

# HW#3

```
df <- data.frame(
  day = factor(rep(1:7, each = 3)),
  conc = factor(c(
    2,4,6,
    8,10,12,
    14,2,4,
    6,8,10,
    12,14,2,
    4,6,8,
    10,12,14
  )),
  strength = c(
    114,126,141,
    120,137,145,
    117,129,120,
    149,150,136,
    120,143,118,
    119,123,130,
    117,134,127
  )
)

model <- aov(strength ~ day + conc, data = df)
summary(model)
```

```
##           Df Sum Sq Mean Sq F value Pr(>F)
## day         6 1114.3 185.71  1.349  0.338
## conc        6  384.3   64.04  0.465  0.817
## Residuals   8 1101.7  137.72
```

```
# Tukey comparison
library(multcomp)
```

```
## Loading required package: mvtnorm
## Loading required package: survival
## Loading required package: TH.data
## Loading required package: MASS
##
## Attaching package: 'TH.data'
```

```
## The following object is masked from 'package:MASS':  
##  
##     geyser
```

```
tukey <- glht(model, mcp(conc = "Tukey"))  
summary(tukey)
```

```
##  
##   Simultaneous Tests for General Linear Hypotheses  
##  
##   Multiple Comparisons of Means: Tukey Contrasts  
##  
##  
## Fit: aov(formula = strength ~ day + conc, data = df)  
##  
## Linear Hypotheses:  
##           Estimate Std. Error t value Pr(>|t|)  
## 4 - 2 == 0     1.9965   10.4598  0.191  1.000  
## 6 - 2 == 0    10.7979   11.6327  0.928  0.954  
## 8 - 2 == 0     4.4530   12.5838  0.354  1.000  
## 10 - 2 == 0    0.8885   12.5838  0.071  1.000  
## 12 - 2 == 0   10.3484   11.6327  0.890  0.962  
## 14 - 2 == 0    9.9303   10.4598  0.949  0.950  
## 6 - 4 == 0     8.8014   10.4598  0.841  0.971  
## 8 - 4 == 0     2.4564   11.6327  0.211  1.000  
## 10 - 4 == 0   -1.1080   12.5838 -0.088  1.000  
## 12 - 4 == 0    8.3519   12.5838  0.664  0.991  
## 14 - 4 == 0    7.9338   11.6327  0.682  0.989  
## 8 - 6 == 0    -6.3449   10.4598 -0.607  0.994  
## 10 - 6 == 0   -9.9094   11.6327 -0.852  0.969  
## 12 - 6 == 0   -0.4495   12.5838 -0.036  1.000  
## 14 - 6 == 0   -0.8676   12.5838 -0.069  1.000  
## 10 - 8 == 0   -3.5645   10.4598 -0.341  1.000  
## 12 - 8 == 0    5.8955   11.6327  0.507  0.998  
## 14 - 8 == 0    5.4774   12.5838  0.435  0.999  
## 12 - 10 == 0   9.4599   10.4598  0.904  0.959  
## 14 - 10 == 0   9.0418   11.6327  0.777  0.980  
## 14 - 12 == 0  -0.4181   10.4598 -0.040  1.000  
## (Adjusted p values reported -- single-step method)
```

```
confint(tukey)
```

```
##  
##   Simultaneous Confidence Intervals  
##  
##   Multiple Comparisons of Means: Tukey Contrasts  
##  
##  
## Fit: aov(formula = strength ~ day + conc, data = df)  
##  
## Quantile = 3.7958  
## 95% family-wise confidence level  
##
```

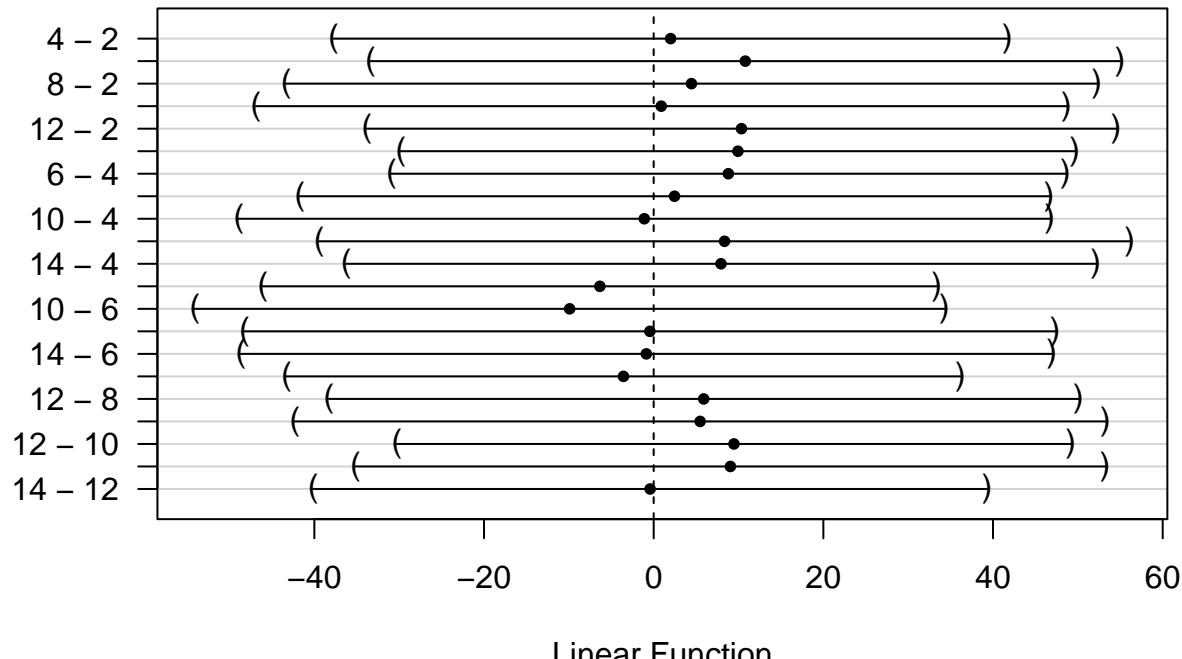
```

## 
## Linear Hypotheses:
##           Estimate lwr      upr
## 4 - 2 == 0    1.9965 -37.7065  41.6995
## 6 - 2 == 0   10.7979 -33.3572  54.9530
## 8 - 2 == 0    4.4530 -43.3124  52.2183
## 10 - 2 == 0   0.8885 -46.8769  48.6539
## 12 - 2 == 0  10.3484 -33.8066  54.5035
## 14 - 2 == 0   9.9303 -29.7727  49.6333
## 6 - 4 == 0    8.8014 -30.9016  48.5044
## 8 - 4 == 0    2.4564 -41.6986  46.6115
## 10 - 4 == 0   -1.1080 -48.8734  46.6574
## 12 - 4 == 0   8.3519 -39.4134  56.1173
## 14 - 4 == 0   7.9338 -36.2213  52.0889
## 8 - 6 == 0   -6.3449 -46.0480  33.3581
## 10 - 6 == 0  -9.9094 -54.0645  34.2457
## 12 - 6 == 0  -0.4495 -48.2148  47.3159
## 14 - 6 == 0  -0.8676 -48.6330  46.8978
## 10 - 8 == 0  -3.5645 -43.2675  36.1386
## 12 - 8 == 0   5.8955 -38.2596  50.0506
## 14 - 8 == 0   5.4774 -42.2880  53.2427
## 12 - 10 == 0  9.4599 -30.2431  49.1630
## 14 - 10 == 0  9.0418 -35.1133  53.1969
## 14 - 12 == 0 -0.4181 -40.1211  39.2849

```

```
plot(tukey)
```

### 95% family-wise confidence level



Linear Function

```

df <- data.frame(
  Sex = factor(rep(c("Male", "Female"), each = 6)),
  Age = factor(rep(c(3,3,5,5,7,7), times = 2)),
  Puzzles = c(24,20,18,16,31,53, 20,8,50,36,54,66)
)

cell_means <- with(df, tapply(Puzzles, list(Sex, Age), mean))
cell_means_with_margins <- addmargins(cell_means, FUN = mean)

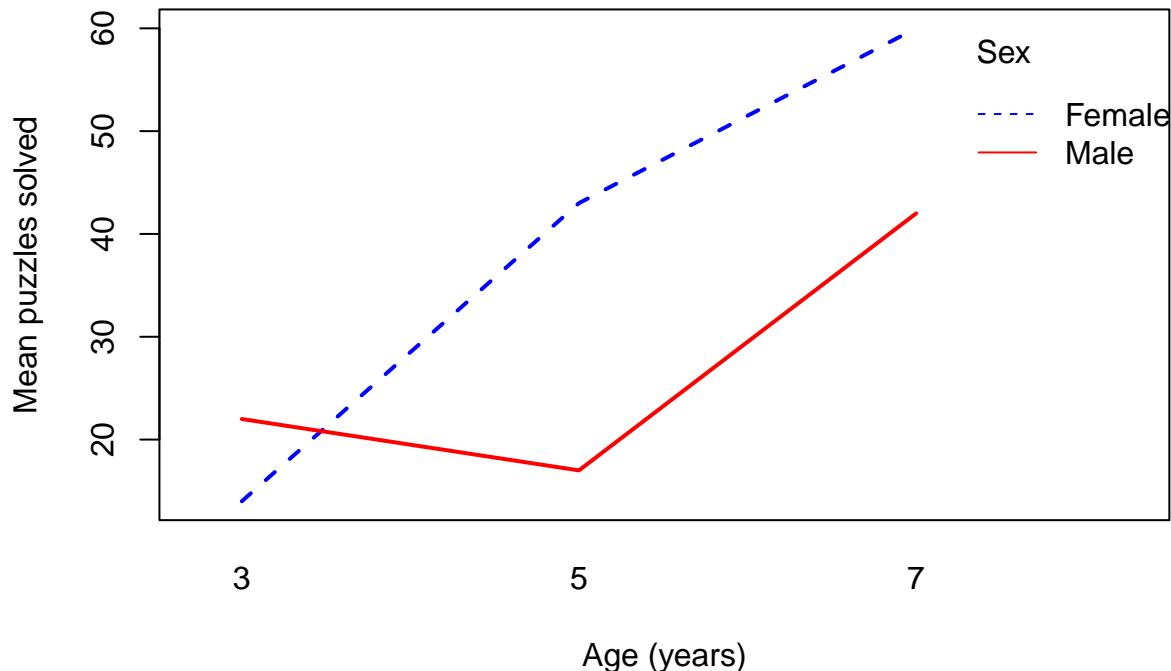
## Margins computed over dimensions
## in the following order:
## 1:
## 2:

cell_means_with_margins

##          3   5   7 mean
## Female 14  43  60   39
## Male    22  17  42   27
## mean    18  30  51   33

interaction.plot(df$Age, df$Sex, df$Puzzles,
                  ylab = "Mean puzzles solved",
                  xlab = "Age (years)",
                  trace.label = "Sex",
                  col = c("blue", "red"),
                  lwd = 2)

```



```
# The lines for boys and girls aren't parallel as they cross between ages 3 and 5.
# So female age 5 is the most out of line
```

```
model <- aov(Puzzles ~ Sex * Age, data = df)
summary(model)
```

```
##          Df Sum Sq Mean Sq F value    Pr(>F)
## Sex        1   432   432.0   5.247 0.06189 .
## Age        2  2232  1116.0  13.555 0.00595 **
## Sex:Age    2   632   316.0   3.838 0.08444 .
## Residuals  6   494    82.3
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# we can conclude that, from the F-ratio, at the 0.05 level:
# age has a statistically significant effect on the response
# Sex and the Sex × Age interaction are not statistically significant at 0.05
```