HC on Cereals_Data

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Data Pre-processing

Find the number of missing values and either remove or omit them

```
cereals_data <- read.csv("Cereals.csv")
cereals<-read.csv("cereals.csv")
str(cereals_data)
```

```
## 'data.frame':    77 obs. of  16 variables:
##  $ name    : Factor w/ 77 levels "100%_Bran","100%_Natural_Bran",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ mfr     : Factor w/ 7 levels "A","G","K","N",..: 4 6 3 3 7 2 3 2 7 5 ...
##  $ type    : Factor w/ 2 levels "C","H": 1 1 1 1 1 1 1 1 1 1 ...
##  $ calories: int  70 120 70 50 110 110 110 130 90 90 ...
##  $ protein : int  4 3 4 4 2 2 2 3 2 3 ...
##  $ fat     : int  1 5 1 0 2 2 0 2 1 0 ...
##  $ sodium  : int  130 15 260 140 200 180 125 210 200 210 ...
##  $ fiber   : num  10 2 9 14 1 1.5 1 2 4 5 ...
##  $ carbo   : num  5 8 7 8 14 10.5 11 18 15 13 ...
##  $ sugars  : int  6 8 5 0 8 10 14 8 6 5 ...
##  $ potass  : int  280 135 320 330 NA 70 30 100 125 190 ...
##  $ vitamins: int  25 0 25 25 25 25 25 25 25 25 ...
##  $ shelf   : int  3 3 3 3 3 1 2 3 1 3 ...
##  $ weight  : num  1 1 1 1 1 1 1 1.33 1 1 ...
##  $ cups    : num  0.33 1 0.33 0.5 0.75 0.75 1 0.75 0.67 0.67 ...
##  $ rating  : num  68.4 34 59.4 93.7 34.4 ...
```

```
sum(is.na(cereals_data))
```

```
## [1] 4
```

To remove any missing value that might be present in the data, type this:

```
cereals_data <- na.omit(cereals_data)
cereals<-na.omit(cereals)
sum(is.na(cereals_data))
```

```
## [1] 0
```

Convert the names of the breakfast cereals to the row names, as this will later help us in visualising the clusters

```
rownames(cereals_data) <- cereals_data$name
rownames(cereals) <- cereals$name
```

Drop the name column as it is now just redundant information

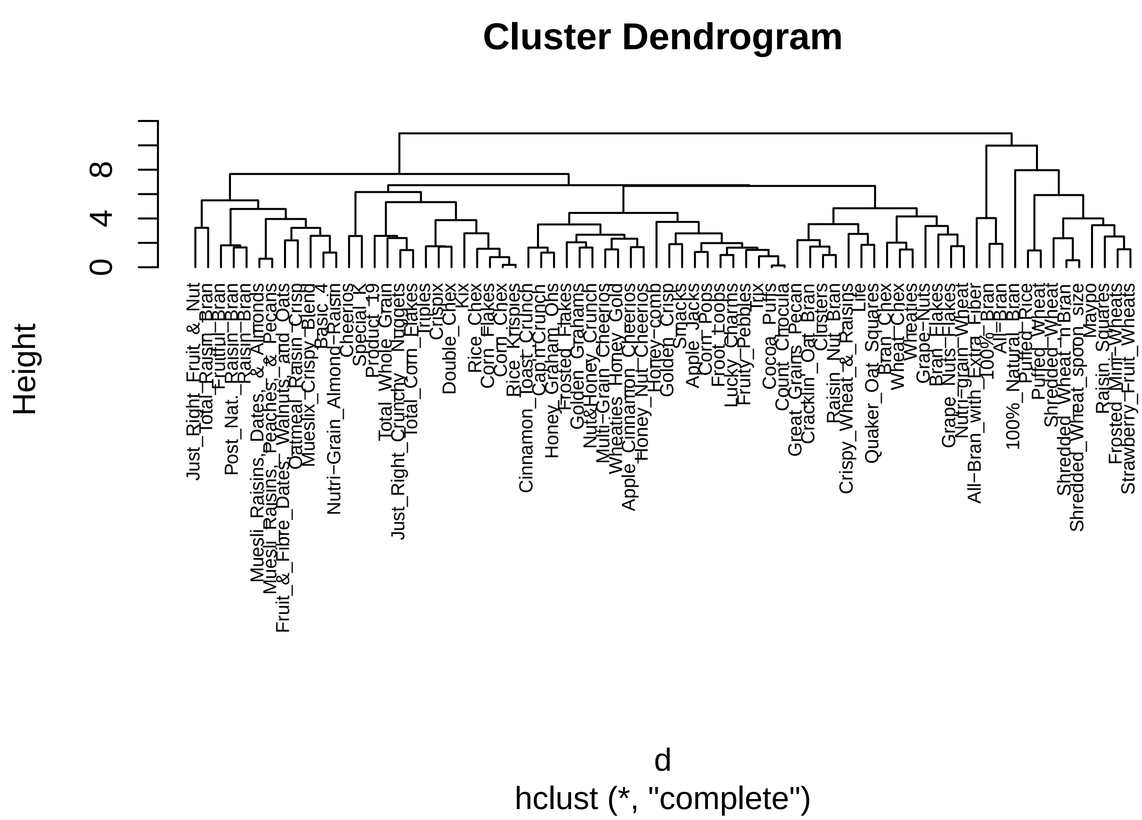
```r
cereals_data$name = NULL
cereals$name = NULL
```

The data must be scaled, before measuring any type of distance metric as the variables with higher ranges will significantly influence the distance

```r
cereals_data <- scale(cereals_data[,3:15])
```

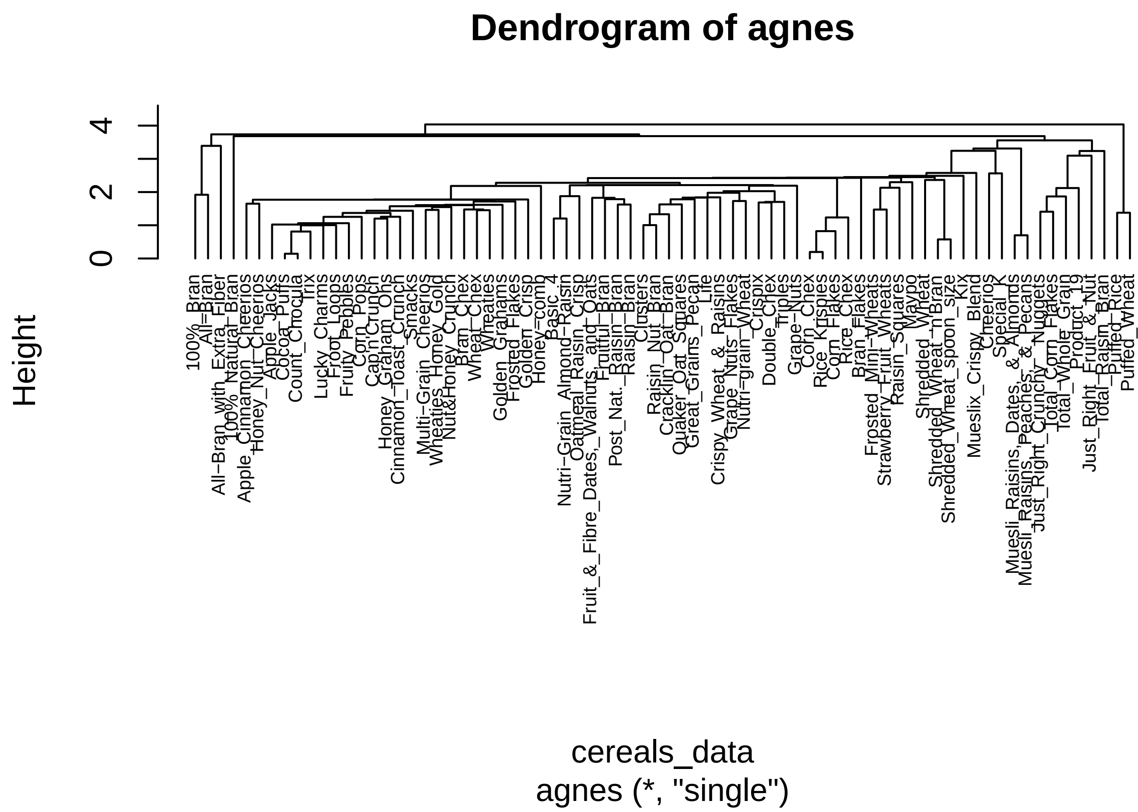
we will apply hierarchical clustering to the data using Euclidean distance

```r
# Dissimilarity matrix
d <- dist(cereals_data, method = "euclidean")

# Hierarchical clustering using Complete Linkage
hc_complete <- hclust(d, method = "complete" )

# Plot the obtained dendrogram
plot(hc_complete, cex = 0.6, hang = -1)
```

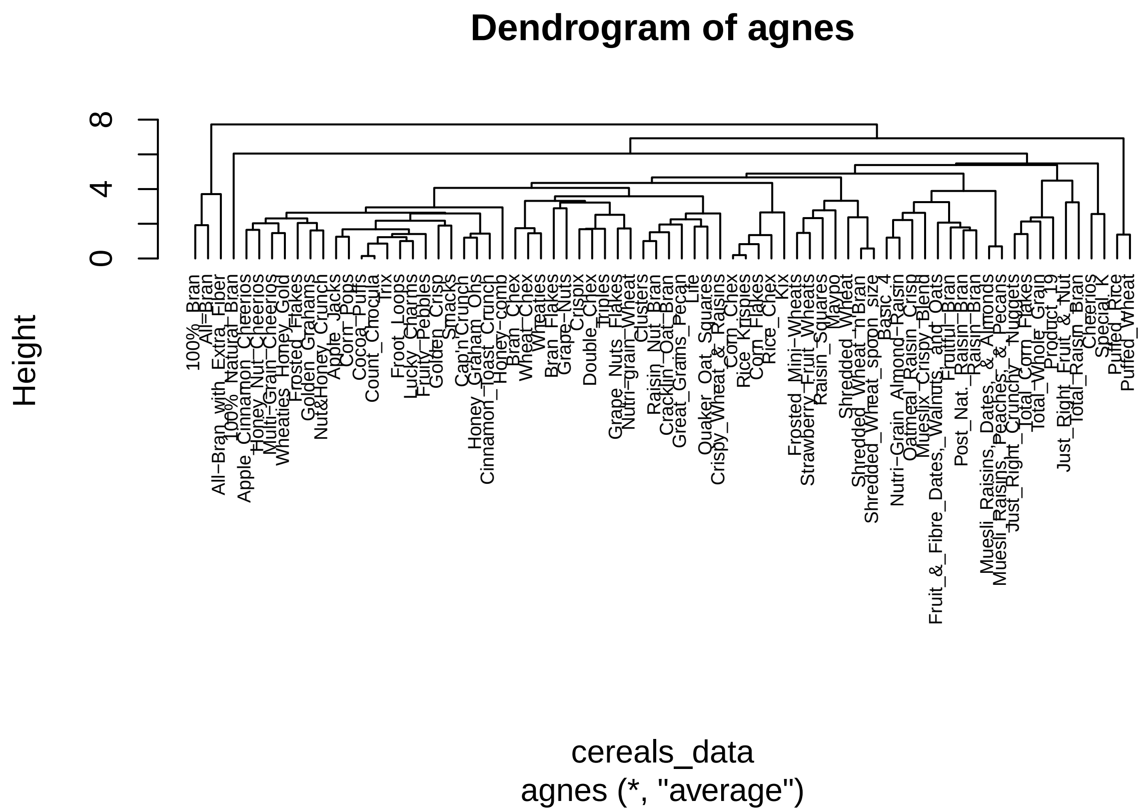


Using Agnes to compare the clustering from single linkage, complete linkage, average linkage, and Ward and comparing agglomerative coefficients of each method.

```r
library(cluster)
hc_single <- agnes(cereals_data, method = "single")
pltree(hc_single, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```




```r
hc_average <- agnes(cereals_data, method = "average")
pltree(hc_average, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



We will find the agnes coefficient of all the methods.

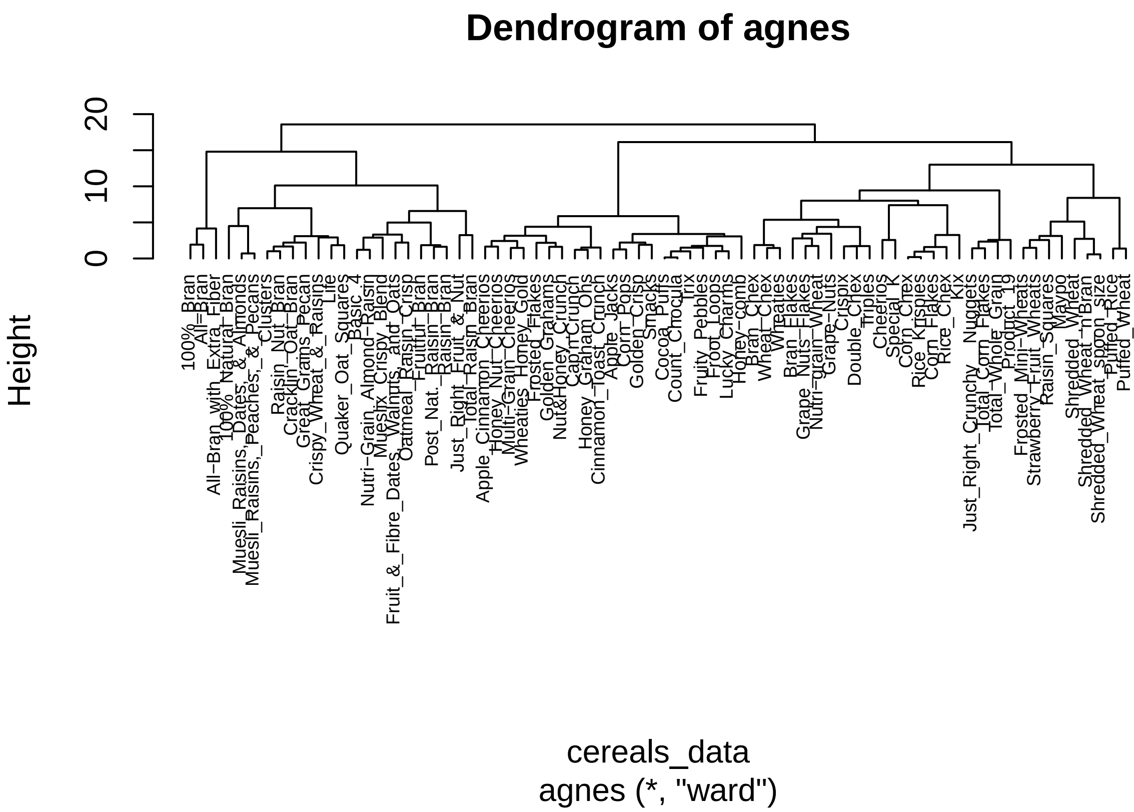
```r
# methods to assess
m <- c( "average", "single", "complete", "ward")
names(m) <- c( "average", "single", "complete", "ward")

# function to compute coefficient
ac <- function(x) {
  agnes(cereals_data, method = x)$ac
}

map_dbl(m, ac)
```

```
##   average    single  complete      ward
## 0.7766075 0.6067859 0.8353712 0.9046042
```

The best linkage method is ward with agglomerative coefficient of 0.9046042.

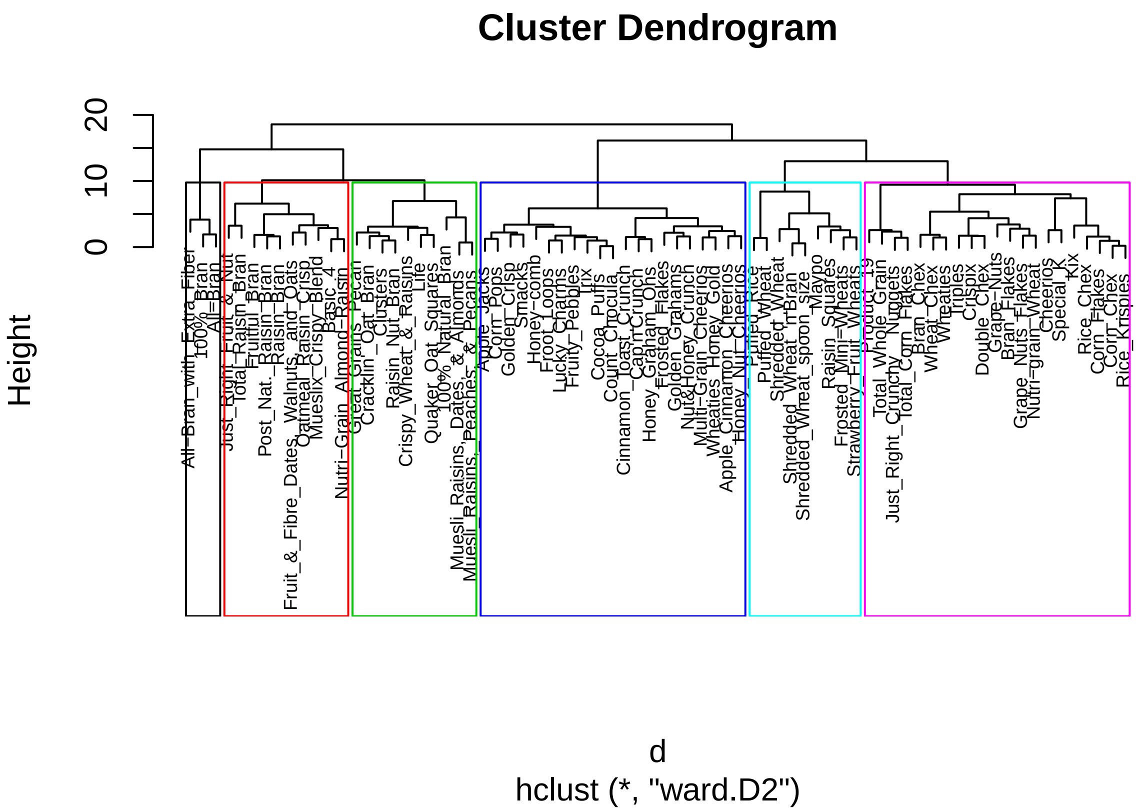
visualizing the dendrogram using wards method:

```r
hc_ward <- agnes(cereals_data, method = "ward")
pltree(hc_ward, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



In order to identify sub-groups (i.e. clusters), we can cut the dendrogram with cutree():

```
#Create the distance matrix
d <- dist(cereals_data, method = "euclidean")

# Ward's method for Hierarchical clustering
hc_ward_cut <- hclust(d, method = "ward.D2" )

plot(hc_ward_cut, cex=0.6 )
rect.hclust(hc_ward_cut,k=6,border = 1:6)
```



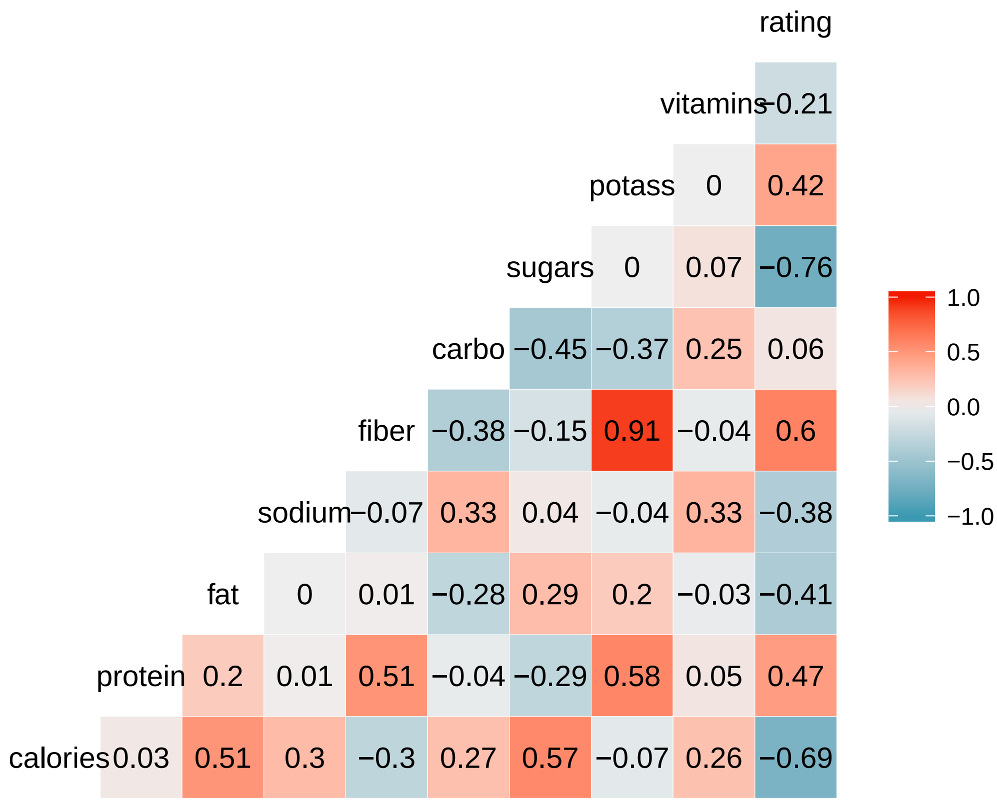
Lets see how many number of records of the data grouped and assigned to clusters:

```
# Cut tree into 6 groups
sub_grp <- cutree(hc_ward_cut, k = 6)

# Number of members in each cluster
table(sub_grp)
```

```
## sub_grp
##  1  2  3  4  5  6
##  3 10 21 10 21  9
```

Correlation matrix:

```
#install.packages("GGally")
cereals %>%
  select(calories, protein, fat, sodium, fiber, carbo, sugars, potass,vitamins,rating) %>%
  ggcorr(palette = "RdBu", label = TRUE, label_round =  2)
```



The correlation matrix helps us in guaging weather strong or weak relation existing between the variables. This will give us a better perspective in deriving descriptive statistics between the variables.

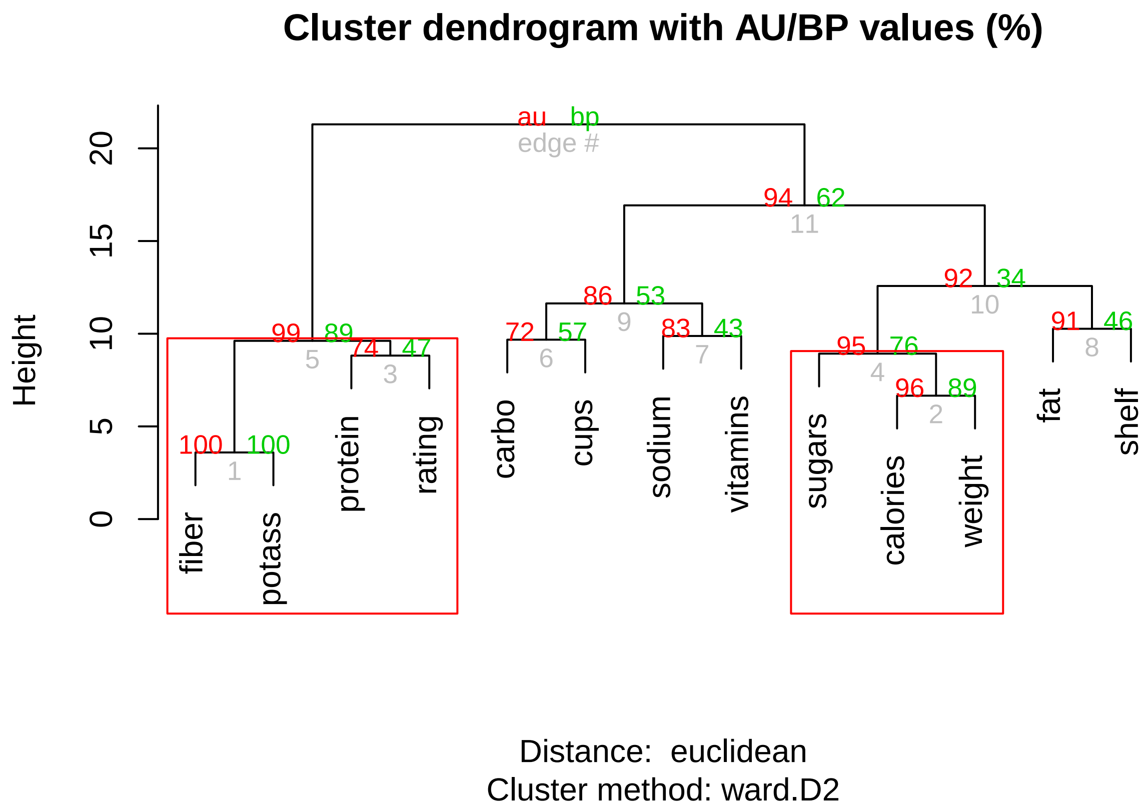
The pvclust( ) function in the pvclust package provides p-values for hierarchical clustering based on multiscale bootstrap resampling. Clusters that are highly supported by the data will have large p values. Interpretation details are provided Suzuki. Be aware that pvclust clusters columns, not rows. Transpose your data before using.

```
# Ward Hierarchical Clustering with Bootstrapped p values
#install.packages("pvclust")
library(pvclust)
```

```
## Registered S3 method overwritten by 'pvclust':
##   method        from
##   text.pvclust dendextend
```

```
fit.pv <- pvclust(cereals_data, method.hclust="ward.D2",
                  method.dist="euclidean")
```

```
plot(fit.pv) # dendogram with p values
# add rectangles around groups highly supported by the data
pvrect(fit.pv, alpha=.95)
```



The cluster stability of each cluster in the original clustering is the mean value of its Jaccard coefficient over all the bootstrap iterations. As a rule of thumb, clusters with a stability value less than 0.6 should be considered unstable. Values between 0.6 and 0.75 indicate that the cluster is measuring a pattern in the data, but there isn't high certainty about which points should be clustered together. Clusters with stability values above about 0.85 can be considered highly stable

1. Clusterwise Jaccard bootstrap mean should be maximised
2. number of dissolved clusters should be minimised and
3. number of recovered clusters should be maximised and as close to the number of pre-defined bootstraps as possible

#Running clusterboot()

```
library(fpc)
library(cluster)
kbest.p<-6
cboot.hclust <- clusterboot(cereals_data,clustermethod=hclustCBI,method="ward.D2", k=kbest.p)
```

```
summary(cboot.hclust$result)
```

```
##                 Length Class  Mode
## result           7      hclust list
## noise            1      -none- logical
## nc               1      -none- numeric
## clusterlist      6      -none- list
```

```
## partition     74     -none- numeric
## clustermethod  1     -none- character
## nccl           1     -none- numeric
```

```r
groups<-cboot.hclust$result$partition
head(data.frame(groups))
```

```
##                            groups
## 100%_Bran                       1
## 100%_Natural_Bran               2
## All-Bran                        1
## All-Bran_with_Extra_Fiber       1
## Apple_Cinnamon_Cheerios         3
## Apple_Jacks                     3
```

```r
#The vector of cluster stabilities
cboot.hclust$bootmean
```

```
## [1] 0.8712583 0.5168806 0.8914939 0.6191970 0.5964205 0.6728449
```

```r
#The count of how many times each cluste was dissolved. By default clusterboot() runs 100 bootstrap ite
cboot.hclust$bootbrd
```

```
## [1] 14 56  0 42 33 37
```

By looking the output, we can say cluster 1 and cluster 3 are Highly stable. Cluster 4, 5 are measuring a pattern and there isn't high certainty about which points should be clustered together. cluster 2 and 5 are unstable.

Extracting the clusters found by hclust()

```r
groups <- cutree(hc_ward_cut, k = 6)
print_clusters <- function(labels, k) {
for(i in 1:k) {
print(paste("cluster", i))
print(cereals[labels==i,c("mfr","calories","protein","fat","sodium","fiber","carbo","sugars","potass","v
}
}
print_clusters(groups, 6)
```

```
## [1] "cluster 1"
##                           mfr calories protein fat sodium fiber carbo sugars
## 100%_Bran                   N       70       4   1    130    10     5      6
## All-Bran                    K       70       4   1    260     9     7      5
## All-Bran_with_Extra_Fiber   K       50       4   0    140    14     8      0
##                           potass vitamins   rating
## 100%_Bran                    280       25 68.40297
## All-Bran                     320       25 59.42551
## All-Bran_with_Extra_Fiber    330       25 93.70491
## [1] "cluster 2"
##                                   mfr calories protein fat sodium fiber carbo
## 100%_Natural_Bran                   Q      120       3   5     15   2.0   8.0
```

```
## Clusters                           G      110       3   2    140   2.0  13.0
## Cracklin'_Oat_Bran                 K      110       3   3    140   4.0  10.0
## Crispy_Wheat_&_Raisins             G      100       2   1    140   2.0  11.0
## Great_Grains_Pecan                 P      120       3   3     75   3.0  13.0
## Life                               Q      100       4   2    150   2.0  12.0
## Muesli_Raisins,_Dates,_&_Almonds   R      150       4   3     95   3.0  16.0
## Muesli_Raisins,_Peaches,_&_Pecans  R      150       4   3    150   3.0  16.0
## Quaker_Oat_Squares                 Q      100       4   1    135   2.0  14.0
## Raisin_Nut_Bran                    G      100       3   2    140   2.5  10.5
##                                  sugars potass vitamins   rating
## 100%_Natural_Bran                     8    135        0 33.98368
## Clusters                              7    105       25 40.40021
## Cracklin'_Oat_Bran                    7    160       25 40.44877
## Crispy_Wheat_&_Raisins               10    120       25 36.17620
## Great_Grains_Pecan                    4    100       25 45.81172
## Life                                  6     95       25 45.32807
## Muesli_Raisins,_Dates,_&_Almonds     11    170       25 37.13686
## Muesli_Raisins,_Peaches,_&_Pecans    11    170       25 34.13976
## Quaker_Oat_Squares                    6    110       25 49.51187
## Raisin_Nut_Bran                       8    140       25 39.70340
## [1] "cluster 3"
##                        mfr calories protein fat sodium fiber carbo sugars
## Apple_Cinnamon_Cheerios   G      110       2   2    180   1.5  10.5     10
## Apple_Jacks               K      110       2   0    125   1.0  11.0     14
## Cap'n'Crunch              Q      120       1   2    220   0.0  12.0     12
## Cinnamon_Toast_Crunch     G      120       1   3    210   0.0  13.0      9
## Cocoa_Puffs               G      110       1   1    180   0.0  12.0     13
## Corn_Pops                 K      110       1   0     90   1.0  13.0     12
## Count_Chocula             G      110       1   1    180   0.0  12.0     13
## Froot_Loops               K      110       2   1    125   1.0  11.0     13
## Frosted_Flakes            K      110       1   0    200   1.0  14.0     11
## Fruity_Pebbles            P      110       1   1    135   0.0  13.0     12
## Golden_Crisp              P      100       2   0     45   0.0  11.0     15
## Golden_Grahams            G      110       1   1    280   0.0  15.0      9
## Honey_Graham_Ohs          Q      120       1   2    220   1.0  12.0     11
## Honey_Nut_Cheerios        G      110       3   1    250   1.5  11.5     10
## Honey-comb                P      110       1   0    180   0.0  14.0     11
## Lucky_Charms              G      110       2   1    180   0.0  12.0     12
## Multi-Grain_Cheerios      G      100       2   1    220   2.0  15.0      6
## Nut&Honey_Crunch          K      120       2   1    190   0.0  15.0      9
## Smacks                    K      110       2   1     70   1.0   9.0     15
## Trix                      G      110       1   1    140   0.0  13.0     12
## Wheaties_Honey_Gold       G      110       2   1    200   1.0  16.0      8
##                        potass vitamins   rating
## Apple_Cinnamon_Cheerios     70       25 29.50954
## Apple_Jacks                 30       25 33.17409
## Cap'n'Crunch                35       25 18.04285
## Cinnamon_Toast_Crunch       45       25 19.82357
## Cocoa_Puffs                 55       25 22.73645
## Corn_Pops                   20       25 35.78279
## Count_Chocula               65       25 22.39651
## Froot_Loops                 30       25 32.20758
## Frosted_Flakes              25       25 31.43597
## Fruity_Pebbles              25       25 28.02576
```

```
## Golden_Crisp                40       25 35.25244
## Golden_Grahams              45       25 23.80404
## Honey_Graham_Ohs            45       25 21.87129
## Honey_Nut_Cheerios          90       25 31.07222
## Honey-comb                  35       25 28.74241
## Lucky_Charms                55       25 26.73451
## Multi-Grain_Cheerios        90       25 40.10596
## Nut&Honey_Crunch            40       25 29.92429
## Smacks                      40       25 31.23005
## Trix                        25       25 27.75330
## Wheaties_Honey_Gold         60       25 36.18756
## [1] "cluster 4"
##                                       mfr calories protein fat sodium fiber
## Basic_4                                 G      130       3   2    210   2.0
## Fruit_&_Fibre_Dates,_Walnuts,_and_Oats  P      120       3   2    160   5.0
## Fruitful_Bran                           K      120       3   0    240   5.0
## Just_Right_Fruit_&_Nut                  K      140       3   1    170   2.0
## Mueslix_Crispy_Blend                    K      160       3   2    150   3.0
## Nutri-Grain_Almond-Raisin               K      140       3   2    220   3.0
## Oatmeal_Raisin_Crisp                    G      130       3   2    170   1.5
## Post_Nat._Raisin_Bran                   P      120       3   1    200   6.0
## Raisin_Bran                             K      120       3   1    210   5.0
## Total_Raisin_Bran                       G      140       3   1    190   4.0
##                                       carbo sugars potass vitamins   rating
## Basic_4                                18.0      8    100       25 37.03856
## Fruit_&_Fibre_Dates,_Walnuts,_and_Oats 12.0     10    200       25 40.91705
## Fruitful_Bran                          14.0     12    190       25 41.01549
## Just_Right_Fruit_&_Nut                 20.0      9     95      100 36.47151
## Mueslix_Crispy_Blend                   17.0     13    160       25 30.31335
## Nutri-Grain_Almond-Raisin              21.0      7    130       25 40.69232
## Oatmeal_Raisin_Crisp                   13.5     10    120       25 30.45084
## Post_Nat._Raisin_Bran                  11.0     14    260       25 37.84059
## Raisin_Bran                            14.0     12    240       25 39.25920
## Total_Raisin_Bran                      15.0     14    230      100 28.59278
## [1] "cluster 5"
##                             mfr calories protein fat sodium fiber carbo sugars
## Bran_Chex                     R       90       2   1    200     4    15      6
## Bran_Flakes                   P       90       3   0    210     5    13      5
## Cheerios                      G      110       6   2    290     2    17      1
## Corn_Chex                     R      110       2   0    280     0    22      3
## Corn_Flakes                   K      100       2   0    290     1    21      2
## Crispix                       K      110       2   0    220     1    21      3
## Double_Chex                   R      100       2   0    190     1    18      5
## Grape_Nuts_Flakes             P      100       3   1    140     3    15      5
## Grape-Nuts                    P      110       3   0    170     3    17      3
## Just_Right_Crunchy__Nuggets   K      110       2   1    170     1    17      6
## Kix                           G      110       2   1    260     0    21      3
## Nutri-grain_Wheat             K       90       3   0    170     3    18      2
## Product_19                    K      100       3   0    320     1    20      3
## Rice_Chex                     R      110       1   0    240     0    23      2
## Rice_Krispies                 K      110       2   0    290     0    22      3
## Special_K                     K      110       6   0    230     1    16      3
## Total_Corn_Flakes             G      110       2   1    200     0    21      3
## Total_Whole_Grain             G      100       3   1    200     3    16      3
```

```
## Triples                        G      110       2   1    250     0    21      3
## Wheat_Chex                     R      100       3   1    230     3    17      3
## Wheaties                       G      100       3   1    200     3    17      3
##                             potass vitamins   rating
## Bran_Chex                      125       25 49.12025
## Bran_Flakes                    190       25 53.31381
## Cheerios                       105       25 50.76500
## Corn_Chex                       25       25 41.44502
## Corn_Flakes                     35       25 45.86332
## Crispix                         30       25 46.89564
## Double_Chex                     80       25 44.33086
## Grape_Nuts_Flakes               85       25 52.07690
## Grape-Nuts                      90       25 53.37101
## Just_Right_Crunchy__Nuggets     60      100 36.52368
## Kix                             40       25 39.24111
## Nutri-grain_Wheat               90       25 59.64284
## Product_19                      45      100 41.50354
## Rice_Chex                       30       25 41.99893
## Rice_Krispies                   35       25 40.56016
## Special_K                       55       25 53.13132
## Total_Corn_Flakes               35      100 38.83975
## Total_Whole_Grain              110      100 46.65884
## Triples                         60       25 39.10617
## Wheat_Chex                     115       25 49.78744
## Wheaties                       110       25 51.59219
## [1] "cluster 6"
##                           mfr calories protein fat sodium fiber carbo sugars
## Frosted_Mini-Wheats         K      100       3   0      0     3    14      7
## Maypo                       A      100       4   1      0     0    16      3
## Puffed_Rice                 Q       50       1   0      0     0    13      0
## Puffed_Wheat                Q       50       2   0      0     1    10      0
## Raisin_Squares              K       90       2   0      0     2    15      6
## Shredded_Wheat              N       80       2   0      0     3    16      0
## Shredded_Wheat_'n'Bran      N       90       3   0      0     4    19      0
## Shredded_Wheat_spoon_size   N       90       3   0      0     3    20      0
## Strawberry_Fruit_Wheats     N       90       2   0     15     3    15      5
##                           potass vitamins   rating
## Frosted_Mini-Wheats          100       25 58.34514
## Maypo                         95       25 54.85092
## Puffed_Rice                   15        0 60.75611
## Puffed_Wheat                  50        0 63.00565
## Raisin_Squares               110       25 55.33314
## Shredded_Wheat                95        0 68.23588
## Shredded_Wheat_'n'Bran       140        0 74.47295
## Shredded_Wheat_spoon_size    120        0 72.80179
## Strawberry_Fruit_Wheats       90       25 59.36399
```

Note***

Since there is no proper mention of measure/scaleto become a healty diet, I decided to choose clusters based on statistical values and rich in nutritional values to form a healthy diet and this is purely subjective.

To answer weather needed to be normalized or not? I would say no. When we normalize the data, the magnitude of the data would be lost and it will become very difficult for us to read and decide.

The clusters contain nutritionally rich, adequate and poor levels of the cereal diet. We grouped all the records in to 6 clusters, we will evaluate these clusters considering all the variables/factors.

even though Cluster 1 has nutritionally stable values to form a healthy diet, the options are very limited. Cluster 2 and cluster 3 have poor ratings and have high Fat and sugars which are not good for a healthy meal. Cluster 4 and 5 have balanced nutritional values with good average customer ratings. Hence Cluster 4 and 5 should be a good option for elementary public schools to include this in their cafeterias.