Chap12

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```
library(xtable)
library(gmodels)
```

We collect the data for each subject for all levels of Factor A and Factor B for each subject.

First, set working directory. 'data' is a table with two columns and same number of rows, and should be numeric. Columns have headers indicating the names of the variables. **User will also input desired variable names in double quotes**

```
data <- read.csv("chap12.csv", header = FALSE, skip = 1)
colnames(data) <- c("b1", "b2")
```

We now combine the observations into one long column (score)

```
colnames(data) <- c("V1", "V2")
score=c(data$V1,data$V2)
```

We now prepare the labels for the 4x5 scores according to the factor levels: a1 a2, a1 a2.....etc for Factor A

```
Learning=gl(2,5*1,5*4*1, labels=c("a1","a2"))
```

b1 b2, b1 b2..... etc for Factor B

```
Testing=gl(2,2*5*1,5*4*1,labels=c("b1","b2"))
```

sub_1 sub_1....., sub_2 sub_2.....,sub_3 sub_3 ....,sub_4 sub_4 ....., sub_5 sub_5....etc for Subjects

```
Subject=gl(5,1,5*4*1, labels=c("sub_1", "sub_2", "sub_3",
                               "sub_4", "sub_5"))
```

We now form a data frame with the dependent variable and the factors, then we print the data

```
data = data.frame(score = score, Learning = factor(Learning),
                  Testing = factor(Testing), Subject = factor(Subject))
knitr::kable(xtable(data))
```

score	Learning	Testing	Subject
34	a1	b1	sub_1
37	a1	b1	sub_2
27	a1	b1	sub_3
43	a1	b1	sub_4
44	a1	b1	sub_5
14	a2	b1	sub_1
21	a2	b1	sub_2
31	a2	b1	sub_3
27	a2	b1	sub_4
32	a2	b1	sub_5

score	Learning	Testing	Subject
18	a1	b2	sub_1
21	a1	b2	sub_2
25	a1	b2	sub_3
37	a1	b2	sub_4
34	a1	b2	sub_5
22	a2	b2	sub_1
25	a2	b2	sub_2
33	a2	b2	sub_3
33	a2	b2	sub_4
42	a2	b2	sub_5

We now perform an anova when "Subject" is considered as a random factor.

```
aov1 = aov(score ~ (Learning * Testing) + Error(Subject /
                                                  (Learning * Testing)), data = data)
```

We now print the results

```
summary(aov(score~Learning*Testing*Subject))
```

```
##                           Df Sum Sq Mean Sq
## Learning                   1     80      80
## Testing                    1     20      20
## Subject                    4    680     170
## Learning:Testing           1    320     320
## Learning:Subject           4    160      40
## Testing:Subject            4     32       8
## Learning:Testing:Subject   4     64      16
```

```
summary(aov1)
```

```
##
## Error: Subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## Residuals  4    680     170
##
## Error: Subject:Learning
##           Df Sum Sq Mean Sq F value Pr(>F)
## Learning   1     80      80       2   0.23
## Residuals  4    160      40
##
## Error: Subject:Testing
##           Df Sum Sq Mean Sq F value Pr(>F)
## Testing    1     20      20     2.5  0.189
## Residuals  4     32       8
##
## Error: Subject:Learning:Testing
##                  Df Sum Sq Mean Sq F value Pr(>F)
## Learning:Testing  1    320     320      20 0.0111 *
## Residuals         4     64      16
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
print(model.tables(aov(score ~ Learning * Testing * Subject,
                       data = data), "means"), digits = 3)
```

```
## Tables of means
## Grand mean
##
## 30
##
##  Learning
## Learning
## a1 a2
## 32 28
##
##  Testing
## Testing
## b1 b2
## 31 29
##
##  Subject
## Subject
## sub_1 sub_2 sub_3 sub_4 sub_5
##    22    26    29    35    38
##
##  Learning:Testing
##          Testing
## Learning b1 b2
##       a1 37 27
##       a2 25 31
##
##  Learning:Subject
##          Subject
## Learning sub_1 sub_2 sub_3 sub_4 sub_5
##       a1 26    29    26    40    39
##       a2 18    23    32    30    37
##
##  Testing:Subject
##         Subject
## Testing sub_1 sub_2 sub_3 sub_4 sub_5
##      b1 24    29    29    35    38
##      b2 20    23    29    35    38
##
##  Learning:Testing:Subject
## , , Subject = sub_1
##
##          Testing
## Learning b1 b2
##       a1 34 18
##       a2 14 22
##
## , , Subject = sub_2
##
##          Testing
## Learning b1 b2
##       a1 37 21
```

```
##       a2 21 25
##
## , , Subject = sub_3
##
##          Testing
## Learning b1 b2
##       a1 27 25
##       a2 31 33
##
## , , Subject = sub_4
##
##          Testing
## Learning b1 b2
##       a1 43 37
##       a2 27 33
##
## , , Subject = sub_5
##
##          Testing
## Learning b1 b2
##       a1 44 34
##       a2 32 42
```