

# Class 07: Machine Learning 1

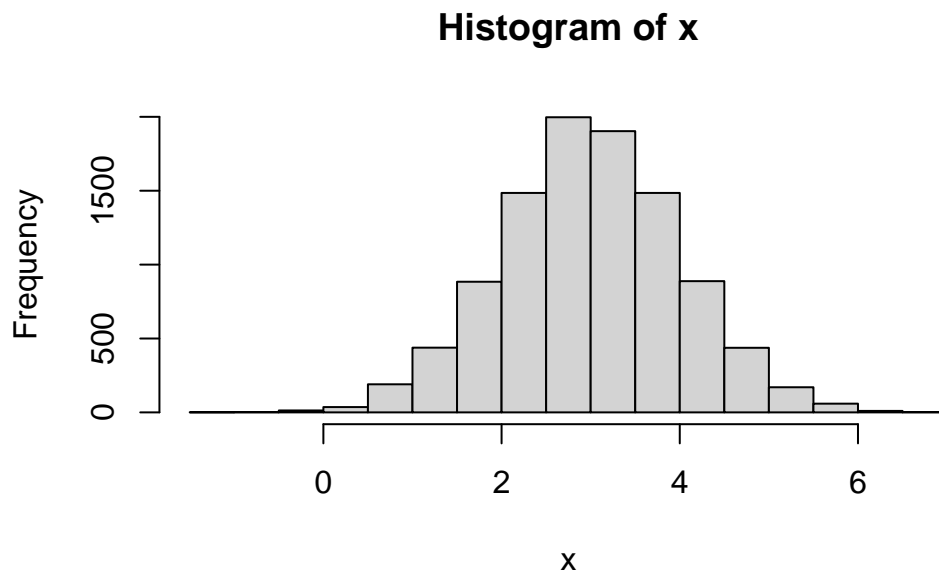
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## Clustering

we will start today's lab with clustering methods, in particular so-called K-means. The main function for this in R is `kmeans()`

Let's try it on some made up data where we know that what the answer should be.

```
x <- rnorm(10000, mean=3)
hist(x)
```



60 points

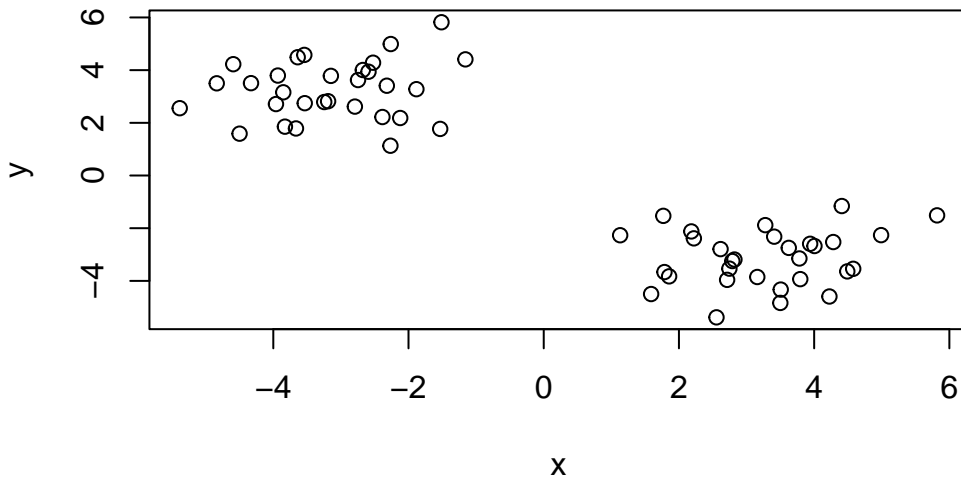
```
tmp <- c(rnorm(30, mean=3), rnorm(30,mean=-3))
x <- cbind(x=tmp, y=rev(tmp))
x
```

	x	y
[1,]	2.789181	-3.246384
[2,]	1.785632	-3.664413
[3,]	4.990367	-2.262505
[4,]	4.004477	-2.675746
[5,]	2.220653	-2.385723
[6,]	2.820759	-3.189301
[7,]	1.768562	-1.531468
[8,]	3.499662	-4.836351
[9,]	4.577516	-3.541133
[10,]	3.276770	-1.883271
[11,]	2.615736	-2.793107
[12,]	2.183321	-2.122602
[13,]	5.818104	-1.512527
[14,]	4.225951	-4.592156
[15,]	2.746062	-3.534720
[16,]	3.781665	-3.148096
[17,]	3.408777	-2.320842
[18,]	3.624595	-2.746581
[19,]	1.130785	-2.267443
[20,]	3.505646	-4.329642
[21,]	1.854807	-3.827730
[22,]	4.408753	-1.158637
[23,]	3.940465	-2.591902
[24,]	4.282357	-2.524787
[25,]	4.490019	-3.639081
[26,]	2.712705	-3.960268
[27,]	3.794480	-3.933003
[28,]	1.588639	-4.498693
[29,]	2.555489	-5.383949
[30,]	3.158643	-3.852315
[31,]	-3.852315	3.158643
[32,]	-5.383949	2.555489
[33,]	-4.498693	1.588639
[34,]	-3.933003	3.794480
[35,]	-3.960268	2.712705
[36,]	-3.639081	4.490019
[37,]	-2.524787	4.282357

```
[38,] -2.591902  3.940465
[39,] -1.158637  4.408753
[40,] -3.827730  1.854807
[41,] -4.329642  3.505646
[42,] -2.267443  1.130785
[43,] -2.746581  3.624595
[44,] -2.320842  3.408777
[45,] -3.148096  3.781665
[46,] -3.534720  2.746062
[47,] -4.592156  4.225951
[48,] -1.512527  5.818104
[49,] -2.122602  2.183321
[50,] -2.793107  2.615736
[51,] -1.883271  3.276770
[52,] -3.541133  4.577516
[53,] -4.836351  3.499662
[54,] -1.531468  1.768562
[55,] -3.189301  2.820759
[56,] -2.385723  2.220653
[57,] -2.675746  4.004477
[58,] -2.262505  4.990367
[59,] -3.664413  1.785632
[60,] -3.246384  2.789181
```

We can pass this to the base R `plot()` function for a quick

```
plot(x)
```



```
k <- kmeans(x, centers=2, nstart=20)
k
```

K-means clustering with 2 clusters of sizes 30, 30

Cluster means:

	x	y
1	3.252019	-3.131813
2	-3.131813	3.252019

Clustering vector:

```
[1] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
[39] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
```

Within cluster sum of squares by cluster:

```
[1] 67.90501 67.90501
      (between_SS / total_SS =  90.0 %)
```

Available components:

```
[1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
[6] "betweenss"    "size"         "iter"         "ifault"
```

Q1. How many points are in each cluster

k\$size

[1] 30 30

Q2. Cluster membership?

```
k$cluster
```

```
[1] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2  
[39] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
```

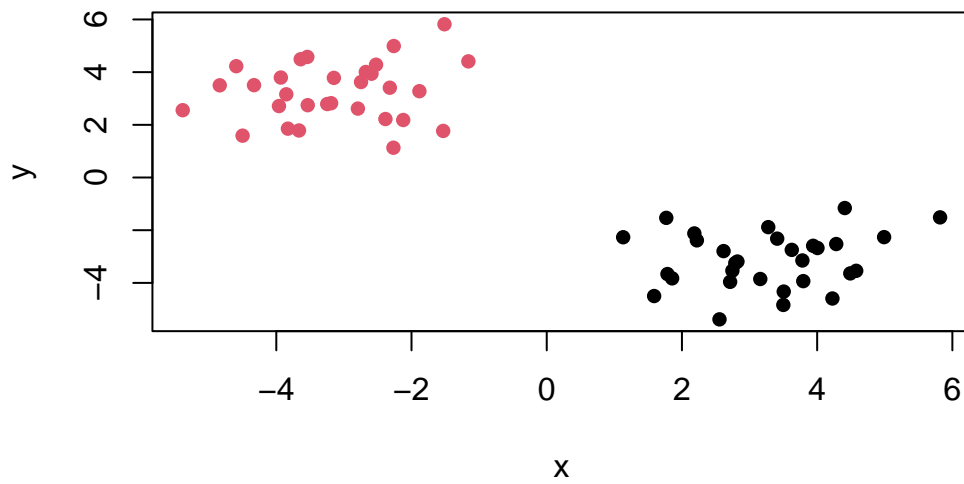
Q3. Cluster centers?

k\$centers

	x	y
1	3.252019	-3.131813
2	-3.131813	3.252019

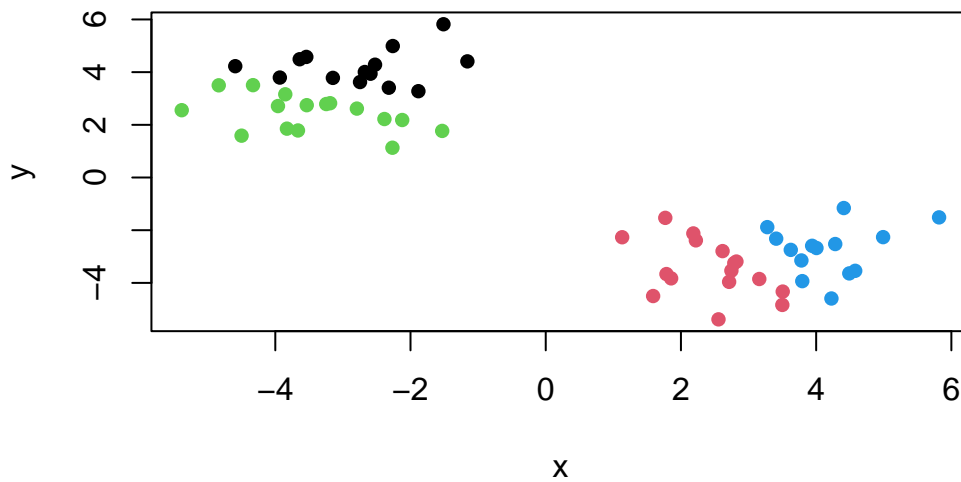
#### Q4 Plot my clustering results

```
plot(x, col= k$cluster, pch=16)
```



Q5 Cluster the data again with `kmean()` into 4 groups and plot the results.

```
k4 <- kmeans(x, center=4, nstart=20)
plot(x, col=k4$cluster, pch=16)
```



K-means is very popular mostly because it is fast and relatively straightforward to run and understand. It has a big limitation in that you need to tell it how many groups(k, or centers) you want.

## hierarchical clustering

The main function in base R is called `hclust()`. You have to pass it in a “distance matrix” not just your input data.

You can generate a distance matrix with the `dist()` function.

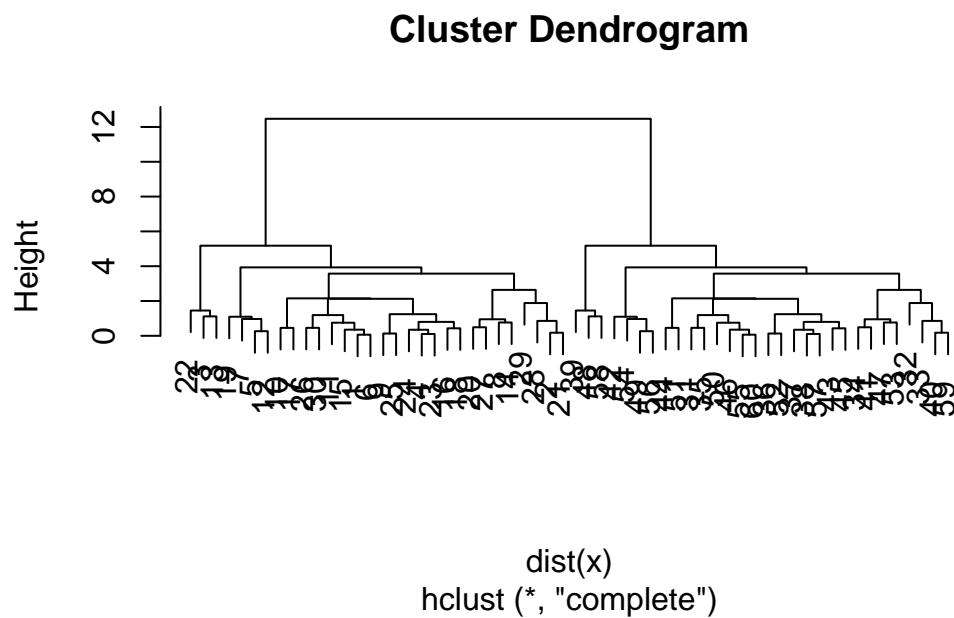
```
hc <- hclust(dist(x))
hc
```

Call:

```
hclust(d = dist(x))
```

```
Cluster method : complete
Distance       : euclidean
Number of objects: 60
```

```
plot(hc)
```

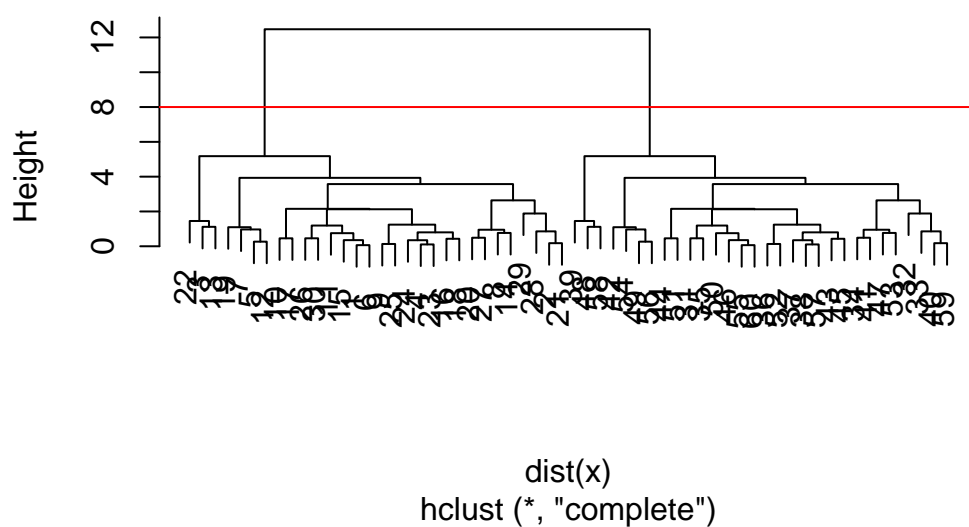


To find the clusters (cluster membership vector) from a `hclust()` result we can “cut” the tree at a certain height taht we like. For this we use the `cutree()` function.

```
plot(hc)  
abline(h=8,col="red")
```



## Cluster Dendrogram



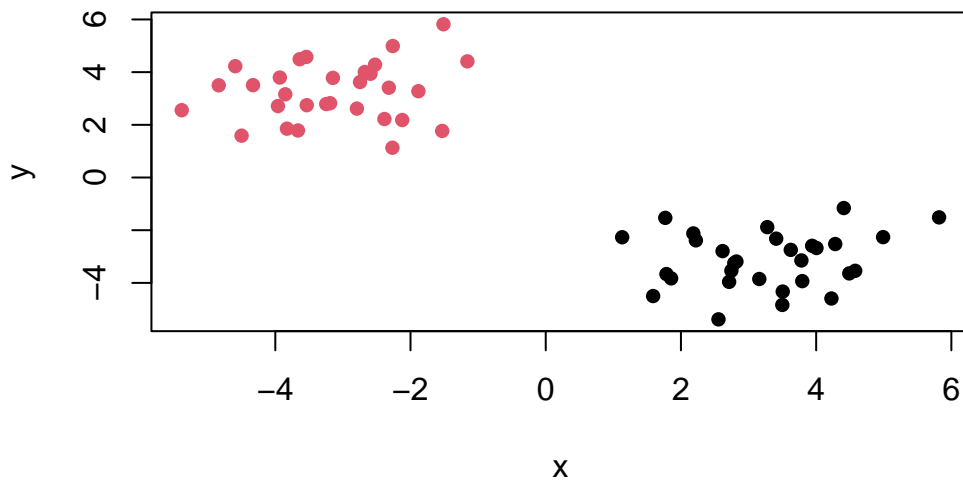
```
grps <- cutree(hc, h=8)
```

```
table(grps)
```

```
grps
 1  2
30 30
```

Q6 Plot our hclust results.

```
plot(x, col=grps, pch=16)
```



## Principal Component Analysis

### PCA of UK food data

Read data showing the consumption in grams(per person, per week) of 17 different types of food-stuff measured and averaged in the four countries of the United Kingdom.

Let's see how PCA can help us but first we can try conventional analysis.

```
url <- "https://tinyurl.com/UK-foods"
x <- read.csv(url)
x
```

		X England	Wales	Scotland	N.Ireland
1	Cheese	105	103	103	66
2	Carcass_meat	245	227	242	267
3	Other_meat	685	803	750	586
4	Fish	147	160	122	93
5	Fats_and_oils	193	235	184	209
6	Sugars	156	175	147	139
7	Fresh_potatoes	720	874	566	1033

8	Fresh_Veg	253	265	171	143
9	Other_Veg	488	570	418	355
10	Processed_potatoes	198	203	220	187
11	Processed_Veg	360	365	337	334
12	Fresh_fruit	1102	1137	957	674
13	Cereals	1472	1582	1462	1494
14	Beverages	57	73	53	47
15	Soft_drinks	1374	1256	1572	1506
16	Alcoholic_drinks	375	475	458	135
17	Confectionery	54	64	62	41

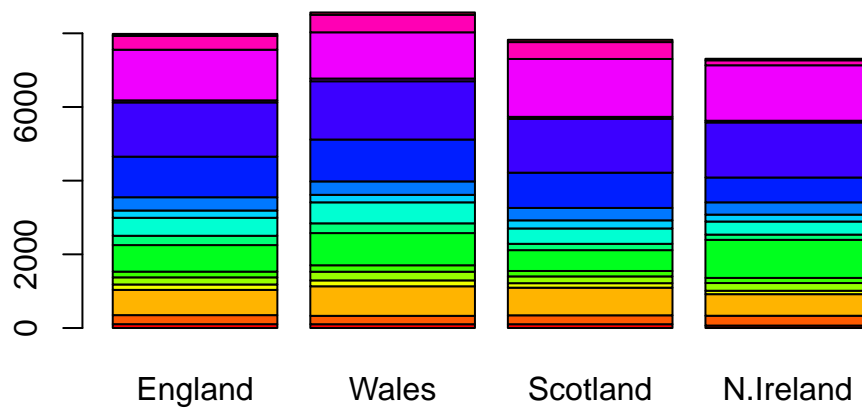
I need to fix that first column...

```
rownames(x) <- x[,1]
x <- x[,1]
head(x)
```

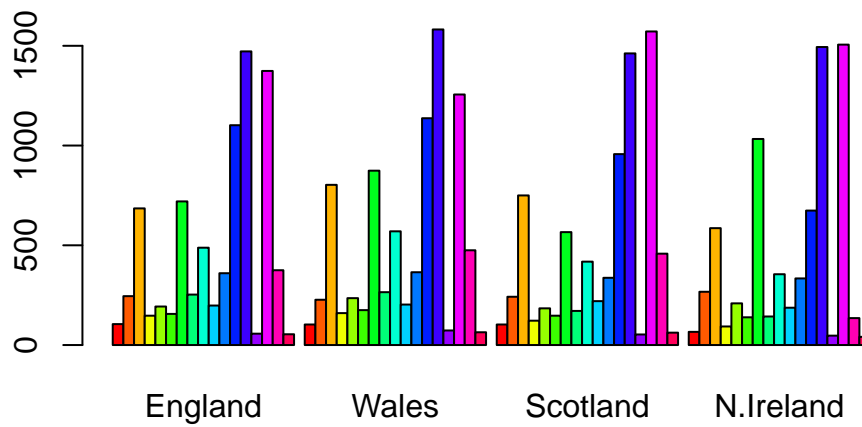
```
[1] "Cheese"          "Carcass_meat " "Other_meat "    "Fish"
[5] "Fats_and_oils " "Sugars"
```

```
url <- "https://tinyurl.com/UK-foods"
x <- read.csv(url, row.names=1)
```

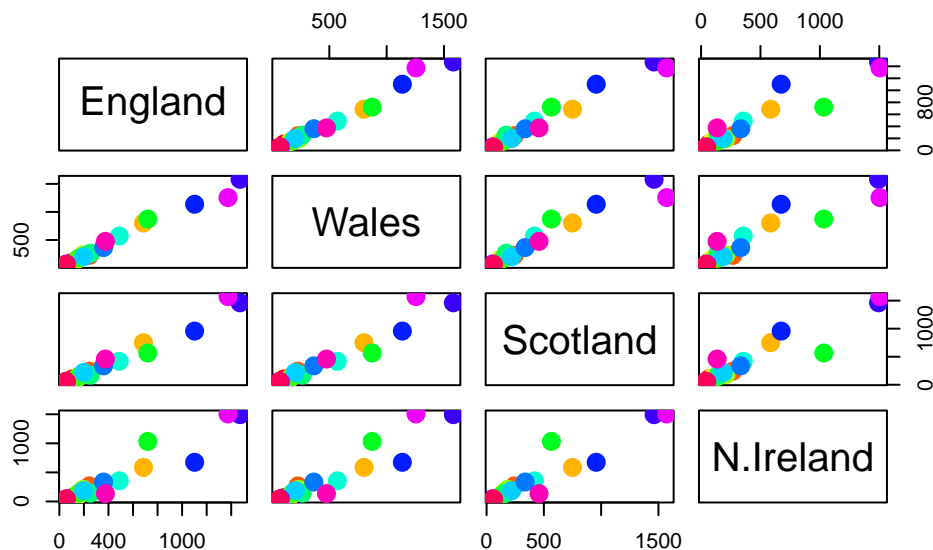
```
cols <- rainbow(nrow(x))
barplot(as.matrix(x), col=cols)
```



```
barplot(as.matrix(x), col=cols, beside=T)
```



```
pairs(x, col=rainbow(17), pch=16, cex=2)
```



## Principal Component Analysis (PCA)

PCA can help us make sense of these types of datasets. Ket's see how it works.

The main function in "base" R is called `prcomp()`. In this case we want to first take the transpose `t()` of our input `x` so the columns are the food types and the countries are the rows.

```
head(t(x))
```

	Cheese	Carcass_meat	Other_meat	Fish	Fats_and_oils	Sugars
England	105	245	685	147	193	156
Wales	103	227	803	160	235	175
Scotland	103	242	750	122	184	147
N.Ireland	66	267	586	93	209	139

	Fresh_potatoes	Fresh_Veg	Other_Veg	Processed_potatoes
England	720	253	488	198
Wales	874	265	570	203
Scotland	566	171	418	220

N.Ireland	1033	143	355	187	
	Processed_Veg	Fresh_fruit	Cereals	Beverages	Soft_drinks
England	360	1102	1472	57	1374
Wales	365	1137	1582	73	1256
Scotland	337	957	1462	53	1572
N.Ireland	334	674	1494	47	1506
	Alcoholic_drinks	Confectionery			
England	375	54			
Wales	475	64			
Scotland	458	62			
N.Ireland	135	41			

```
pca <- prcomp(t(x))
summary(pca)
```

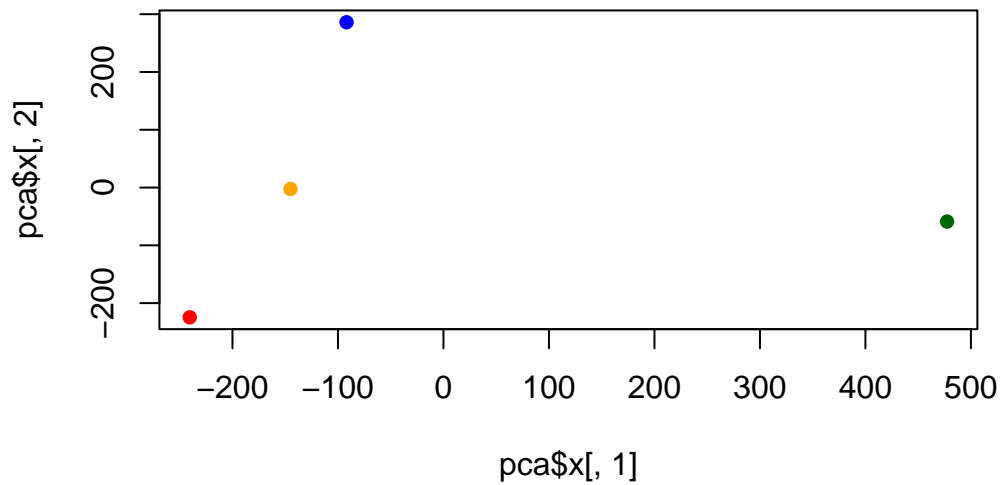
Importance of components:

	PC1	PC2	PC3	PC4
Standard deviation	324.1502	212.7478	73.87622	3.176e-14
Proportion of Variance	0.6744	0.2905	0.03503	0.000e+00
Cumulative Proportion	0.6744	0.9650	1.00000	1.000e+00

```
pca$x
```

	PC1	PC2	PC3	PC4
England	-144.99315	-2.532999	105.768945	-4.894696e-14
Wales	-240.52915	-224.646925	-56.475555	5.700024e-13
Scotland	-91.86934	286.081786	-44.415495	-7.460785e-13
N.Ireland	477.39164	-58.901862	-4.877895	2.321303e-13

```
plot( pca$x[,1], pca$x[,2], col=c("orange", "red", "blue", "darkgreen"), pch=16)
```

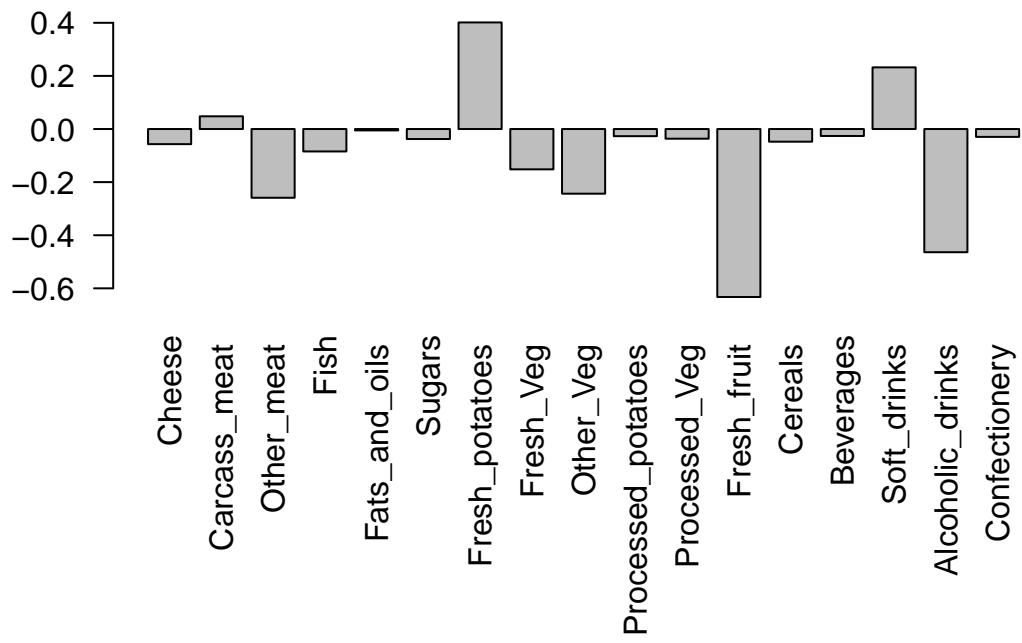


The “loadings” tell us how much the original variables (in our case the food) contribute to the new variables i.e. the PCs.

```
head(pca$rotation)
```

	PC1	PC2	PC3	PC4
Cheese	-0.056955380	0.01601285	0.02394295	-0.694538519
Carcass_meat	0.047927628	0.01391582	0.06367111	0.489884628
Other_meat	-0.258916658	-0.01533114	-0.55384854	0.279023718
Fish	-0.084414983	-0.05075495	0.03906481	-0.008483145
Fats_and_oils	-0.005193623	-0.09538866	-0.12522257	0.076097502
Sugars	-0.037620983	-0.04302170	-0.03605745	0.034101334

```
## Lets focus on PC1 as it accounts for > 90% of variance
par(mar=c(10, 3, 0.35, 0))
barplot( pca$rotation[,1], las=2 )
```



Stop at Q9