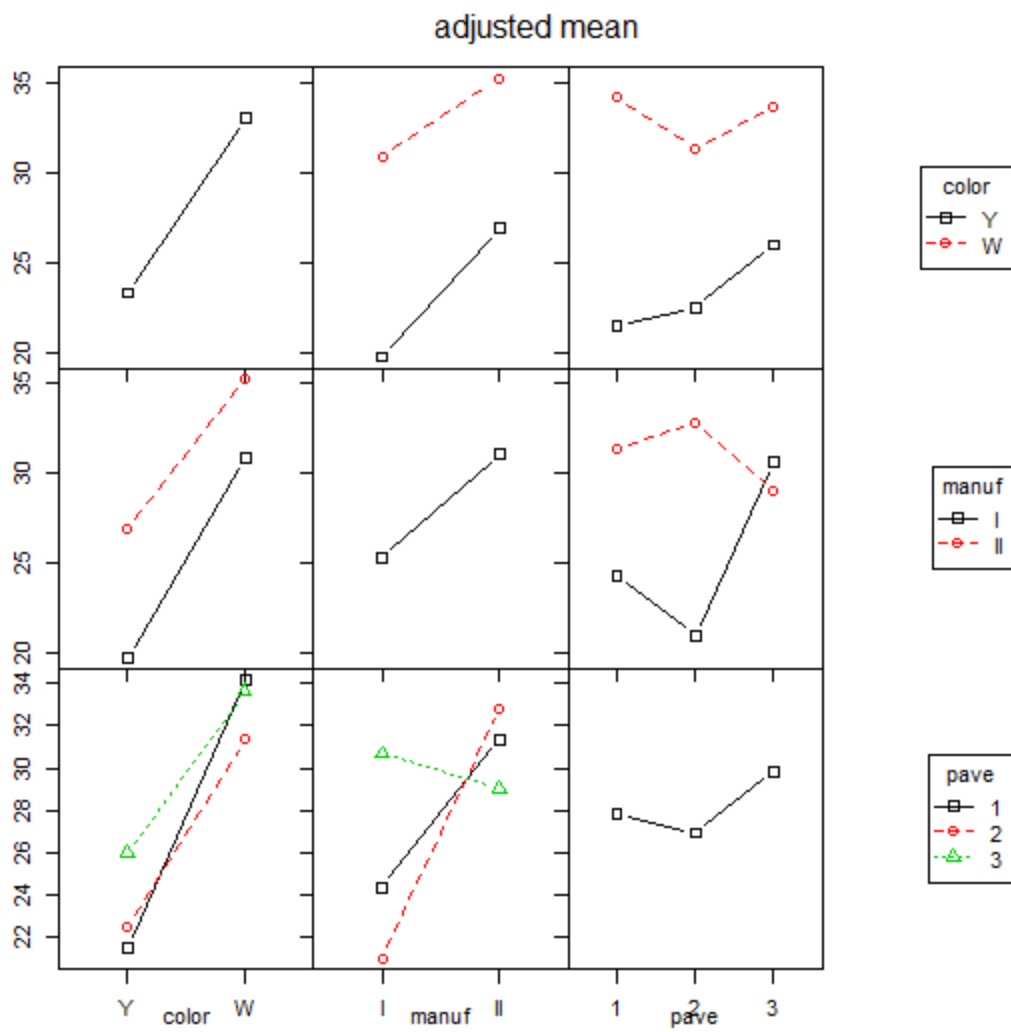


Output from paving.R

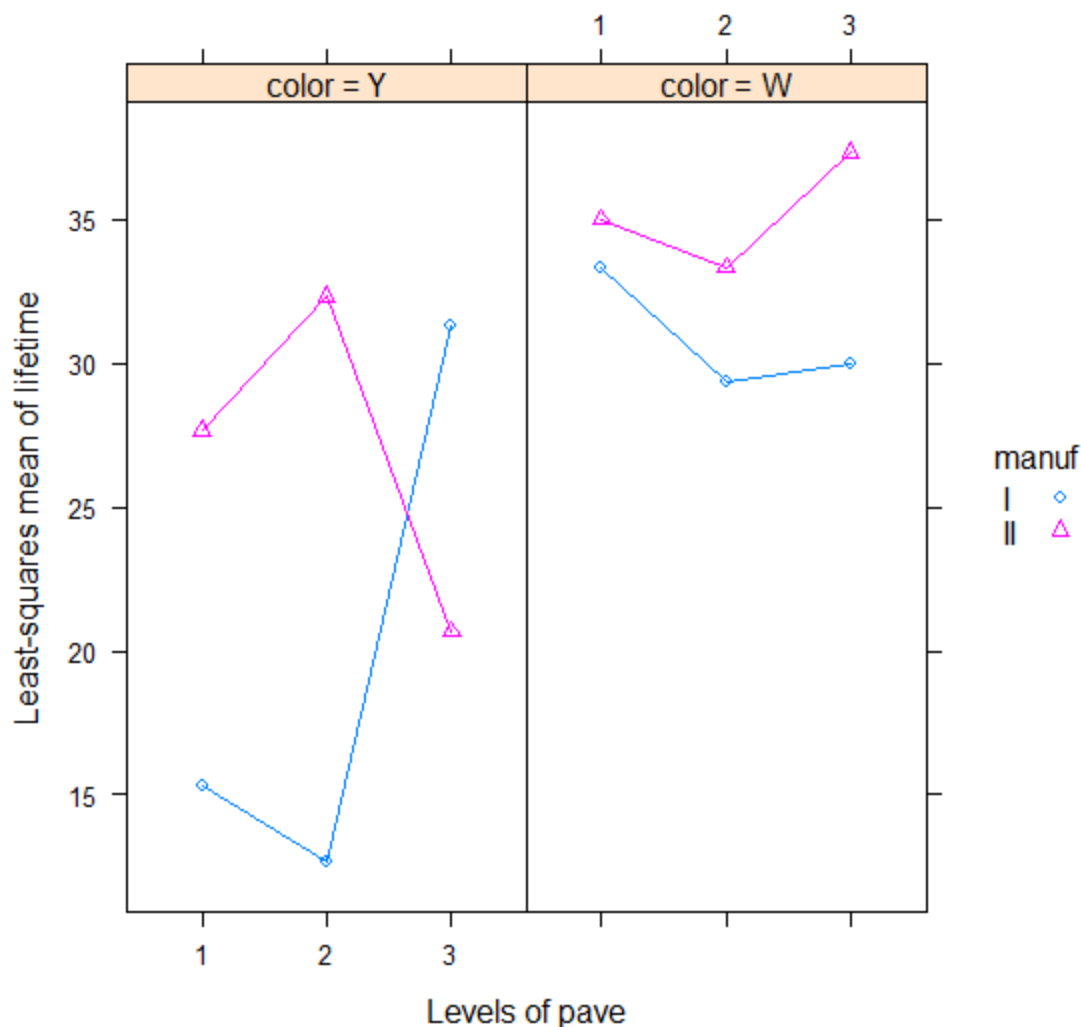
```
> #paving.R
>
> library(lsmmeans)
> library(phia)
>
> # get the data
> pavdata <- read.table(file="paving.dat",header=T)
> pavdata$color <- gl(n=2,k=18,labels=c("Y","W"))
> pavdata$manuf <- gl(n=2,k=9,length=36,labels=c("I","II"))
> pavdata$pave <- factor(pavdata$pavement)
> head(pavdata)
  paint pavement lifetime color  manuf  pave
1     1         1         11     Y     I     1
2     1         1         23     Y     I     1
3     1         1         12     Y     I     1
4     1         2         11     Y     I     2
5     1         2         14     Y     I     2
6     1         2         13     Y     I     2
> levels(pavdata$color)
[1] "Y" "W"
> # note that the levels of color are reversed as compared with paving.sas
>
>
> # fit the two-way anova model
> m1 <- aov(lifetime~color*manuf*pave,data=pavdata)
> summary(m1)
              Df Sum Sq Mean Sq F value    Pr(>F)
color          1  850.7   850.7  43.013 8.78e-07 ***
manuf          1  294.7   294.7  14.900 0.000750 ***
pave           2   53.4    26.7   1.350 0.278298
color:manuf    1   17.4    17.4   0.878 0.358136
color:pave     2   41.1    20.5   1.038 0.369551
manuf:pave     2  280.7   140.4   7.097 0.003790 **
color:manuf:pave 2  495.1   247.5  12.515 0.000189 ***
Residuals     24  474.7    19.8
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
> # get profile plots (uses package phia)
> ( trtmns <- interactionMeans(m1) )
  color manuf pave adjusted mean
1     Y     I     1     15.33333
2     W     I     1     33.33333
3     Y    II     1     27.66667
4     W    II     1     35.00000
5     Y     I     2     12.66667
6     W     I     2     29.33333
7     Y    II     2     32.33333
8     W    II     2     33.33333
9     Y     I     3     31.33333
10    W     I     3     30.00000
11    Y    II     3     20.66667
12    W    II     3     37.33333
> plot(trtmns)
```



```

>
> # alternatively can use function ls mip from lsmeans package
> # for profile plots:
> ls mip(m1,manuf~pave|color)

```



```
>
> # now test the contrasts corresponding to the manuf*pave interaction,
> # and the manuf and pave main effects within each color separately
>
> #refit model m1 as a cell means model
> m1a <-lm(lifetime~pave:manuf:color-1,data=pavdata)
> summary(m1a)
```

```
Call:
lm(formula = lifetime ~ pave:manuf:color - 1, data = pavdata)
```

```
Residuals:
    Min       1Q   Median       3Q      Max
-6.3333 -2.4167  0.1667  2.4167  8.3333
```

```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
pave1:manufI:colorY    15.333     2.568   5.972 3.65e-06 ***
pave2:manufI:colorY    12.667     2.568   4.933 4.92e-05 ***
pave3:manufI:colorY    31.333     2.568  12.203 8.82e-12 ***
pave1:manufII:colorY   27.667     2.568  10.775 1.12e-10 ***
pave2:manufII:colorY   32.333     2.568  12.593 4.58e-12 ***
pave3:manufII:colorY   20.667     2.568   8.049 2.83e-08 ***
pave1:manufI:colorW    33.333     2.568  12.982 2.41e-12 ***
```

```

pave2:manufI:colorW      29.333      2.568  11.424  3.43e-11 ***
pave3:manufI:colorW      30.000      2.568  11.684  2.17e-11 ***
pave1:manufII:colorW     35.000      2.568  13.631  8.55e-13 ***
pave2:manufII:colorW     33.333      2.568  12.982  2.41e-12 ***
pave3:manufII:colorW     37.333      2.568  14.540  2.13e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 4.447 on 24 degrees of freedom
Multiple R-squared:  0.9847,    Adjusted R-squared:  0.9771
F-statistic: 129.1 on 12 and 24 DF,  p-value: < 2.2e-16

```

```

> # notice the order of the mu_ijk's in the
> # fitted model (different from SAS)
>
> c1 <- c(1, 1, 1, -1, -1, -1, 0, 0, 0, 0, 0, 0) # manuf (Y)
> c2 <- c(1, 1, -2, 1, 1, -2, 0, 0, 0, 0, 0, 0) # pave 1 (Y)
> c3 <- c(1, -1, 0, 1, -1, 0, 0, 0, 0, 0, 0, 0) # pave 2 (Y)
> c4 <- c1*c2 # manuf*pave 1 (Y)
> c5 <- c1*c3 # manuf*pave 2 (Y)
>
> c6 <- c(0, 0, 0, 0, 0, 0, 1, 1, 1, -1, -1, -1) # manuf (W)
> c7 <- c(0, 0, 0, 0, 0, 0, 1, 1, -2, 1, 1, -2) # pave 1 (W)
> c8 <- c(0, 0, 0, 0, 0, 0, 1, -1, 0, 1, -1, 0) # pave 2 (W)
> c9 <- c6*c7 # manuf*pave 1 (W)
> c10 <- c6*c8 # manuf*pave 2 (W)
>
> # the linearHypothesis function is from the car package
>
> linearHypothesis(m1a,c6) # manuf main effect for white paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorW + pave2:manufI:colorW + pave3:manufI:colorW -
pave1:manufII:colorW - pave2:manufII:colorW - pave3:manufII:colorW = 0

```

```

Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1

```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	25	559.17				
2	24	474.67	1	84.5	4.2725	0.04968 *

```

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> linearHypothesis(m1a,rbind(c7,c8)) # pave main effect for white paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorW + pave2:manufI:colorW - 2 pave3:manufI:colorW +
pave1:manufII:colorW + pave2:manufII:colorW - 2 pave3:manufII:colorW = 0
pave1:manufI:colorW - pave2:manufI:colorW + pave1:manufII:colorW -
pave2:manufII:colorW = 0

```

```

Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1

```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
--	--------	-----	----	-----------	---	--------

```

1      26 502.11
2      24 474.67  2      27.444 0.6938 0.5094
> linearHypothesis(m1a, rbind(c9, c10)) # manuf*pave effect for white paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorW + pave2:manufI:colorW - 2 pave3:manufI:colorW -
pave1:manufII:colorW - pave2:manufII:colorW + 2 pave3:manufII:colorW = 0
pave1:manufI:colorW - pave2:manufI:colorW - pave1:manufII:colorW +
pave2:manufII:colorW = 0

```

```

Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1

```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	26	499.00				
2	24	474.67	2	24.333	0.6152	0.5489

```

>
> linearHypothesis(m1a, c1) # manuf main effect for yellow paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorY + pave2:manufI:colorY + pave3:manufI:colorY -
pave1:manufII:colorY - pave2:manufII:colorY - pave3:manufII:colorY = 0

```

```

Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1

```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	25	702.22				
2	24	474.67	1	227.56	11.506	0.002404 **

```

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> linearHypothesis(m1a, rbind(c2, c3)) # pave main effect for yellow paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorY + pave2:manufI:colorY - 2 pave3:manufI:colorY +
pave1:manufII:colorY + pave2:manufII:colorY - 2 pave3:manufII:colorY = 0
pave1:manufI:colorY - pave2:manufI:colorY + pave1:manufII:colorY -
pave2:manufII:colorY = 0

```

```

Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1

```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	26	541.67				
2	24	474.67	2	67	1.6938	0.2051

```

> linearHypothesis(m1a, rbind(c4, c5)) # manuf*pave effect for yellow paint
Linear hypothesis test

```

```

Hypothesis:
pave1:manufI:colorY + pave2:manufI:colorY - 2 pave3:manufI:colorY -
pave1:manufII:colorY - pave2:manufII:colorY + 2 pave3:manufII:colorY = 0
pave1:manufI:colorY - pave2:manufI:colorY - pave1:manufII:colorY +
pave2:manufII:colorY = 0

```

```
Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1
```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	26	1226.11				
2	24	474.67	2	751.44	18.997	1.133e-05 ***

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

```
>
> linearHypothesis(m1a,c4) # manuf*pave type for yellow paint
Linear hypothesis test
```

Hypothesis:

```
pave1:manufI:colorY + pave2:manufI:colorY - 2 pave3:manufI:colorY -
pave1:manufII:colorY - pave2:manufII:colorY + 2 pave3:manufII:colorY = 0
```

```
Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1
```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	25	1185.78				
2	24	474.67	1	711.11	35.955	3.439e-06 ***

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

```
> linearHypothesis(m1a,c5) # manuf*asphalt for yellow paint
Linear hypothesis test
```

Hypothesis:

```
pave1:manufI:colorY - pave2:manufI:colorY - pave1:manufII:colorY +
pave2:manufII:colorY = 0
```

```
Model 1: restricted model
Model 2: lifetime ~ pave:manuf:color - 1
```

	Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	25	515.00				
2	24	474.67	1	40.333	2.0393	0.1662