Ch 12. Question 7.

Solution 1. *Our model here is still with the form:*

$$Y_{hqi} = \mu + \theta_h + \phi_q + \tau_i + \epsilon_{hqi}$$

while $\epsilon_{hqi} \sim N(0, \sigma^2), i.i.d..$ *Also* $h = 1, \ldots, b; q = 1, \ldots, c; i = 1, \ldots, v; (h, q, i)$ *in the design.*

In our case, we have $b = v = 5, c = 4$.

To obtain the ANOVA table, the work is similar to question 6:

```
#read in the data
setwd("C:\\Akira\\R")
game2 = read.csv("game2.csv", header = TRUE)

#fit the model
fit <- lm(response ~ factor(day) + factor(time) +
             factor(treatment), data = game2)
anova(fit)

## Analysis of Variance Table
##
## Response: response
##                    Df Sum Sq Mean Sq F value  Pr(>F)
## factor(day)         3 1597.0  532.32  3.0383 0.09279 .
## factor(time)        4  411.5  102.87  0.5872 0.68132
## factor(treatment)   4 1289.7  322.43  1.8403 0.21457
## Residuals           8 1401.6  175.20
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the anova table we see that now the sum square of column block(day) is larger than error sum of square error, which indicates effect on treatment from the column block However the treatment factor still has a p value > 0.05 *indicates there is no treatment effect.*

Now to work part (e):

Under the Yuden mode, the least square estimate for any contrast $\sum_i d_i \tau_i$*(without replication) is:*

$$\sum d_i \hat{\tau}_i = \frac{c}{\lambda v} \sum_i d_i Q_i = \left(\frac{v-1}{v(c-1)}\right) \sum_i d_i Q_i$$

where

$$Q_i = T_i - \frac{1}{c} \sum_h n_{h \cdot i} B_h$$

So if we use scheffe's method, the $100(1-\alpha)\%$ *confidence interval is:*

$$\sum_i d_i\tau_i \in \left(\left(\frac{v-1}{v(c-1)}\right)\sum_i d_iQ_i \pm \sqrt{(v-1)F_{v-1,(v-1)(c-1)-(v-1),\alpha}}\sqrt{msE\left(\frac{v-1}{v(c-1)}\right)\sum d_i^2}\right)$$

So we have:

```
a<-c(1, -1, 0, 0, 0)
b<-c(1, 0, -1, 0, 0)
c<-c(1, 0, 0, -1, 0)
d<-c(1, 0, 0, 0, -1)
e<-c(0, 1, -1, 0, 0)
f<-c(0, 1, 0, -1, 0)
g<-c(0, 1, 0, 0, -1)
h<-c(0, 0, 1, -1, 0)
k<-c(0, 0, 1, 0, -1)
l<-c(0, 0, 0, 1, -1)
m<-c(0.33, 0.33, 0.33, -0.5, -0.5)
o<-c(0.25, 0.25, 0.25, 0.25, -1)
contrast <- list(a, b, c, d, e, f, g, h, k, l, m, o)
n <- length(contrast)
msE <- anova(fit)[[3]][[4]]
msE

## [1] 175.2

#compute T_i
T <- as.vector(tapply(game2$response, game2$treatment, sum))
#compute B_h
B <- as.vector(tapply(game2$response, game2$time, sum))
#compute Q_i
n_1 <- c(1, 1, 1, 1, 0)
n_2 <- c(1, 1, 0, 1, 1)
n_3 <- c(1, 1, 1, 0, 1)
n_4 <- c(1, 0, 1, 1, 1)
n_5 <- c(0, 1, 1, 1, 1)
n_hi <- list(n_1, n_2, n_3, n_4, n_5)
Q <- c()
for (i in 1:5){
  Q[i] <- T[i] - 1/4*sum(n_hi[[i]]*B)
}
#compute Scheffe critical coefficient
w_S <- sqrt(4*qf(0.05, 4, 8, lower.tail=FALSE))
w_S

## [1] 3.918088
```

```
#compute 95% confidence interval
for (i in 1:n){
#compute least square estimate
lse <- sum(contrast[[i]]*Q)*4/15
#compute msd
msd <- w_S*sqrt(msE*sum(contrast[[i]]^2)*4/15)
#compute lower and upper bound for CI
ci_lower<- lse-msd
ci_upper<- lse+msd
#print the result of CI
cat("The CI for (", contrast[[i]], ") is (",
    ci_lower<- lse-msd, ", ", ci_upper<- lse+msd, ")", "\n")
}

## The CI for ( 1 -1 0 0 0 ) is ( -57.60728 ,  18.14062 )
## The CI for ( 1 0 -1 0 0 ) is ( -50.47395 ,  25.27395 )
## The CI for ( 1 0 0 -1 0 ) is ( -54.87395 ,  20.87395 )
## The CI for ( 1 0 0 0 -1 ) is ( -62.20728 ,  13.54062 )
## The CI for ( 0 1 -1 0 0 ) is ( -30.74062 ,  45.00728 )
## The CI for ( 0 1 0 -1 0 ) is ( -35.14062 ,  40.60728 )
## The CI for ( 0 1 0 0 -1 ) is ( -42.47395 ,  33.27395 )
## The CI for ( 0 0 1 -1 0 ) is ( -42.27395 ,  33.47395 )
## The CI for ( 0 0 1 0 -1 ) is ( -49.60728 ,  26.14062 )
## The CI for ( 0 0 0 1 -1 ) is ( -45.20728 ,  30.54062 )
## The CI for ( 0.33 0.33 0.33 -0.5 -0.5 ) is ( -34.19937 ,  14.5007 )
## The CI for ( 0.25 0.25 0.25 0.25 -1 ) is ( -41.94199 ,  17.94199 )
```

All the confidence intervals still include 0 *as are in question* 6*. So we still conclude that there is no statistically significant difference between different background music, or between having game sound or not, or between having backgorund music or not.*

For part (f):

so we conclude the same as in question 6*, that different backgorund music, or having music or not, having game sound or not, does not make a statistically significant difference on the perfor-mence on the game. So the professor should pick any arbitrary sound mode to play.*