

Analyzing Sensory and Consumer Data : the salmon case study

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Preface

The data are provided courtesy from participants to the European project EU-ROSALMON -Improved quality of smoked salmon for the European consumer (MATRA - Technological Institute of Iceland, Iceland; IFREMER - Institut Français de Recherche pour l'Exploitation de la Mer, France; IMR - Institute of Marine Research, Norway; ADRIANT, France) (See Ph. Courcoux (2006)).

Chapter 1

Understanding the data from a product perspective

1.1 Understanding the products from a chemical and physical point of view

In the following code, we first import the data with the **read.delim2** function, then we print the first rows with the **head** function ; finally we make a summary of the dataset with the **summary** function. All these steps are really important when you begin you analysis.

```
salmon_car <- read.delim2("salmon_characteristics.txt",  
header=TRUE, row.names=1, comment.char="#",dec="," ,stringsAsFactors=TRUE)  
head(salmon_car)
```

```
##           water  lipid  TVBN    TMA    salt  phenol    pH  
## prod1_Fr -0.8644  1.1375 -0.7629 -0.8717 -0.1471 -0.3776  1.5412  
## prod2_Fr -1.1476  0.7036  0.2357  0.3204  0.1626  0.0112  1.2098  
## prod3_Fr -0.4172  0.3378  0.4354  1.2144  0.3174  0.4001  0.3812  
## prod4_Scot -0.8147 -0.0961 -0.5632 -0.8717  0.3174 -0.4554  0.2154  
## prod5_Ger -1.6991  0.0366 -0.7629 -0.8717  2.1752 -0.3776 -0.2817  
## prod6_Ire -0.9886  0.9653 -0.7629 -0.8717  0.0077  0.6594  1.0441  
##           total.viable.count  lactic.flora  lactobacilli  brochothrix  yeast  
## prod1_Fr           0.1112           0.6665           1.1382           0.5461  0.7729  
## prod2_Fr           0.4302          -0.4514           0.1290          -0.7559  1.2034  
## prod3_Fr           0.8225           0.8725           0.4088           0.6465  0.2875  
## prod4_Scot        -0.2432          -1.5861          -1.0624          -0.7559 -1.0340  
## prod5_Ger        -1.5584          -1.5861          -1.0624          -0.7559 -1.0340
```

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```
## prod6_Ire          -2.5977      -1.5861      -1.0624      -0.7559 -1.0340
##      enterobacteriaceae      L      a      b      origin
## prod1_Fr          0.8314  0.9917 -0.6467 -0.4567      France
## prod2_Fr          0.5998  0.8542  0.5297  0.9551      France
## prod3_Fr          0.2524 -0.8548  0.3927  0.2813      France
## prod4_Scot        -1.5793  0.3020  1.7439  3.3236 Scotland
## prod5_Ger         -0.9582 -1.3485  0.7341  0.5485      Germany
## prod6_Ire         -1.5793 -0.4322  0.4016  0.4278      Ireland
```

```
summary(salmon_car)
```

```
##      water      lipid      TVBN      TMA
## Min.      :-1.69910  Min.      :-2.4628000  Min.      :-1.1623  Min.      :-0.8717000
## 1st Qu.: -0.85198  1st Qu.: -0.4259750  1st Qu.: -0.7629  1st Qu.: -0.8717000
## Median : -0.07435  Median : 0.2159000  Median : -0.3635  Median : -0.2757000
## Mean      : -0.00001  Mean      : 0.0000067  Mean      : 0.0000  Mean      : 0.0000033
## 3rd Qu.: 0.47713  3rd Qu.: 0.5763000  3rd Qu.: 0.4354  3rd Qu.: 0.5439000
## Max.      : 2.02730  Max.      : 1.6251000  Max.      : 2.6322  Max.      : 2.4065000
##
##      salt      phenol      pH      total.viable.count
## Min.      :-2.0049  Min.      :-1.20730  Min.      :-1.7733000  Min.      :-2.5977000
## 1st Qu.: -0.6115  1st Qu.: -0.65633  1st Qu.: -0.8617500  1st Qu.: -0.3530250
## Median : 0.0077  Median : -0.29985  Median : -0.0331500  Median : 0.2699000
## Mean      : 0.0000  Mean      : 0.00001  Mean      : -0.0000067  Mean      : 0.0000067
## 3rd Qu.: 0.3174  3rd Qu.: 0.40010  3rd Qu.: 0.8368750  3rd Qu.: 0.8187750
## Max.      : 2.4848  Max.      : 3.45930  Max.      : 2.0384000  Max.      : 1.1384000
##
##      lactic.flora      lactobacilli      brochothrix
## Min.      :-1.5861000  Min.      :-1.0624000  Min.      :-0.7559
## 1st Qu.: -0.4710500  1st Qu.: -1.0624000  1st Qu.: -0.7559
## Median : 0.3886500  Median : 0.2064500  Median : -0.7559
## Mean      : 0.0000033  Mean      : -0.0000067  Mean      : 0.0000
## 3rd Qu.: 0.8312750  3rd Qu.: 0.9333500  3rd Qu.: 0.8192
## Max.      : 1.5327000  Max.      : 1.9639000  Max.      : 2.4632
##
##      yeast      enterobacteriaceae      L      a
## Min.      :-1.0340000  Min.      :-1.57930  Min.      :-1.8353  Min.      :-3.9939
## 1st Qu.: -1.0340000  1st Qu.: -0.65815  1st Qu.: -0.8034  1st Qu.: -0.4152
## Median : 0.2608000  Median : 0.04190  Median : 0.1441  Median : 0.2868
## Mean      : 0.0000033  Mean      : -0.00001  Mean      : 0.0000  Mean      : 0.0000
## 3rd Qu.: 0.7537750  3rd Qu.: 0.79060  3rd Qu.: 0.5455  3rd Qu.: 0.5362
## Max.      : 2.1072000  Max.      : 1.64720  Max.      : 2.5982  Max.      : 1.7439
##
##      b      origin
## Min.      :-1.827700  France :8
```


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```
## 1st Qu.: -0.577750    Germany:6
## Median : 0.073650    UK      :4
## Mean   : -0.000003    Belgium:3
## 3rd Qu.: 0.388475    DK      :3
## Max.   : 3.323600    Ireland:3
##                               (Other):3
```

As you can see in the output, something is missing in the description of the variable *origin*. By default, the numbers of levels to be displayed is equal to 7. Let's set the argument *maxsum* to 8 and see what happens.

```
summary(salmon_car,maxsum=8)
```

```
##      water      lipid      TVBN      TMA
## Min.   : -1.69910   Min.   : -2.4628000   Min.   : -1.1623   Min.   : -0.8717000
## 1st Qu.: -0.85198   1st Qu.: -0.4259750   1st Qu.: -0.7629   1st Qu.: -0.8717000
## Median : -0.07435   Median : 0.2159000   Median : -0.3635   Median : -0.2757000
## Mean   : -0.00001   Mean    : 0.0000067   Mean    : 0.0000   Mean    : 0.0000033
## 3rd Qu.: 0.47713   3rd Qu.: 0.5763000   3rd Qu.: 0.4354   3rd Qu.: 0.5439000
## Max.   : 2.02730   Max.    : 1.6251000   Max.    : 2.6322   Max.    : 2.4065000
##
##
##      salt      phenol      pH      total.viable.count
## Min.   : -2.0049   Min.   : -1.20730   Min.   : -1.7733000   Min.   : -2.5977000
## 1st Qu.: -0.6115   1st Qu.: -0.65633   1st Qu.: -0.8617500   1st Qu.: -0.3530250
## Median : 0.0077   Median : -0.29985   Median : -0.0331500   Median : 0.2699000
## Mean   : 0.0000   Mean    : 0.00001   Mean    : -0.0000067   Mean    : 0.0000067
## 3rd Qu.: 0.3174   3rd Qu.: 0.40010   3rd Qu.: 0.8368750   3rd Qu.: 0.8187750
## Max.   : 2.4848   Max.    : 3.45930   Max.    : 2.0384000   Max.    : 1.1384000
##
##
##      lactic.flora      lactobacilli      brochothrix
## Min.   : -1.5861000   Min.   : -1.0624000   Min.   : -0.7559
## 1st Qu.: -0.4710500   1st Qu.: -1.0624000   1st Qu.: -0.7559
## Median : 0.3886500   Median : 0.2064500   Median : -0.7559
## Mean   : 0.0000033   Mean    : -0.0000067   Mean    : 0.0000
## 3rd Qu.: 0.8312750   3rd Qu.: 0.9333500   3rd Qu.: 0.8192
## Max.   : 1.5327000   Max.    : 1.9639000   Max.    : 2.4632
##
##
##      yeast      enterobacteriaceae      L      a
## Min.   : -1.0340000   Min.   : -1.57930   Min.   : -1.8353   Min.   : -3.9939
## 1st Qu.: -1.0340000   1st Qu.: -0.65815   1st Qu.: -0.8034   1st Qu.: -0.4152
## Median : 0.2608000   Median : 0.04190   Median : 0.1441   Median : 0.2868
## Mean   : 0.0000033   Mean    : -0.00001   Mean    : 0.0000   Mean    : 0.0000
```

```
## 3rd Qu.: 0.7537750 3rd Qu.: 0.79060 3rd Qu.: 0.5455 3rd Qu.: 0.5362
## Max. : 2.1072000 Max. : 1.64720 Max. : 2.5982 Max. : 1.7439
##
##
##          b          origin
## Min.   :-1.827700 Belgium :3
## 1st Qu.: -0.577750 DK      :3
## Median : 0.073650 France  :8
## Mean    :-0.000003 Germany :6
## 3rd Qu.: 0.388475 Ireland :3
## Max.    : 3.323600 Italy   :1
##          Scotland:2
##          UK      :4
```

Now we want to get a multivariate description of the smoked salmons based on their chemical and physical measurements. As all the measures (except *origin*) are continuous, we're going to run a PCA on the dataset. It seems fair to consider all the variables as *active*, and to scale them to unit variance. Here, the last variable *origin* is considered as *illustrative*.

To do so, we are using the **FactoMineR** package and the **PCA** function. First, load the **FactoMineR** package and run the **PCA** function.

```
library(FactoMineR)
res <- PCA(salmon_car, quali.sup=17, graph=F)
names(res)
```

```
## [1] "eig"      "var"      "ind"      "svd"      "quali.sup" "call"
```

When you run a PCA, you often want to save the results in an R object, in order to use them latter. This is what we did: we saved them in an object we named *res*, then we applied the **names** function to that object. This function allows you to obtain the names of the different components of the input. For instance, if you want to see of the variance is decomposed:

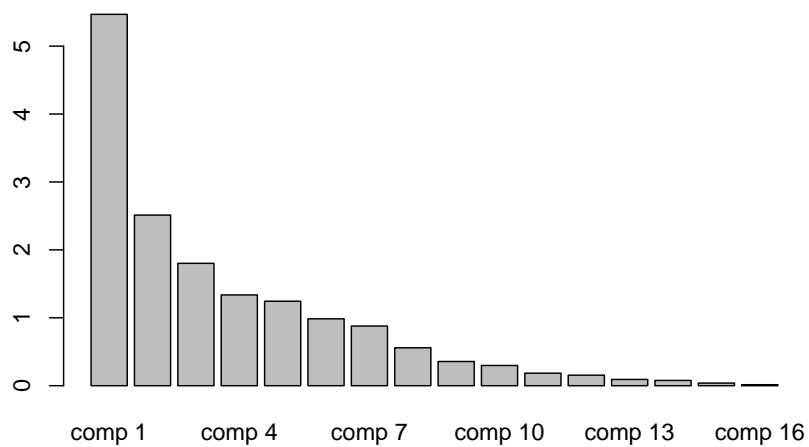
```
res$eig
```

```
##          eigenvalue percentage of variance cumulative percentage of variance
## comp 1  5.46821199          34.17632493          34.17632
## comp 2  2.51222592          15.70141202          49.87774
## comp 3  1.80173714          11.26085714          61.13859
## comp 4  1.33622262           8.35139136          69.48999
## comp 5  1.24367295           7.77295594          77.26294
## comp 6  0.98474448           6.15465300          83.41759
## comp 7  0.87880761           5.49254757          88.91014
```

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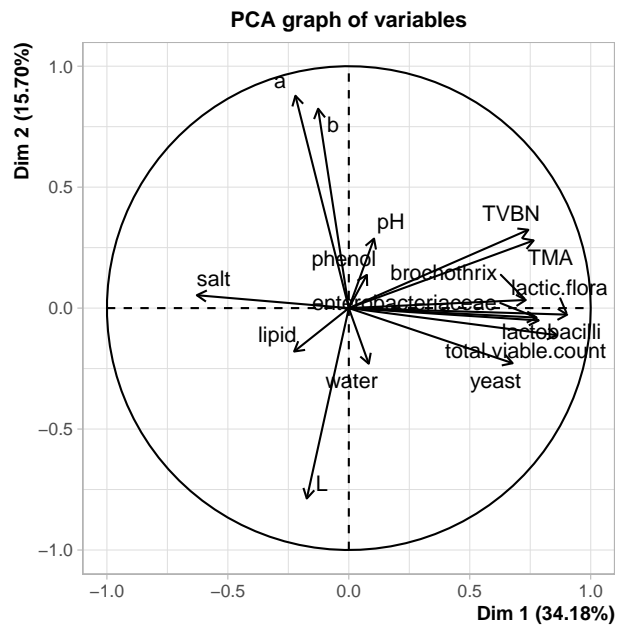
## comp 8	0.55820900	3.48880625	92.39895
## comp 9	0.35637332	2.22733324	94.62628
## comp 10	0.29787183	1.86169893	96.48798
## comp 11	0.18417610	1.15110061	97.63908
## comp 12	0.15473811	0.96711318	98.60619
## comp 13	0.09236742	0.57729636	99.18349
## comp 14	0.07795966	0.48724787	99.67074
## comp 15	0.03834453	0.23965332	99.91039
## comp 16	0.01433732	0.08960828	100.00000

```
barplot(res$eig[,1])
```

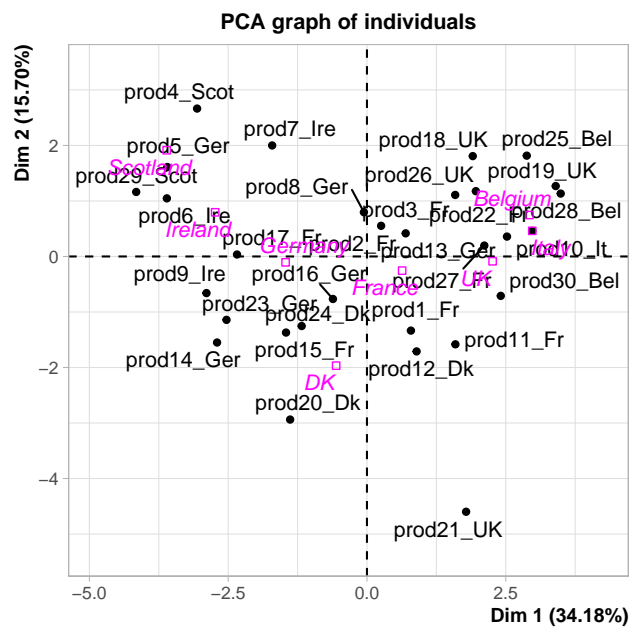


Now, let's see what happens if we run the **plot.PCA** function to the *res* object.

```
plot.PCA(res,choix="var")
```

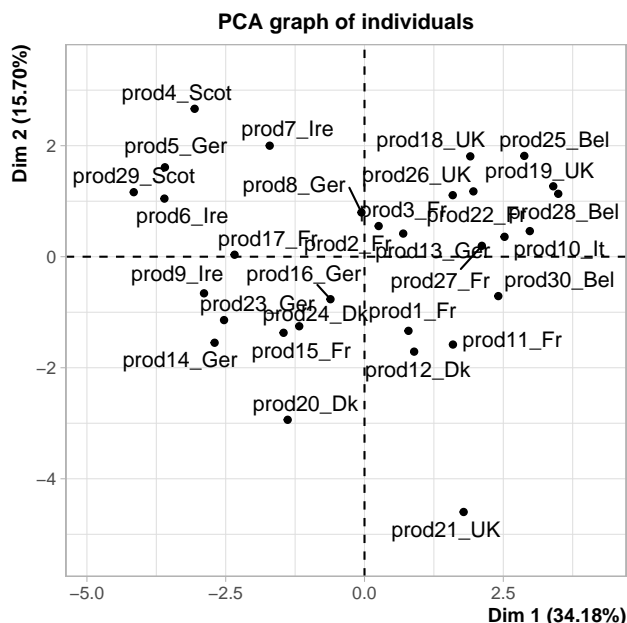


```
plot.PCA(res, choix="ind")
```



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```
plot.PCA(res,choix="ind",invisible="quali")
```



As you can see, some news feature have been added to the **FactoMineR** package, notably the *ggplot* type representation of the individuals and the variables. In this example, we can see how important *supplementary* variables can be. We can also see how they can be represented, which is the case by default. Here, we projected the information on the origin of the smoked salmon. Look at the product 10, how do you think this product is salty?

Any questions about the concept of *illustrative* variables? What do you think about the percentage associated with each axis?

Now that we know how to differentiate *illustrative* or *supplementary* variables from the *active* ones, let's spend some time to interpret this PCA. As you know, the two graphical representations have to be interpreted jointly.

You may want to use the **dimdesc** function to get an interpretation of the axis.

```
resdim <- dimdesc(res)
names(resdim)
```

```
## [1] "Dim.1" "Dim.2" "Dim.3" "call"
```

```
resdim$Dim.1
```

```
## $quanti
##               correlation      p.value
## lactic.flora      0.9027708 9.041485e-12
## total.viable.count 0.8608419 1.046362e-09
## lactobacilli      0.7850662 2.795050e-07
## enterobacteriaceae 0.7762724 4.619296e-07
## TMA               0.7642286 8.873792e-07
## TVBN             0.7421954 2.668420e-06
## brochothrix       0.7317464 4.332436e-06
## yeast            0.6773779 3.930677e-05
## salt             -0.6282864 2.011201e-04
##
## $quali
##               R2      p.value
## origin 0.7348005 3.964817e-05
##
## $category
##               Estimate      p.value
## origin=Belgium  2.871677 0.02182312
## origin=UK       2.208683 0.03851838
## origin=Ireland -2.788912 0.03325308
## origin=Scotland -3.662799 0.02354381
##
## attr(,"class")
## [1] "condes" "list"
```

Now, you can try to explore the dataset in a more dynamical manner. What is the difference between this,

```
library(explor)
res <- PCA(salmon_car, quali.sup=17, graph=F)
explor(res)
```

and this?

```
res <- PCA(salmon_car[, -17], graph=F)
explor(res)
```

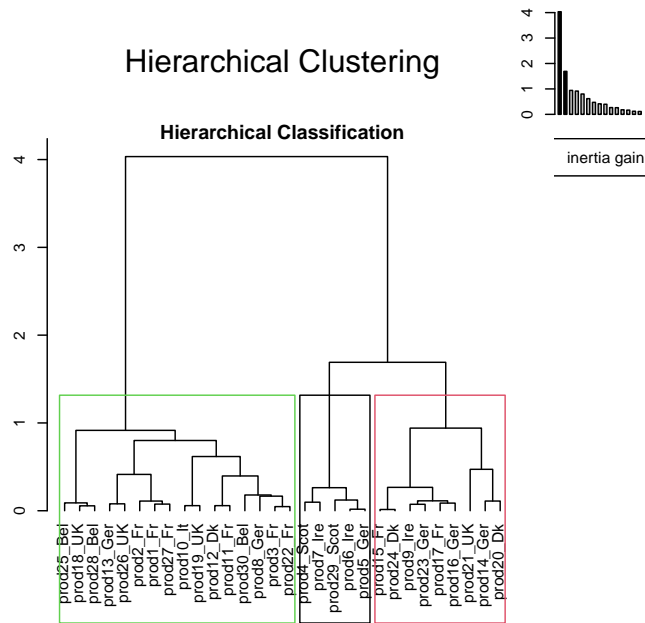
Exercise. You can play with the different arguments of the **PCA** and the **plot.PCA** functions.

Remark. PCA, by extracting dimensions, can be seen as a method to summarize the data, or more precisely the relations amongst the variables of your dataset. Some people would say that by running a PCA you cluster variables into dimensions. It's very convenient, because you simplify your understanding

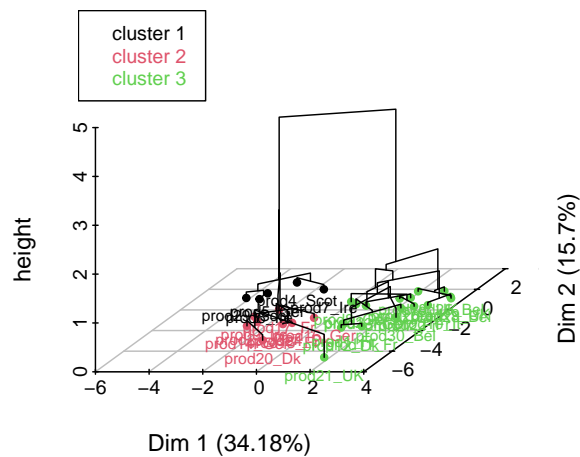
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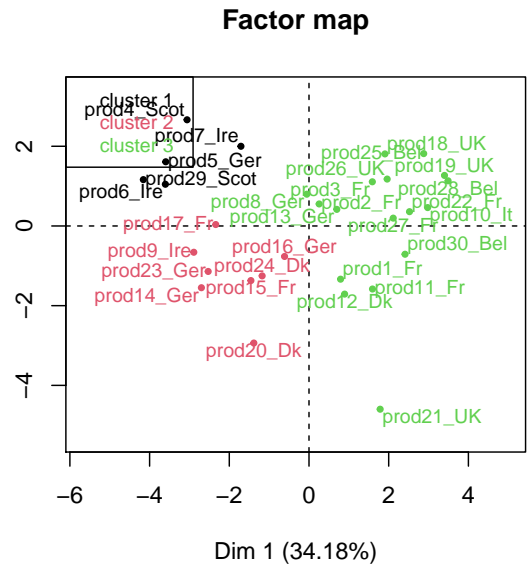
by using a few dimensions instead of all the variables. You could do the same thing with the individuals. Instead of reducing the complexity on your variables, you will reduce the complexity on the individuals.

```
reshcpc <- HCPC(res,nb.clust=3)
```



Hierarchical clustering on the factor map





```
names(reshcpc)

## [1] "data.clust" "desc.var" "desc.axes" "desc.ind" "call"

names(reshcpc$desc.var)

## [1] "test.chi2" "category" "quanti.var" "quanti" "call"

names(reshcpc$desc.var$quanti)

## [1] "1" "2" "3"

reshcpc$desc.var$quanti$`1`
```

##	v.test	Mean in category	Overall mean	sd in category
## b	2.967108	1.23202	-3.333333e-06	1.1663873
## salt	2.404836	0.99856	-1.457168e-17	1.0973584
## a	2.291474	0.95148	-3.700743e-18	0.4806493
## TMA	-2.099319	-0.87170	3.333333e-06	0.0000000
## yeast	-2.490229	-1.03400	3.333333e-06	0.0000000
## water	-2.519590	-1.04622	-1.000000e-05	0.5634578

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```
## enterobacteriaceae -3.052957          -1.26770 -1.000000e-05      0.3944804
## lactic.flora       -3.077490          -1.27786  3.333333e-06      0.6164800
## total.viable.count -3.819886          -1.58612  6.666667e-06      0.9248322
##                      Overall sd      p.value
## b                   0.9999991 0.0030061550
## salt                1.0000064 0.0161797401
## a                   0.9999972 0.0219360319
## TMA                 1.0000099 0.0357888054
## yeast              0.9999921 0.0127660659
## water              1.0000067 0.0117491490
## enterobacteriaceae 1.0000148 0.0022659864
## lactic.flora       1.0000041 0.0020875189
## total.viable.count 1.0000033 0.0001335133
```

```
reshcpc$desc.var$quanti$`2`
```

```
##                      v.test Mean in category Overall mean sd in category Overall sd
## L                   2.442596      0.7521750 -1.619075e-18      0.5146511 0.9999999
## water              2.241235      0.6901625 -1.000000e-05      0.9409535 1.0000067
## lactic.flora      -2.264032     -0.6971875  3.333333e-06      0.7459357 1.0000041
## TMA               -2.291215     -0.7055625  3.333333e-06      0.2520950 1.0000099
## b                 -2.309972     -0.7113375 -3.333333e-06      0.4989181 0.9999991
## TVBN              -2.396348     -0.7379375 -1.966020e-17      0.3225866 1.0000055
## brochothrix       -2.454675     -0.7559000 -5.551115e-18      0.0000000 1.0000069
## lactobacilli      -2.903449     -0.8941125 -6.666667e-06      0.4452469 1.0000168
##                      p.value
## L                   0.014582067
## water              0.025010865
## lactic.flora       0.023572148
## TMA                0.021950968
## b                  0.020889703
## TVBN               0.016559366
## brochothrix        0.014101201
## lactobacilli       0.003690765
```

```
reshcpc$desc.var$quanti$`3`
```

```
##                      v.test Mean in category Overall mean sd in category
## lactic.flora         4.334916      0.7039353  3.333333e-06      0.4319264
## total.viable.count   4.055101      0.6585000  6.666667e-06      0.3942778
## lactobacilli         3.996881      0.6490412 -6.666667e-06      0.7748847
## enterobacteriaceae   3.794019      0.6160941 -1.000000e-05      0.6448174
## TMA                  3.623520      0.5884176  3.333333e-06      0.9648019
## yeast                3.602067      0.5849235  3.333333e-06      0.8154801
```

```
## brochothrix      3.559652      0.5780412 -5.551115e-18      0.9968236
## TVBN             3.303261      0.5364059 -1.966020e-17      1.0210896
## salt            -3.148943     -0.5113471 -1.457168e-17      0.6917277
##                Overall sd      p.value
## lactic.flora      1.0000041 1.458157e-05
## total.viable.count 1.0000033 5.011257e-05
## lactobacilli      1.0000168 6.418262e-05
## enterobacteriaceae 1.0000148 1.482285e-04
## TMA               1.0000099 2.906203e-04
## yeast            0.9999921 3.156966e-04
## brochothrix      1.0000069 3.713463e-04
## TVBN             1.0000055 9.556725e-04
## salt            1.0000064 1.638622e-03
```

Instead of having 30 smoked salmons, we now have 3 groups of salmons: that's how we reduce the complexity of our problem.

Let's use a very interesting output of our **HCPC** function, and play with it.

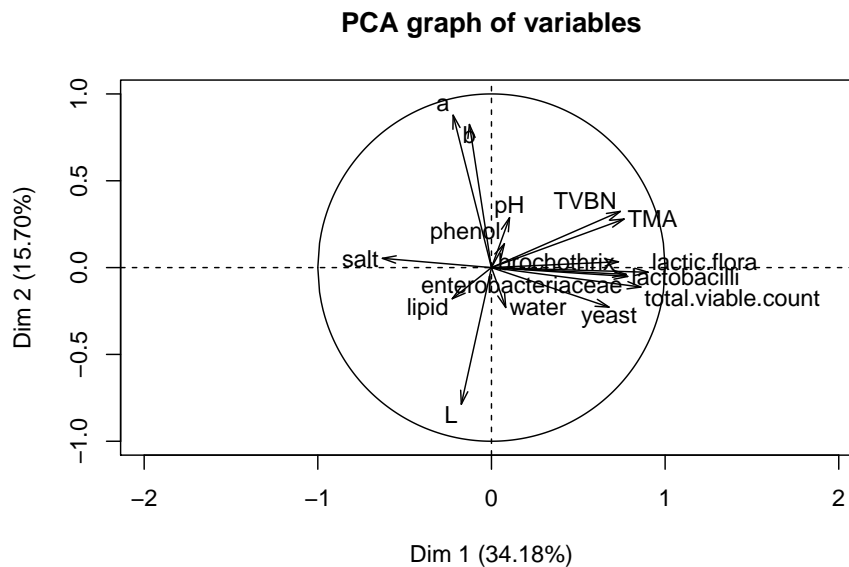
```
summary(reshcpc$data.clust)
```

```
##      water      lipid      TVBN      TMA
## Min.   :-1.69910  Min.   :-2.4628000  Min.   :-1.1623  Min.   :-0.8717000
## 1st Qu.: -0.85198  1st Qu.: -0.4259750  1st Qu.: -0.7629  1st Qu.: -0.8717000
## Median :-0.07435  Median : 0.2159000  Median :-0.3635  Median :-0.2757000
## Mean   :-0.00001  Mean   : 0.0000067  Mean   : 0.0000  Mean   : 0.0000033
## 3rd Qu.: 0.47713  3rd Qu.: 0.5763000  3rd Qu.: 0.4354  3rd Qu.: 0.5439000
## Max.    : 2.02730  Max.    : 1.6251000  Max.    : 2.6322  Max.    : 2.4065000
##
##      salt      phenol      pH      total.viable.count
## Min.   :-2.0049  Min.   :-1.20730  Min.   :-1.7733000  Min.   :-2.5977000
## 1st Qu.: -0.6115  1st Qu.: -0.65633  1st Qu.: -0.8617500  1st Qu.: -0.3530250
## Median : 0.0077   Median :-0.29985  Median :-0.0331500  Median : 0.2699000
## Mean   : 0.0000   Mean   : 0.00001  Mean   :-0.0000067  Mean   : 0.0000067
## 3rd Qu.: 0.3174   3rd Qu.: 0.40010  3rd Qu.: 0.8368750  3rd Qu.: 0.8187750
## Max.    : 2.4848   Max.    : 3.45930  Max.    : 2.0384000  Max.    : 1.1384000
##
##      lactic.flora      lactobacilli      brochothrix
## Min.   :-1.5861000  Min.   :-1.0624000  Min.   :-0.7559
## 1st Qu.: -0.4710500  1st Qu.: -1.0624000  1st Qu.: -0.7559
## Median : 0.3886500   Median : 0.2064500   Median :-0.7559
## Mean   : 0.0000033   Mean   :-0.0000067   Mean   : 0.0000
## 3rd Qu.: 0.8312750   3rd Qu.: 0.9333500   3rd Qu.: 0.8192
## Max.    : 1.5327000   Max.    : 1.9639000   Max.    : 2.4632
##
```

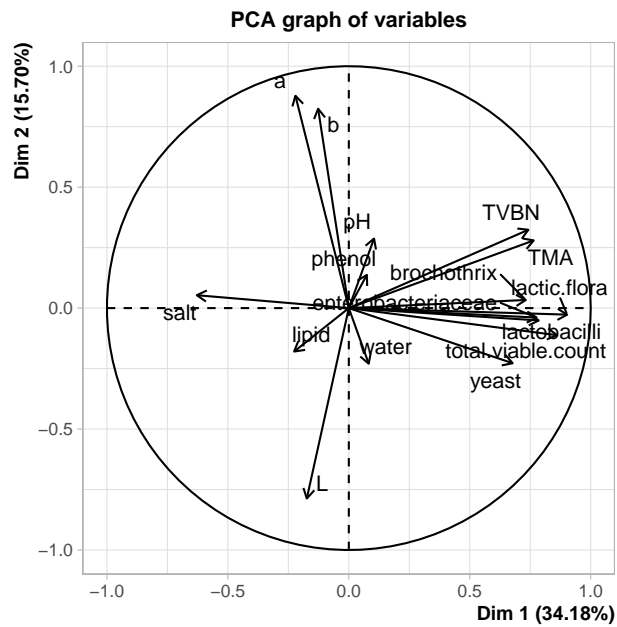
1.1. UNDERSTANDING THE PRODUCTS FROM A CHEMICAL AND PHYSICAL POINT OF VIEW19

```
##      yeast      enterobacteriaceae      L      a
## Min.   :-1.0340000 Min.   :-1.57930 Min.   :-1.8353 Min.   :-3.9939
## 1st Qu.: -1.0340000 1st Qu.: -0.65815 1st Qu.: -0.8034 1st Qu.: -0.4152
## Median : 0.2608000 Median : 0.04190 Median : 0.1441 Median : 0.2868
## Mean   : 0.0000033 Mean   :-0.00001 Mean   : 0.0000 Mean   : 0.0000
## 3rd Qu.: 0.7537750 3rd Qu.: 0.79060 3rd Qu.: 0.5455 3rd Qu.: 0.5362
## Max.   : 2.1072000 Max.   : 1.64720 Max.   : 2.5982 Max.   : 1.7439
##
##      b      origin clust
## Min.   :-1.827700 France :8 1: 5
## 1st Qu.: -0.577750 Germany:6 2: 8
## Median : 0.073650 UK      :4 3:17
## Mean   :-0.000003 Belgium:3
## 3rd Qu.: 0.388475 DK      :3
## Max.   : 3.323600 Ireland:3
##      (Other):3
```

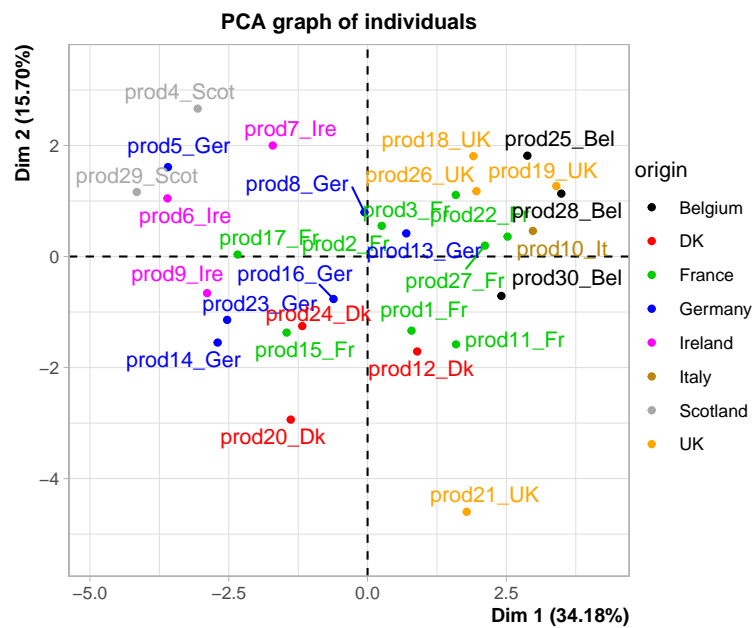
```
res <- PCA(reshcpc$data.clust,quali.sup=c(17,18),graph=F)
plot.PCA(res,choix="var",graph.type = "classic")
```



```
plot.PCA(res,choix="var",graph.type = "ggplot")
```

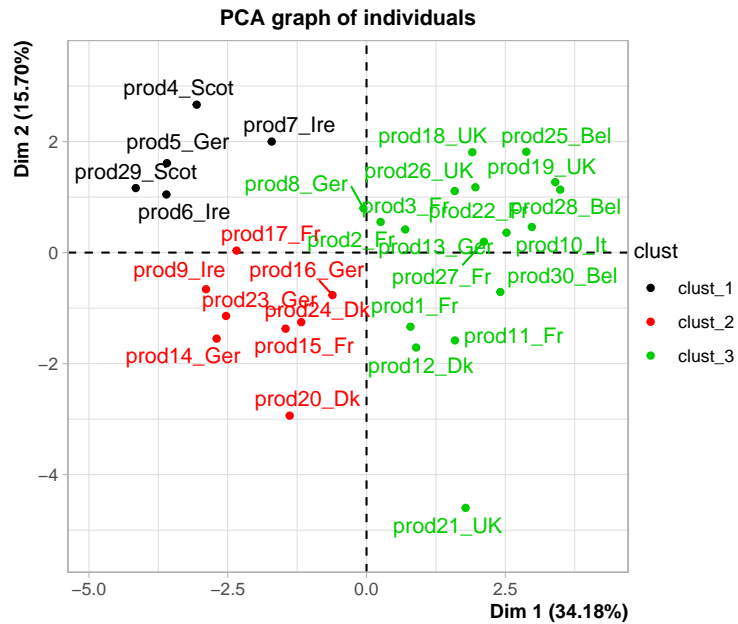


```
plot.PCA(res, choix="ind", invisible="quali", habillage = 17)
```

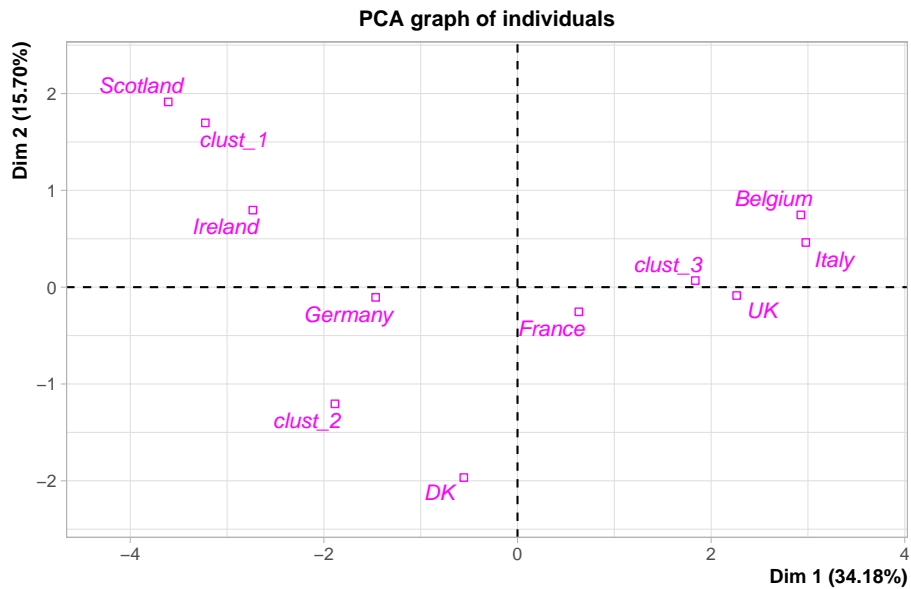


1.1. UNDERSTANDING THE PRODUCTS FROM A CHEMICAL AND PHYSICAL POINT OF VIEW21

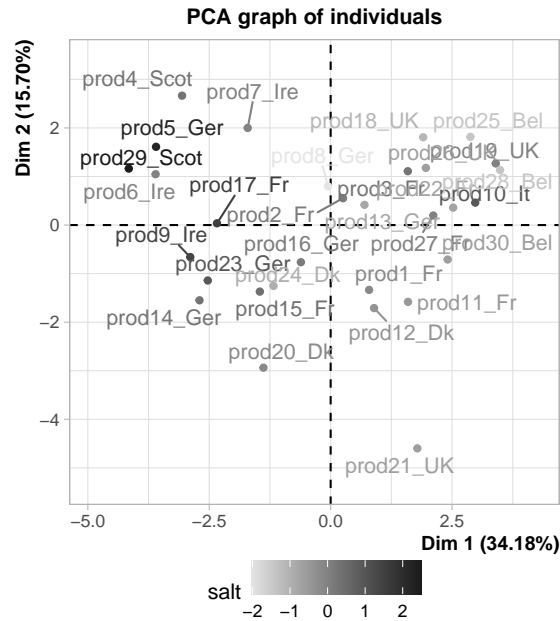
```
plot.PCA(res,choix="ind",invisible="quali",habillage = 18)
```



```
plot.PCA(res,choix="ind",invisible="ind")
```



```
plot(res, habillage="salt", ggoptions=list(low.col.quanti="grey90", high.col.quanti="grey",
legend=list(x="bottom"), invisible = "quali")
```



Exercise. This exercise is very important as it presents two very useful functions of the **FactoMineR** package.

```
descfreq(table(reshcpc$data.clust$clust, reshcpc$data.clust$origin))
catdes(reshcpc$data.clust, num.var=18)
```

To understand the code, you should first run this:

```
table(reshcpc$data.clust$clust, reshcpc$data.clust$origin)
colnames(reshcpc$data.clust)
```

Exercise. Please, provide a description of the French salmons.

1.2 Understanding the products from a hedonic point of view

This part will be more easy than the first one, now that you know how to run R functions. The only complicated thing is the dataset we're going to use.

1.2. UNDERSTANDING THE PRODUCTS FROM A HEDONIC POINT OF VIEW²³

```
salmon_hedo_conso <- read.delim2("salmon_hedo_conso.txt", header=TRUE, row.names=1, comment.char=
colnames(salmon_hedo_conso)
```

```
##      [1] "IKIDEN"                "Country"
##      [3] "prod1_Fr"              "prod2_Fr"
##      [5] "prod3_Fr"              "prod4_Scot"
##      [7] "prod5_Ger"             "prod6_Ire"
##      [9] "prod7_Ire"             "prod8_Ger"
##     [11] "prod9_Ire"             "prod10_It"
##     [13] "prod11_Fr"             "prod12_Dk"
##     [15] "prod13_Ger"            "prod14_Ger"
##     [17] "prod15_Fr"             "prod16_Ger"
##     [19] "prod17_Fr"             "prod18_UK"
##     [21] "prod19_UK"             "prod20_Dk"
##     [23] "prod21_UK"             "prod22_Fr"
##     [25] "prod23_Ger"            "prod24_Dk"
##     [27] "prod25_Bel"            "prod26_UK"
##     [29] "prod27_Fr"             "prod28_Bel"
##     [31] "prod29_Scot"           "prod30_Bel"
##     [33] "Who"                   "Frequence"
##     [35] "When"                  "Taste"
##     [37] "Healthy"               "Pleasure"
##     [39] "No.preparation"        "Ways"
##     [41] "Guest"                 "Authentic"
##     [43] "Not.expensive"         "Supermarket"
##     [45] "Deli"                  "Caterer"
##     [47] "Fish.shop"             "Market"
##     [49] "Mobile.van"            "Everyday"
##     [51] "Special"               "Day.snack"
##     [53] "Evening.snack"         "Aperitif"
##     [55] "Starter"               "Salad"
##     [57] "Cooked.meal"           "Sandwich"
##     [59] "Main"                  "Vegetable"
##     [61] "Lemon"                 "Bread..butter"
##     [63] "Lemon..bread..butter"  "C..fraiche"
##     [65] "C..fraiche.with.herbs" "Fresh.cheese"
##     [67] "Fresh.cheese.with.herbs" "Shallots"
##     [69] "Mustard"               "Butter"
##     [71] "Black.pepper"          "Horseradish"
##     [73] "Scottish"              "Norwegian"
##     [75] "Atlantic"              "Irish"
##     [77] "Wild"                  "Do.not.know"
##     [79] "Colour"                "Price"
##     [81] "Origin"                "Brand"
##     [83] "Advertising"           "Glossiness"
```

```
## [85] "Packaging"          "Labelling.information"
## [87] "Number.slices"      "Weight"
## [89] "Use.by.date"        "Usual.brand"
## [91] "Appetising"         "Firm"
## [93] "Regular"            "Nice.colour"
## [95] "Nice.odour"         "Smooth.texture"
## [97] "Firm.texture"       "Greasy.mouth"
## [99] "Characteristic.taste" "Not.too.salty"
```

```
salmon_hedo <- salmon_hedo_conso[,3:32]
head(salmon_hedo)
```

```
##      prod1_Fr prod2_Fr prod3_Fr prod4_Scot prod5_Ger prod6_Ire prod7_Ire
## 5101Lyon  0.5433  0.5433 -0.0187  0.5433  0.5433  -0.0187  1.1054
## 5102Lyon  0.4685 -0.3123  0.4685  0.4685  1.2494  -1.0932 -0.3123
## 5103Lyon  0.4354  1.3683 -0.9641  0.4354  1.3683  -0.4976  0.4354
## 5106Lyon  1.6920  1.6920  0.6004  1.1462  0.6004  -0.4912 -1.0371
## 5107Lyon  0.6167 -0.2056  0.2056  -0.6167 -1.4389  0.6167  0.6167
## 5108Lyon -0.0165  0.9714 -1.9922  0.9714 -1.0043  0.9714 -0.5104
##      prod8_Ger prod9_Ire prod10_It prod11_Fr prod12_Dk prod13_Ger
## 5101Lyon -0.5808  0.5433 -0.5808  -0.0187 -2.8290  0.5433
## 5102Lyon  1.2494  0.4685 -0.3123  1.2494  0.4685  -0.3123
## 5103Lyon -0.4976  0.4354 -0.9641  -0.9641 -0.0311 -0.0311
## 5106Lyon -1.5829  0.6004  0.0546  -0.4912  0.0546 -1.5829
## 5107Lyon  0.2056  1.0278  0.6167  -0.6167  0.6167  1.0278
## 5108Lyon  1.4653  0.4775 -0.5104  1.4653  0.4775  0.4775
##      prod14_Ger prod15_Fr prod16_Ger prod17_Fr prod18_UK prod19_UK
## 5101Lyon -1.7049 -1.7049  -1.1428  1.6674  -0.0187  0.5433
## 5102Lyon  1.2494 -2.6550  1.2494  -1.8741  -1.0932  0.4685
## 5103Lyon -0.9641  0.9019  -2.3635  0.4354  -1.8970  0.4354
## 5106Lyon -1.0371  0.6004  0.0546  -1.0371  -1.5829 -1.0371
## 5107Lyon  0.2056 -1.8500  -0.6167  0.6167  0.6167  1.0278
## 5108Lyon  0.9714  0.4775  -0.0165  0.4775  -1.9922 -1.4983
##      prod20_Dk prod21_UK prod22_Fr prod23_Ger prod24_Dk prod25_Bel
## 5101Lyon -0.5808  1.1054  1.6674  -0.5808  0.5433  0.5433
## 5102Lyon -1.0932  0.4685  1.2494  -1.0932 -1.0932  0.4685
## 5103Lyon  0.9019  0.4354 -1.4305  0.4354  0.9019  1.3683
## 5106Lyon -0.4912  1.6920  0.0546  1.1462  0.6004  -0.4912
## 5107Lyon  1.4389 -1.4389  1.0278  1.4389 -1.8500 -1.0278
## 5108Lyon -0.5104 -0.5104 -0.5104  1.4653 -1.0043 -0.0165
##      prod26_UK prod27_Fr prod28_Bel prod29_Scot prod30_Bel
## 5101Lyon -0.0187 -1.1428  -0.5808  1.1054  -0.0187
## 5102Lyon -0.3123 -0.3123  -0.3123  1.2494  -0.3123
## 5103Lyon -0.4976 -0.0311  1.3683  0.9019  -1.4305
## 5106Lyon  0.0546 -1.0371  -0.4912  0.0546  1.6920
```


1.2. UNDERSTANDING THE PRODUCTS FROM A HEDONIC POINT OF VIEW²⁵

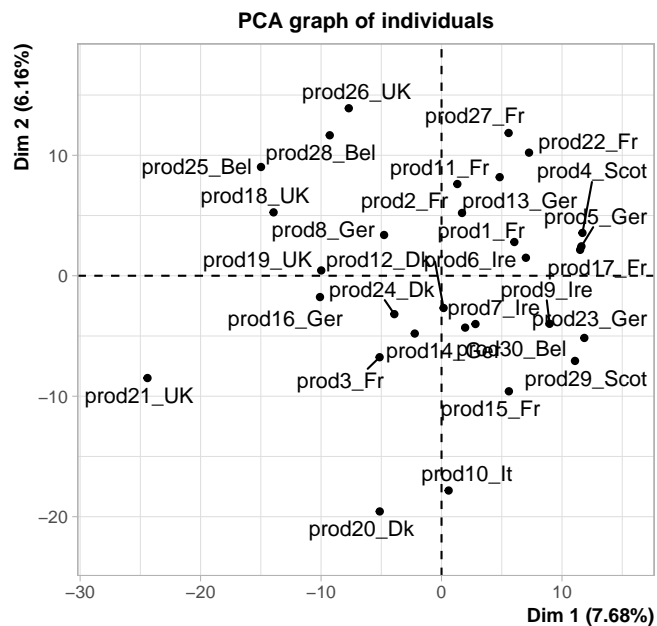
```
## 5107Lyon    -0.6167   -1.0278   -1.8500     0.6167     0.6167
## 5108Lyon    -1.0043   -0.0165   -1.4983     0.9714     0.9714
```

```
summary(salmon_hedo)
```

```
##      prod1_Fr      prod2_Fr      prod3_Fr      prod4_Scot
## Min.   :-2.1360   Min.   :-3.72220   Min.   :-2.7302   Min.   :-2.1235
## 1st Qu.: -0.3774   1st Qu.: -0.68700   1st Qu.: -0.9501   1st Qu.: -0.3297
## Median :  0.3375   Median :  0.13755   Median : -0.1479   Median :  0.3313
## Mean   :  0.2452   Mean   :  0.04939   Mean   : -0.1508   Mean   :  0.2508
## 3rd Qu.:  0.9498   3rd Qu.:  0.86118   3rd Qu.:  0.6817   3rd Qu.:  0.9079
## Max.   :  2.9666   Max.   :  2.26040   Max.   :  2.2639   Max.   :  2.6550
##      prod5_Ger      prod6_Ire      prod7_Ire      prod8_Ger
## Min.   :-2.5337   Min.   :-2.4287   Min.   :-3.1814   Min.   :-2.88000
## 1st Qu.: -0.4006   1st Qu.: -0.5253   1st Qu.: -0.9135   1st Qu.: -0.85177
## Median :  0.4531   Median :  0.2530   Median : -0.1530   Median :  0.08645
## Mean   :  0.2866   Mean   :  0.1304   Mean   : -0.1728   Mean   : -0.02451
## 3rd Qu.:  1.0272   3rd Qu.:  0.8346   3rd Qu.:  0.5827   3rd Qu.:  0.83683
## Max.   :  2.2748   Max.   :  2.3256   Max.   :  2.1494   Max.   :  2.47150
##      prod9_Ire      prod10_It      prod11_Fr      prod12_Dk
## Min.   :-5.3852   Min.   :-3.1743   Min.   :-3.230300   Min.   :-3.33710
## 1st Qu.: -0.4916   1st Qu.: -1.1219   1st Qu.: -0.753850   1st Qu.: -0.80768
## Median :  0.3034   Median : -0.3754   Median :  0.084350   Median :  0.11725
## Mean   :  0.1769   Mean   : -0.3395   Mean   : -0.005055   Mean   :  0.01955
## 3rd Qu.:  0.9271   3rd Qu.:  0.4337   3rd Qu.:  0.777050   3rd Qu.:  0.86140
## Max.   :  2.1506   Max.   :  2.6033   Max.   :  2.221300   Max.   :  2.23290
##      prod13_Ger      prod14_Ger      prod15_Fr      prod16_Ger
## Min.   :-2.3088   Min.   :-2.268400   Min.   :-2.99480   Min.   :-2.8800
## 1st Qu.: -0.5555   1st Qu.: -0.804800   1st Qu.: -0.79033   1st Qu.: -1.0654
## Median :  0.2975   Median :  0.082850   Median :  0.05575   Median : -0.1009
## Mean   :  0.1776   Mean   :  0.001343   Mean   : -0.03593   Mean   : -0.1462
## 3rd Qu.:  0.9225   3rd Qu.:  0.786775   3rd Qu.:  0.75270   3rd Qu.:  0.7339
## Max.   :  2.5355   Max.   :  2.171200   Max.   :  2.92530   Max.   :  2.5916
##      prod17_Fr      prod18_UK      prod19_UK      prod20_Dk
## Min.   :-3.1593   Min.   :-4.7616   Min.   :-3.02240   Min.   :-2.9866
## 1st Qu.: -0.5062   1st Qu.: -1.0661   1st Qu.: -0.96808   1st Qu.: -1.0533
## Median :  0.3222   Median : -0.0846   Median :  0.01865   Median : -0.2525
## Mean   :  0.2043   Mean   : -0.1246   Mean   : -0.06525   Mean   : -0.2454
## 3rd Qu.:  0.9367   3rd Qu.:  0.8095   3rd Qu.:  0.83368   3rd Qu.:  0.5702
## Max.   :  2.2967   Max.   :  2.4062   Max.   :  2.17190   Max.   :  2.2533
##      prod21_UK      prod22_Fr      prod23_Ger      prod24_Dk
## Min.   :-3.2295   Min.   :-2.5573   Min.   :-2.7796   Min.   :-2.9200
## 1st Qu.: -1.3330   1st Qu.: -0.3786   1st Qu.: -0.5193   1st Qu.: -0.9318
## Median : -0.6263   Median :  0.4188   Median :  0.3100   Median : -0.1135
## Mean   : -0.4891   Mean   :  0.2796   Mean   :  0.2141   Mean   : -0.1635
```


1.2. UNDERSTANDING THE PRODUCTS FROM A HEDONIC POINT OF VIEW²⁷

```
plot.PCA(res, choix="ind")
```



Here, we've transposed the dataset, which means that the statistical individuals are now the smoked salmons, and not the consumers any more: salmons are described by the preferences provided by the consumers.

Exercise. How can you get a better representation of the variables?

Chapter 2

Understanding the data from a consumer perspective

2.1 Playing with R and the data

In this part, the analyses are not going to be too complicated, but you will see that data manipulation and visualization is not simple when you deal with categorical variables. Please install and load the two following packages.

```
install.packages("questionr")  
install.packages("dataMaid")
```

```
library(questionr)  
library(dataMaid)
```

Exercise. Comment on the different ways of describing the data.

```
summary(salmon_hedo_conso)  
str(salmon_hedo_conso)  
describe(salmon_hedo_conso)  
describe(salmon_hedo_conso[,32:40])
```

In the following part, we're going to change the names of the variables as well as their labels, to change the order of the levels of a given factor of interest as well as their value ; finally, we're going to plot a categorical variable, in a simple way and in a more complicated way.

```
#Manipulating data
#Names of the variables
colnames(salmon_hedo_conso)
```

```
## [1] "IKIDEN" "Country"
## [3] "prod1_Fr" "prod2_Fr"
## [5] "prod3_Fr" "prod4_Scot"
## [7] "prod5_Ger" "prod6_Ire"
## [9] "prod7_Ire" "prod8_Ger"
## [11] "prod9_Ire" "prod10_It"
## [13] "prod11_Fr" "prod12_Dk"
## [15] "prod13_Ger" "prod14_Ger"
## [17] "prod15_Fr" "prod16_Ger"
## [19] "prod17_Fr" "prod18_UK"
## [21] "prod19_UK" "prod20_Dk"
## [23] "prod21_UK" "prod22_Fr"
## [25] "prod23_Ger" "prod24_Dk"
## [27] "prod25_Bel" "prod26_UK"
## [29] "prod27_Fr" "prod28_Bel"
## [31] "prod29_Scot" "prod30_Bel"
## [33] "Who" "Frequence"
## [35] "When" "Taste"
## [37] "Healthy" "Pleasure"
## [39] "No.preparation" "Ways"
## [41] "Guest" "Authentic"
## [43] "Not.expensive" "Supermarket"
## [45] "Deli" "Caterer"
## [47] "Fish.shop" "Market"
## [49] "Mobile.van" "Everyday"
## [51] "Special" "Day.snack"
## [53] "Evening.snack" "Aperitif"
## [55] "Starter" "Salad"
## [57] "Cooked.meal" "Sandwich"
## [59] "Main" "Vegetable"
## [61] "Lemon" "Bread..butter"
## [63] "Lemon..bread..butter" "C..fraiche"
## [65] "C..fraiche.with.herbs" "Fresh.cheese"
## [67] "Fresh.cheese.with.herbs" "Shallots"
## [69] "Mustard" "Butter"
## [71] "Black.pepper" "Horseradish"
## [73] "Scottish" "Norwegian"
## [75] "Atlantic" "Irish"
## [77] "Wild" "Do.not.know"
## [79] "Colour" "Price"
## [81] "Origin" "Brand"
```

```
## [83] "Advertising"           "Glossiness"
## [85] "Packaging"             "Labelling.information"
## [87] "Number.slices"         "Weight"
## [89] "Use.by.date"           "Usual.brand"
## [91] "Appetising"            "Firm"
## [93] "Regular"               "Nice.colour"
## [95] "Nice.odour"             "Smooth.texture"
## [97] "Firm.texture"          "Greasy.mouth"
## [99] "Characteristic.taste"  "Not.too.salty"
```

```
colnames(salmon_hedo_conso)[62] <- "Bread, butter"
colnames(salmon_hedo_conso)[63] <- "Lemon, bread, butter"
colnames(salmon_hedo_conso)[64] <- "Crème fraîche"
colnames(salmon_hedo_conso)[65] <- "Crème fraîche with herbs"
colnames(salmon_hedo_conso)[66] <- "Fresh cheese"
colnames(salmon_hedo_conso)[100] <- "Not too salty"
colnames(salmon_hedo_conso)
```

```
## [1] "IKIDEN"                "Country"
## [3] "prod1_Fr"              "prod2_Fr"
## [5] "prod3_Fr"              "prod4_Scot"
## [7] "prod5_Ger"             "prod6_Ire"
## [9] "prod7_Ire"             "prod8_Ger"
## [11] "prod9_Ire"             "prod10_It"
## [13] "prod11_Fr"             "prod12_Dk"
## [15] "prod13_Ger"            "prod14_Ger"
## [17] "prod15_Fr"             "prod16_Ger"
## [19] "prod17_Fr"             "prod18_UK"
## [21] "prod19_UK"             "prod20_Dk"
## [23] "prod21_UK"             "prod22_Fr"
## [25] "prod23_Ger"            "prod24_Dk"
## [27] "prod25_Bel"            "prod26_UK"
## [29] "prod27_Fr"             "prod28_Bel"
## [31] "prod29_Scot"           "prod30_Bel"
## [33] "Who"                   "Frequence"
## [35] "When"                  "Taste"
## [37] "Healthy"               "Pleasure"
## [39] "No.preparation"        "Ways"
## [41] "Guest"                 "Authentic"
## [43] "Not.expensive"         "Supermarket"
## [45] "Deli"                  "Caterer"
## [47] "Fish.shop"             "Market"
## [49] "Mobile.van"            "Everyday"
## [51] "Special"               "Day.snack"
## [53] "Evening.snack"         "Aperitif"
```

```
## [55] "Starter" "Salad"
## [57] "Cooked.meal" "Sandwich"
## [59] "Main" "Vegetable"
## [61] "Lemon" "Bread, butter"
## [63] "Lemon, bread, butter" "Crème fraîche"
## [65] "Crème fraîche with herbs" "Fresh cheese"
## [67] "Fresh.cheese.with.herbs" "Shallots"
## [69] "Mustard" "Butter"
## [71] "Black.pepper" "Horseradish"
## [73] "Scottish" "Norwegian"
## [75] "Atlantic" "Irish"
## [77] "Wild" "Do.not.know"
## [79] "Colour" "Price"
## [81] "Origin" "Brand"
## [83] "Advertising" "Glossiness"
## [85] "Packaging" "Labelling.information"
## [87] "Number.slices" "Weight"
## [89] "Use.by.date" "Usual.brand"
## [91] "Appetising" "Firm"
## [93] "Regular" "Nice.colour"
## [95] "Nice.odour" "Smooth.texture"
## [97] "Firm.texture" "Greasy.mouth"
## [99] "Characteristic.taste" "Not too salty"
```

#Labels of the variables

```
library(labelled)
str(salmon_hedo_conso$Pleasure)
```

```
## Factor w/ 5 levels "Comp. Agree",...: 1 1 1 1 1 1 1 1 3 3 ...
```

```
var_label(salmon_hedo_conso$Pleasure) <- "I eat smoked salmon because it is a product v
var_label(salmon_hedo_conso$Pleasure)
```

```
## [1] "I eat smoked salmon because it is a product which gives me pleasure"
```

```
str(salmon_hedo_conso$Pleasure)
```

```
## Factor w/ 5 levels "Comp. Agree",...: 1 1 1 1 1 1 1 1 3 3 ...
```

```
## - attr(*, "label")= chr "I eat smoked salmon because it is a product which gives m
```

#Changing the order of the levels

#Before

```
levels(salmon_hedo_conso$Pleasure)
```



```
## [1] "Comp. Agree" "Comp. Disa." "Most. Agree" "Most. Disa." "Neither"
```

```
describe(salmon_hedo_conso$Pleasure)
```

```
## [1062 obs.] I eat smoked salmon because it is a product which gives me pleasure
## nominal factor: "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. A
## 5 levels: Comp. Agree | Comp. Disa. | Most. Agree | Most. Disa. | Neither
## NAs: 0 (0%)
##
##           n      %
## Comp. Agree  509  47.9
## Comp. Disa.   16   1.5
## Most. Agree  386  36.3
## Most. Disa.   27   2.5
## Neither      124  11.7
## Total        1062 100.0
```

```
#plot(salmon_hedo_conso$Pleasure)
```

```
#After
```

```
salmon_hedo_conso$Pleasure <- factor(salmon_hedo_conso$Pleasure, levels=c("Comp. Disa.", "Most. Di
levels(salmon_hedo_conso$Pleasure)
```

```
## [1] "Comp. Disa." "Most. Disa." "Neither"      "Most. Agree" "Comp. Agree"
```

```
describe(salmon_hedo_conso$Pleasure)
```

```
## [1062 obs.]
## nominal factor: "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. Agree" "Comp. A
## 5 levels: Comp. Disa. | Most. Disa. | Neither | Most. Agree | Comp. Agree
## NAs: 0 (0%)
##
##           n      %
## Comp. Disa.   16   1.5
## Most. Disa.   27   2.5
## Neither      124  11.7
## Most. Agree  386  36.3
## Comp. Agree  509  47.9
## Total        1062 100.0
```

```
#plot(salmon_hedo_conso$Pleasure)
```

You may also want to use this interactive alternative.

```
iorder(salmon_hedo_conso,"Who")
```

Now, let's have a look at some graphical representation.

```
#Graphical representation (level 1)
salmon_hedo_conso$Country[1:100]
```

```
## [1] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [16] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [31] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [46] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [61] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [76] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## [91] Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon Lyon
## 11 Levels: Bremerhaven BXL F Lyon Milan Munchen Nantes Rome Sittingbourne ... Whitl
```

```
#plot(salmon_hedo_conso$Country)
```

Exercise. Please, comment on this alternative.

```
#table uses the cross-classifying factors to build a contingency table of the counts a
bp <- table(salmon_hedo_conso$Country)
bp
barplot(bp)
bp <- sort(bp,decreasing = F)
bp
barplot(bp)
```

Exercise. Please, run the following code.

```
#When crossing two variables
plot(saumon_hedo_conso$"Bread, butter")
plot(saumon_hedo_conso$"Bread, butter",saumon_hedo_conso$prod2)
```

Now, let's have a look at a more professional graphical output.

```
#Graphical representation (level 2)
bp <- table(salmon_hedo_conso$Country)
bp <- sort(bp,decreasing = F)
#Step 1
par(omi=c(0.65,0.25,0.75,0.75) ,mai=c(0.3,2,0.35,0) ,mgp=c(3,3,0) , las=1)
x <- barplot(bp,names.arg=F,horiz=T,border=NA,xlim=c(0,120) , col="grey" , cex.names=0.8)
```

```

for (i in 1:length(bp))
{
  text(-18,x[i],names(bp)[i],xpd=T,adj=1,cex=0.85)
  text(-3.5,x[i],bp[i],xpd=T,adj=1,cex=0.85)
}
rect(0,-0.5,20,28,col=rgb(191,239,255,80, maxColorValue=255), border=NA)
rect(20,-0.5,40,28,col=rgb(191,239,255,120, maxColorValue=255), border=NA)
rect(40,-0.5,60,28,col=rgb(191,239,255,80,maxColorValue=255), border=NA)
rect(60,-0.5,80,28,col=rgb(191,239,255,120, maxColorValue=255), border=NA)
rect(80,-0.5,100,28, col=rgb(191,239,255,80, maxColorValue =255), border=NA)
rect(100,-0.5,120,28, col=rgb(191,239,255,80, maxColorValue =255), border=NA)

myValue2<-c(0,0,73,0,0,0,0,0,113,0,0)
myColour2 <-rgb(255,0,210, maxColorValue =255)
x2<- barplot(myValue2,names.arg=F,horiz=T,border=NA,xlim=c(0,120),col=myColour2,cex.names=0.85,ax

```

#Step 2

```

m <- mean(bp) #The mean function
arrows(m,-0.5,m,14, lwd=1.5,length=0,xpd=T,col="skyblue3")
arrows(m,-0.5,m,-0.75,lwd=3,length=0,xpd=T)
arrows(m,14,m,14.25, lwd=3,length=0,xpd=T)
text(m-18,14.5,"Average",adj=1,xpd=T,cex=0.65,font=3)
text(m-3,14.5,"96.5",adj=1,xpd=T,cex=0.65,font=4)

```

#Step 3

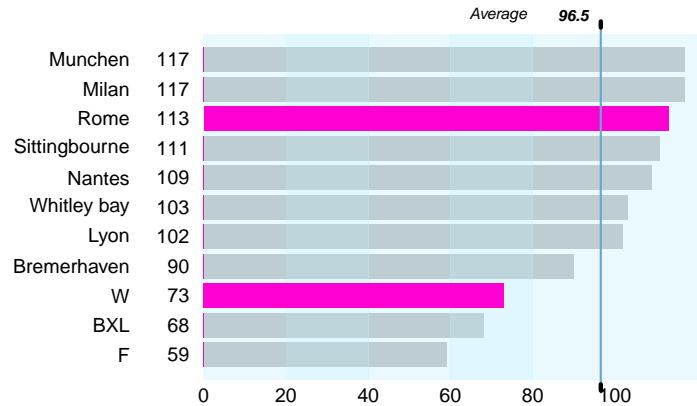
```

mtext(c(0,20,40,60,80,100) ,at=c(0,20,40,60,80,100),1,line=0,cex=0.80)
mtext("European survey on consumers habits",3,line=1.3,adj=0,cex=1.1,outer=T)
mtext("European project EUROSALMON",3,line=-0.4,adj=0,cex=0.9,outer=T)
mtext("MATRA - IFREMER - ADRIANT",1,line=1,adj=1.0,cex=0.65,outer=T,font=3)

```

European survey on consumers habits

European project EUROSALMON



MATRA – IFREMER – ADRIANT

2.2 Understanding the consumers' behaviour

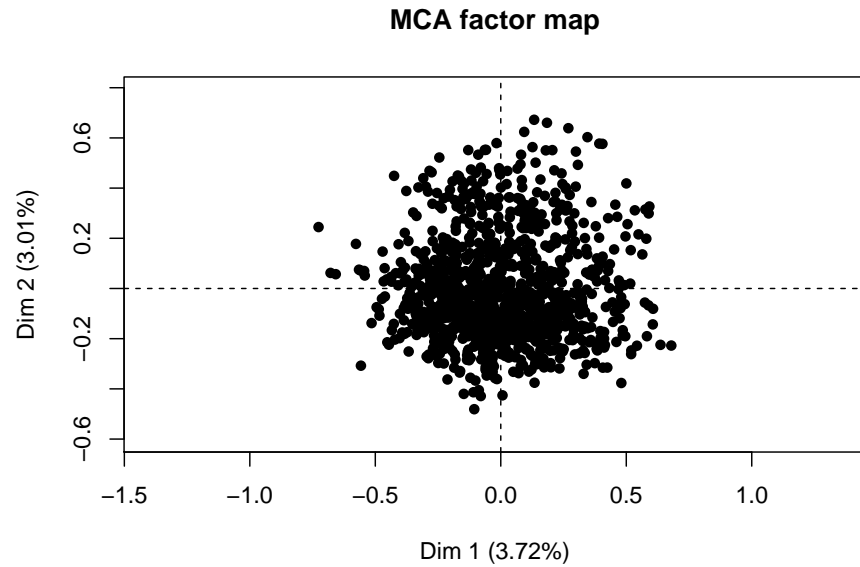
In this part, we're going to play with the questionnaire data. These data are categorical, and you have to use a specific method for these particular data: Multiple Correspondence Analysis (MCA).

```
colnames(salmon_hedo_conso)
```

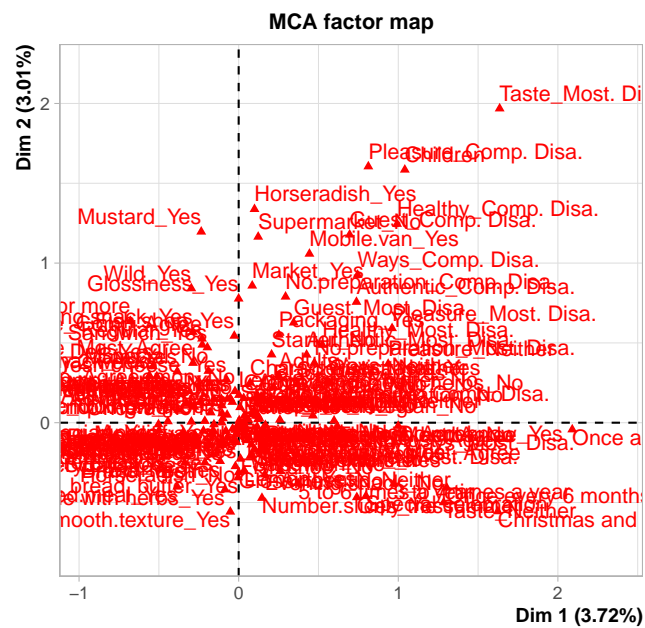
```
## [1] "IKIDEN" "Country"
## [3] "prod1_Fr" "prod2_Fr"
## [5] "prod3_Fr" "prod4_Scot"
## [7] "prod5_Ger" "prod6_Ire"
## [9] "prod7_Ire" "prod8_Ger"
## [11] "prod9_Ire" "prod10_It"
## [13] "prod11_Fr" "prod12_Dk"
## [15] "prod13_Ger" "prod14_Ger"
## [17] "prod15_Fr" "prod16_Ger"
## [19] "prod17_Fr" "prod18_UK"
## [21] "prod19_UK" "prod20_Dk"
## [23] "prod21_UK" "prod22_Fr"
## [25] "prod23_Ger" "prod24_Dk"
## [27] "prod25_Bel" "prod26_UK"
## [29] "prod27_Fr" "prod28_Bel"
```

##	[31]	"prod29_Scot"	"prod30_Bel"
##	[33]	"Who"	"Frequence"
##	[35]	"When"	"Taste"
##	[37]	"Healthy"	"Pleasure"
##	[39]	"No.preparation"	"Ways"
##	[41]	"Guest"	"Authentic"
##	[43]	"Not.expensive"	"Supermarket"
##	[45]	"Deli"	"Caterer"
##	[47]	"Fish.shop"	"Market"
##	[49]	"Mobile.van"	"Everyday"
##	[51]	"Special"	"Day.snack"
##	[53]	"Evening.snack"	"Aperitif"
##	[55]	"Starter"	"Salad"
##	[57]	"Cooked.meal"	"Sandwich"
##	[59]	"Main"	"Vegetable"
##	[61]	"Lemon"	"Bread, butter"
##	[63]	"Lemon, bread, butter"	"Crème fraîche"
##	[65]	"Crème fraîche with herbs"	"Fresh cheese"
##	[67]	"Fresh.cheese.with.herbs"	"Shallots"
##	[69]	"Mustard"	"Butter"
##	[71]	"Black.pepper"	"Horseradish"
##	[73]	"Scottish"	"Norwegian"
##	[75]	"Atlantic"	"Irish"
##	[77]	"Wild"	"Do.not.know"
##	[79]	"Colour"	"Price"
##	[81]	"Origin"	"Brand"
##	[83]	"Advertising"	"Glossiness"
##	[85]	"Packaging"	"Labelling.information"
##	[87]	"Number.slices"	"Weight"
##	[89]	"Use.by.date"	"Usual.brand"
##	[91]	"Appetising"	"Firm"
##	[93]	"Regular"	"Nice.colour"
##	[95]	"Nice.odour"	"Smooth.texture"
##	[97]	"Firm.texture"	"Greasy.mouth"
##	[99]	"Characteristic.taste"	"Not too salty"

```
res.mca <- MCA(salmon_hedo_conso[,33:100],graph=F)
plot.MCA(res.mca,choix="ind",invisible = "var",label="none",graph.type = "classic")
```

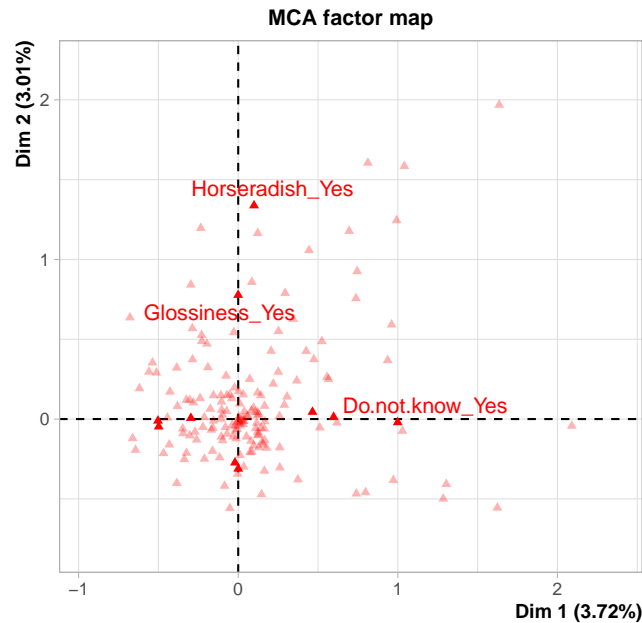


```
plot.MCA(res.mca,choix="ind",invisible = "ind")
```



```
plot.MCA(res.mca,choix="ind",invisible = "ind",selectMod="cos2 10")
```

```
## Warning: ggrepel: 7 unlabeled data points (too many overlaps). Consider
## increasing max.overlaps
```



Exercise. Let's spend some time on these outputs and on the theory behind MCA.

Now, let's run **MCA** again with some particular inputs. But before that, let's have a look at the variance associated with our dimensions.

```
res.mca$eig
```

##	eigenvalue	percentage of variance	cumulative percentage of variance
## dim 1	5.473825e-02	3.722201e+00	3.722201
## dim 2	4.431036e-02	3.013104e+00	6.735305
## dim 3	4.003557e-02	2.722419e+00	9.457724
## dim 4	3.392450e-02	2.306866e+00	11.764590
## dim 5	3.108617e-02	2.113860e+00	13.878450
## dim 6	2.967338e-02	2.017790e+00	15.896239
## dim 7	2.855847e-02	1.941976e+00	17.838216
## dim 8	2.588124e-02	1.759924e+00	19.598140
## dim 9	2.528128e-02	1.719127e+00	21.317267
## dim 10	2.450188e-02	1.666128e+00	22.983394

## dim 11	2.405695e-02	1.635872e+00	24.619267
## dim 12	2.287132e-02	1.555249e+00	26.174516
## dim 13	2.266484e-02	1.541209e+00	27.715725
## dim 14	2.184724e-02	1.485612e+00	29.201337
## dim 15	2.143759e-02	1.457756e+00	30.659094
## dim 16	2.102278e-02	1.429549e+00	32.088643
## dim 17	2.044787e-02	1.390455e+00	33.479098
## dim 18	1.973262e-02	1.341818e+00	34.820916
## dim 19	1.964806e-02	1.336068e+00	36.156984
## dim 20	1.953184e-02	1.328165e+00	37.485148
## dim 21	1.901586e-02	1.293078e+00	38.778227
## dim 22	1.879663e-02	1.278171e+00	40.056398
## dim 23	1.841331e-02	1.252105e+00	41.308503
## dim 24	1.808677e-02	1.229901e+00	42.538403
## dim 25	1.799709e-02	1.223802e+00	43.762205
## dim 26	1.787002e-02	1.215161e+00	44.977367
## dim 27	1.760494e-02	1.197136e+00	46.174503
## dim 28	1.748220e-02	1.188789e+00	47.363292
## dim 29	1.711750e-02	1.163990e+00	48.527282
## dim 30	1.687421e-02	1.147446e+00	49.674728
## dim 31	1.656551e-02	1.126455e+00	50.801183
## dim 32	1.644550e-02	1.118294e+00	51.919477
## dim 33	1.615074e-02	1.098251e+00	53.017728
## dim 34	1.597042e-02	1.085988e+00	54.103716
## dim 35	1.567450e-02	1.065866e+00	55.169582
## dim 36	1.562135e-02	1.062252e+00	56.231834
## dim 37	1.528656e-02	1.039486e+00	57.271320
## dim 38	1.512550e-02	1.028534e+00	58.299854
## dim 39	1.498150e-02	1.018742e+00	59.318596
## dim 40	1.483964e-02	1.009096e+00	60.327692
## dim 41	1.471166e-02	1.000393e+00	61.328085
## dim 42	1.436120e-02	9.765616e-01	62.304646
## dim 43	1.412491e-02	9.604939e-01	63.265140
## dim 44	1.408263e-02	9.576190e-01	64.222759
## dim 45	1.394252e-02	9.480915e-01	65.170850
## dim 46	1.381506e-02	9.394244e-01	66.110275
## dim 47	1.370087e-02	9.316590e-01	67.041934
## dim 48	1.358617e-02	9.238597e-01	67.965794
## dim 49	1.346130e-02	9.153686e-01	68.881162
## dim 50	1.333994e-02	9.071159e-01	69.788278
## dim 51	1.307056e-02	8.887983e-01	70.677076
## dim 52	1.294615e-02	8.803382e-01	71.557414
## dim 53	1.282083e-02	8.718162e-01	72.429231
## dim 54	1.262218e-02	8.583081e-01	73.287539
## dim 55	1.249028e-02	8.493392e-01	74.136878
## dim 56	1.230169e-02	8.365149e-01	74.973393

## dim 57	1.215842e-02	8.267726e-01	75.800166
## dim 58	1.207068e-02	8.208064e-01	76.620972
## dim 59	1.168354e-02	7.944807e-01	77.415453
## dim 60	1.161892e-02	7.900864e-01	78.205539
## dim 61	1.130664e-02	7.688518e-01	78.974391
## dim 62	1.119342e-02	7.611523e-01	79.735543
## dim 63	1.111680e-02	7.559427e-01	80.491486
## dim 64	1.092116e-02	7.426388e-01	81.234125
## dim 65	1.084369e-02	7.373710e-01	81.971496
## dim 66	1.067418e-02	7.258442e-01	82.697340
## dim 67	1.034072e-02	7.031693e-01	83.400509
## dim 68	1.028899e-02	6.996510e-01	84.100160
## dim 69	1.017623e-02	6.919836e-01	84.792144
## dim 70	1.001043e-02	6.807096e-01	85.472853
## dim 71	9.931163e-03	6.753191e-01	86.148172
## dim 72	9.819269e-03	6.677103e-01	86.815883
## dim 73	9.678037e-03	6.581065e-01	87.473989
## dim 74	9.512016e-03	6.468171e-01	88.120806
## dim 75	9.192120e-03	6.250642e-01	88.745870
## dim 76	8.990496e-03	6.113537e-01	89.357224
## dim 77	8.898534e-03	6.051003e-01	89.962324
## dim 78	8.784312e-03	5.973332e-01	90.559658
## dim 79	8.658067e-03	5.887486e-01	91.148406
## dim 80	8.385134e-03	5.701891e-01	91.718595
## dim 81	8.362101e-03	5.686229e-01	92.287218
## dim 82	8.224928e-03	5.592951e-01	92.846513
## dim 83	8.045518e-03	5.470952e-01	93.393609
## dim 84	7.965330e-03	5.416425e-01	93.935251
## dim 85	7.684237e-03	5.225281e-01	94.457779
## dim 86	7.538355e-03	5.126081e-01	94.970387
## dim 87	7.383017e-03	5.020451e-01	95.472432
## dim 88	7.252892e-03	4.931967e-01	95.965629
## dim 89	7.029512e-03	4.780068e-01	96.443636
## dim 90	6.974460e-03	4.742633e-01	96.917899
## dim 91	6.646082e-03	4.519336e-01	97.369833
## dim 92	6.334576e-03	4.307511e-01	97.800584
## dim 93	6.128442e-03	4.167340e-01	98.217318
## dim 94	5.857748e-03	3.983269e-01	98.615645
## dim 95	5.560695e-03	3.781273e-01	98.993772
## dim 96	4.696508e-03	3.193625e-01	99.313135
## dim 97	4.314317e-03	2.933735e-01	99.606508
## dim 98	3.334220e-03	2.267270e-01	99.833235
## dim 99	2.452426e-03	1.667650e-01	100.000000
## dim 100	1.016417e-30	6.911637e-29	100.000000

In the following code, we store the results from the 50 first dimensions, and we

get rid of the categories that are not chosen, according to a given threshold.

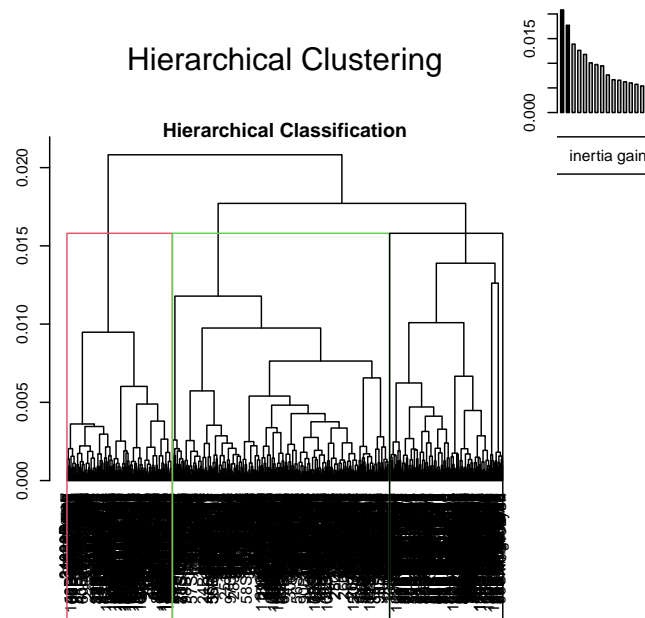
```
res.mca <- MCA(salmon_hedo_conso[,c(2,33:100)],quali.sup=1,graph=F,ncp=50,level.ventil=
```

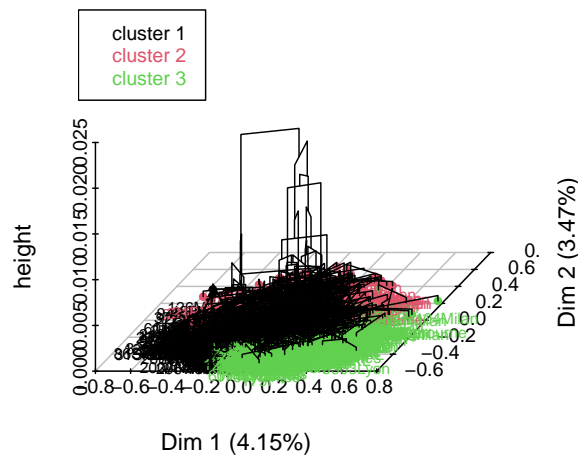
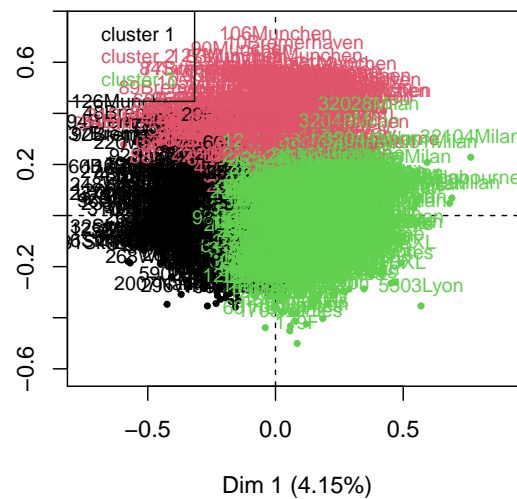
Exercise. Let's give some interpretation to the results.

```
res.dim <- dimdesc(res.mca)
names(res.dim)
names(res.dim$`Dim 1`)
res.dim$`Dim 1`$"quali"
res.dim$`Dim 1`$"category"
res.dim$`Dim 2`$"category"
```

As we said previously, MCA as PCA will reduce the complexity of your data by extracting relevant dimensions. To reduce the complexity from an individual point of view, you have to cluster the individuals.

```
res.hcpc <- HCPC(res.mca,nb.clust = 3)
```



Hierarchical clustering on the factor map**Factor map**

Exercise. Let's give some interpretation to the results.

```
round(res.hcpc$desc.var$category$`1`,2)
round(res.hcpc$desc.var$category$`2`,2)
round(res.hcpc$desc.var$category$`3`,2)
```

2.3 Understanding the consumers' preferences

Exercise. You should be able to do that by yourself using PCA.

2.4 Linking consumers' preferences and behaviour

To do so, we're going to import a new dataset.

```
salmon_final <- read.delim2("saumon_final.txt", header=TRUE, row.names=1, comment.char="")
colnames(salmon_final)
```

```
## [1] "Country"                "prod1_Fr"
## [3] "prod2_Fr"               "prod3_Fr"
## [5] "prod4_Scot"             "prod5_Ger"
## [7] "prod6_Ire"              "prod7_Ire"
## [9] "prod8_Ger"              "prod9_Ire"
## [11] "prod10_It"              "prod11_Fr"
## [13] "prod12_Dk"              "prod13_Ger"
## [15] "prod14_Ger"             "prod15_Fr"
## [17] "prod16_Ger"             "prod17_Fr"
## [19] "prod18_UK"              "prod19_UK"
## [21] "prod20_Dk"              "prod21_UK"
## [23] "prod22_Fr"              "prod23_Ger"
## [25] "prod24_Dk"              "prod25_Bel"
## [27] "prod26_UK"              "prod27_Fr"
## [29] "prod28_Bel"             "prod29_Scot"
## [31] "prod30_Bel"             "Who"
## [33] "Frequence"              "When"
## [35] "Taste"                  "Healthy"
## [37] "Pleasure"               "No.preparation"
## [39] "Ways"                   "Guest"
## [41] "Authentic"              "Not.expensive"
## [43] "Supermarket"            "Deli"
## [45] "Caterer"                "Fish.shop"
## [47] "Market"                 "Mobile.van"
## [49] "Everyday"               "Special"
## [51] "Day.snack"              "Evening.snack"
## [53] "Aperitif"               "Starter"
## [55] "Salad"                  "Cooked.meal"
## [57] "Sandwich"               "Main"
## [59] "Vegetable"              "Lemon"
## [61] "Bread..butter"          "Lemon..bread..butter"
```

```
## [63] "C..fraiche"          "C..fraiche.with.herbs"
## [65] "Fresh.cheese"        "Fresh.cheese.with.herbs"
## [67] "Shallots"            "Mustard"
## [69] "Butter"              "Black.pepper"
## [71] "Horseradish"         "Scottish"
## [73] "Norwegian"           "Atlantic"
## [75] "Irish"               "Wild"
## [77] "Do.not.know"         "Colour"
## [79] "Price"               "Origin"
## [81] "Brand"               "Advertising"
## [83] "Glossiness"          "Packaging"
## [85] "Labelling.information" "Number.slices"
## [87] "Weight"              "Use.by.date"
## [89] "Usual.brand"         "Appetising"
## [91] "Firm"                "Regular"
## [93] "Nice.colour"         "Nice.odour"
## [95] "Smooth.texture"      "Firm.texture"
## [97] "Greasy.mouth"        "Characteristic.taste"
## [99] "Not.too.salty"
```

```
summary(salmon_final)
```

```
##          Country      prod1_Fr      prod2_Fr      prod3_Fr
## Milan          :117   Min.    :-2.1360   Min.    :-3.72220   Min.    :-2.7302
## Munchen         :117   1st Qu.: -0.3792   1st Qu.: -0.68227   1st Qu.: -0.9418
## Rome            :113   Median : 0.3375   Median : 0.14975   Median : -0.1079
## Sittingbourne :111   Mean     : 0.2449   Mean     : 0.05328   Mean     : -0.1432
## Nantes          :109   3rd Qu.: 0.9498   3rd Qu.: 0.85860   3rd Qu.: 0.6805
## (Other)         :495   Max.     : 2.9666   Max.     : 2.26040   Max.     : 2.2639
## NA's            : 16
##   prod4_Scot      prod5_Ger      prod6_Ire      prod7_Ire
## Min.    :-2.1235   Min.    :-2.5337   Min.    :-2.5977   Min.    :-3.1814
## 1st Qu.: -0.3402   1st Qu.: -0.4214   1st Qu.: -0.5485   1st Qu.: -0.9107
## Median : 0.3216   Median : 0.4385   Median : 0.2509   Median : -0.1588
## Mean     : 0.2441   Mean     : 0.2742   Mean     : 0.1209   Mean     : -0.1716
## 3rd Qu.: 0.9045   3rd Qu.: 1.0171   3rd Qu.: 0.8300   3rd Qu.: 0.5827
## Max.     : 3.3236   Max.     : 2.2748   Max.     : 2.3256   Max.     : 2.1494
##
##   prod8_Ger      prod9_Ire      prod10_It      prod11_Fr
## Min.    :-2.88000   Min.    :-5.3852   Min.    :-3.1743   Min.    :-3.230300
## 1st Qu.: -0.85177   1st Qu.: -0.5113   1st Qu.: -1.1188   1st Qu.: -0.755450
## Median : 0.08645   Median : 0.2898   Median : -0.3628   Median : 0.082500
## Mean     : -0.02674   Mean     : 0.1705   Mean     : -0.3298   Mean     : -0.004231
## 3rd Qu.: 0.83125   3rd Qu.: 0.9240   3rd Qu.: 0.4482   3rd Qu.: 0.779475
## Max.     : 2.47150   Max.     : 2.1506   Max.     : 2.6033   Max.     : 2.221300
```

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```

##
##      prod12_Dk      prod13_Ger      prod14_Ger      prod15_Fr
## Min.      :-3.33710  Min.      :-2.3088  Min.      :-2.268400  Min.      :-2.9948
## 1st Qu.: -0.80417  1st Qu.: -0.5555  1st Qu.: -0.811625  1st Qu.: -0.7893
## Median : 0.11725  Median : 0.2959  Median : 0.068150  Median : 0.0400
## Mean    : 0.02101  Mean    : 0.1762  Mean    : -0.004349  Mean    : -0.0387
## 3rd Qu.: 0.86582  3rd Qu.: 0.9180  3rd Qu.: 0.776725  3rd Qu.: 0.7484
## Max.    : 2.23290  Max.    : 2.5355  Max.    : 2.171200  Max.    : 2.9253
##
##      prod16_Ger      prod17_Fr      prod18_UK      prod19_UK
## Min.      :-2.8800  Min.      :-3.1593  Min.      :-4.76160  Min.      :-3.02240
## 1st Qu.: -1.0514  1st Qu.: -0.5131  1st Qu.: -1.05927  1st Qu.: -0.96270
## Median : -0.1039  Median : 0.2937  Median : -0.08125  Median : 0.03750
## Mean    : -0.1459  Mean    : 0.1955  Mean    : -0.11816  Mean    : -0.05406
## 3rd Qu.: 0.7220  3rd Qu.: 0.9249  3rd Qu.: 0.80950  3rd Qu.: 0.84418
## Max.    : 2.5916  Max.    : 2.2967  Max.    : 2.40620  Max.    : 2.46320
##
##      prod20_Dk      prod21_UK      prod22_Fr      prod23_Ger
## Min.      :-2.9866  Min.      :-3.9939  Min.      :-2.5573  Min.      :-2.7796
## 1st Qu.: -1.0533  1st Qu.: -1.3312  1st Qu.: -0.3749  1st Qu.: -0.5266
## Median : -0.2591  Median : -0.6193  Median : 0.4213  Median : 0.2942
## Mean    : -0.2464  Mean    : -0.4841  Mean    : 0.2813  Mean    : 0.2050
## 3rd Qu.: 0.5691  3rd Qu.: 0.3917  3rd Qu.: 0.9916  3rd Qu.: 0.9395
## Max.    : 2.2533  Max.    : 2.5982  Max.    : 2.9192  Max.    : 2.2837
##
##      prod24_Dk      prod25_Bel      prod26_UK      prod27_Fr
## Min.      :-2.9200  Min.      :-3.7989  Min.      :-3.246900  Min.      :-3.4338
## 1st Qu.: -0.9318  1st Qu.: -1.0870  1st Qu.: -0.775475  1st Qu.: -0.5243
## Median : -0.1290  Median : -0.2250  Median : 0.031850  Median : 0.2656
## Mean    : -0.1660  Mean    : -0.2191  Mean    : 0.006847  Mean    : 0.1487
## 3rd Qu.: 0.5792  3rd Qu.: 0.6603  3rd Qu.: 0.836275  3rd Qu.: 0.9037
## Max.    : 2.1106  Max.    : 2.6322  Max.    : 2.335100  Max.    : 2.1495
##
##      prod28_Bel      prod29_Scot      prod30_Bel      Who
## Min.      :-3.86570  Min.      :-2.85220  Min.      :-3.09880  Adults :483
## 1st Qu.: -0.90548  1st Qu.: -0.67820  1st Qu.: -0.80875  Both  :578
## Median : -0.06030  Median : 0.14665  Median : 0.07245  Children: 1
## Mean    : -0.07935  Mean    : 0.07244  Mean    : 0.01685  NA's   : 16
## 3rd Qu.: 0.78902  3rd Qu.: 0.84535  3rd Qu.: 0.90955
## Max.    : 2.26810  Max.    : 2.48480  Max.    : 3.45930
##
##      Frequency      When      Taste
## Once a month      :364  All year round      :785  Comp. Agree:809
## Once every 2 weeks :245  Christmas and NY    : 21  Most. Agree:232
## 5 to 6 times a year:235  Only the summer     : 22  Most. Disa.: 3
## Once a week or more: 96  Only the winter     : 74  Neither    : 18

```

```

## 3 to 4 times a year: 81    Special celebration:160    NA's      : 16
## (Other)                : 41    NA's                : 16
## NA's                    : 16
##      Healthy           Pleasure           No.preparation           Ways
## Comp. Agree:240    Comp. Agree:509    Comp. Agree:367    Comp. Agree:467
## Comp. Disa.: 26    Comp. Disa.: 16    Comp. Disa.: 50    Comp. Disa.: 11
## Most. Agree:345    Most. Agree:386    Most. Agree:330    Most. Agree:382
## Most. Disa.: 60    Most. Disa.: 27    Most. Disa.: 91    Most. Disa.: 49
## Neither :391    Neither :124    Neither :224    Neither :153
## NA's : 16    NA's : 16    NA's : 16    NA's : 16
##
##      Guest           Authentic           Not.expensive Supermarket    Deli
## Comp. Agree:639    Comp. Agree:200    Comp. Agree: 43    No :101    No :865
## Comp. Disa.: 16    Comp. Disa.: 75    Comp. Disa.:136    Yes :961    Yes :197
## Most. Agree:290    Most. Agree:291    Most. Agree:168    NA's: 16    NA's: 16
## Most. Disa.: 15    Most. Disa.:108    Most. Disa.:361
## Neither :102    Neither :388    Neither :354
## NA's : 16    NA's : 16    NA's : 16
##
## Caterer    Fish.shop    Market    Mobile.van    Everyday    Special    Day.snack
## No :970    No :750    No :989    No :1042    No :642    No :360    No :888
## Yes : 92    Yes :312    Yes : 73    Yes : 20    Yes :420    Yes :702    Yes :174
## NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
##
## Evening.snack    Aperitif    Starter    Salad    Cooked.meal    Sandwich
## No :676    No :398    No :383    No :787    No :776    No :740
## Yes :386    Yes :664    Yes :679    Yes :275    Yes :286    Yes :322
## NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
##
##      Main    Vegetable    Lemon    Bread..butter    Lemon..bread..butter    C..fraiche
## No :806    No :720    No :640    No :484    No :706    No :890
## Yes :256    Yes :342    Yes :422    Yes :578    Yes :356    Yes :172
## NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
##
## C..fraiche.with.herbs    Fresh.cheese    Fresh.cheese.with.herbs    Shallots
## No :777    No :922    No :919    No :859
## Yes :285    Yes :140    Yes :143    Yes :203

```

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```
## NA's: 16          NA's: 16      NA's: 16          NA's: 16
##
##
##
##
## Mustard      Butter      Black.pepper Horseradish Scottish      Norwegian
## No :1051     No :973      No :906       No :882      No :498      No :485
## Yes : 11     Yes : 89       Yes :156      Yes :180     Yes :564     Yes :577
## NA's: 16     NA's: 16      NA's: 16      NA's: 16     NA's: 16     NA's: 16
##
##
##
## Atlantic     Irish       Wild       Do.not.know Colour      Price      Origin
## No :814      No :897     No :851     No :819     No :244     No :391     No :549
## Yes :248     Yes :165    Yes :211    Yes :243    Yes :818    Yes :671    Yes :513
## NA's: 16     NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
## Brand        Advertising Glossiness Packaging Labelling.information
## No :827      No :1022    No :758     No :981     No :650
## Yes :235     Yes : 40    Yes :304     Yes : 81     Yes :412
## NA's: 16     NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
## Number.slices Weight      Use.by.date Usual.brand Appetising      Firm
## No :833      No :892     No :521     No :967     No :588     No :903
## Yes :229     Yes :170    Yes :541     Yes : 95     Yes :474     Yes :159
## NA's: 16     NA's: 16    NA's: 16    NA's: 16    NA's: 16    NA's: 16
##
##
##
## Regular      Nice.colour Nice.odour Smooth.texture Firm.texture Greasy.mouth
## No :1016     No :522     No :611     No :905     No :831     No :649
## Yes : 46     Yes :540    Yes :451     Yes :157     Yes :231     Yes :413
## NA's: 16     NA's: 16    NA's: 16    NA's: 16     NA's: 16     NA's: 16
##
##
##
##
## Characteristic.taste Not.too.salty
```



```
## No :738          No :671
## Yes :324         Yes :391
## NA's: 16         NA's: 16
##
##
##
##
```

```
salmon_final[1063:1078,1:33]
```

```
##          Country prod1_Fr prod2_Fr prod3_Fr prod4_Scot prod5_Ger
## water          <NA> -0.8644 -1.1476 -0.4172 -0.8147 -1.6991
## lipid          <NA>  1.1375  0.7036  0.3378 -0.0961  0.0366
## TVBN          <NA> -0.7629  0.2357  0.4354 -0.5632 -0.7629
## TMA          <NA> -0.8717  0.3204  1.2144 -0.8717 -0.8717
## salt          <NA> -0.1471  0.1626  0.3174  0.3174  2.1752
## phenol        <NA> -0.3776  0.0112  0.4001 -0.4554 -0.3776
## pH            <NA>  1.5412  1.2098  0.3812  0.2154 -0.2817
## total viable count <NA>  0.1112  0.4302  0.8225 -0.2432 -1.5584
## lactic flora    <NA>  0.6665 -0.4514  0.8725 -1.5861 -1.5861
## lactobacilli   <NA>  1.1382  0.1290  0.4088 -1.0624 -1.0624
## brochothrix    <NA>  0.5461 -0.7559  0.6465 -0.7559 -0.7559
## yeast          <NA>  0.7729  1.2034  0.2875 -1.0340 -1.0340
## enterobacteriaceae <NA>  0.8314  0.5998  0.2524 -1.5793 -0.9582
## L              <NA>  0.9917  0.8542 -0.8548  0.3020 -1.3485
## a              <NA> -0.6467  0.5297  0.3927  1.7439  0.7341
## b              <NA> -0.4567  0.9551  0.2813  3.3236  0.5485
##          prod6_Ire prod7_Ire prod8_Ger prod9_Ire prod10_It prod11_Fr
## water        -0.9886 -1.5848  0.3380  1.9081  0.1095  1.4659
## lipid         0.9653  1.2809  0.0940 -0.2969 -2.1795 -1.2830
## TVBN        -0.7629 -0.3635 -0.9626 -1.1623  0.8348 -0.7629
## TMA         -0.8717 -0.8717 -0.5737 -0.8717  0.0224 -0.2757
## salt         0.0077  0.0077 -2.0049  1.4011  0.9366 -0.4567
## phenol       0.6594 -0.1702  1.1260  1.4631  0.9964 -0.9350
## pH           1.0441  0.8783 -1.1104  0.5469  0.3812 -1.7733
## total viable count -2.5977 -0.9336 -0.2561 -1.1271  0.2176  0.8505
## lactic flora  -1.5861 -0.0449  0.4294 -1.5861  1.5327  0.5524
## lactobacilli -1.0624  0.3686  0.6069 -1.0624  1.9639  0.9344
## brochothrix  -0.7559 -0.7559 -0.7559 -0.7559  1.9004 -0.7559
## yeast        -1.0340 -1.0340  0.4282 -1.0340  0.7852  2.1072
## enterobacteriaceae -1.5793 -0.6424 -0.6634 -0.5266  0.8372  1.4683
## L            -0.4322 -0.4737 -1.0916  0.0550 -1.8353  0.2448
## a            0.4016  1.2366  0.6655 -0.3624 -1.0433 -0.5423
## b            0.4278  1.6822  0.9331 -0.6856 -0.5130 -0.0307
##          prod12_Dk prod13_Ger prod14_Ger prod15_Fr prod16_Ger
```

## water	1.3615	0.1939	-0.1787	0.3976	1.5752	
## lipid	-0.3005	-0.3722	1.6072	0.5135	-0.9711	
## TVBN	-0.7629	0.2357	-1.1623	-0.9626	-0.7629	
## TMA	-0.5737	0.6184	-0.8717	-0.7346	-0.2757	
## salt	-0.3793	-0.7663	0.3174	0.3948	0.1626	
## phenol	0.3223	-1.1036	-0.4554	-0.5591	-0.5980	
## pH	0.8783	0.5469	-0.9446	-0.2817	-0.2817	
## total viable count	0.3222	0.8076	-0.8553	-0.1907	-0.2814	
## lactic flora	0.8725	0.0282	-0.4082	-0.2986	0.5306	
## lactobacilli	1.2442	-1.0624	-1.0624	-1.0624	-1.0624	
## brochothrix	-0.7559	0.9831	-0.7559	-0.7559	-0.7559	
## yeast	1.2038	-1.0340	-1.0340	-1.0340	0.4980	
## enterobacteriaceae	0.0419	0.9735	-0.9582	1.0419	0.0419	
## L	0.3527	0.5279	1.3714	0.9614	0.3384	
## a	-0.4328	0.4921	-0.0805	-0.2456	0.2588	
## b	-1.5026	0.2601	-0.6433	-0.7466	-0.5323	
##	prod17_Fr	prod18_UK	prod19_UK	prod20_Dk	prod21_UK	prod22_Fr
## water	-0.3228	-0.5563	1.1131	-0.3675	-1.2072	-0.9985
## lipid	-0.5623	0.3665	-2.4628	1.6251	0.5709	0.5529
## TVBN	-0.3635	2.0330	1.2342	-0.7629	0.8348	1.4339
## TMA	-0.8717	2.1085	0.3204	-0.8717	0.3204	1.2144
## salt	1.5559	-1.0760	0.0077	-0.1471	-0.6115	-0.6889
## phenol	-0.6628	1.0483	1.4890	0.0631	-1.2073	0.0631
## pH	-1.4418	-0.1160	0.7126	-1.2761	-1.4418	-0.4475
## total viable count	-0.3769	0.6098	0.9992	-0.8152	1.0168	0.6157
## lactic flora	-0.4776	0.8165	1.2062	-0.1654	0.3479	0.8681
## lactobacilli	-1.0624	-1.0624	1.1989	0.2839	0.4541	1.0535
## brochothrix	-0.7559	0.4217	2.4632	-0.7559	1.3957	1.1371
## yeast	-1.0340	0.0682	0.2875	0.9324	0.2341	0.5504
## enterobacteriaceae	-0.6266	0.0216	1.5470	-1.5793	0.0109	0.5577
## L	0.1846	-0.7728	-0.2587	1.5224	2.5982	0.1901
## a	0.3111	0.7864	0.2626	-1.3598	-3.9939	-0.0805
## b	0.2349	0.2931	0.8976	-1.3411	-1.8277	0.3227
##	prod23_Ger	prod24_Dk	prod25_Bel	prod26_UK	prod27_Fr	
## water	2.0273	0.4821	0.4622	0.7554	-0.9240	
## lipid	-1.5341	0.4310	-0.0853	-1.2472	0.3665	
## TVBN	-0.3635	-0.3635	2.6322	0.4354	-0.0439	
## TMA	-0.8717	-0.2757	2.4065	0.6184	-0.1892	
## salt	0.9366	-0.9212	-1.3856	-0.6115	0.0077	
## phenol	-0.2221	-0.6369	-0.8443	-1.1813	-0.9739	
## pH	-0.4475	1.3755	-1.2761	2.0384	1.0441	
## total viable count	-0.0665	0.4494	1.0223	1.0932	0.3376	
## lactic flora	-1.5861	-1.5861	0.8165	0.8362	0.7697	
## lactobacilli	-1.0624	-1.0624	1.2312	0.0909	0.5204	
## brochothrix	-0.7559	-0.7559	-0.7559	0.9443	1.7156	
## yeast	-1.0340	-1.0340	0.2875	-1.0340	1.9679	

## enterobacteriaceae	-1.5793	0.0508	-0.1055	1.4803	1.6472
## L	1.0328	0.5514	-1.6298	-0.8136	-0.3829
## a	-0.3553	-0.5153	0.7578	0.5383	0.3803
## b	-0.4847	-1.4920	0.4104	-0.0762	-0.0363
##	prod28_Bel	prod29_Scot	prod30_Bel	Who	Frequence
## water	-0.0048	-0.1439	0.0300	<NA>	<NA>
## lipid	0.5781	-0.4439	0.6677	<NA>	<NA>
## TVBN	1.8333	-0.7629	0.2357	<NA>	<NA>
## TMA	2.1085	-0.8717	1.2144	<NA>	<NA>
## salt	-1.3856	2.4848	-0.6115	<NA>	<NA>
## phenol	-0.7406	0.4001	3.4593	<NA>	<NA>
## pH	0.0497	-1.1104	-0.6132	<NA>	<NA>
## total viable count	1.1384	-2.5977	1.0558	<NA>	<NA>
## lactic flora	0.8491	-1.5861	0.9539	<NA>	<NA>
## lactobacilli	1.2539	-1.0624	0.9302	<NA>	<NA>
## brochothrix	0.5758	-0.7559	0.8767	<NA>	<NA>
## yeast	1.1315	-1.0340	0.6964	<NA>	<NA>
## enterobacteriaceae	0.6682	-1.5793	0.3051	<NA>	<NA>
## L	-1.0399	-1.2488	0.1036	<NA>	<NA>
## a	0.4114	0.6412	-0.8857	<NA>	<NA>
## b	0.2132	0.1780	-0.5929	<NA>	<NA>

Exercise. Let's run the following code and comment.

```
res_final <- PCA(salmon_final, ind.sup = 1063:1078, quali.sup=c(1,32:99), graph = F)
plot.PCA(res_final, choix="ind", invisible = c("ind", "quali"))
plot.PCA(res_final, choix="var")

res.dim <- dimdesc(res_final)
res.dim$Dim.1$quanti
res.dim$Dim.1$quali

cluster_final <- HCPC(res_final)
cluster_final$desc.var$category$`1`
cluster_final$desc.var$category$`3`
```

Now, it's your turn to work and to interpret.

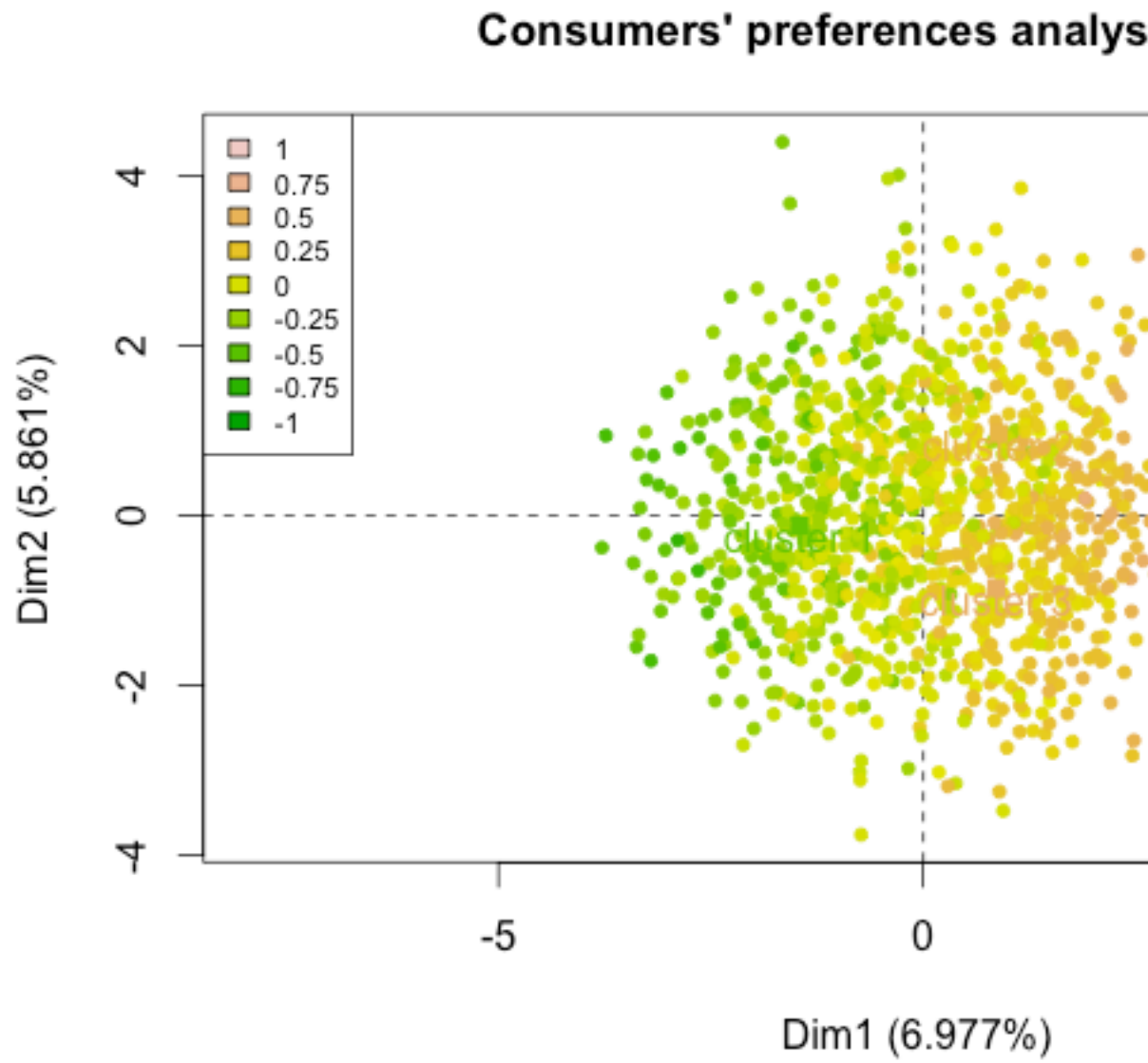


Figure 2.1: Consumers according to the variable salt

Bibliography

Ph. Courcoux, E.M. Qannari, P. S. (2006). Sensometrics workshop: Segmentation of consumers and characterization of cross-cultural differences. *Food Quality and Preference*, 17(2):3–5.