

## Output from paper.R

```
> # paper.R
>
> library(lsmmeans)
> library(phia)
> library(doBy)
> library(car)
> library(nlme)
>
>
> # get the data
> paper<-read.table(file="paper.dat",header=T,
+                   colClasses=c("factor","numeric","numeric"))
> head(paper)
  day conc strength
1  1  2   114
2  1  4   126
3  1  8   141
4  2  4   120
5  2  6   137
6  2 10   145
> is.factor(paper$day)
[1] TRUE
> is.factor(paper$strength)
[1] FALSE
> is.factor(paper$conc)
[1] FALSE
> is.ordered(paper$day)
[1] FALSE
> is.ordered(paper$conc)
[1] FALSE
> paper$concOrd <- ordered(paper$conc)
> levels(paper$concOrd)
[1] "2" "4" "6" "8" "10" "12" "14"
>
> ##### part 1
> # Intrablock Analysis using ANOVA
> m1<-aov(strength~day+concOrd,data=paper)
> summary(m1)
      Df Sum Sq Mean Sq F value Pr(>F)
day      6 1114.3  185.71  8.814 0.00358 **
concOrd  6 1317.4  219.57 10.420 0.00205 **
Residuals 8  168.6   21.07
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
> # type III SSs
> Anova(m1,type=3)
Anova Table (Type III tests)

Response: strength
      Sum Sq Df  F value  Pr(>F)
```

```

(Intercept) 40995 1 1945.5348 7.703e-11 ***
day          394 6  3.1171 0.070148 .
concOrd     1317 6 10.4203 0.002054 **
Residuals   169 8
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

>
> # below are the linear, nonlinear, quadratic and nonquadratic contrasts
> c1<-c(-3,-2,-1,0,1,2,3)
> c21<-c(5,0,-3,-4,-3,0,5)
> c22<-c(-1,1,1,0,-1,-1,1)
> c23<-c(3,-7,1,6,1,-7,3)
> c24<-c(-1,4,-5,0,5,-4,1)
> c25<-c(1,-6,15,-20,15,-6,1)
> c3<-c(5,0,-3,-4,-3,0,5)
> c41<-c(-1,1,1,0,-1,-1,1)
> c42<-c(3,-7,1,6,1,-7,3)
> c43<-c(-1,4,-5,0,5,-4,1)
> c44<-c(1,-6,15,-20,15,-6,1)
>
> # test the linear and quadratic contrasts first
> lsmeans(m1,specs=ls~concOrd,
+   contr=list(lsm=list(linear_conc=c1,
+     quadratics_conc=c3)))
$`concOrd lsmeans`
concOrd lsmean SE df lower.CL upper.CL
  2 116.8571 2.957013 8 110.0383 123.6760
  4 120.7143 2.957013 8 113.8954 127.5332
  6 131.8571 2.957013 8 125.0383 138.6760
  8 140.0000 2.957013 8 133.1811 146.8189
 10 143.0000 2.957013 8 136.1811 149.8189
 12 124.1429 2.957013 8 117.3240 130.9617
 14 128.4286 2.957013 8 121.6097 135.2475

$`concOrd lsm`
      estimate SE df t.ratio p.value
linear_conc  52.71429 15.90148 8 3.31505 0.01062
quadratics_conc -158.14286 27.54218 8 -5.74184 0.00043
p values are not adjusted

>
> # then test the nonlinear and nonquadratic contrasts using glht
> K1<-rbind("nonlinear 1"=c21,"nonlinear 2"=c22,"nonlinear 3"=c23,
+   "nonlinear 4"=c24,"nonlinear 5"=c25)
> K2<-rbind("nonquadratic 1"=c41,"nonquadratic 2"=c42,"nonquadratic 3"=c43,
+   "nonquadratic 4"=c44)
> summary(glht(m1,linfct=mcp(concOrd=K1)),test=Ftest())

```

## General Linear Hypotheses

Multiple Comparisons of Means: User-defined Contrasts

Linear Hypotheses:

Estimate

```
nonlinear 1 == 0 -158.14
nonlinear 2 == 0 -3.00
nonlinear 3 == 0 136.71
nonlinear 4 == 0 53.57
nonlinear 5 == 0 99.00
```

Global Test:

F DF1 DF2 Pr(>F)

```
1 10.31 5 8 0.002482
```

```
> summary(glht(m1,linfct=mcp(concOrd=K2)),test=Ftest())
```

General Linear Hypotheses

Multiple Comparisons of Means: User-defined Contrasts

Linear Hypotheses:

Estimate

```
nonquadratic 1 == 0 -3.00
nonquadratic 2 == 0 136.71
nonquadratic 3 == 0 53.57
nonquadratic 4 == 0 99.00
```

Global Test:

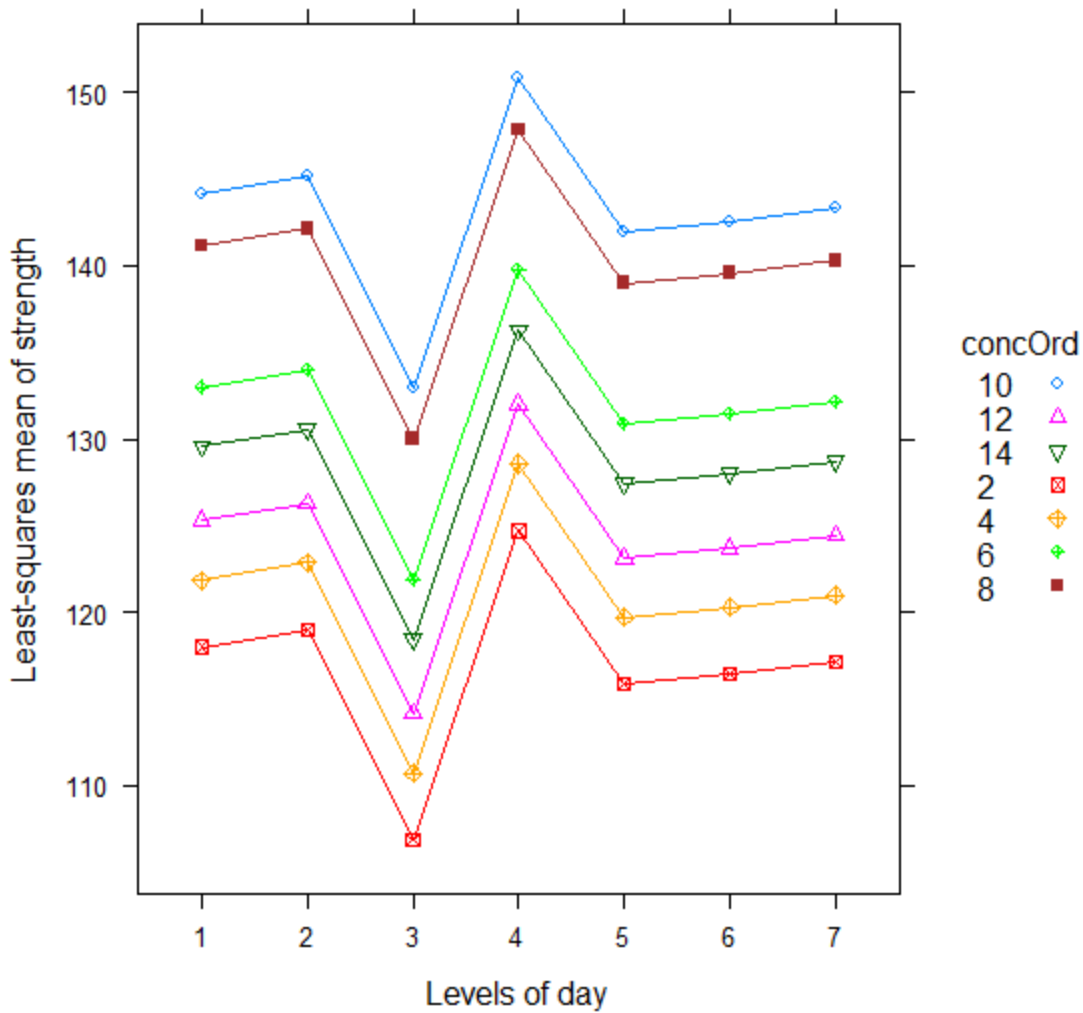
F DF1 DF2 Pr(>F)

```
1 4.641 4 8 0.03122
```

```
>
```

```
> # get interaction plot for strength
```

```
> lsmip(m1,concOrd~day)
```



```

>
> # plot the estimated means for each level of conc
> concmeans<-lsmeans(m1,specs=~concOrd)[[1]]
> head(concmeans)
concOrd lsmean SE df lower.CL upper.CL
 2 116.8571 2.957013 8 110.0383 123.6760
 4 120.7143 2.957013 8 113.8954 127.5332
 6 131.8571 2.957013 8 125.0383 138.6760
 8 140.0000 2.957013 8 133.1811 146.8189
10 143.0000 2.957013 8 136.1811 149.8189
12 124.1429 2.957013 8 117.3240 130.9617
> is.factor(concmeans$concOrd)
[1] TRUE
> concmeans$conc <- as.numeric(levels(concmeans$concOrd))
> head(concmeans)
concOrd lsmean SE df lower.CL upper.CL conc
 2 116.8571 2.957013 8 110.0383 123.6760 2
 4 120.7143 2.957013 8 113.8954 127.5332 4
 6 131.8571 2.957013 8 125.0383 138.6760 6
 8 140.0000 2.957013 8 133.1811 146.8189 8
10 143.0000 2.957013 8 136.1811 149.8189 10
12 124.1429 2.957013 8 117.3240 130.9617 12

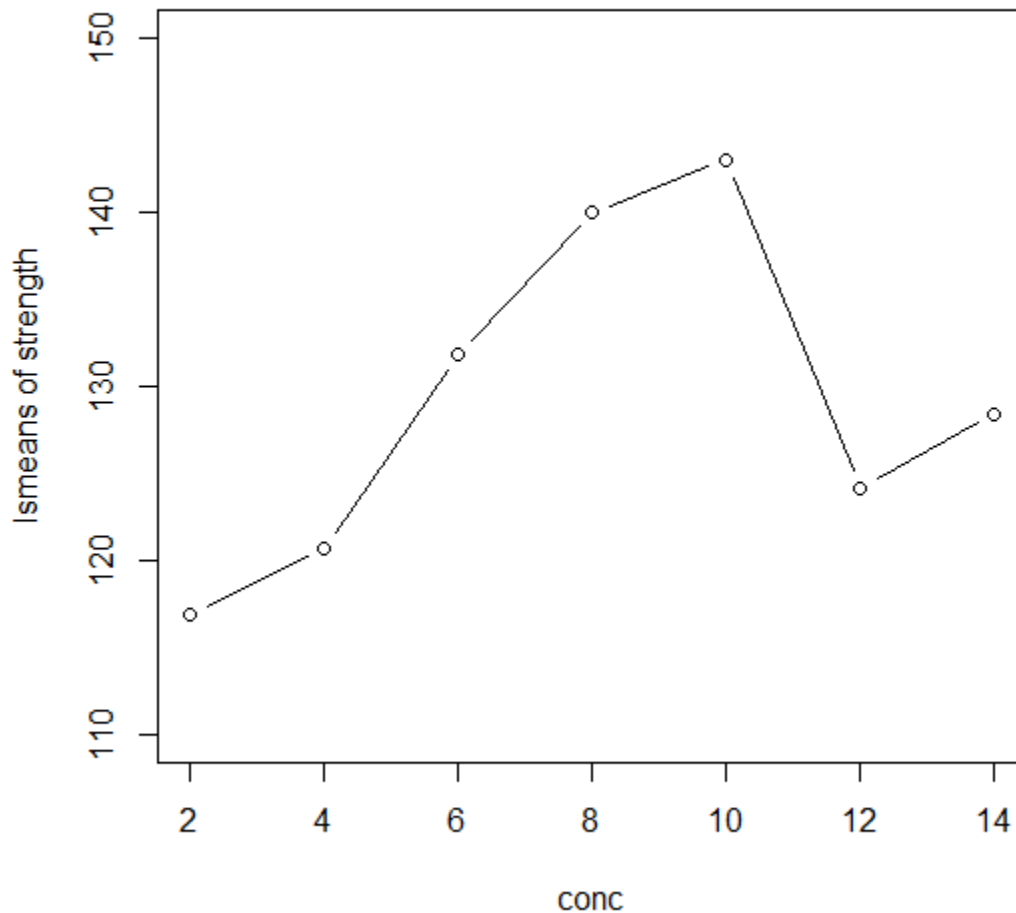
```

```

>
> plot(concmeans$conc[1:7],concmeans$lsmmean[1:7],ylim=c(110,150),
+ type="b",lty=1,pch=1,col=1,
+ main="Estimated Treatment Means from Intrablock Analysis",
+ ylab="lsmmeans of strength",xlab="conc")

```

## Estimated Treatment Means from Intrablock Analysis



```

>
>
> ##### part 2
> # Combined Intrablock and Interblock Analysis
> # mixed model with random effect "day"
>
> m2<-lme(strength~concOrd,data=paper,random=~1|day)
> summary(m2)
Linear mixed-effects model fit by REML
Data: paper
      AIC   BIC logLik
116.8588 122.6103 -49.42941

Random effects:
Formula: ~1 | day
      (Intercept) Residual
StdDev:  4.372533  4.590363

```

Fixed effects: strength ~ concOrd

	Value	Std.Error	DF	t-value	p-value
(Intercept)	129.28571	1.932536	8	66.89953	0.0000
concOrd.L	10.16127	2.896000	8	3.50872	0.0080
concOrd.Q	-16.78309	2.896000	8	-5.79527	0.0004
concOrd.C	-1.00646	2.896000	8	-0.34754	0.7372
concOrd^4	11.70489	2.896000	8	4.04174	0.0037
concOrd^5	7.56360	2.896000	8	2.61174	0.0310
concOrd^6	3.61217	2.896000	8	1.24730	0.2476

Correlation:

(Intr)	cncO.L	cncO.Q	cncO.C	cncO^4	cncO^5
concOrd.L	0				
concOrd.Q	0	0			
concOrd.C	0	0	0		
concOrd^4	0	0	0	0	
concOrd^5	0	0	0	0	0
concOrd^6	0	0	0	0	0

Standardized Within-Group Residuals:

Min	Q1	Med	Q3	Max
-1.58060679	-0.53319518	0.07204558	0.60092382	0.97968297

Number of Observations: 21

Number of Groups: 7

>

> # type 3 F test

> anova(m2,type="marginal")

	numDF	denDF	F-value	p-value
(Intercept)	1	8	4475.546	<.0001
concOrd	6	8	11.788	0.0014

>

> # Now test contrasts:

> # test the linear and quadratic contrasts first

> # the test statistics given below are labeled "z.ratio" and are

> # treated as Z tests, not t tests. Nevertheless, for these 1 df

> # contrasts, their squares are the F statistics given by PROC MIXED

> # in SAS

>

> lsmeans(m2,specs=ls~concOrd,

+ contr=list(lsm=list(linear\_conc=c1,

+ quadratics\_conc=c3)))

\$`concOrd lsmeans`

concOrd	lsmean	SE	df	asyp.LCL	asyp.UCL
2	116.9030	3.305056	NA	110.4252	123.3808
4	121.0198	3.305056	NA	114.5420	127.4976
6	131.0475	3.305056	NA	124.5697	137.5253
8	139.8931	3.305056	NA	133.4153	146.3709
10	143.9624	3.305056	NA	137.4846	150.4402
12	122.9207	3.305056	NA	116.4429	129.3985
14	129.2535	3.305056	NA	122.7757	135.7313

\$`concOrd lsm`

```
      estimate    SE df  z.ratio p.value
linear_conc    53.76837 15.32419 NA  3.50872 0.00045
quadratics_conc -153.81960 26.54228 NA -5.79527 0.00000
p values are not adjusted
```

```
>
> # then test the nonlinear and nonquadratic contrasts using glht
> # similarly, the tests for the 2 df contrasts given below are large sample
> # chisquare tests
> # not F tests. However the relationship between these chisq test statistics
> # and the F test statistics given by PROC MIXED is simple
> # (F test stat)*(num df) = chisq test stat.
>
> summary(glht(m2,linfct=mcp(concOrd=K1)),test=Ftest())
```

### General Linear Hypotheses

#### Multiple Comparisons of Means: User-defined Contrasts

##### Linear Hypotheses:

```
      Estimate
nonlinear 1 == 0 -153.820
nonlinear 2 == 0  -2.465
nonlinear 3 == 0 145.254
nonlinear 4 == 0  69.322
nonlinear 5 == 0 109.801
```

##### Global Test:

```
Chisq DF Pr(>Chisq)
1 58.42 5 2.578e-11
```

##### Warning message:

```
In test(object) :
```

```
'df.residual' is not available for 'model' a Chisq test is performed instead of the requested F test.
```

```
> summary(glht(m2,linfct=mcp(concOrd=K2)),test=Ftest())
```

### General Linear Hypotheses

#### Multiple Comparisons of Means: User-defined Contrasts

##### Linear Hypotheses:

```
      Estimate
nonquadratic 1 == 0 -2.465
nonquadratic 2 == 0 145.254
nonquadratic 3 == 0  69.322
nonquadratic 4 == 0 109.801
```

##### Global Test:

```
Chisq DF Pr(>Chisq)
1 24.83 4 5.434e-05
```

##### Warning message:

```
In test(object) :
```

'df.residual' is not available for 'model' a Chisq test is performed instead of the requested F test.

>