STAT461 HW4

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#### Problem 1. Consider a completely randomized design with observations on three treatments coded 1,2,3. For the one-way ANOVA model, determine which of the following are estimable. For those that are estimable, write out the estimable function as and clearly state b1, b2, b3. Finally, for those that are estimable, state the least squares estimator.

1. This can’t be estimated.

#### Problem 2. Recall the soap experiment from Homework 1. Look back at Homework 1 for an explanation of the experiment. The data are the weight lost over 24 hours by different types of soap.

##### (a) Write out the one-way ANOVA model for this experiment.

# Yit = mu + ti + eit  
# i = regular,deodorant,moisturizing  
# t = 1,2,3,4  
# eit~N(0,s^2)  
# Yit -> observation corresponding to i\_th soap\_type and t\_th cube  
# mu -> general effect  
# ti -> additional effect due to i\_th soap\_type

##### (b) By hand or calculator (without using R), obtain the LS estimate for the mean weight lost by acube of deodorant soap. Show all calculations.

# Y\_bar\_deodorant = (2.63+2.61+2.41+3.15)/4 = 2.7  
# Y\_bar = (-0.3-0.1-0.14+0.4+2.63+2.61+2.41+3.15+1.86+2.03+2.26+1.82)/12 = 1.5525  
# LS estimate for the mean weight lost by acube of deodorant soap = 2.7-1.5525 = 1.1475

##### (c) Consider estimating the difference in weight loss between regular soap and any other type of soap.That is, consider estimatingτregular−(τdeodorant+τmoisturizing)/2. Show that this is estimable,and find the LS estimate by hand or calculator. Show all calculations.

# τr-(τd+τm)/2 = 1\*Y\_bar\_r-1/2\*Y\_bar\_d-1/2\*Y\_bar\_m = ∑\_i=1^3 bi(μ+τi) where b1=1,b2=-1/2,b3=-1/2, therefore, it can be estimated   
# Y\_bar\_r = (-0.3-0.1-0.14+0.4)/4 = -0.035  
# Y\_bar\_m = (1.86+2.03+2.26+1.82)/4 = 1.9925  
# Y\_bar\_d = 2.7  
# τ\_regular−(τ\_deodorant+τ\_moisturizing)/2=-0.035-(2.7+1.9925)/2-=2.38125

##### (d) Now use R to obtain the LS estimates in parts (b) and (c). Include your R code and the relevant output in your homework.

type = c(rep("Regular", 4), rep("Deodorant", 4), rep("Moisturizing", 4))  
lost = c(-0.3, -0.1, -0.14, 0.4, 2.63, 2.61, 2.41, 3.15, 1.86, 2.03, 2.26, 1.82)  
soap = data.frame(type, lost)  
soap

## type lost  
## 1 Regular -0.30  
## 2 Regular -0.10  
## 3 Regular -0.14  
## 4 Regular 0.40  
## 5 Deodorant 2.63  
## 6 Deodorant 2.61  
## 7 Deodorant 2.41  
## 8 Deodorant 3.15  
## 9 Moisturizing 1.86  
## 10 Moisturizing 2.03  
## 11 Moisturizing 2.26  
## 12 Moisturizing 1.82

aov.soap = aov(lost~type)  
print(aov.soap)

## Call:  
## aov(formula = lost ~ type)  
##   
## Terms:  
## type Residuals  
## Sum of Squares 16.122050 0.694575  
## Deg. of Freedom 2 9  
##   
## Residual standard error: 0.2778039  
## Estimated effects may be unbalanced

lsm.soap = lsmeans::lsmeans(aov.soap, "type")  
lsm.soap

## type lsmean SE df lower.CL upper.CL  
## Deodorant 2.700 0.139 9 2.386 3.014  
## Moisturizing 1.992 0.139 9 1.678 2.307  
## Regular -0.035 0.139 9 -0.349 0.279  
##   
## Confidence level used: 0.95

mean\_r = mean(soap$lost[soap$type=="Regular"])  
mean\_d = mean(soap$lost[soap$type=="Deodorant"])  
mean\_m = mean(soap$lost[soap$type=="Moisturizing"])  
mean\_all = mean(lost)  
  
# question b  
LS\_d = mean\_d-mean\_all  
LS\_d

## [1] 1.1475

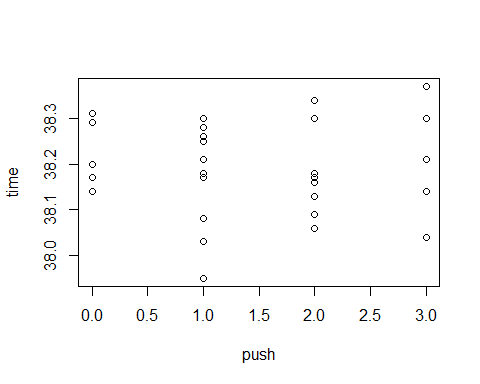
# question c  
LS = mean\_r - 1 / 2 \* (mean\_d + mean\_m)  
LS

## [1] -2.38125

#### Problem 3. Pedestrian light experiment (Larry Lesher, 1985) This experiment questions whether pushing a certain pedestrian light button had an effect on the wait time before the pedestrian light showed “walk.” The treatment factor of interest was the number of pushes of the button, and 32 observations were taken with a mix of 0, 1, 2, and 3 pushes of the button. The waiting times for the “walk” sign are shown in the following table, with r0 = 7, r1 = r2 = 10, r3 = 5 (where the levels of the treatment factor are coded as 0, 1, 2, 3 for simplicity).

##### (a) Plot the waiting times against the number of pushes of the button. What does the plot show?

p0 = c(38.14, 38.2, 38.31, 38.14, 38.29, 38.17, 38.2)  
p1 = c(38.28, 38.17, 38.08, 38.25, 38.18, 38.03, 37.95, 38.26, 38.3, 38.21)  
p2 = c(38.17, 38.13, 38.16, 38.3, 38.34, 38.34, 38.17, 38.18, 38.09, 38.06)  
p3 = c(38.14, 38.3, 38.21, 38.04, 38.37)  
push = c(rep(0, 7), rep(1, 10), rep(2, 10), rep(3, 5))  
time = c(p0, p1, p2, p3)  
exp = data.frame(push,time)  
plot(x = push,y = time)



# No significant difference in the plot

##### (b) Write out the one-way ANOVA model for this experiment.

# Yit = mu+ti+eit  
# i = 0,1,2,3  
# for i=0, t=[1,7]; for i=1, t=[1,10]; for i=2, t=[1,10]; for i=3, t=[1,5];  
# eit~N(0,s^2)  
# Yit -> observation corresponding to i\_th push and t\_th observation  
# mu -> general effect  
# ti -> additional effect due to i\_th push

##### (c) Use R to estimate the mean waiting time for each number of pushes.

m0 = mean(p0)  
m1 = mean(p1)  
m2 = mean(p2)  
m3 = mean(p3)  
m0

## [1] 38.20714

m1

## [1] 38.171

m2

## [1] 38.194

m3

## [1] 38.212

##### (d) Show that the contrast is estimable, and use R to find it’s LS estimate. This contrast compares the effect of no pushes of the button with the effect of pushing the button once.

LS = m1 - m0  
LS

## [1] -0.03614286

##### (e) Show that the contrast(τ1+τ2+τ3)/3−τ0is estimable, and use R to find it’s LS estimate. This contrast compares the effect of no pushes of the button with the effect of pushing the button at least once.

LS = -1 \* m0 + 1 / 3 \* (m1 + m2 + m3)  
LS

## [1] -0.01480952