

## 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)
```

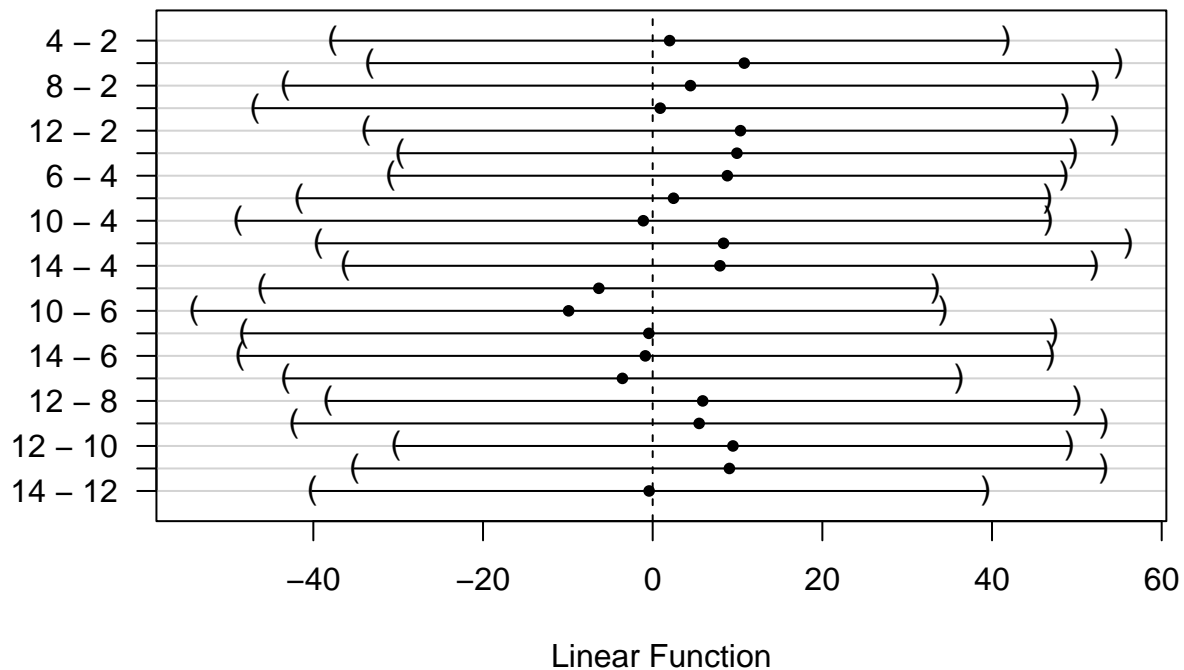
```
confint(tukey)
```

```
##
##      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



```
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)
)

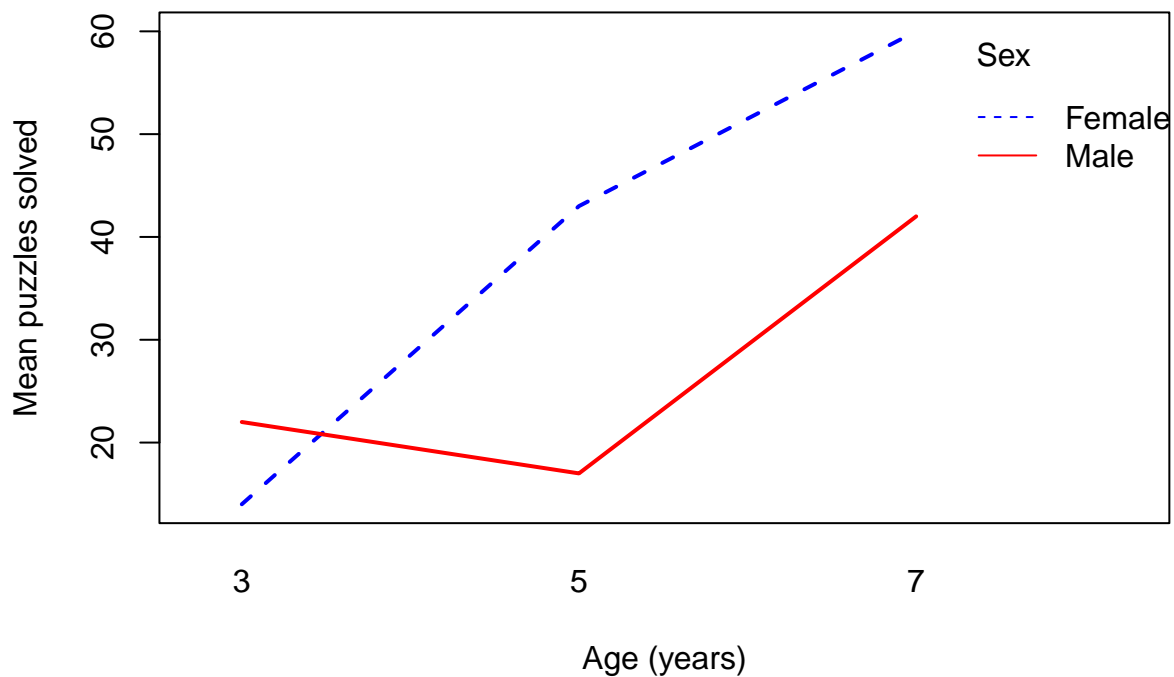
cell_means <- with(df, tapply(Puzzles, list(Sex, Age), mean))
cell_means_with_margins <- addmargins(cell_means, FUN = mean)
```

```
## 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*