Assignment5

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First load the required pacakges using library function.

Data Pre-processing

Determine the amount of missing values and either eliminate or omit them.

```
Cereals_Data1 <- read.csv("C:/Users/lavak/Documents/R/Assignment5/Cereals.csv")
Cereals1<-read.csv("C:/Users/lavak/Documents/R/Assignment5/Cereals.csv")
str(Cereals_Data1)
```

```
## 'data.frame':    77 obs. of  16 variables:
##  $ name    : chr  "100%_Bran" "100%_Natural_Bran" "All-Bran" "All-Bran_with_Extra_Fiber" ...
##  $ mfr     : chr  "N" "Q" "K" "K" ...
##  $ type    : chr  "C" "C" "C" "C" ...
##  $ 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_Data1))
```

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

To eliminate any missing values from the data, enter the following:

```
Cereals_Data1 <- na.omit(Cereals_Data1)
Cereals1<-na.omit(Cereals1)
sum(is.na(Cereals_Data1))
```

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

Convert the names of the breakfast cereals to row names so that we can visualize the clusters later.

```
rownames(Cereals_Data1) <- Cereals_Data1$name
rownames(Cereals1) <- Cereals1$name
```

Remove the name column because it contains no longer any useful information.

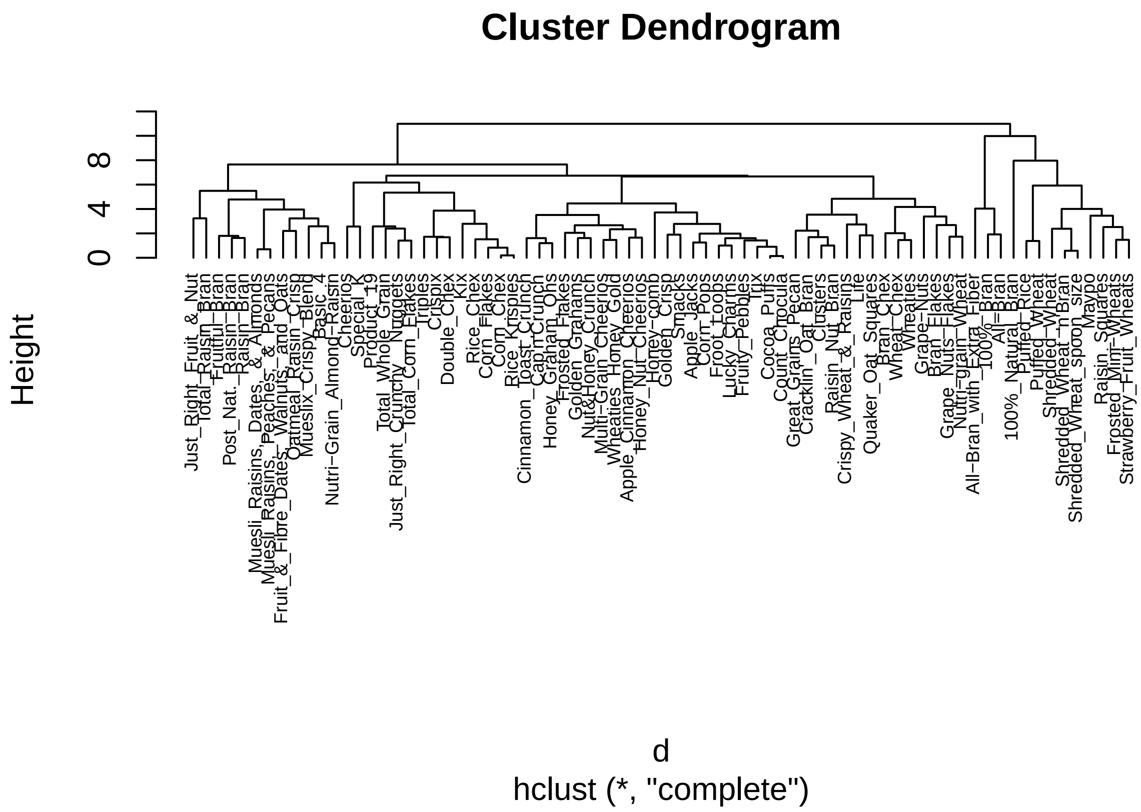
```
Cereals_Data1$name = NULL
Cereals1$name = NULL
```

Before measuring any form of distance metric, the data must be scaled, as factors with greater ranges will have a substantial effect on the distance.

```
Cereals_Data1 <- scale(Cereals_Data1[,3:15])
```

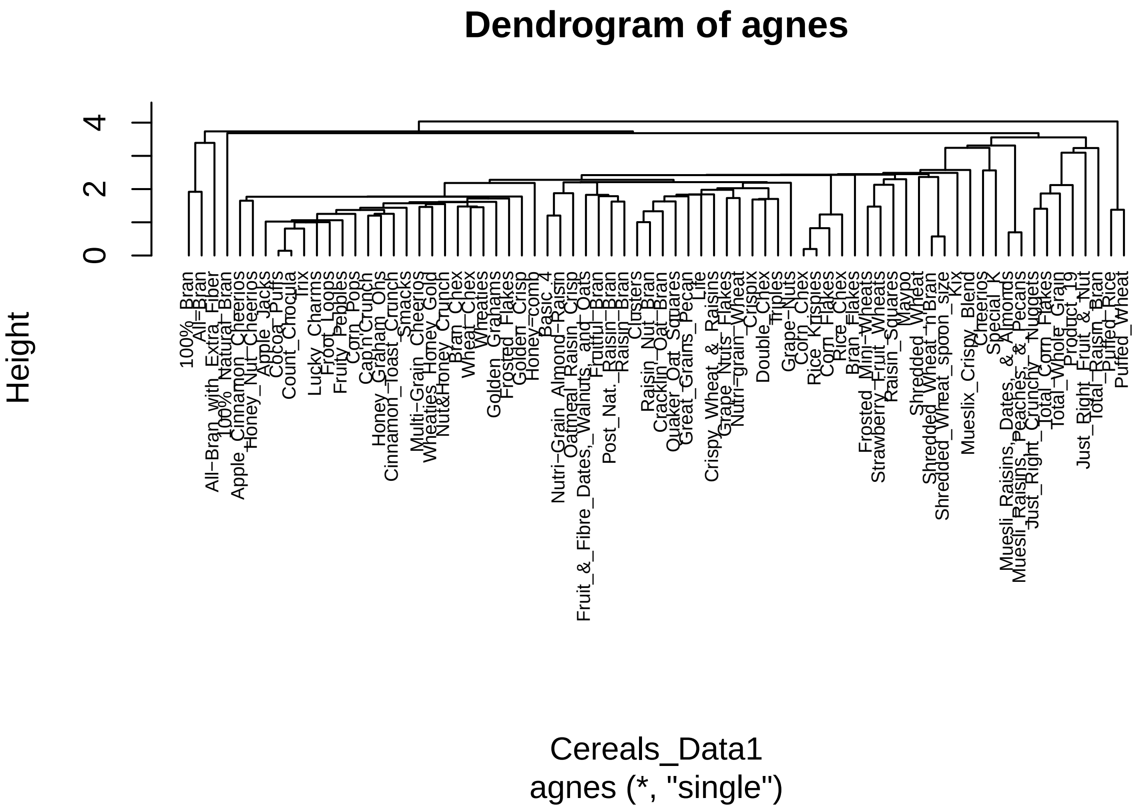
We will use Euclidean distance to do hierarchical clustering on the data.

```
# Dissimilarity matrix
d <- dist(Cereals_Data1, method = "euclidean")
# Hierarchical clustering using Complete Linkage
HC_comp <- hclust(d, method = "complete" )
# Plot the obtained dendrogram
plot(HC_comp, cex = 0.6, hang = -1)
```

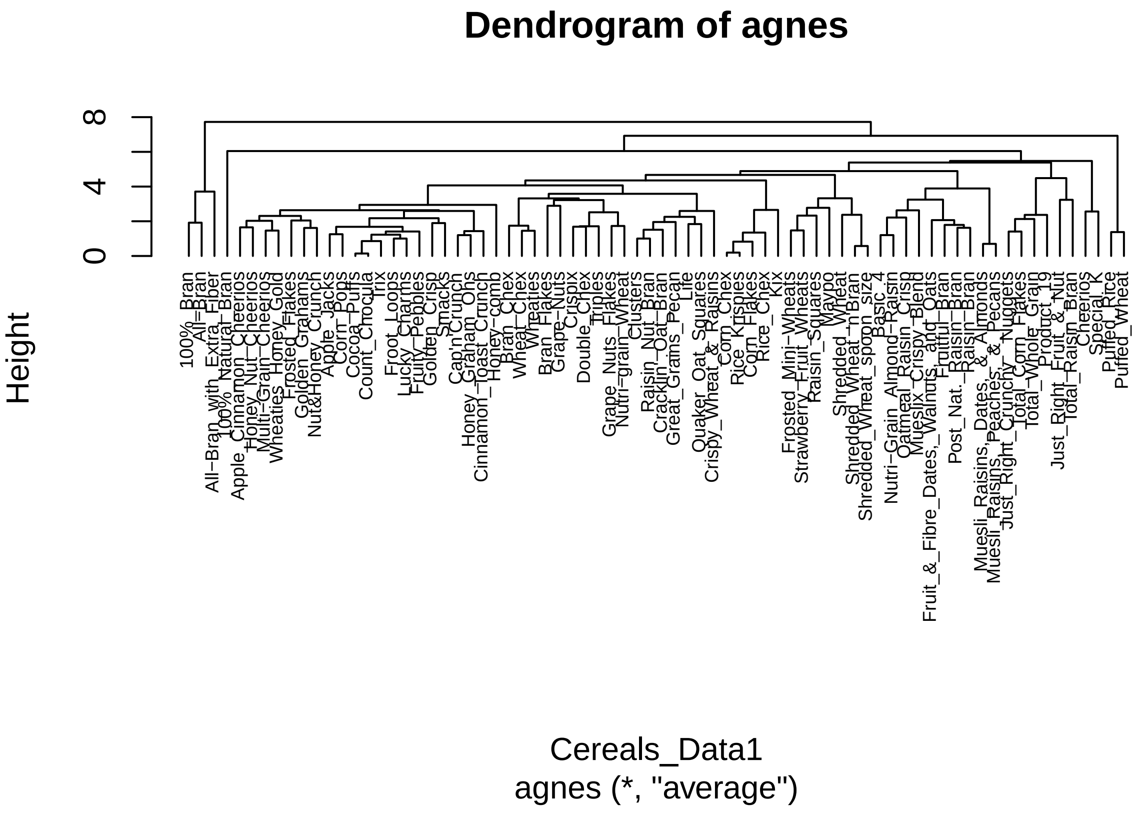


Using Agnes to examine clustering from single linkage, complete linkage, average linkage, and Ward, as well as the agglomerative coefficients of each approach.

```
library(cluster)
HC_single1 <- agnes(Cereals_Data1, method = "single")
pltree(HC_single1, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



```
HC_avg <- agnes(Cereals_Data1, method = "average")
pltree(HC_avg, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



We shall calculate the agnes coefficient for each approach.

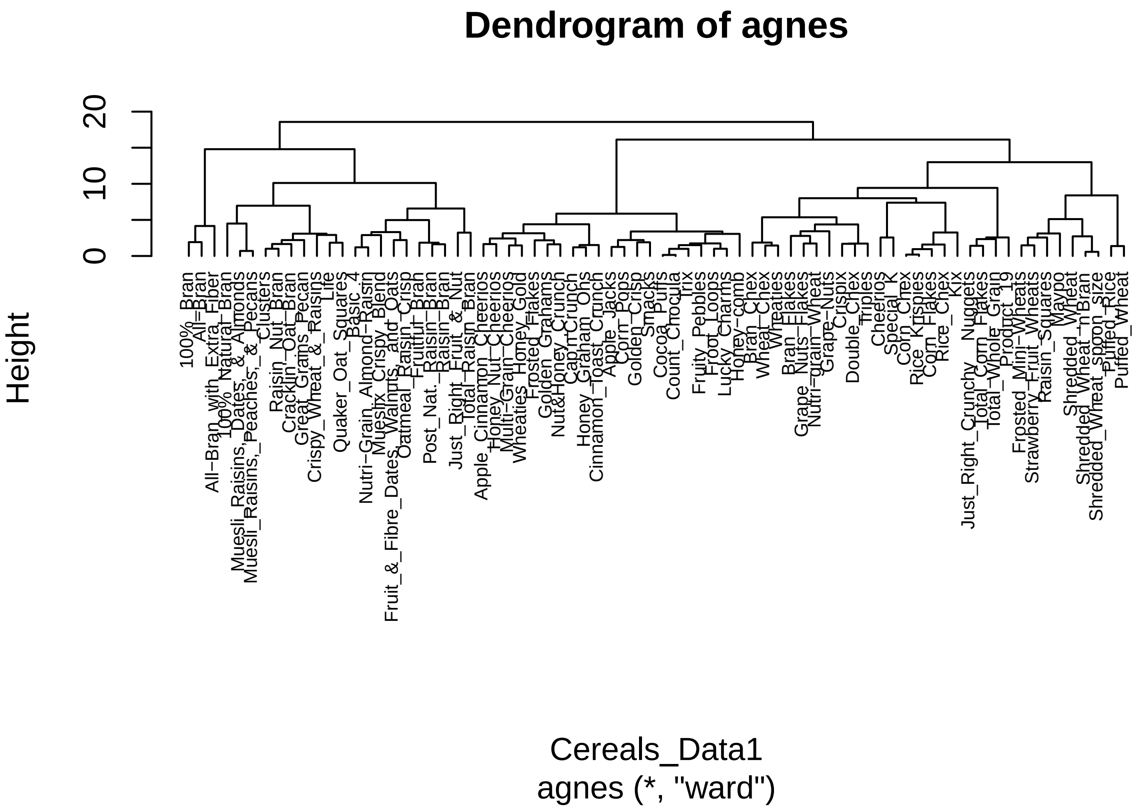
```
# methods to assess
m <- c( "average", "single", "complete", "ward")
names(m) <- c( "average", "single", "complete", "ward")
# function to compute coefficient
ac <- function(x) {
  agnes(Cereals_Data1, method = x)$ac
}
map_dbl(m, ac)
```

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

Ward is the best linking method, with an agglomerative coefficient of 0.9046042.

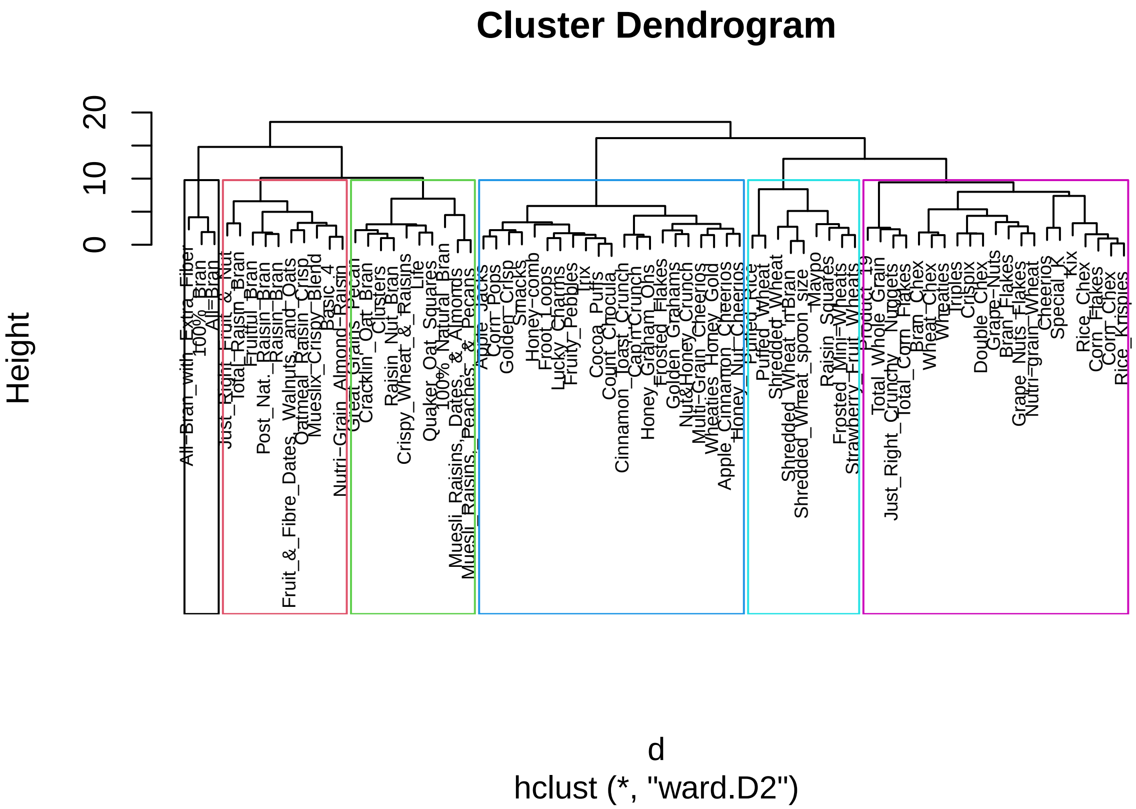
Using the wards approach to visualize the dendrogram:

```
HC_Wards <- agnes(Cereals_Data1, method = "ward")
pltree(HC_Wards, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



Cut the dendrogram with cutree() to find sub-groups (i.e. clusters):

```
#Create the distance matrix
d <- dist(Cereals_Data1, method = "euclidean")
# Ward's method for Hierarchical clustering
HC_Ward_clust <- hclust(d, method = "ward.D2" )
plot(HC_Ward_clust, cex=0.6 )
rect.hclust(HC_Ward_clust,k=6,border = 1:6)
```



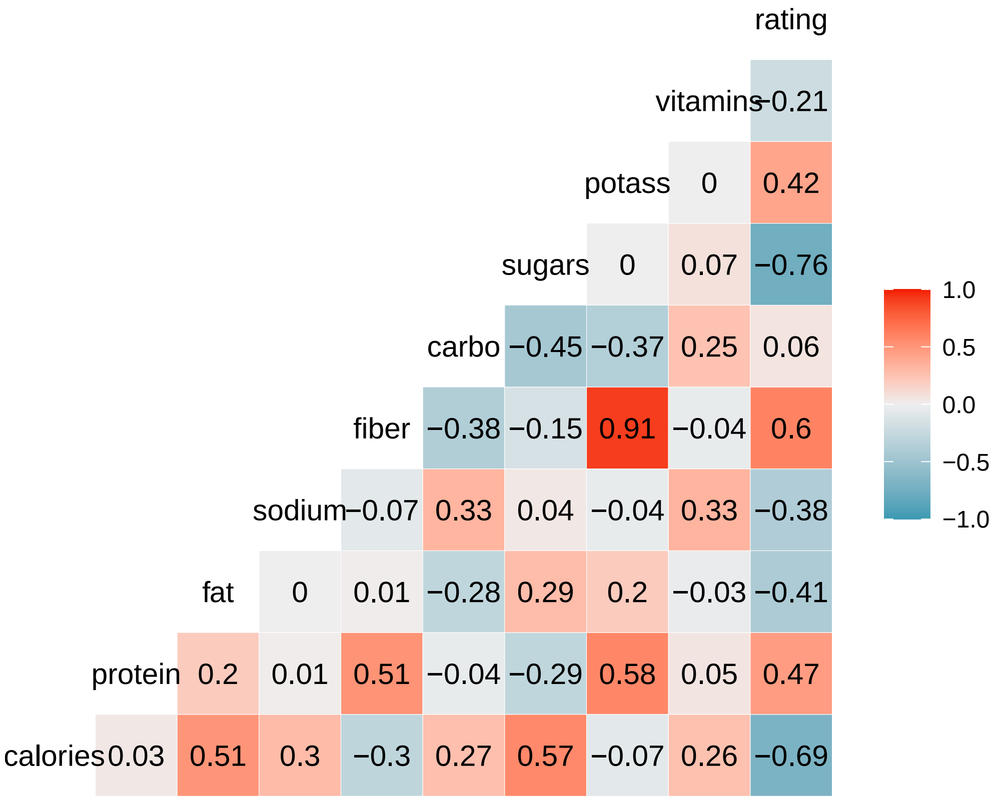
Let's examine how many data records have been categorized and allocated to clusters:

```
# Cut tree into 6 groups
sub_grup <- cutree(HC_Ward_clust, k = 6)
# Number of members in each cluster
table(sub_grup)
```

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

Correlation matrix:

```
#install.packages("GGally")
Cereals1 %>%
  select(calories, protein, fat, sodium, fiber, carbo, sugars, potass,vitamins,rating) %>%
  ggcorr(palette = "RdBu", label = TRUE, label_round =  2)
```



The correlation matrix assists us in determining if there is a strong or weak relationship between the variables. This will provide us with a better perspective for calculating descriptive statistics between variables.

The pvclust() method from the pvclust package returns p-values for hierarchical clustering using multiscale bootstrap resampling. Large p values will be assigned to clusters that are strongly supported by the data. Suzuki provides interpretation information. Keep in mind that pvclust clusters columns rather of rows. Before you use your data, make sure you transpose it.

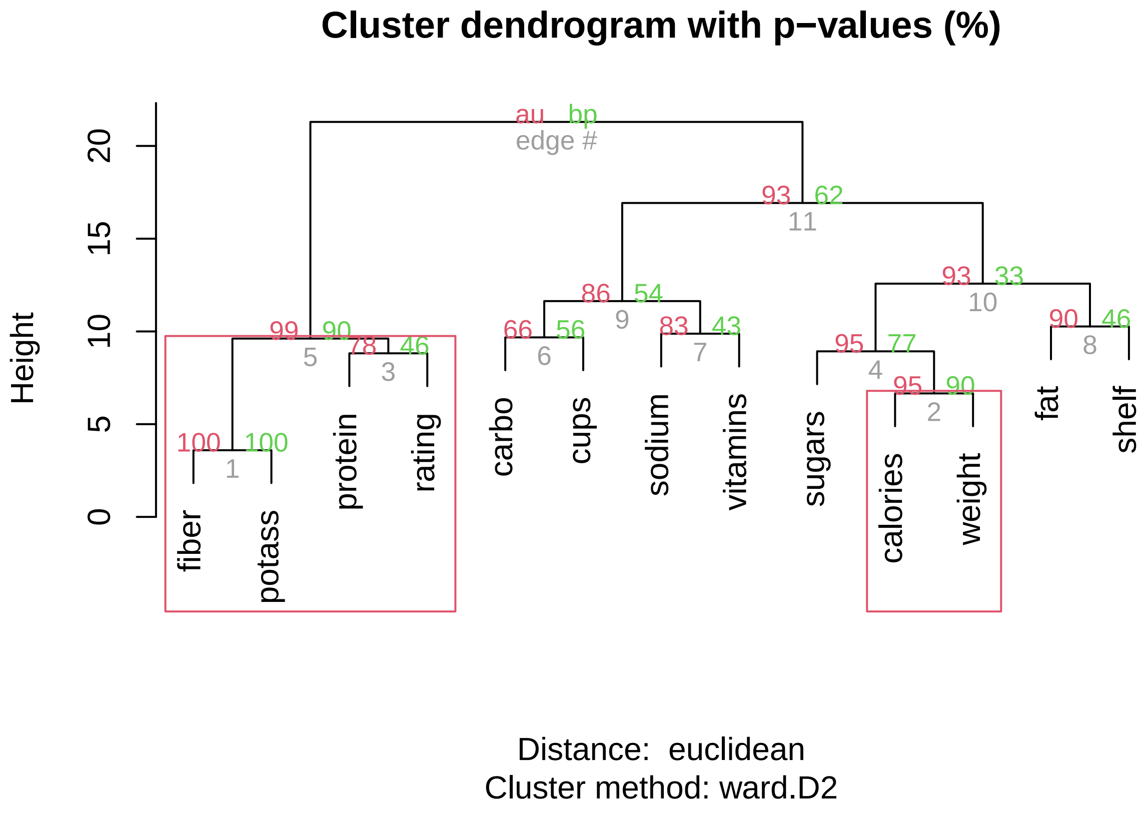
```
# Ward Hierarchical Clustering with Bootstrapped p values
#install.packages("pvclust")
library(pvclust)
```

```
## Warning: package 'pvclust' was built under R version 4.1.3
```

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

```
fit.pv <- pvclust(Cereals_Data1, 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)
```



In the initial clustering, the cluster stability of each cluster is the mean value of its Jaccard coefficient over all bootstrap iterations. Clusters having a stability rating of less than 0.6 should be deemed unstable. Values between 0.6 and 0.75 show that the cluster is detecting a pattern in the data, but there isn't a lot of conviction regarding which points should be grouped together. Clusters with stability ratings greater than 0.85 are regarded extremely stable.

1. 1.The mean of the clusterwise Jaccard bootstrap should be maximized.
2. The number of dissolved clusters should be kept to a minimum.
3. The number of recovered clusters should be maximized while remaining as close to the number of pre-specified bootstraps as feasible.

#Running clusterboot()

```
library(fpc)
```

```
## Warning: package 'fpc' was built under R version 4.1.3
```

```
library(cluster)
Kbest_p<-6
cboot_hclust <- clusterboot(Cereals_Data1,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
```

```
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
```

```
#The vector of cluster stabilities
cboot_hclust$bootmean
```

```
## [1] 0.8861899 0.4725252 0.8923053 0.6919398 0.5837242 0.6673889
```

```
#The count of how many times each cluster was dissolved. By default clusterboot() runs 100 bootstrap
#iterations.
cboot_hclust$bootbrd
```

```
## [1] 12 68  0 28 36 39
```

Based on the output, we may conclude that clusters 1 and 3 are highly stable. Clusters 4 and 5 are measuring a pattern, but there isn't a lot of agreement on which points should be grouped together. Clusters 2 and 5 are in a state of instability.

Extracting the clusters found by hclust()

```
groups <- cutree(HC_Ward_clust, k = 6)
print_clusters <- function(labels, k) {
for(i in 1:k) {
print(paste("cluster", i))
print(Cereals1[labels==i,c("mfr","calories","protein","fat","sodium","fiber","carbo","sugars","potass",
                "vitamins","rating")])
}
}
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***

Because there is no mention of an appropriate measure/scale to construct a healthy diet, I chose to pick clusters based on statistical values and rich in nutritional values to form a healthy diet, which is totally subjective.

To determine whether or not normalization was required. No, I would say. When we normalize the data, the magnitude of the data is gone, making it exceedingly difficult to interpret and decide.

The cereal diet levels in the clusters are nutritionally rich, sufficient, and poor. We divided all of the data into six groups, and we will analyze these clusters based on all of the variables/factors.

Despite the fact that Cluster 1 contains nutritionally consistent parameters for forming a balanced diet, the possibilities are quite restricted. Clusters 2 and 3 have low ratings and high fat and sugar content, which is not ideal for a healthy lunch.

Clusters 4 and 5 offer well-balanced nutritional values and high customer satisfaction scores. Hence Clusters 4 and 5 should be ideal choices for primary public schools to include this into their cafeterias.