## CHAPTER 9. ANALYSIS OF VARIANCE (TWO-WAY)

9.1. Recap: One-way Analysis of variance

9.2. What is “Two-Way Analysis of Variance”?

9.3. How can I interpret the results of a “Two-way ANOVA”?

1. Example Magazines (Dataset 1)
2. Example Magazines (Dataset 2)
3. Example Magazines (Dataset 3)
4. Example Magazines (Dataset 4)

## Chapter 9: Assignments

1. The director of a university department wishes to see whether there is a difference in the knowledge of students of a course, depending on the teaching method used (1 or 2), and professor that teaches the course (A or B). Four students from each professor and teaching method are randomly selected and they are asked to attend to a single exam. Is there a significant effect of the professor and the teaching method on the student´s results? Which professor and/or method provided the best results?

| | Professor A | Professor B |
|---|---|---|
| **Method 1** | 20, 25, 22, 29 | 30, 32, 35, 29 |
| **Method 2** | 15, 18, 22, 21 | 21, 27, 18, 15 |

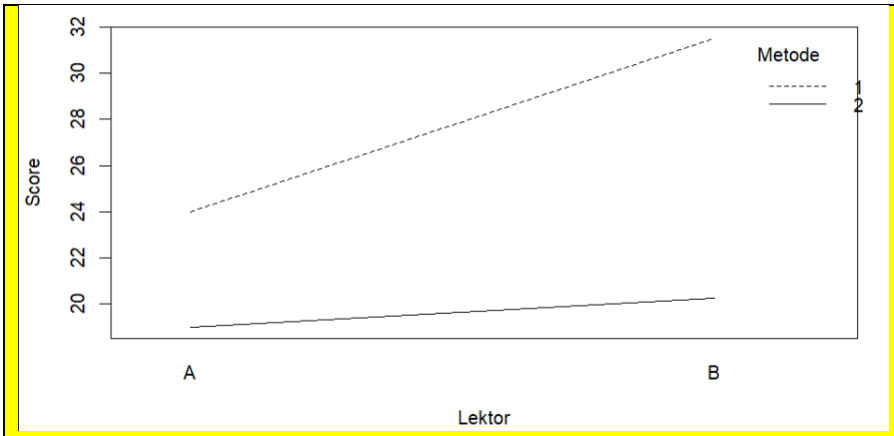
a. Vi starter med at opdele dataet inde i to variabler og en score.

```
"Opgave 1"
Uni <- data.frame(Metode=c("1","1","1","1","1","1","1","1","2","2","2","2","2","2","2","2"),Lektor=c("A","A","A","A","B","B","B","B","A","A","A","A","B","B","B","B"),Score=c(20,25,2
Uni$Metode <- as.factor(Uni$Metode)
Uni$Lektor <- as.factor(Uni$Lektor)
Two_way_anova_Uni <- aov(Score~Metode+Lektor+Metode*Lektor,data=Uni)
summary(Two_way_anova_Uni)
interaction.plot(Uni$Lektor,Uni$Metode,Uni$Score,xlab="Lektor",ylab="Score",trace.label="Metode")
#Vi kan i tilfældet se fra vores interaktionsplot at metode 1 og lektor b er den rigtige kombination!
```

b. Vi får følgende resultater tilbage:

```
> summary(Two_way_anova_Uni)
             Df Sum Sq Mean Sq F value  Pr(>F)
Metode        1 264.06  264.06  18.030 0.00114 **
Lektor        1  76.56   76.56   5.228 0.04120 *
Metode:Lektor 1  39.06   39.06   2.667 0.12838
Residuals    12 175.75   14.65
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

c. Vi får følgende interaktionsplot!




- Vi kan konkludere udefra vores P(<F)-værdier at selve Lektor og Metode er signifikante fordi de befinder sig under 0,05=95%. Hvorimod Metode:Lektor viser det sig til ikke at være signifikante.
- Kigges det overimod, grafen kan det tydeligt ses på højre ende at metode 1 er den bedste kombination med lektor/professor B fordi de er højt oppe i tendenslinjen ☺

2. A gardening company is testing new ways to improve plant growth. Plants are randomly selected and exposed to a combination of two factors, a "Light" in two different strengths and a plant food supplement with two different mineral supplements. After a number of weeks, the plants are measured for growth and the results (in cm) are the following. Which combination of light and supplement provides the best results?

| | Supp. 1 | Supp. 2 |
|---|---|---|
| **Light 1** | 26.7<br>25.2 | 28.6<br>29.3 |
| **Light 2** | 32.3<br>32.8 | 26.1<br>24.2 |

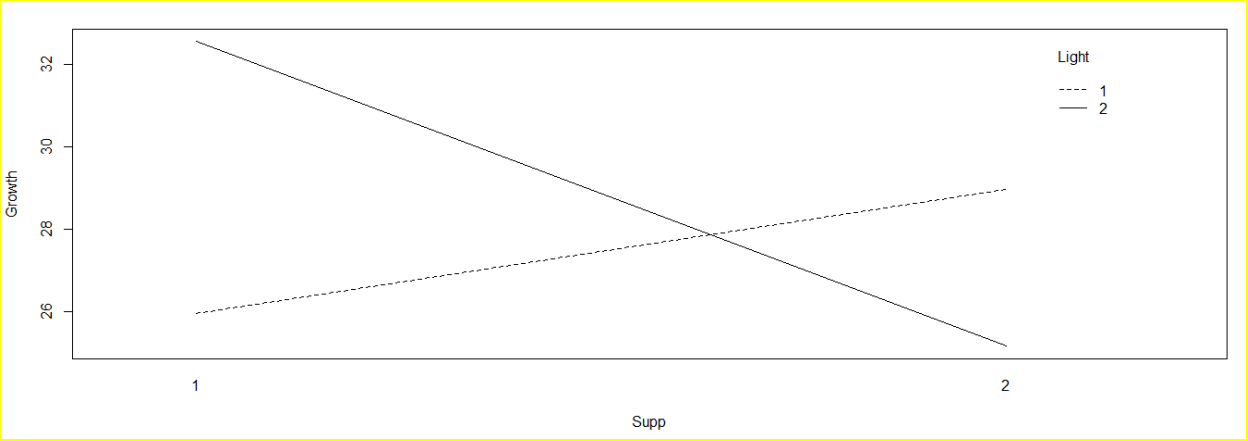
a. Vi starter med at opdele dataet inde i to variabler og en score.

```
"Opgave 2"
Plant <- data.frame(Light=c("1","1","1","1","1","1","1","1","2","2","2","2","2","2","2","2"),Supp=c("A","A","A","A","B","B","B","B","A","A","A","A","B","B","B","B"),Growth=c(26.7,25.
Plant$Light <- as.factor(Plant$Light)
Plant$Supp <- as.factor(Plant$Supp)
Two_way_anova_Plant <- aov(Growth~Light+Supp+Light*Supp,data=Plant)
summary(Two_way_anova_Plant)
interaction.plot(Plant$Light,Plant$Growth,Plant$Supp,xlab="Light",ylab="Growth",trace.label="Supp")
```

b. Vi får følgende resultater tilbage:

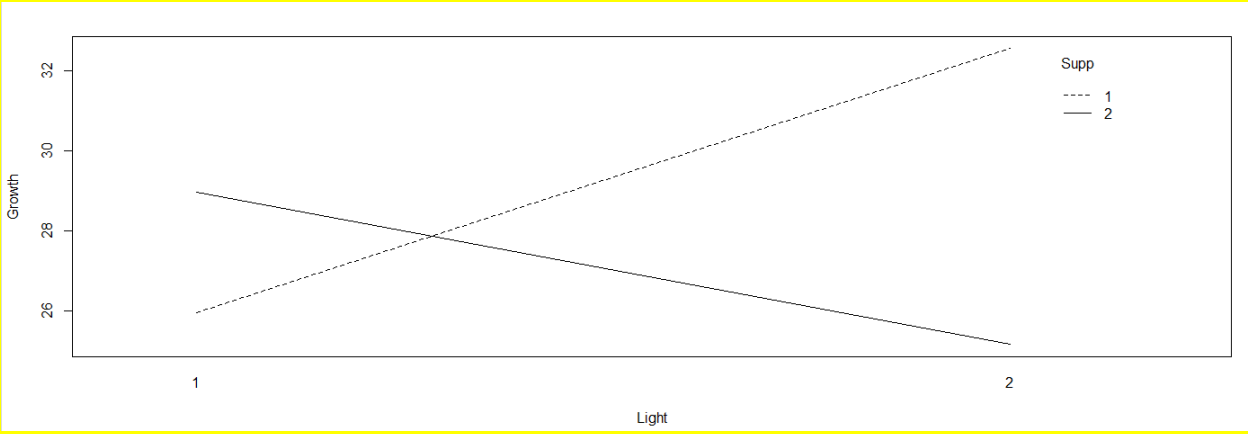
```
> Two_way_anova_Plant <- aov(Growth~Light+Supp+Light*Supp,data=Plant)
> summary(Two_way_anova_Plant)
            Df Sum Sq Mean Sq F value Pr(>F)
Light        1   0.00    0.00   0.000  1.000
Supp         1   7.84    7.84   0.701  0.419
Light:Supp   1   0.00    0.00   0.000  1.000
Residuals   12 134.12   11.18
```

c. Vi får følgende interaktionsplot!




- OBS: Det skal understreges, at fordi grafen er vendt forkert har vi rykket rundt på følgende værdier og derved rettet på grafen!

```
interaction.plot(GrowthPlants$Light, GrowthPlants$Supp, GrowthPlants$Growth, xlab = "Light", ylab ="Growth", trace.label="Supp")
```




3. Two types of paint (A and B) were tested to see how many months they lasted before it began to peel. They were tested in two climatic conditions to study the effects of climate on the paint. Each group contained five test panels. At α=0.01, analyze the data shown. Which paint lasts longer and in which climate?

| | Climate 1 | Climate 2 |
|---|---|---|
| **Paint A** | 60, 53, 58, 62, 57 | 58, 66, 68, 76, 80 |
| **Paint B** | 36, 41, 54, 65, 53 | 58, 63, 79, 55, 66 |

a. Vi starter med at opdele dataet inde i to variabler og en score.

```
"Opgave 3"
Klima <- data.frame(Paint=c("A","A","A","A","A","A","A","A","A","A","B","B","B","B","B","B","B","B","B","B"),Climate=c("1","1","1","1","1","2","2","2","2","2","1","1","1","1","1","2","2","2","2","2"),Peel=c
Klima$Paint <- as.factor(Klima$Paint)
Klima$Climate <- as.factor(Klima$Climate)
Two_way_anova_Klima <- aov(Peel~Paint+Climate+Paint+Climate,data=Klima)
summary(Two_way_anova_Klima)
interaction.plot(Klima$Climate,Plant$Peel,Plant$Paint,xlab="Climate",ylab="Peel",trace.label="Paint")
```

b. Vi får følgende resultater tilbage:

```
> Two_way_anova_Klima <- aov(Peel~Paint+Climate+Paint*Climate,data=Klima)
> summary(Two_way_anova_Klima)
             Df Sum Sq Mean Sq F value  Pr(>F)
Paint         1  231.2   231.2   3.035 0.10067
Climate       1  845.0   845.0  11.093 0.00424 **
Paint:Climate 1    9.8     9.8   0.129 0.72452
Residuals    16 1218.8    76.2
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

c. Vi får følgende interaktionsplot!