# Displays for Statistics 5401

Lecture 2

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Class Web Page

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## Some ways of looking at multivariate data

A **scatterplot matrix** combines scatter plots of every variable against every other in a single display. You can make one using `plotmatrix()`

I will illustrate it on the famous Fisher iris data in J&W Table 11.5 (data set `T11_05` in file `JWData5.txt`.

You can read this directly using `read()` (or `matread()`).

Or, provided `CHARACTER` variable `DATAFILE` contains the file name, upi can read it using `getdata()` .

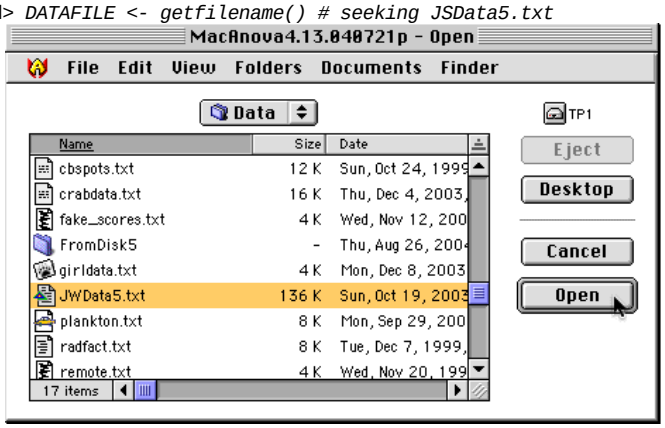
You can ensure this is the case by using `getfilename()`. This brings up a file navigation dialog box in which you select `JWData5.txt`





This is what it looks like in the Classic Macintosh MacAnova.

```
Cmd> DATAFILE <- getfilename() # seeking JSData5.txt
```




```
Cmd> DATAFILE # now contains the full "path name"
(1) "TP1:Stat5401:Stat5401F04:Data:JWData5.txt"

Cmd> irisdata <- getdata(t11_05,quiet:T) # get T11_05
Read from file "TP1:Stat5401:Data:JWData5.txt"

Cmd> list(irisdata) # dimensions of the matrix
irisdata        REAL   150   5

Cmd> head(irisdata,5) #same as irisdata[run(5),]
        Variety      SepLen      SepWid      PetLen      PetWid
(1)           1         5.1         3.5         1.4         0.2
(2)           1         4.9           3         1.4         0.2
(3)           1         4.7         3.2         1.3         0.2
(4)           1         4.6         3.1         1.5         0.2
(5)           1           5         3.6         1.4         0.2

Cmd> variety <- irisdata[,1] # column 1 contains 1, 2 or 3

Cmd> setosa <- irisdata[variety == 1,-1]#group 1 w/o col. 1
```

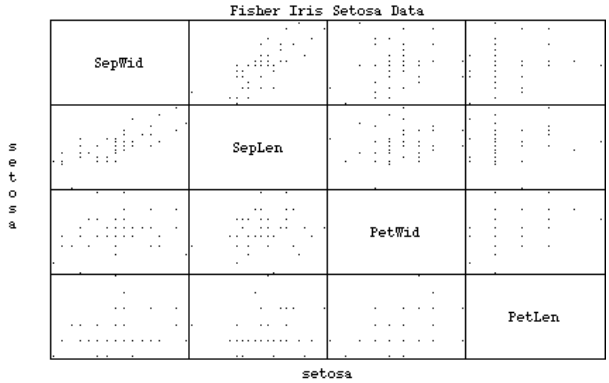
`variety == 1` selects variety 1 (setosa).





Now make scatterplot matrix using `plotmatrix()`.

```
Cmd> plotmatrix(setosa,title:"Fisher Iris Setosa Data")
```




## Vocabulary

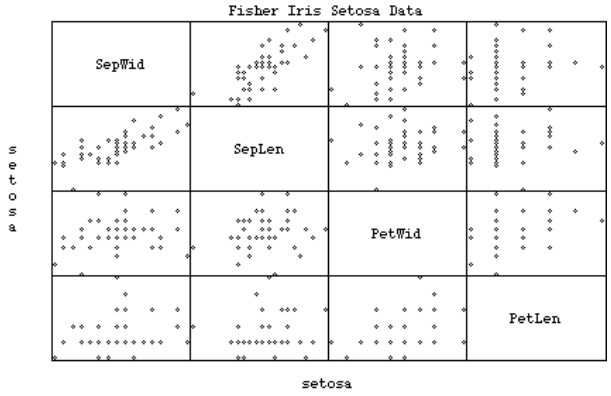
`title:"Fisher Iris Setosa Data"` in the command is a **keyword phrase**. Keyword phrases have the form `name:value` and are often used to control or change what a command does behavior of an operation.

Particularly common are `name:T` (true or yes) and `name:F` (false or no). For example, `quiet:T` is sometimes used to suppress the usual printed output.

If you think default symbols in the plot might are too small you can change them.

Symbol code "\21" specifies small diamonds using keyword **symbols**.

```
Cmd> plotmatrix(setosa,title:"Fisher Iris Setosa Data",\
       symbols:"\21")
```




These are easier to see.

## Limitation of scatter plot matrix

It provides information only on relationships of pairs of variables but no information about 3 and 4 variable relationships.





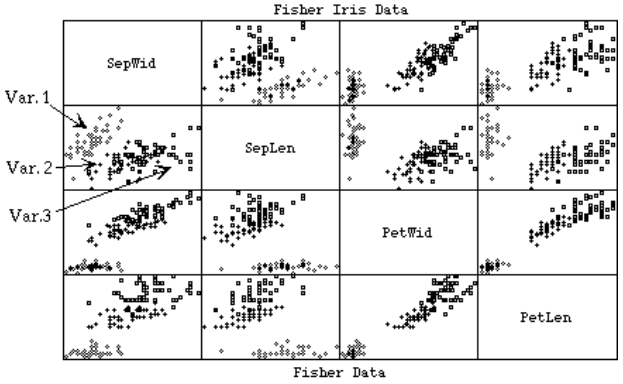
You can make a plot of *all* the iris data, distinguishing the three varieties of iris (1, 2 or 3) by differing symbols.

```
Cmd> y <- irisdata[,-1] # everything but column 1, 150 by 4
Cmd> symbols <- vector("\21","\22","\23")[variety] #150 by 1
```

"\21","\22","\23" are codes for small diamond (◇), cross (+) and square (▫).

[variety] is a *subscript*, selecting elements from vector("\21","\22","\23") All variety 1 cases get "\21", all variety 2 cases get "\22" and all variety 3 cases get "\23".

```
Cmd> plotmatrix(y,title:"Fisher Iris Data",xlab:"Fisher Data",\
ylab:" ",symbols:symbols)
```








## Chernoff Faces

This is a very clever idea that can sometimes be useful. It exploits the fact that people have a lot of experience in recognizing and differentiating *faces*.

A caricature of a face is drawn with the size and shape of features derived from a multivariate observation $\mathbf{x} = (x_1, x_2, \ldots, x_p)$.

You can use macro **faces()** to draw Chernoff faces. Unfortunately, there is a bug in one of the standard macro files **Graphics.mac** and you need a new version to use **faces()**.

```
Cmd> addmacrofile("") # Get macrofile containg faces()
Cmd> addmacrofile("") # Get new graphics.mac
Cmd> MACROFILES
 (1) "TP1:Macros:graphics:Graphics.mac"   New Graphics.mac
 (2) "TP1:Macros:Mulvar:mvgraphics.mac"   File with faces()
 (3) "Graphics.mac"
 (4) "Regress.mac"
 (5) "Design.mac"
 (6) "Tser.mac"
 (7) "Arima.mac"
 (8) "Mulvar.mac"
 (9) "Math.mac"
(10) "MacAnova.mac"
```





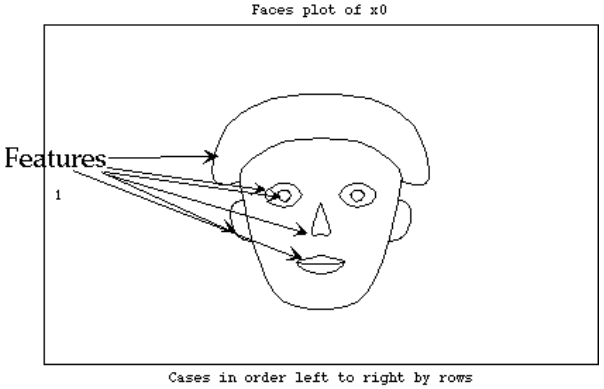
You always need to use **addmacrofile("")** before you can use a non-standard macro.

Here is a boring vector of p = 10 values:

```
Cmd> x0 <- rep(1,10)'; x0 # repeat 1 ten times
(1,1)        1          1          1          1          1
(1,6)        1          1          1          1          1
```

"'" indicates *transpose*, turning the column vector **rep(1,10)** into a row vector. **faces()** treats rows as cases.

```
Cmd> faces(x0) # draw generic face for featureless data
WARNING: searching for unrecognized macro faces near faces(
```

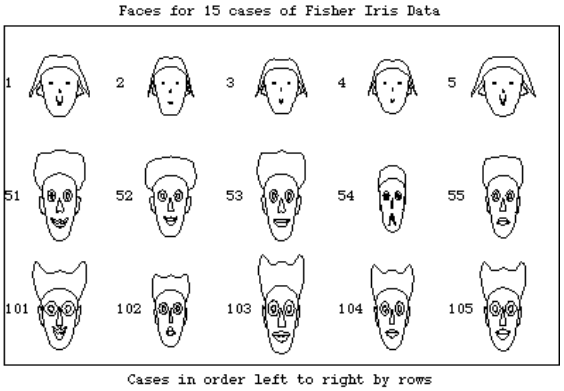



This is a generic face when all x's are the same.

Cases 1 - 50 of iris data are variety 1, cases 51-100 are variety 2, and cases 101-150 are variety 3.

Here is a faces plot of the first 5 cases in each group (cases 1-5, 510-55, 101-105) as selected by vector `J`.

```
Cmd> J <- vector(run(5), 50+run(5), 100+run(5)); J
 (1)          1          2          3          4          5
 (6)         51         52         53         54         55
(11)        101        102        103        104        105
Cmd> faces(y[J,],nrows:3,ncols:5,\
       title:"Faces for 15 cases of Fisher Iris Data",\
       labels:paste(J,multiline:T))
```




The backslashes (\) mean the command is continued on the following line.





`nrows:3,ncols:5` says there should be 3 rows of faces, 5 faces per row.

The face labels to their left come from `labels:paste(J,multiline:T)`. `paste(J,multiline:T)` is the same as `vector("1","2","3","4",...,"103", "104","105")`.

`paste()` is the way to turn numbers into character information. `multiline:T` directs that each number goes in a separate element.

There are several options. The help is in the same file as the macro.

```
Cmd> addhelpfile("") # locate file mvgraphics.mac

Cmd> usage(faces)
faces(Y [, whichvars:varnos] [,byrow:T] [,mods:Mods] [,scale:F]\
  [,min:Max] [,max:Max] [,keep:T] [,draw:T] [,nrows:nr] \
  [,ncols:nc] [,panel:F] [,labels:facelabs] [,labelplace:lp] \
  [,gridlines:T]  [,npoints:npts] [graph keywords]), Y REAL
  nonMISSING matrix, Mods a structure with positive scalar
  components, nr > 0, nc > 0 integers, CHARACTER vector
  facelabs, CHARACTER scalar lp, integer npts > 0
```

You can get more information by `help(faces)`, although the information is fairly rudimentary.





## Andrews plots

Each case $\mathbf{x} = (x_1, x_2, \ldots, x_p)$ is used to compute a curve f(t) which gets plotted.

Specifically, for Andrews plots the curve is

$$f(t) = \tilde{x}_1/\sqrt{2} + \tilde{x}_2\cos(2\pi t) + \tilde{x}_3\sin(2\pi t) + \tilde{x}_4\cos(4\pi t) + \tilde{x}_5\sin(4\pi t) + \ldots,$$
$$-.5 \le t \le +.5$$

where $\tilde{x}_j$ is a rescaled version of $x_j$, usually mapping the range of $x_j$ into the interval from -1 to 1.

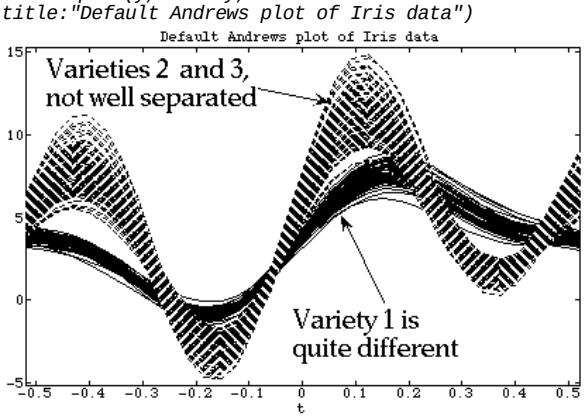
For each t, f(t) is a different linear combination of the variables.

You can make Andrews plots using macro `andrewsplot()`. Argument 1 is a data matrix, with each case in a row. You can use an optional second argument to specify groups so that different line types are used for different groups.

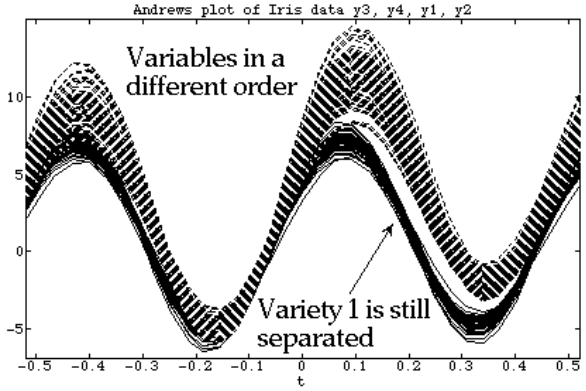




```
Cmd> andrewsplot(y,variety,\
     title:"Default Andrews plot of Iris data")
```




```
Cmd> andrewsplot(y[,vector(3,4,1,2)],variety,\
     title:"Andrews plot of Iris data y3, y4, y1, y2")
```



# More on MacAnova

## Entering data

- Single number: Just type it, using "scientific" notation if desired

```
Cmd> 3.54e3  # 3.54 x 10^3
(1)        3540

Cmd> -3.676e-3  # -3.676 x 10^-3
(1)    -0.003676
```

- Several numbers, creating a *vector*

```
Cmd> y <- vector(3, 2, 5, 4, 9, -1)

Cmd> y # typing name of variable, prints it
(1)          3          2          5          4          9
(6)         -1
```

(1) and (6) identify the first numbers in the rows as being elements y[1] and y[6].

```
Cmd> z <- enter(1 2 3 4 5) # commas not needed

Cmd> z
(1)          1          2          3          4          5

Cmd> 1/z # reciprocals; expression you type is printed
(1)          1        0.5    0.33333       0.25        0.2

Cmd> sqrt(z) # square roots
(1)          1     1.4142     1.7321          2     2.2361

Cmd> z^3 # cubes; "^" designates power
(1)          1          8         27         64        125

Cmd> 2*z + enter(10 0 0 0 0) # or 2*z + vector(10,0,0,0,0)
(1)         12          4          6          8         10
```





# Matrix and vector notation

A *matrix* is like a *rectangular table*, having rows and columns.

Here is a 4 × 3 matrix, that is a matrix with 4 rows and 3 columns

$$\mathbf{A} = \begin{bmatrix} 1 & 2 & -3 \\ 0 & 11 & 4 \\ 7 & 17 & 12 \\ -3 & 4 & 5 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \\ a_{41} & a_{42} & a_{43} \end{bmatrix}$$

A lot of statistical data and analysis, especially multivariate statistics, are best expressed using matrices.

One way you create a matrix in MacAnova is to use function matrix() with usage

```
Cmd> a <- matrix(data,nrows)
```

data, usually a vector, provides the contents of the matrix, put into a column by column. nrows = the number of rows = length of each column.





# Create A in MacAnova.

Matrix is "built" column by column, *not* row by row.

```
Cmd> a <- matrix(vector(1,0,7,-3, 2,11,17,4, -3,4,12,5), 4)

Cmd> # the final 4 is number of rows
```

```
Cmd> a
(1,1)          1          2         -3
(2,1)          0         11          4
(3,1)          7         17         12
(4,1)         -3          4          5
```

Row 2

Column 3

(1,1), (2,1), (3,1) and (4,1) identify the first numbers in each line as being elements in rows 1 through 4 and in column 1 of x.

For example 7 is in row 3 and column 1.

You extract elements using **subscripts**.

```
Cmd> a[2,3] # element in row 2 of column 3
(1,1)          4

Cmd> a[3,2] # element in row 3 of column 2
(1,1)         17
```

Each are these are essentially 1 by 1 matrices as the (1,1) suggests.