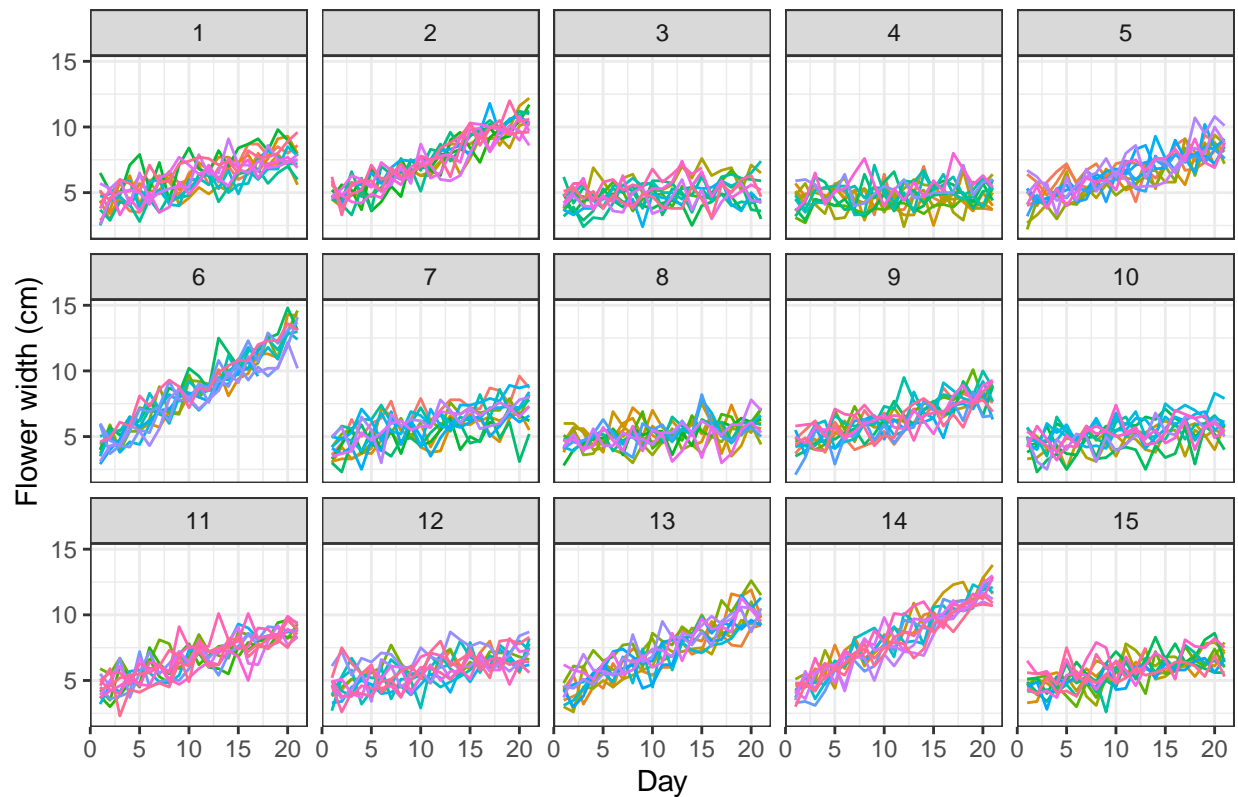
```
ggplot(data = dataG_combo)+  
  geom_line(aes(x = days, y = width, color = flowerID)) +  
  facet_wrap(~compound, ncol=5)+  
  scale_size_discrete(range=c(0.8,1.5),guide="none")+  
  scale_alpha_discrete(range=c(0.65,1), guide="none")+  
  theme_bw()+theme(legend.position = "none")+  
  ylab("Flower width (cm)")+  
  xlab("Day")+labs(title = "Evolution of the individual flower width per compound")
```

```
## Warning: Using size for a discrete variable is not advised.
```

```
## Warning: Using alpha for a discrete variable is not advised.
```

```
## Warning: Removed 88 row(s) containing missing values (geom_path).
```

Evolution of the individual flower width per coumpound

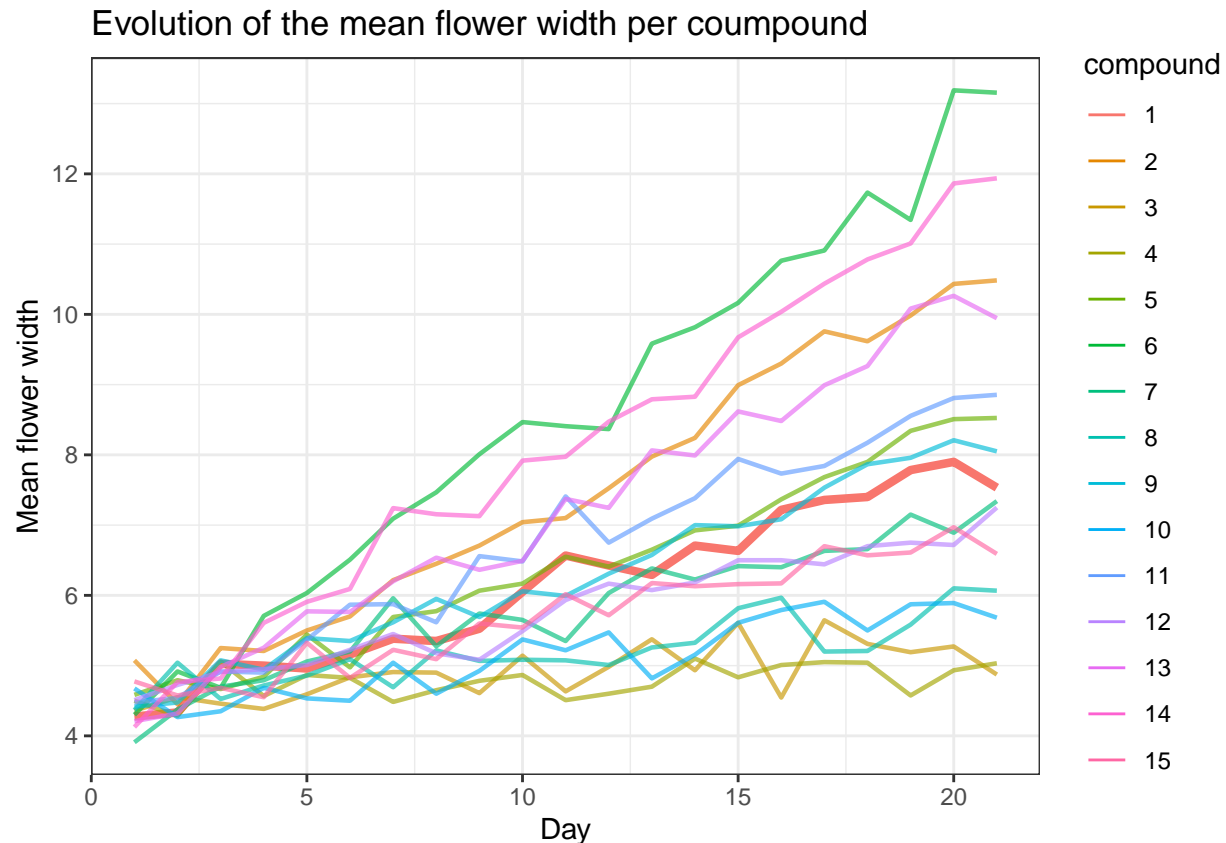


```
data_cc <- aggregate(width ~ compound + days, data = dataG_combo, FUN = mean) %>%
  mutate(water=ifelse(compound==1,T,F))
```

```
ggplot(data = data_cc)+
  geom_line(aes(x = days, y = width, color = compound, size=water, alpha=water)) +
  scale_size_discrete(range=c(0.8,1.5),guide="none")+
  scale_alpha_discrete(range=c(0.65,1), guide="none")+
  theme_bw()+
  ylab("Mean flower width")+
  xlab("Day")+labs(title = "Evolution of the mean flower width per coumpound")
```

```
## Warning: Using size for a discrete variable is not advised.
```

```
## Warning: Using alpha for a discrete variable is not advised.
```



The takeaway from this graph is that for each graph, the change in the Width of the flower is not the same for each of the Compounds.

I fit a linear model to the gaussian outcome data where Compound, Type, Garden and Days are included as fixed effects, a compound and days interaction is included and subplot is included as a random effect. Rater is not included because we only have one rater.

Initial model.

```
lme_out1 <- lmer(width ~ compound + type + garden + days + compound:days + (1|subplot)+ (1|flowerID),
summary(lme_out1)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ compound + type + garden + days + compound:days + (1 |
## subplot) + (1 | flowerID)
## Data: dataG_long
##
## REML criterion at convergence: 9337.2
##
## Scaled residuals:
##   Min       1Q   Median       3Q      Max
## -3.7740 -0.6638 -0.0155  0.6524  3.2160
##
## Random effects:
## Groups Name Variance Std.Dev.
## flowerID (Intercept) 0.04034 0.2008
```

```
## subplot (Intercept) 0.04263 0.2065
## Residual 0.67433 0.8212
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
##
## Fixed effects:
##
```

	Estimate	Std. Error	df	t value	Pr(> t)
## (Intercept)	3.973e+00	1.437e-01	1.877e+02	27.657	< 2e-16 ***
## compound2	-9.995e-02	1.744e-01	7.763e+02	-0.573	0.566645
## compound3	3.123e-01	1.747e-01	7.802e+02	1.787	0.074285 .
## compound4	4.127e-01	1.724e-01	8.031e+02	2.393	0.016927 *
## compound5	-4.275e-03	1.744e-01	7.763e+02	-0.025	0.980443
## compound6	-1.936e-01	1.756e-01	7.919e+02	-1.102	0.270610
## compound7	7.615e-02	1.724e-01	8.031e+02	0.442	0.658891
## compound8	3.368e-01	1.744e-01	7.763e+02	1.931	0.053797 .
## compound9	1.402e-01	1.744e-01	7.762e+02	0.804	0.421580
## compound10	1.147e-01	1.729e-01	8.098e+02	0.663	0.507504
## compound11	8.809e-02	1.747e-01	7.813e+02	0.504	0.614315
## compound12	3.187e-01	1.744e-01	7.762e+02	1.828	0.067923 .
## compound13	-1.579e-01	1.765e-01	8.005e+02	-0.895	0.371300
## compound14	-2.205e-01	1.750e-01	7.863e+02	-1.260	0.207961
## compound15	2.942e-01	1.753e-01	7.855e+02	1.679	0.093581 .
## type2	-3.436e-01	4.049e-02	1.465e+02	-8.487	2.14e-14 ***
## garden2	6.579e-01	1.054e-01	1.590e+01	6.241	1.22e-05 ***
## days	1.808e-01	8.543e-03	3.499e+03	21.165	< 2e-16 ***
## compound2:days	1.305e-01	1.208e-02	3.499e+03	10.801	< 2e-16 ***
## compound3:days	-1.323e-01	1.223e-02	3.520e+03	-10.820	< 2e-16 ***
## compound4:days	-1.614e-01	1.208e-02	3.499e+03	-13.356	< 2e-16 ***
## compound5:days	2.587e-02	1.208e-02	3.499e+03	2.141	0.032345 *
## compound6:days	2.454e-01	1.250e-02	3.544e+03	19.626	< 2e-16 ***
## compound7:days	-3.607e-02	1.208e-02	3.499e+03	-2.986	0.002849 **
## compound8:days	-1.159e-01	1.208e-02	3.499e+03	-9.592	< 2e-16 ***
## compound9:days	8.312e-03	1.208e-02	3.499e+03	0.688	0.491513
## compound10:days	-1.019e-01	1.226e-02	3.547e+03	-8.307	< 2e-16 ***
## compound11:days	4.500e-02	1.219e-02	3.509e+03	3.690	0.000228 ***
## compound12:days	-5.460e-02	1.208e-02	3.499e+03	-4.519	6.41e-06 ***
## compound13:days	1.190e-01	1.235e-02	3.499e+03	9.630	< 2e-16 ***
## compound14:days	2.031e-01	1.226e-02	3.547e+03	16.562	< 2e-16 ***
## compound15:days	-5.918e-02	1.244e-02	3.562e+03	-4.758	2.03e-06 ***

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 32 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it
```

```
anova(lme_out1)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##
```

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
## compound	26.6	1.9	14	789.8	2.8191	0.0003911 ***
## type	48.6	48.6	1	146.5	72.0335	2.145e-14 ***
## garden	26.3	26.3	1	15.9	38.9469	1.215e-05 ***

```
## days          4750.7  4750.7      1 3532.4 7045.0486 < 2.2e-16 ***
## compound:days 1822.3   130.2     14 3527.0  193.0323 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
-2*logLik(lme_out1)
```

```
## 'log Lik.' 9337.189 (df=35)
```

```
AIC(lme_out1)
```

```
## [1] 9407.189
```

```
BIC(lme_out1)
```

```
## [1] 9624.677
```

Model selection

Dropping compound.

```
lme_out2 <- lmer(width ~ type + garden + days + compound:days + (1|subplot)+ (1|flowerID), data=dataG_long)
summary(lme_out2)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ type + garden + days + compound:days + (1 | subplot) +
##          (1 | flowerID)
## Data: dataG_long
##
## REML criterion at convergence: 9346.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7568 -0.6548 -0.0153  0.6618  3.1937
##
## Random effects:
## Groups Name Variance Std.Dev.
## flowerID (Intercept) 0.04624 0.2150
## subplot (Intercept) 0.04010 0.2003
## Residual 0.67695 0.8228
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   4.069250   0.079837 22.736103  50.969 < 2e-16 ***
## type2        -0.345141   0.042119 136.921244  -8.194 1.60e-13 ***
## garden2       0.659438   0.103372  15.985623   6.379 9.17e-06 ***
## days          0.175807   0.005876 562.404786  29.920 < 2e-16 ***
## days:compound2 0.125640   0.007995 427.713660  15.714 < 2e-16 ***
```

```
## days:compound3 -0.116217 0.008101 429.851157 -14.345 < 2e-16 ***
## days:compound4 -0.139773 0.007887 400.852589 -17.722 < 2e-16 ***
## days:compound5 0.026024 0.007995 427.713660 3.255 0.00122 **
## days:compound6 0.233933 0.008277 430.111294 28.264 < 2e-16 ***
## days:compound7 -0.032088 0.007887 400.852589 -4.068 5.70e-05 ***
## days:compound8 -0.097888 0.007995 427.713660 -12.243 < 2e-16 ***
## days:compound9 0.015170 0.007996 427.664820 1.897 0.05846 .
## days:compound10 -0.095842 0.008048 403.171528 -11.908 < 2e-16 ***
## days:compound11 0.050014 0.008066 427.595996 6.200 1.33e-09 ***
## days:compound12 -0.038401 0.007996 427.664821 -4.803 2.17e-06 ***
## days:compound13 0.110678 0.008074 402.971480 13.707 < 2e-16 ***
## days:compound14 0.191730 0.008159 426.905642 23.499 < 2e-16 ***
## days:compound15 -0.043771 0.008263 430.332934 -5.297 1.88e-07 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
anova(lme_out2)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## type           45.5    45.46     1 136.92  67.149 1.597e-13 ***
## garden          27.5    27.55     1  15.99  40.695 9.172e-06 ***
## days           606.0   606.02     1 562.40 895.220 < 2.2e-16 ***
## days:compound 3546.9   253.35    14 418.36 374.253 < 2.2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
-2*logLik(lme_out2)
```

```
## 'log Lik.' 9346.073 (df=21)
```

```
AIC(lme_out2)
```

```
## [1] 9388.073
```

```
BIC(lme_out2)
```

```
## [1] 9518.566
```

```
LRT.2=2*(logLik(lme_out1)-logLik(lme_out2))
c(LRT.2,1-pchisq(LRT.2,14))
```

```
## [1] 8.8838457 0.8384186
```

Dropping species.

```
lme_out3 <- lmer(width ~ compound + garden + days + compound:days + (1|subplot)+ (1|flowerID), data=dataG_long)
summary(lme_out3)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ compound + garden + days + compound:days + (1 | subplot) +
##      (1 | flowerID)
##      Data: dataG_long
##
## REML criterion at convergence: 9391.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7892 -0.6526 -0.0129  0.6413  3.2754
##
## Random effects:
##      Groups      Name      Variance Std.Dev.
## flowerID (Intercept) 0.07541  0.2746
## subplot  (Intercept) 0.03905  0.1976
## Residual              0.67445  0.8212
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   3.805e+00  1.518e-01  2.081e+02  25.072 < 2e-16 ***
## compound2     -9.913e-02  1.910e-01  5.419e+02  -0.519  0.603893
## compound3      3.069e-01  1.913e-01  5.449e+02   1.604  0.109296
## compound4      4.127e-01  1.886e-01  5.497e+02   2.188  0.029109 *
## compound5     -3.458e-03  1.910e-01  5.419e+02  -0.018  0.985557
## compound6     -2.009e-01  1.922e-01  5.530e+02  -1.045  0.296317
## compound7      7.615e-02  1.886e-01  5.497e+02   0.404  0.686605
## compound8      3.376e-01  1.910e-01  5.419e+02   1.768  0.077671 .
## compound9      1.336e-01  1.910e-01  5.418e+02   0.699  0.484545
## compound10     1.139e-01  1.891e-01  5.541e+02   0.602  0.547345
## compound11     8.948e-02  1.913e-01  5.454e+02   0.468  0.640173
## compound12     3.121e-01  1.910e-01  5.418e+02   1.634  0.102757
## compound13    -1.744e-01  1.931e-01  5.489e+02  -0.903  0.366703
## compound14    -2.192e-01  1.916e-01  5.481e+02  -1.144  0.252926
## compound15     2.850e-01  1.918e-01  5.491e+02   1.486  0.137949
## garden2       6.543e-01  1.054e-01  1.585e+01   6.209  1.31e-05 ***
## days          1.808e-01  8.544e-03  3.498e+03  21.163 < 2e-16 ***
## compound2:days 1.305e-01  1.208e-02  3.498e+03  10.800 < 2e-16 ***
## compound3:days -1.325e-01  1.223e-02  3.514e+03 -10.830 < 2e-16 ***
## compound4:days -1.614e-01  1.208e-02  3.498e+03 -13.355 < 2e-16 ***
## compound5:days 2.587e-02  1.208e-02  3.498e+03   2.141  0.032361 *
## compound6:days 2.455e-01  1.252e-02  3.532e+03  19.607 < 2e-16 ***
## compound7:days -3.607e-02  1.208e-02  3.498e+03  -2.985  0.002851 **
## compound8:days -1.159e-01  1.208e-02  3.498e+03  -9.591 < 2e-16 ***
## compound9:days 8.312e-03  1.208e-02  3.498e+03   0.688  0.491552
## compound10:days -1.016e-01  1.228e-02  3.540e+03  -8.274 < 2e-16 ***
## compound11:days 4.491e-02  1.220e-02  3.505e+03   3.682  0.000235 ***
## compound12:days -5.460e-02  1.208e-02  3.498e+03  -4.519  6.42e-06 ***
## compound13:days 1.190e-01  1.235e-02  3.498e+03   9.630 < 2e-16 ***
```



```
## compound14:days 2.024e-01 1.228e-02 3.543e+03 16.486 < 2e-16 ***
## compound15:days -5.870e-02 1.246e-02 3.548e+03 -4.711 2.56e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 31 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out3)
```

```
## 'log Lik.' 9391.741 (df=34)
```

```
AIC(lme_out3)
```

```
## [1] 9459.741
```

```
BIC(lme_out3)
```

```
## [1] 9671.015
```

```
LRT.3=2*(logLik(lme_out1)-logLik(lme_out3))
c(LRT.3,1-pchisq(LRT.3,1))
```

```
## [1] 5.455189e+01 1.514344e-13
```

Dropping garden.

```
lme_out4 <- lmer(width ~ compound + type + days + compound:days + (1|subplot)+(1|flowerID), data=dataG_
summary(lme_out4)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ compound + type + days + compound:days + (1 | subplot) +
##      (1 | flowerID)
##      Data: dataG_long
##
## REML criterion at convergence: 9355.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7652 -0.6626 -0.0115  0.6508  3.2492
##
## Random effects:
##   Groups   Name                Variance Std.Dev.
## flowerID (Intercept) 0.04043   0.2011
## subplot  (Intercept) 0.15445   0.3930
## Residual                0.67430   0.8212
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
```

```
##
## Fixed effects:
##
```

	Estimate	Std. Error	df	t value	Pr(> t)	
## (Intercept)	4.299e+00	1.553e-01	1.148e+02	27.681	< 2e-16	***
## compound2	-1.005e-01	1.747e-01	7.585e+02	-0.575	0.565463	
## compound3	3.208e-01	1.751e-01	7.624e+02	1.832	0.067274	.
## compound4	4.127e-01	1.725e-01	8.014e+02	2.393	0.016955	*
## compound5	-4.780e-03	1.747e-01	7.585e+02	-0.027	0.978180	
## compound6	-1.849e-01	1.760e-01	7.737e+02	-1.051	0.293705	
## compound7	7.615e-02	1.725e-01	8.014e+02	0.441	0.658973	
## compound8	3.363e-01	1.747e-01	7.585e+02	1.925	0.054641	.
## compound9	1.491e-01	1.747e-01	7.583e+02	0.854	0.393557	
## compound10	1.150e-01	1.730e-01	8.081e+02	0.665	0.506162	
## compound11	8.715e-02	1.751e-01	7.633e+02	0.498	0.618797	
## compound12	3.277e-01	1.747e-01	7.583e+02	1.876	0.061092	.
## compound13	-1.599e-01	1.765e-01	7.977e+02	-0.906	0.365380	
## compound14	-2.210e-01	1.754e-01	7.682e+02	-1.260	0.207917	
## compound15	3.032e-01	1.756e-01	7.675e+02	1.726	0.084674	.
## type2	-3.435e-01	4.052e-02	1.464e+02	-8.479	2.26e-14	***
## days	1.808e-01	8.543e-03	3.499e+03	21.166	< 2e-16	***
## compound2:days	1.305e-01	1.208e-02	3.499e+03	10.801	< 2e-16	***
## compound3:days	-1.322e-01	1.223e-02	3.520e+03	-10.815	< 2e-16	***
## compound4:days	-1.614e-01	1.208e-02	3.499e+03	-13.357	< 2e-16	***
## compound5:days	2.587e-02	1.208e-02	3.499e+03	2.141	0.032341	*
## compound6:days	2.454e-01	1.250e-02	3.544e+03	19.629	< 2e-16	***
## compound7:days	-3.607e-02	1.208e-02	3.499e+03	-2.986	0.002848	**
## compound8:days	-1.159e-01	1.208e-02	3.499e+03	-9.593	< 2e-16	***
## compound9:days	8.312e-03	1.208e-02	3.499e+03	0.688	0.491502	
## compound10:days	-1.020e-01	1.226e-02	3.547e+03	-8.318	< 2e-16	***
## compound11:days	4.506e-02	1.219e-02	3.510e+03	3.695	0.000223	***
## compound12:days	-5.460e-02	1.208e-02	3.499e+03	-4.519	6.41e-06	***
## compound13:days	1.190e-01	1.235e-02	3.499e+03	9.631	< 2e-16	***
## compound14:days	2.030e-01	1.226e-02	3.547e+03	16.557	< 2e-16	***
## compound15:days	-5.918e-02	1.244e-02	3.561e+03	-4.758	2.03e-06	***

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 31 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out4)
```

```
## 'log Lik.' 9355.44 (df=34)
```

```
AIC(lme_out4)
```

```
## [1] 9423.44
```

```
BIC(lme_out4)
```

```
## [1] 9634.714
```

```
LRT.4=2*(logLik(lme_out1)-logLik(lme_out4))  
c(LRT.4,1-pchisq(LRT.4,1))
```

```
## [1] 1.825067e+01 1.936575e-05
```

Dropping days.

```
lme_out5 <- lmer(width ~ compound + type + garden + compound:days + (1|subplot)+(1|flowerID), data=dataG_long)  
summary(lme_out5)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [  
## lmerModLmerTest]  
## Formula: width ~ compound + type + garden + compound:days + (1 | subplot) +  
##      (1 | flowerID)  
## Data: dataG_long  
##  
## REML criterion at convergence: 9337.2  
##  
## Scaled residuals:  
##      Min       1Q   Median       3Q      Max   
## -3.7740 -0.6638 -0.0155  0.6524  3.2160   
##  
## Random effects:  
## Groups Name Variance Std.Dev.  
## flowerID (Intercept) 0.04034 0.2008  
## subplot (Intercept) 0.04263 0.2065  
## Residual 0.67433 0.8212  
## Number of obs: 3692, groups: flowerID, 179; subplot, 18  
##  
## Fixed effects:  
##              Estimate Std. Error      df t value Pr(>|t|)      
## (Intercept)  3.973e+00  1.437e-01 1.877e+02  27.657 < 2e-16 ***  
## compound2    -9.995e-02  1.744e-01  7.763e+02  -0.573  0.5666  
## compound3     3.123e-01  1.747e-01  7.802e+02   1.787  0.0743 .  
## compound4     4.127e-01  1.724e-01  8.031e+02   2.393  0.0169 *  
## compound5    -4.275e-03  1.744e-01  7.763e+02  -0.025  0.9804  
## compound6    -1.936e-01  1.756e-01  7.919e+02  -1.102  0.2706  
## compound7     7.615e-02  1.724e-01  8.031e+02   0.442  0.6589  
## compound8     3.368e-01  1.744e-01  7.763e+02   1.931  0.0538 .  
## compound9     1.402e-01  1.744e-01  7.762e+02   0.804  0.4216  
## compound10    1.147e-01  1.729e-01  8.098e+02   0.663  0.5075  
## compound11     8.809e-02  1.747e-01  7.813e+02   0.504  0.6143  
## compound12     3.187e-01  1.744e-01  7.762e+02   1.828  0.0679 .  
## compound13    -1.579e-01  1.765e-01  8.005e+02  -0.895  0.3713  
## compound14    -2.205e-01  1.750e-01  7.863e+02  -1.260  0.2080  
## compound15     2.942e-01  1.753e-01  7.855e+02   1.679  0.0936 .  
## type2        -3.436e-01  4.049e-02  1.465e+02  -8.487 2.14e-14 ***
```

```
## garden2          6.579e-01  1.054e-01  1.590e+01   6.241 1.22e-05 ***
## compound1:days  1.808e-01  8.543e-03  3.499e+03  21.165 < 2e-16 ***
## compound2:days  3.113e-01  8.543e-03  3.499e+03  36.440 < 2e-16 ***
## compound3:days  4.850e-02  8.749e-03  3.539e+03   5.544 3.17e-08 ***
## compound4:days  1.945e-02  8.543e-03  3.499e+03   2.277  0.0229 *
## compound5:days  2.067e-01  8.543e-03  3.499e+03  24.193 < 2e-16 ***
## compound6:days  4.262e-01  9.129e-03  3.577e+03  46.684 < 2e-16 ***
## compound7:days  1.447e-01  8.543e-03  3.499e+03  16.943 < 2e-16 ***
## compound8:days  6.492e-02  8.543e-03  3.499e+03   7.600 3.78e-14 ***
## compound9:days  1.891e-01  8.543e-03  3.499e+03  22.138 < 2e-16 ***
## compound10:days 7.895e-02  8.796e-03  3.584e+03   8.977 < 2e-16 ***
## compound11:days 2.258e-01  8.701e-03  3.519e+03  25.951 < 2e-16 ***
## compound12:days 1.262e-01  8.543e-03  3.499e+03  14.774 < 2e-16 ***
## compound13:days 2.998e-01  8.923e-03  3.499e+03  33.597 < 2e-16 ***
## compound14:days 3.839e-01  8.796e-03  3.584e+03  43.644 < 2e-16 ***
## compound15:days 1.216e-01  9.040e-03  3.604e+03  13.455 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 32 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out5)
```

```
## 'log Lik.' 9337.189 (df=35)
```

```
AIC(lme_out5)
```

```
## [1] 9407.189
```

```
BIC(lme_out5)
```

```
## [1] 9624.677
```

```
LRT.5=2*(logLik(lme_out1)-logLik(lme_out5))
c(LRT.5,1-pchisq(LRT.5,0))
```

```
## [1] -1.818989e-11  1.000000e+00
```

Dropping compounds:days.

```
lme_out6 <- lmer(width ~ compound + type + garden + days + (1|subplot) + (1|flowerID), data=dataG_long)
summary(lme_out6)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ compound + type + garden + days + (1 | subplot) + (1 |
##      flowerID)
```

```

## Data: dataG_long
##
## REML criterion at convergence: 11251
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.2897 -0.6285  0.0063  0.6389  4.1119
##
## Random effects:
## Groups Name Variance Std.Dev.
## flowerID (Intercept) 0.02500 0.1581
## subplot (Intercept) 0.04314 0.2077
## Residual 1.18692 1.0895
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 3.898e+00 1.175e-01 7.725e+01 33.165 < 2e-16 ***
## compound2 1.345e+00 1.197e-01 1.388e+02 11.237 < 2e-16 ***
## compound3 -1.111e+00 1.203e-01 1.410e+02 -9.238 3.49e-16 ***
## compound4 -1.362e+00 1.166e-01 1.354e+02 -11.687 < 2e-16 ***
## compound5 2.897e-01 1.197e-01 1.388e+02 2.421 0.01677 *
## compound6 2.383e+00 1.210e-01 1.440e+02 19.691 < 2e-16 ***
## compound7 -3.206e-01 1.166e-01 1.354e+02 -2.751 0.00676 **
## compound8 -9.285e-01 1.197e-01 1.388e+02 -7.758 1.68e-12 ***
## compound9 2.371e-01 1.197e-01 1.387e+02 1.982 0.04950 *
## compound10 -9.719e-01 1.178e-01 1.388e+02 -8.248 1.11e-13 ***
## compound11 5.858e-01 1.200e-01 1.400e+02 4.882 2.83e-06 ***
## compound12 -2.764e-01 1.197e-01 1.387e+02 -2.309 0.02240 *
## compound13 1.150e+00 1.195e-01 1.356e+02 9.630 < 2e-16 ***
## compound14 1.970e+00 1.210e-01 1.416e+02 16.279 < 2e-16 ***
## compound15 -3.217e-01 1.212e-01 1.441e+02 -2.655 0.00883 **
## type2 -3.367e-01 4.303e-02 1.382e+02 -7.825 1.19e-12 ***
## garden2 6.679e-01 1.069e-01 1.588e+01 6.245 1.21e-05 ***
## days 1.864e-01 2.974e-03 3.544e+03 62.684 < 2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it

-2*logLik(lme_out6)

## 'log Lik.' 11251.02 (df=21)

AIC(lme_out6)

## [1] 11293.02

```

```
BIC(lme_out6)
```

```
## [1] 11423.52
```

```
LRT.6=2*(logLik(lme_out1)-logLik(lme_out6))  
c(LRT.6,1-pchisq(LRT.6,14))
```

```
## [1] 1913.835    0.000
```

Dropping subplot random intercept.

```
lme_out7 <- lmer(width ~ compound + type + garden + days + compound:days + (1|flowerID), data=dataG_long,  
summary(lme_out7)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [  
## lmerModLmerTest]  
## Formula: width ~ compound + type + garden + days + compound:days + (1 |  
##     flowerID)  
## Data: dataG_long  
##  
## REML criterion at convergence: 9379.2  
##  
## Scaled residuals:  
##      Min       1Q   Median       3Q      Max   
## -3.7968 -0.6602 -0.0171  0.6447  3.0964   
##  
## Random effects:  
## Groups Name Variance Std.Dev.  
## flowerID (Intercept) 0.08117 0.2849  
## Residual 0.67442 0.8212  
## Number of obs: 3692, groups: flowerID, 179  
##  
## Fixed effects:  
##              Estimate Std. Error      df t value Pr(>|t|)        
## (Intercept)  3.991e+00  1.398e-01  5.162e+02  28.550 < 2e-16 ***  
## compound2    -9.567e-02  1.912e-01  5.751e+02  -0.500  0.616931  
## compound3     2.570e-01  1.916e-01  5.788e+02   1.341  0.180324  
## compound4     4.127e-01  1.912e-01  5.751e+02   2.159  0.031276 *  
## compound5     2.223e-13  1.912e-01  5.751e+02   0.000  1.000000  
## compound6    -2.515e-01  1.924e-01  5.866e+02  -1.307  0.191581  
## compound7     7.615e-02  1.912e-01  5.751e+02   0.398  0.690522  
## compound8     3.410e-01  1.912e-01  5.751e+02   1.784  0.074959 .  
## compound9     8.238e-02  1.912e-01  5.751e+02   0.431  0.666675  
## compound10    1.147e-01  1.916e-01  5.796e+02   0.598  0.549753  
## compound11     9.269e-02  1.915e-01  5.785e+02   0.484  0.628555  
## compound12     2.609e-01  1.912e-01  5.751e+02   1.365  0.172836  
## compound13    -1.519e-01  1.955e-01  5.749e+02  -0.777  0.437368  
## compound14    -2.161e-01  1.918e-01  5.816e+02  -1.127  0.260122  
## compound15     2.335e-01  1.920e-01  5.828e+02   1.216  0.224520  
## type2        -3.435e-01  5.053e-02  1.616e+02  -6.799  1.93e-10 ***  
## garden2       6.580e-01  5.053e-02  1.616e+02  13.022 < 2e-16 ***
```

```
## days      1.808e-01  8.543e-03  3.498e+03  21.164 < 2e-16 ***
## compound2:days 1.305e-01  1.208e-02  3.498e+03  10.800 < 2e-16 ***
## compound3:days -1.327e-01  1.223e-02  3.514e+03 -10.848 < 2e-16 ***
## compound4:days -1.614e-01  1.208e-02  3.498e+03 -13.356 < 2e-16 ***
## compound5:days  2.587e-02  1.208e-02  3.498e+03   2.141 0.032357 *
## compound6:days  2.454e-01  1.252e-02  3.533e+03  19.604 < 2e-16 ***
## compound7:days -3.607e-02  1.208e-02  3.498e+03  -2.986 0.002851 **
## compound8:days -1.159e-01  1.208e-02  3.498e+03  -9.592 < 2e-16 ***
## compound9:days  8.312e-03  1.208e-02  3.498e+03   0.688 0.491542
## compound10:days -1.019e-01  1.228e-02  3.540e+03  -8.297 < 2e-16 ***
## compound11:days  4.495e-02  1.220e-02  3.506e+03   3.685 0.000232 ***
## compound12:days -5.460e-02  1.208e-02  3.498e+03  -4.519 6.42e-06 ***
## compound13:days  1.190e-01  1.235e-02  3.498e+03   9.630 < 2e-16 ***
## compound14:days  2.029e-01  1.228e-02  3.543e+03  16.526 < 2e-16 ***
## compound15:days -5.864e-02  1.246e-02  3.549e+03  -4.707 2.61e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 32 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out7)
```

```
## 'log Lik.' 9379.241 (df=34)
```

```
AIC(lme_out7)
```

```
## [1] 9447.241
```

```
BIC(lme_out7)
```

```
## [1] 9658.515
```

```
LRT.7=2*(logLik(lme_out1)-logLik(lme_out7))
c(LRT.7,1-pchisq(LRT.7,1))
```

```
## [1] 4.205182e+01 8.888645e-11
```

Dropping subplot flowerID intercept.

```
lme_out8 <- lmer(width ~ compound + type + garden + days + compound:days + (1|subplot), data=dataG_long)
summary(lme_out8)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: width ~ compound + type + garden + days + compound:days + (1 |
##      subplot)
##      Data: dataG_long
```

```

##
## REML criterion at convergence: 9396.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.8652 -0.6738  0.0032  0.6621  3.1845
##
## Random effects:
##      Groups   Name      Variance Std.Dev.
## subplot (Intercept) 0.04611  0.2147
## Residual          0.70773  0.8413
## Number of obs: 3692, groups: subplot, 18
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   3.969e+00  1.330e-01  1.606e+02  29.840 < 2e-16 ***
## compound2     -1.005e-01  1.565e-01  3.653e+03  -0.642  0.520996
## compound3      3.213e-01  1.569e-01  3.652e+03   2.048  0.040680 *
## compound4      4.127e-01  1.554e-01  3.644e+03   2.656  0.007953 **
## compound5     -4.800e-03  1.565e-01  3.653e+03  -0.031  0.975541
## compound6     -1.888e-01  1.579e-01  3.653e+03  -1.196  0.231705
## compound7      7.615e-02  1.554e-01  3.644e+03   0.490  0.624166
## compound8      3.362e-01  1.565e-01  3.653e+03   2.148  0.031780 *
## compound9      1.465e-01  1.565e-01  3.653e+03   0.936  0.349389
## compound10     1.125e-01  1.559e-01  3.644e+03   0.721  0.470674
## compound11     9.079e-02  1.569e-01  3.653e+03   0.578  0.562973
## compound12     3.250e-01  1.565e-01  3.653e+03   2.076  0.037919 *
## compound13    -1.584e-01  1.590e-01  3.645e+03  -0.996  0.319202
## compound14    -2.212e-01  1.573e-01  3.653e+03  -1.406  0.159765
## compound15     3.082e-01  1.574e-01  3.653e+03   1.957  0.050370 .
## type2         -3.422e-01  2.773e-02  3.645e+03 -12.340 < 2e-16 ***
## garden2        6.599e-01  1.050e-01  1.595e+01   6.288  1.10e-05 ***
## days           1.808e-01  8.752e-03  3.644e+03  20.660 < 2e-16 ***
## compound2:days 1.305e-01  1.238e-02  3.644e+03  10.543 < 2e-16 ***
## compound3:days -1.327e-01  1.251e-02  3.644e+03 -10.614 < 2e-16 ***
## compound4:days -1.614e-01  1.238e-02  3.644e+03 -13.037 < 2e-16 ***
## compound5:days 2.587e-02  1.238e-02  3.644e+03   2.090  0.036701 *
## compound6:days 2.455e-01  1.276e-02  3.645e+03  19.241 < 2e-16 ***
## compound7:days -3.607e-02  1.238e-02  3.644e+03  -2.914  0.003585 **
## compound8:days -1.159e-01  1.238e-02  3.644e+03  -9.363 < 2e-16 ***
## compound9:days 8.312e-03  1.238e-02  3.644e+03   0.672  0.501914
## compound10:days -1.011e-01  1.252e-02  3.645e+03  -8.077  8.91e-16 ***
## compound11:days 4.451e-02  1.248e-02  3.644e+03   3.566  0.000367 ***
## compound12:days -5.460e-02  1.238e-02  3.644e+03  -4.411  1.06e-05 ***
## compound13:days 1.190e-01  1.265e-02  3.644e+03   9.401 < 2e-16 ***
## compound14:days 2.032e-01  1.252e-02  3.644e+03  16.224 < 2e-16 ***
## compound15:days -6.060e-02  1.268e-02  3.645e+03  -4.780  1.83e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 32 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

```



```
-2*logLik(lme_out8)
```

```
## 'log Lik.' 9396.192 (df=34)
```

```
AIC(lme_out8)
```

```
## [1] 9464.192
```

```
BIC(lme_out8)
```

```
## [1] 9675.466
```

```
LRT.8=2*(logLik(lme_out1)-logLik(lme_out8))  
c(LRT.8,1-pchisq(LRT.8,1))
```

```
## [1] 5.900287e+01 1.576517e-14
```

Testing adding random slopes for flowerID to Model 2. The random slopes are set to be uncorrelated from the flowerID intercept otherwise there are convergence issues (see below Model 11).

```
lme_out9 <- lmer(width ~ type + garden + days + compound:days + (0+days|flowerID)+(1|flowerID) + (1|subplot),  
summary(lme_out9)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [  
## lmerModLmerTest]  
## Formula:  
## width ~ type + garden + days + compound:days + (0 + days | flowerID) +  
## (1 | flowerID) + (1 | subplot)  
## Data: dataG_long  
##  
## REML criterion at convergence: 9319.1  
##  
## Scaled residuals:  
##      Min       1Q   Median       3Q      Max   
## -3.4711 -0.6582 -0.0019  0.6575  3.2656   
##  
## Random effects:  
## Groups      Name                Variance Std.Dev.  
## flowerID    days                0.0002877 0.01696  
## flowerID.1 (Intercept) 0.0126011 0.11225  
## subplot     (Intercept) 0.0423471 0.20578  
## Residual                    0.6667168 0.81653  
## Number of obs: 3692, groups: flowerID, 179; subplot, 18  
##  
## Fixed effects:  
##              Estimate Std. Error      df t value Pr(>|t|)      
## (Intercept)    4.062097   0.079576 21.209799  51.047 < 2e-16 ***  
## type2          -0.331515   0.039814 132.233211 -8.327 9.16e-14 ***  
## garden2         0.659889   0.104859  15.989410   6.293 1.07e-05 ***  
## days            0.174684   0.007046 174.624168 24.791 < 2e-16 ***
```

```
## days:compound2    0.124604    0.009654 151.647790   12.907 < 2e-16 ***
## days:compound3   -0.112063    0.009744 154.869183  -11.500 < 2e-16 ***
## days:compound4   -0.135004    0.009533 146.438379  -14.162 < 2e-16 ***
## days:compound5    0.026093    0.009654 151.647790    2.703 0.007661 **
## days:compound6    0.231235    0.009883 160.100499   23.398 < 2e-16 ***
## days:compound7   -0.031208    0.009533 146.438379   -3.274 0.001325 **
## days:compound8   -0.093878    0.009654 151.647790   -9.724 < 2e-16 ***
## days:compound9    0.016723    0.009655 151.652136    1.732 0.085294 .
## days:compound10  -0.094666    0.009708 148.700394   -9.751 < 2e-16 ***
## days:compound11    0.051142    0.009710 153.750634    5.267 4.60e-07 ***
## days:compound12  -0.034785    0.009655 151.652136   -3.603 0.000426 ***
## days:compound13    0.108862    0.009759 146.866808   11.155 < 2e-16 ***
## days:compound14    0.189057    0.009843 152.517564   19.207 < 2e-16 ***
## days:compound15  -0.040024    0.009904 158.318025   -4.041 8.28e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out9)
```

```
## 'log Lik.' 9319.109 (df=22)
```

```
AIC(lme_out9)
```

```
## [1] 9363.109
```

```
BIC(lme_out9)
```

```
## [1] 9499.816
```

```
LRT.9=2*(logLik(lme_out9)-logLik(lme_out2))
c(LRT.9,1-pchisq(LRT.9,1))
```

```
## [1] 2.696399e+01 2.072814e-07
```

Given that a model with random slopes seems to be better we test removing all variables again. Only when dropping random intercept for flowerID the model appears to improve.

```
drop1(lme_out9)
```

```
## Single term deletions using Satterthwaite's method:
```

```
##
```

```
## Model:
```

```
## width ~ type + garden + days + compound:days + (0 + days | flowerID) + (1 | flowerID) + (1 | subplot)
```

```
##      Sum Sq Mean Sq NumDF    DenDF F value    Pr(>F)
```

```
## type      46.22   46.225     1 132.233   69.332 9.161e-14 ***
```

```
## garden          26.40  26.404      1 15.989  39.603 1.074e-05 ***
## days:compound 2329.52 166.395     14 152.675 249.573 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lme_out10 <- lmer(width ~ type + garden + days + compound:days + (0+days|flowerID) + (1|subplot), data=
summary(lme_out10)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## width ~ type + garden + days + compound:days + (0 + days | flowerID) +
## (1 | subplot)
## Data: dataG_long
##
## REML criterion at convergence: 9321.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.4335 -0.6618 -0.0008  0.6546  3.2644
##
## Random effects:
## Groups Name Variance Std.Dev.
## flowerID days 0.0003356 0.01832
## subplot (Intercept) 0.0435800 0.20876
## Residual 0.6700408 0.81856
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  4.061216   0.079370 20.741552  51.168 < 2e-16 ***
## type2        -0.329751   0.037105 487.718239  -8.887 < 2e-16 ***
## garden2       0.660000   0.105172 15.986998   6.275 1.11e-05 ***
## days         0.174085   0.007031 178.185898  24.759 < 2e-16 ***
## days:compound2 0.124036   0.009600 153.764034  12.921 < 2e-16 ***
## days:compound3 -0.110121   0.009682 157.305235 -11.373 < 2e-16 ***
## days:compound4 -0.132571   0.009469 148.844578 -14.001 < 2e-16 ***
## days:compound5 0.026090   0.009600 153.764034   2.718 0.007327 **
## days:compound6 0.230104   0.009807 163.035465  23.463 < 2e-16 ***
## days:compound7 -0.030759   0.009469 148.844578  -3.248 0.001435 **
## days:compound8 -0.091871   0.009600 153.764034  -9.570 < 2e-16 ***
## days:compound9 0.017614   0.009600 153.764690   1.835 0.068485 .
## days:compound10 -0.093920   0.009640 151.465146  -9.743 < 2e-16 ***
## days:compound11 0.051673   0.009649 156.023074   5.355 3.01e-07 ***
## days:compound12 -0.032842   0.009600 153.764690  -3.421 0.000800 ***
## days:compound13 0.107926   0.009694 149.242182  11.133 < 2e-16 ***
## days:compound14 0.187768   0.009786 154.816316  19.188 < 2e-16 ***
## days:compound15 -0.038244   0.009834 161.381204  -3.889 0.000147 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 18 > 12.
```

```
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
-2*logLik(lme_out10)
```

```
## 'log Lik.' 9321.082 (df=21)
```

```
AIC(lme_out10)
```

```
## [1] 9363.082
```

```
BIC(lme_out10)
```

```
## [1] 9493.574
```

```
LRT.10=2*(logLik(lme_out9)-logLik(lme_out10))
c(LRT.10,1-pchisq(LRT.10,1))
```

```
## [1] 1.9724190 0.1601913
```

Similar to model 9, but with correlated random intercept and random slopes for flowerID.

```
lme_out11 <- lmer(width ~ type + garden + days + compound:days + (1+days|flowerID)+(1|subplot), data=da
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.0356484 (tol = 0.002, component 1)
```

```
summary(lme_out11)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## width ~ type + garden + days + compound:days + (1 + days | flowerID) +
##      (1 | subplot)
##      Data: dataG_long
##
## REML criterion at convergence: 9315
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.4152 -0.6589 -0.0020  0.6552  3.2901
##
## Random effects:
##   Groups   Name                Variance Std.Dev. Corr
## flowerID (Intercept) 0.041088 0.20270
##           days       0.000534 0.02311  -0.61
## subplot  (Intercept) 0.042488 0.20613
## Residual              0.660498 0.81271
## Number of obs: 3692, groups: flowerID, 179; subplot, 18
```

```

##
## Fixed effects:
##
##      Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   4.063334   0.080462  22.239129  50.500 < 2e-16 ***
## type2         -0.333836   0.039147 134.208434  -8.528 2.76e-14 ***
## garden2        0.659862   0.104757  16.010434   6.299 1.06e-05 ***
## days           0.174111   0.007104 181.753971  24.509 < 2e-16 ***
## days:compound2 0.123992   0.009602 153.531183  12.913 < 2e-16 ***
## days:compound3 -0.110154   0.009689 157.077472 -11.369 < 2e-16 ***
## days:compound4 -0.132625   0.009458 148.282433 -14.023 < 2e-16 ***
## days:compound5 0.026033   0.009602 153.531183   2.711 0.007470 **
## days:compound6 0.230358   0.009816 162.595896  23.467 < 2e-16 ***
## days:compound7 -0.030769   0.009458 148.282433  -3.253 0.001413 **
## days:compound8 -0.091972   0.009602 153.531183  -9.578 < 2e-16 ***
## days:compound9 0.017610   0.009603 153.506375   1.834 0.068615 .
## days:compound10 -0.093808   0.009634 150.767208  -9.737 < 2e-16 ***
## days:compound11 0.051481   0.009652 155.745394   5.334 3.34e-07 ***
## days:compound12 -0.032869   0.009603 153.506375  -3.423 0.000795 ***
## days:compound13 0.107948   0.009684 148.700673  11.147 < 2e-16 ***
## days:compound14 0.187788   0.009790 154.441192  19.182 < 2e-16 ***
## days:compound15 -0.038628   0.009846 160.967790  -3.923 0.000129 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (nloptwrap) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.0356484 (tol = 0.002, component 1)

-2*logLik(lme_out11)

## 'log Lik.' 9314.997 (df=23)

AIC(lme_out11)

## [1] 9360.997

BIC(lme_out11)

## [1] 9503.917

LRT.11=2*(logLik(lme_out9)-logLik(lme_out11))
c(LRT.11,1-pchisq(LRT.11,1))

## [1] -4.112155 1.000000

```

```

{r, lme} # lme_coefficients<-as.data.frame(summary(lme_out1)$tTable)
%>% #   rownames_to_column("predictor_full") %>% #   filter(grepl("compo
%>% #   filter(grepl("days",predictor_full)) %>% #   #dplyr::rename(pval
%>% #   #we want to have p-adjusted (Holm) values for one-sided
test H.alt: lambda(compound)>lambda(water) #   #dplyr::mutate(one_sided_
pval/2, (1-pval/2)), #   dplyr::mutate(p_adjusted=p.adjust(`p-value`,
method="holm"), #   significant=ifelse(p_adjusted<0.05,
T, F), #   predictor=gsub(":days","",predictor_full))
# # ggplot(lme_coefficients %>% #   mutate(compound=factor(gsub(
levels=2:15))), #   aes(x=compound, y=Value, color=p_adjusted<0.05)
#   geom_hline(yintercept=0, linetype="dashed")+ #   geom_errorbar(aes(y
- `Std.Error`, ymax=Value +`Std.Error`), width=0.2)+geom_point(size=3)+t
#   scale_color_manual(values=c("grey","#85ADAC"))+coord_flip()+
#   ylab(expression(beta["compound*time"])) # # # also nice
#BEE3DB #   #

```