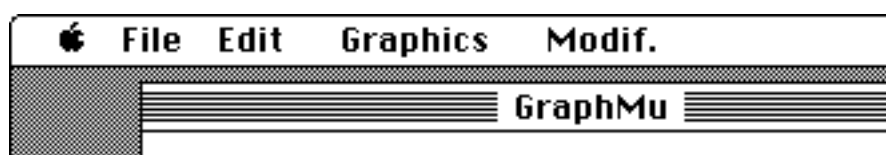


GraphMu

**Multivariate Graphical
Display for Macintosh**



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3 June 1991

GRAPHMU

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This document is the GraphMu user manual. A detailed introduction describes the basic principles. The various commands of each menu are then reviewed with a description of each of the dialog boxes. At the end of the manual several examples of graph construction are given.

GraphMu can be used independently of any multivariate data analysis method. The MacMul program facilitates the carrying out of basic analyses (principal component analysis (PCA), correspondence analysis (CA) and multiple correspondence analysis (MCA)) and supplies files which are directly compatible with GraphMu. ADECO (Analysis of Ecological Data) is a complete system based on HyperCard and Microsoft QuickBasic, with developed analysis methods, and also provides files which are compatible with GraphMu.

MacMul and GraphMu are available from the author. ADECO is available from:

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I should like to mention here the importance of the work of Y. Auda in the field of graphical display in data analysis and in particular his thesis, which is the origin of the development of GraphMu (Y. Auda, 1983. Rôle des méthodes graphiques en analyse des données: application au dépouillement des enquêtes écologiques. 3rd cycle thesis, Lyon 1 University, 127 p.).

Publication of results obtained with this software in scientific reviews is submitted to citation of one of the following papers:

Thioulouse J. (1989). Statistical analysis and graphical display of multivariate data on the Macintosh. *Computer Applications in the Biosciences*, **5**, 4, 287-292.

Thioulouse J. (1990). MacMul and GraphMu : two Macintosh programs for the display and analysis of multivariate data. *Computers and Geosciences*, **16**, 8, 1235-1240.

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1 - INTRODUCTION

General remarks

GraphMu is a program for Macintosh which produces graphical displays suitable for the analysis of multivariate data. In particular it can draw the factorial diagrams of analyses carried out using MacMul or ADECO very quickly. The drawings obtained can be recorded in PICT files or handled with the Macintosh "clipboard" which can pass them on to commercial drawing programs (MacDraw, SuperPaint, etc.).

The main principles of this program are taken from the thesis by Y. Auda, 1983. *Rôle des méthodes graphiques en analyse des données: application au dépouillement des enquêtes écologiques*. 3rd cycle thesis, Lyon 1 University

The basic feature is the facility to produce **graphic collections automatically**, as each elementary graphic may correspond either to a variable or to a group of individuals of a table.

As well as factorial diagrams, characteristic of multivariate data analysis, GraphMu can draw different types of curves, maps and graphic models (ellipses and Gauss curves), as well as map backgrounds, with automatic generation of sets of graphics possible each time.

This manual assumes that the user is already familiar with multivariate data analysis methods (PCA, CA and MCA), with MacMul or ADECO, and that he has some mastery of the Macintosh program environment (scrolling menus, dialog windows, mouse, etc.).

Input files

The files used by GraphMu are special files (called "binary" files) whose icon is shown in the left part of figure 1.1. These files may be produced by MacMul or ADECO programs (e.g. in the case of factor coordinates) or may have been created by GraphMu from a TEXT file from any Macintosh program (cf MacMul user's manual).

The file size limits are as follows: the maximum number of columns is 256 and the maximum number of points per graph is 50000. Thus, if one draws 10 variables (columns) simultaneously the number of individuals (lines) is limited to 5000.

Output files

The graphs created with GraphMu can be recorded in PICT files, whose icon is shown at the right of figure 1.1. These files may be opened with various commercial graphics programs.



Figure 1.1 :
Icons of files created by MacMul and GraphMu.

If one clicks twice on a PICT file created by GraphMu the GraphMu program itself is called. One may also start from GraphMu to open PICT files created by it which then allows handling of the images it contains using the clipboard to perform overlays by copy/paste.

GraphMu has some commands which allow it to create binary files (their icon is the same as that of files created by MacMul); these include the "Transfo. TEXT -> BIN" command, which transforms any TEXT file into a binary file and the "MVC File" and "01DI File" commands. As in MacMul, the "Transfo. BIN -> TEXT" command allows transformation of a binary file into a TEXT file which can be used by various Mac programs. The icon of the text files created by GraphMu is the same as that of the Edit files (cf MacMul Manual, p. 1).

GraphStack

GraphStack is a HyperCard stack which presents the program's main characteristics and explains the use of all the menus and dialog boxes.

Basic principles

In GraphMu the graphics are divided into 3 categories: curves, maps and models. Each category has a precise corresponding file structure, the different files involved being called "X" files, "XY" files, "G" files and "MVC" files. These names are taken from Auda (1983) who was inspired by the work of Bertin (1967, 77 and 79 in Auda, op. cit.). These files can have any number of columns less than 256 (one can select those which are used) and they must be binary.

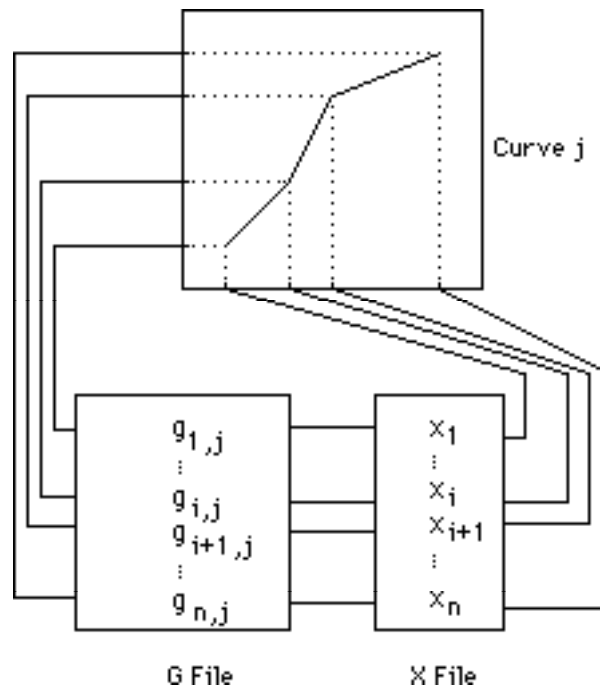
Curves

Five types of curve are available: curves made of points, lines, bars, histograms and steps. For all the curves one must have an X file containing the abscissae of all the points of the curve and a G file containing their ordinates. These two files must therefore have the same number of lines (except for histograms and step curves), each of the line corresponding to one of the points of one of the curves. The value

contained in the G file indicates, depending on the type of curve chosen, the ordinate of the point, the bar height, the **area** of the histogram rectangles, or the step height.

The factor coordinate files produced by MacMul can be used directly. For files from other programs (which must be of Text type), the "Transfo TEXT -> BIN" command of the File menu must be used. For all the curves, the X file is in fact optional: if no file name is given the abscissae are chosen automatically as being 1, 2, 3,... up to the total number of lines of the G file.

The diagram below gives the general operating principles.

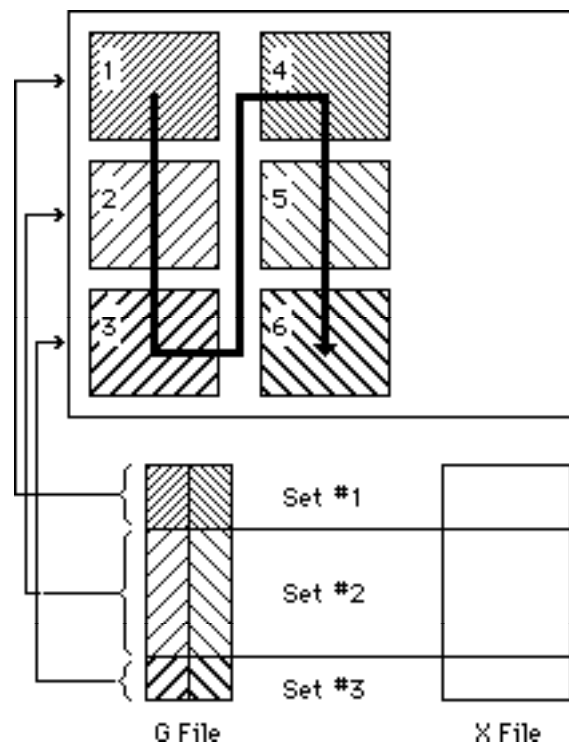


Each of the curves of a drawing corresponds to one of the columns of the G file and to a group of lines of the two files. A drawing will thus have a number of curves equal to the number of variables selected in the G file, multiplied by the number of groups of lines selected. All the curves of a same group will have the **same abscissae** (one can only select **one** column in the X file). The curves are drawn on the screen from top to bottom and from left to right, according to the number of horizontal and vertical graphics required. Figure 1.2 shows the dialog zone in which the user can specify the number of horizontal and vertical graphics he requires.

Horizontal graphics:	3
Vertical graphics:	3
Drawing: ☒ Square ☐ Rectangular	Frame: ☒ Yes ☐ No
Min. & max. of absc. & ordin.:	
Comput.: ☐ Yes ☒ No	Modif.: ☒ Yes ☐ No
OK	

Figure 1.2 :
Dialog box of the general graphic parameters.

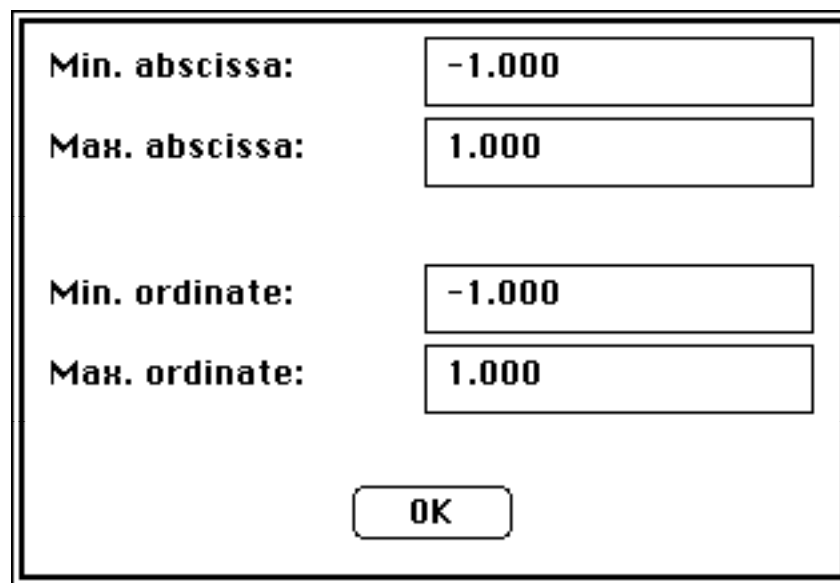
In the same dialog box the user must also indicate whether he requires a square or rectangular drawing (cf page 11), whether a frame must be drawn around each graphic, whether GraphMu must itself calculate the minimum and maximum of the curve abscissae and ordinates and finally whether the program must display these values, so that the user may change them.



For example, in the diagram above, the user has requested 3 horizontal graphics and 3 vertical graphics. The 2 variables of the G file are drawn for 3 groups of individuals, which gives 6 curves, each in one of the 6 graphics. The graphics are drawn in the order indicated on the diagram, from top to bottom then from left to right. The filling motifs indicate the values of the G file used to draw each graphic.

If the number of graphics (equal to the number of variables multiplied by the number of groups of individuals) is greater than the number of graphics which can be drawn in a window (equal to the product of the number of horizontal graphics by the number of vertical graphics), GraphMu automatically creates one or several other windows, which are stacked up on the GraphMu window, slightly staggered towards the bottom and the right. The window title gives their ordinal number (e.g. "Curve 1", "Curve 2", "Curve 3", etc.) which allows them to be recognised, even if they are moved with the mouse.

If the user has selected the "Modif." button in the general parameter dialog box (figure 1.2) before beginning to draw, GraphMu displays a new dialog zone which gives the minimum and maximum values of the abscissae and ordinates calculated by the program (figure 1.3.). These values may of course be modified.



Min. abscissa:	-1.000
Max. abscissa:	1.000
Min. ordinate:	-1.000
Max. ordinate:	1.000
OK	

Figure 1.3:
Dialog box for display and modification of the minimum and maximum of the abscissae and ordinates

Maps

Five types of map are available: maps with characters, with circles, with squares, with circles plus squares and digitized maps.

The "map with characters" command may be used to place a character string at a point of coordinates (x,y) on the diagram (classical "factor plane" in multivariate analysis).

The "maps with circles" and the "maps with squares" commands may be used to place a circle or square (which size is proportional to the absolute value of a variable) at a point of coordinates (x,y) on the diagram. The map with circles and squares may mix circles and squares, the circles corresponding to negative values and the squares to positive values.

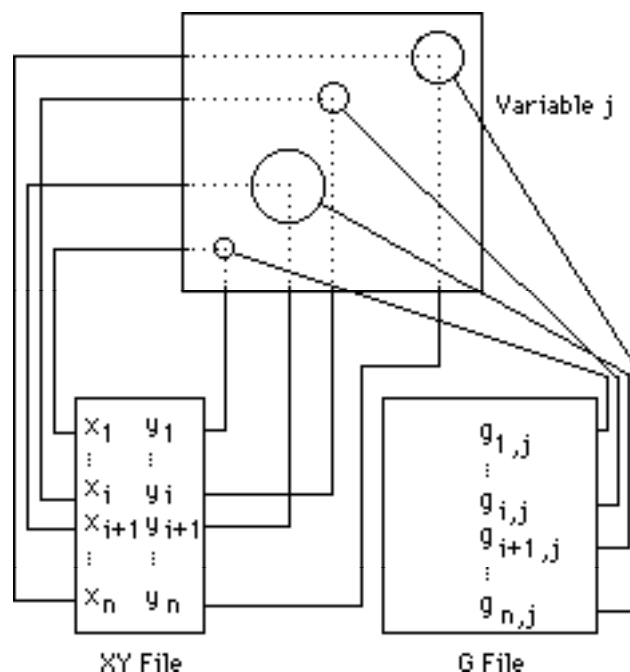
The digitized maps command may be used to draw map backgrounds (obtained with the "Digitization" command of the "File" menu) or some graphics from files created by ADECO programs.

Two types of file are needed : an "XY file", which contains the coordinates of each point to be placed on the map and a "G file", which contains either the character strings (in the case of maps with characters), or the variable(s) determining the size of the circles or squares.

In the case of the maps with characters, only the XY file must be binary; the G file must contain the character strings which will be placed on the maps. There must be just one string per line and the number of characters per string must be constant (i.e. the same for all lines). This G file is optional: if no file name is given the characters are chosen automatically as being "1", "2", "3", ... up to the total number of lines of the XY file.

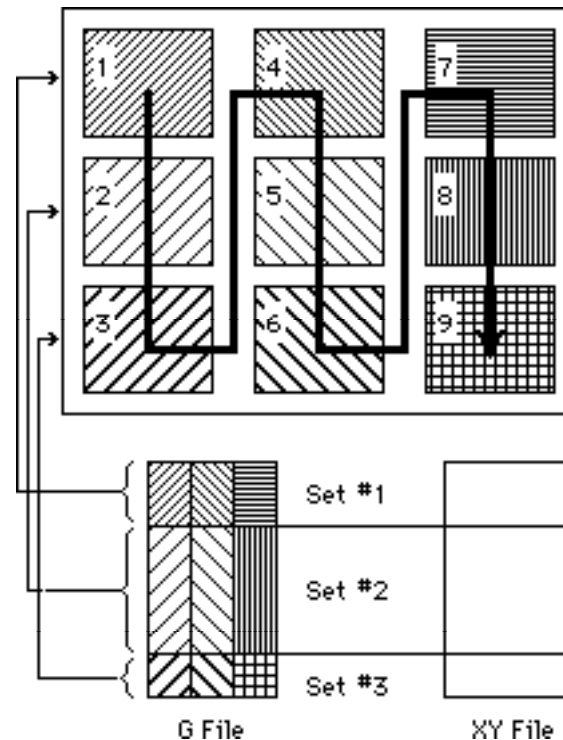
The diagram below gives the general operation principle for a map with circles.

In the case of digitized maps, the G file must contain 1 if two successive points on the map are to be joined by a straight line, or else 0.



The XY and G files must have the same number of lines and each of these lines corresponds to one of the points on one of the maps of a drawing.

As for the curves, one can make collections of maps, each map of a graphic thus corresponding to a variable of the G file and to a group of lines (cf example below). This is particularly useful in the case of factorial diagrams in multivariate analysis, because one can thus draw a map for each group of individuals revealed by the analysis. All the maps of a same drawing will have the same abscissae and ordinates: one can only select 2 columns in the XY file (an abscissa column and an ordinate column).



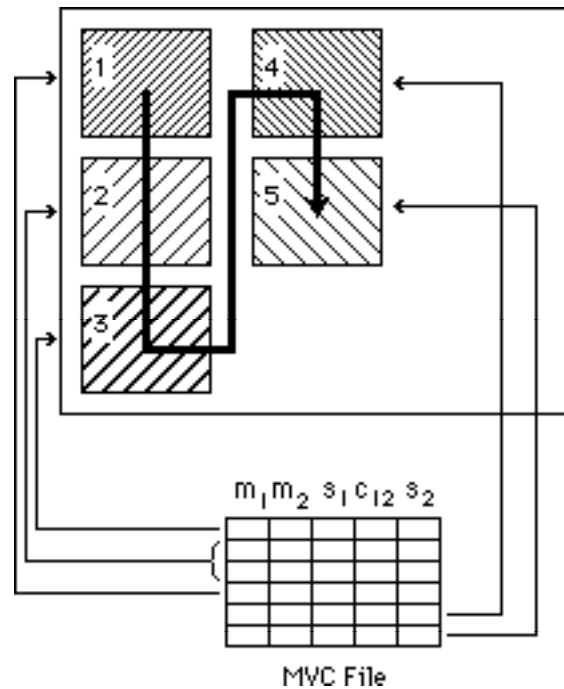
Models

Two types of modelled displays are available: ellipses and Gauss curves. The display by ellipses is used to draw an ellipse, characterised by the length of its large axis and its small axis and by its slope, at point with coordinates (x,y). The display by Gauss curves allows the drawing of Gauss curves, characterised by their mean and their variance.

Both ellipses and the Gauss curves need a special type of file, called "MVC files". These files contain the means, variances and covariances of a set of variables. For a number p of variables this file must have $2p + p(p-1)/2$ columns.

The first p columns correspond to the means of the p variables and the following correspond to the elements of the lower triangle of the covariance matrix of the p variables ($p + p(p-1)/2$ columns). For example, for $p=2$ variables, the first two columns must contain the means of two variables and the 3 following must contain, in order, the variance of the first variable, the covariance of the two variables, then the variance of the second variable, i.e.: $m_1, m_2, s_1, c_{12}, s_2$. For $p=3$, one must have the order: $m_1, m_2, m_3, s_1, c_{12}, s_2, c_{13}, c_{23}, s_3$.

The lines in the file must correspond to the groups of individuals on which the parameters have been calculated. On the p variables of the file, one must choose two for a display by ellipses and one for a display by Gauss curves.



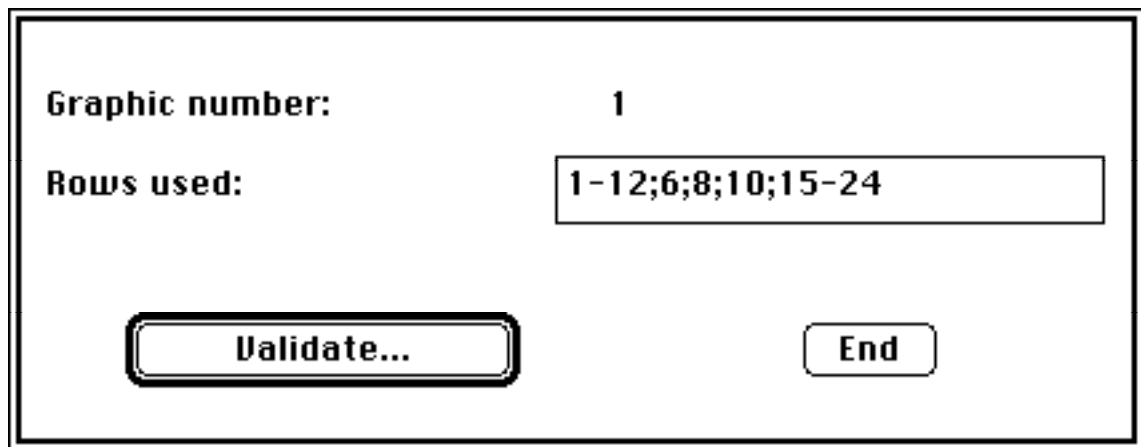
One may also make collections of ellipses or Gauss curves. Each graphic thus corresponds to one line or one group of lines of the MVC file, as for lines 2 and 3 of the example above (**one** line always corresponds to **one** ellipse or to **one** Gauss curve, but several ellipses or Gauss curves may be present in the same graphic).

Selection of lines and columns

In GraphMu, the lines of a file associated to each graphic may be selected in two ways: either by typing on the keyboard their number in the appropriate dialog boxes, or by using a selection file. Columns are only selected on the keyboard.

Selection on the keyboard takes place by typing in the appropriate zone the numbers separated by semi-colons (e.g.: 1 ; 2 ; 5 ; 3) or, in the case of successive elements, the number of the first and the last, separated by the word "to" or "TO", or by any one or several but different characters of the semi-colon and 10 figures (e.g. "1to5" or "1-5" or "1through5"). Both can also be used (e.g.: 5 ; 4to8; 1-6; 9; 7).

Figure 1.4 gives an example of the line selection dialog (this dialog is used each time the user must select lines on the keyboard).



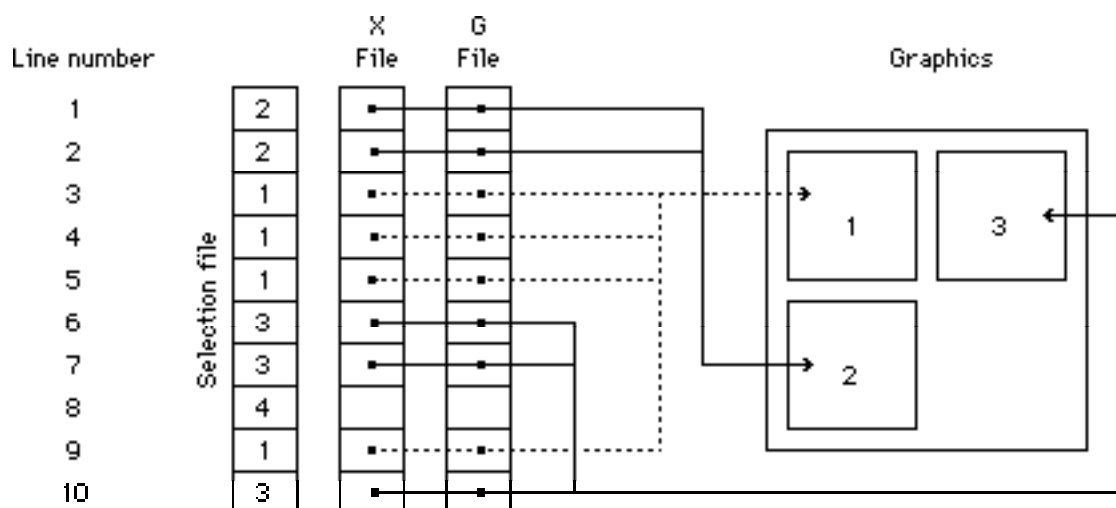
The dialog box is titled "Graphic number:" with the value "1" displayed next to it. Below this, it says "Rows used:" followed by a text input field containing the string "1-12;6;8;10;15-24". At the bottom of the dialog, there are two buttons: "Validate..." on the left and "End" on the right.

Figure 1.4
Dialog box for the selection of lines on the keyboard.

When the numbers of the lines corresponding to a graphic have been typed, one just needs to click the "Validate" button, which confirms the selection of these lines, and allows the user to pass to the group of lines associated with the next graphic. When all the desired graphics have been associated to groups of lines, one has to click the "End" button to continue in the program.

Selection by file uses a file which must be binary and must have a number of lines equal to the number of lines of the X, XY, G or MVC files. One can choose the column which is used for selection. It must contain a qualitative variable whose categories indicate the number of the graph with which each line of the X, XY, G or MVC file is associated. For example, if in the selection file line No. 5 contains the value 3, this means that the 5th line of the graphics file must be associated with graphic number 3. A maximum category may be specified, from which the file lines will no longer be used in the graphics. For example, if one types 5 for this maximum category, the lines corresponding to the selection file lines which contain values greater than or equal to 5 will not be used (there will thus be no more than 4 graphics).

The example below shows the use of a line selection file. One supposes that 4 was specified as maximum category number, which is why line No. 8 of the X and G files is not used.



One sees that lines number 3, 4, 5 and 9 of the X and G files are used to draw the first graphic, then that lines 1 and 2 are used for graphic 2 and that lines 6, 7 and 10 go to graphic 3. In this simplified example, one supposes that the selection file, the X file and the G file have only one column.

The dialog which allows indication of the selection file is shown in figure 1.5. In this dialog, there is no automatic file selection button : the name of the file must be typed in the corresponding appropriate field. As there is no cancel button either, the user must take care to remember exactly the name of the file.

Selection file:	Select
Rows:	24
Columns:	3
Selection column:	2
No. categories (add 1):	7
OK	

Figure 1.5
Dialog box for the line selection file

Shape of graphics

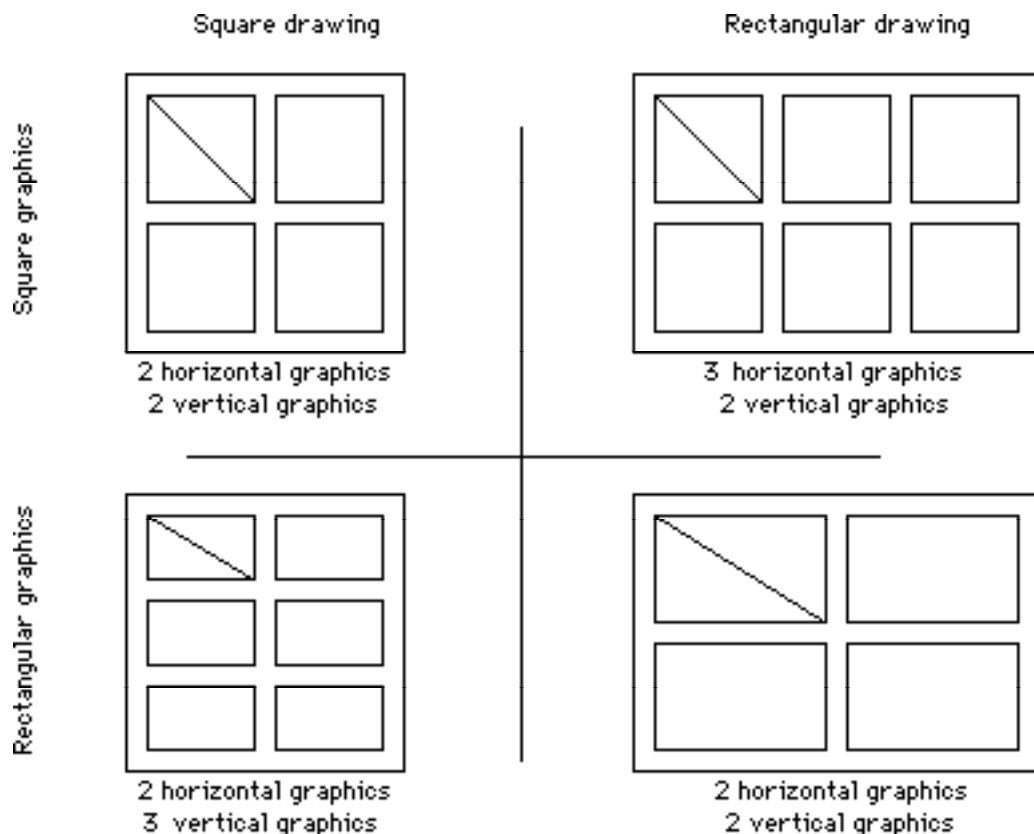
When collections of graphics are made with GraphMu, the shape of each elementary graphic is a function of the drawing shape required (square or rectangular, see figure 1.2), of the number of horizontal and vertical graphics (see also figure 1.2) and, in the case where a rectangular drawing is required, of the window shape.

The shape of each graphic is determined by the following rules :

If one requires a **square** drawing, each graphic will be **square** on condition that the number of **horizontal** graphics is **equal** to the number of **vertical** graphics, whichever is the shape of the window.

If one requires a rectangular drawing, each graphic will be square on condition that the ratio of the number of horizontal graphics to vertical graphics is equal to the width/height ratio of the window.

In all other cases, each graphic is rectangular, with a width/height ratio being a function of the 3 following parameters: number of horizontal graphics, number of vertical graphics and window shape.



2 - USE

We will now study the commands of each menu (figure 2.1):

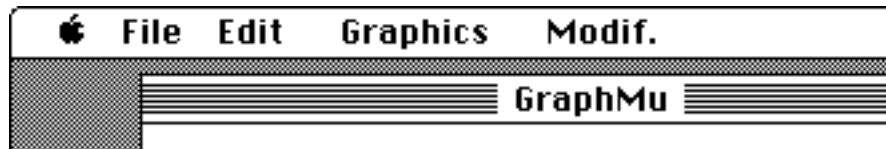


Figure 2.1:
GraphMu menu bar.

□ Menu

The first command of the "Apple" menu is the "About GraphMu..." command. This command displays a dialog window (figure 2.2) containing some general information and in particular the number of the version of the program being used. Click the OK button to return to GraphMu.

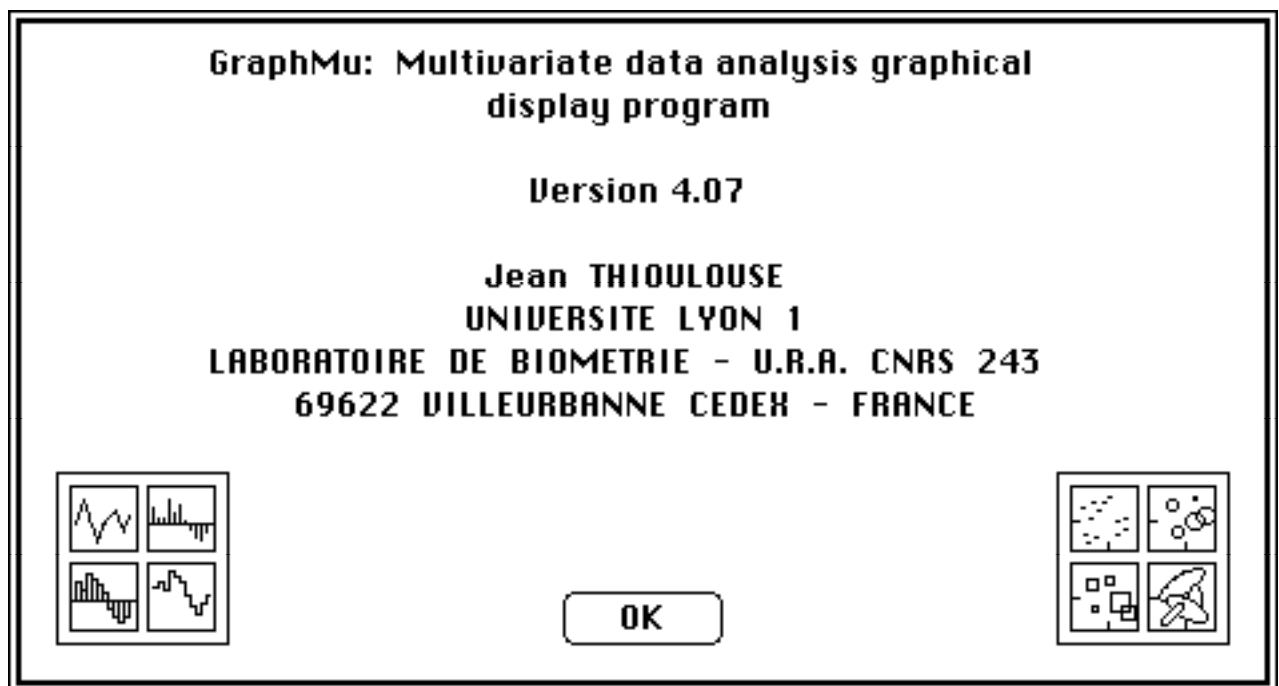


Figure 2.2:
Window called by the "About GraphMu..." command.

File menu

The "File" menu offers the usual commands (New, Open, Save, Close). They allow handling of PICT files created by GraphMu (figure 2.3). A series of utility commands follows which is described below.



Figure 2.3:
GraphMu "File" menu

New

Creates a new empty window (called "Untitled" plus a number), which can be used, e.g., to paste graphics from another window, when superimpositions are being made. The window size is the same as that of the last window created (by default, it is the size of the "GraphMu" window, automatically displayed when the program is run). It is placed in front of the active window. Like all the drawing windows created by GraphMu, its size can be changed by clicking in the bottom right corner: the cursor changes appearance when it is in the size modification area (figure 2.4). The "Screen size" command of the "File" menu also allows changing the size of the "GraphMu" defaults window.

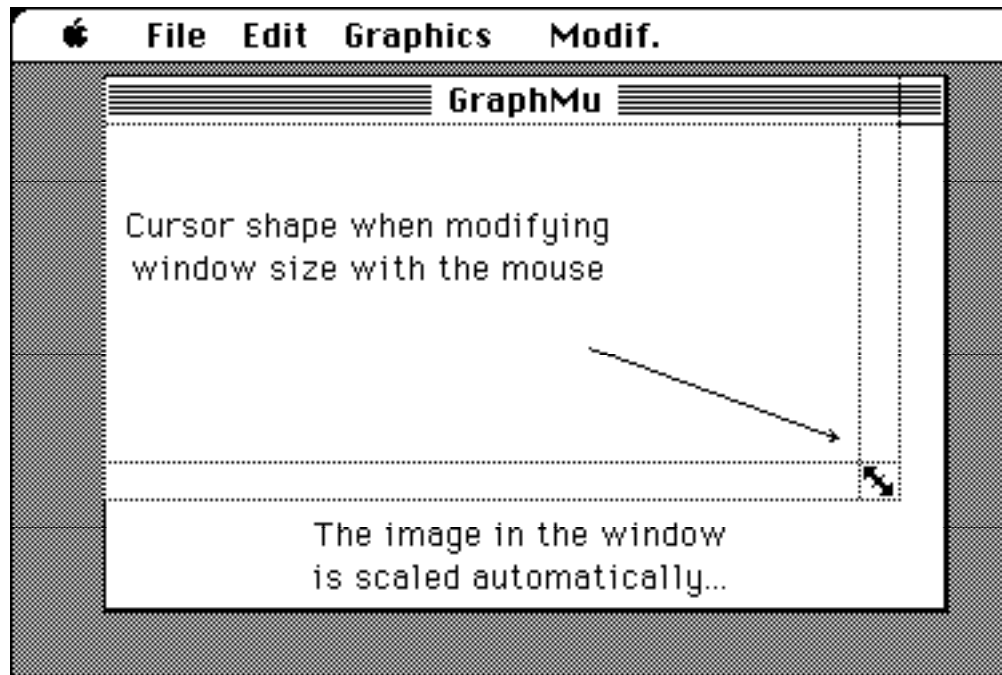


Figure 2.4:
Changing the size of a window with the mouse in GraphMu

Open

Opens a PICT file (generally a file created by GraphMu) and displays the image which it contains in a new window. This command is especially useful when one wishes to superimpose (by copy/paste) an image which has just been drawn and an image which was previously saved in a file.

Save

Allows saving of the drawing contained in a window to a PICT file. These files can be reread and changed with various Macintosh programs, such as MacDraw or SuperPaint. The image contained in a window can also be saved in a PICT file when one closes the window by clicking in the close box, or by using the "Close" command of the "File" menu. A dialog box (figure 2.5) then appears to ask if the drawing is to be saved. In this dialog box, the default answer (selected when the user types the carriage-return key), is "No".

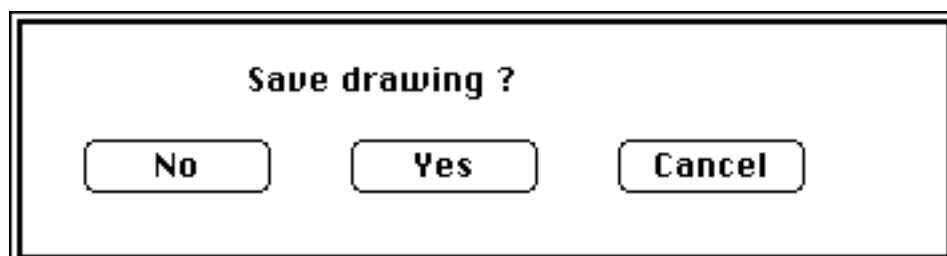


Figure 2.5:
Dialog box to ask for confirmation of the saving of an image.

Close

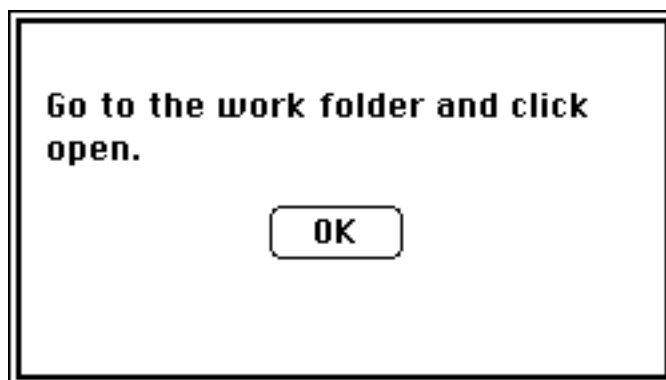
Allows a window to be closed and possibly saving of the drawing it contains in a file. The dialog box of figure 2.5 then appears.

Close all

This command allows all the open windows to be closed quickly, without asking for each one whether the image it contains is to be saved.

Work folder

Allows selection of the folder containing the work files. Just go to the folder containing the needed files, select any one, then click on open. All the files to be used for the same graphic must be found in the same folder, but the folder can be changed to produce different graphics.



*Figure 2.6:
Dialog window of the "Work folder" command.*

Transfo. TEXT -> BIN

GraphMu uses binary files. This command allows transformation of any numerical file of TEXT type into a binary file (this transformation is not needed for the files of factor coordinates from MacMul or ADECO, which are already binary files). After having selected the text file to be transformed, the user must indicate its number of columns, the column separators and the decimal point symbol (dot or comma, see figure 2.7).

The text file must contain numbers, written in any format. The real numbers can be written with a comma as decimal symbol, e.g.: **3,14** (only for compatibility with French or Gallicized programs) or a full stop, e.g.: **3.14**.

Column separators can be chosen; **the options presented by default (spaces, commas, tabs and line jumps) allow reading of most text files found on the Macintosh.** Two successive columns can be separated by any number of separators.

When the decimal point symbol is a comma, this character obviously cannot be used as separator. A separator different from those proposed in the list can be specified by checking the "Other" box and typing its ASCII code in the corresponding field.

Number of columns:

Separated by:

- ☒ Spaces (ASCII 32):
- ☒ Comma (ASCII 44):
- ☒ Tabs (ASCII 9):
- ☒ Line feed (ASCII 10):
- ☐ Vert. Tab. (ASCII 11):
- ☐ Form feed (ASCII 12):
- ☐ Carriage return (ASCII 13):
- ☐ Other: ASCII code=

Decimal point:

- ☒ Period (.)
- ☐ Comma (,)

Figure 2.7:
Dialog window for the transformation of text files into binary files.

During the transformation, GraphMu displays the number of lines read. At the end, if the number of values contained in the file is not a multiple of the number of columns indicated, GraphMu displays the following error message (figure 2.8):

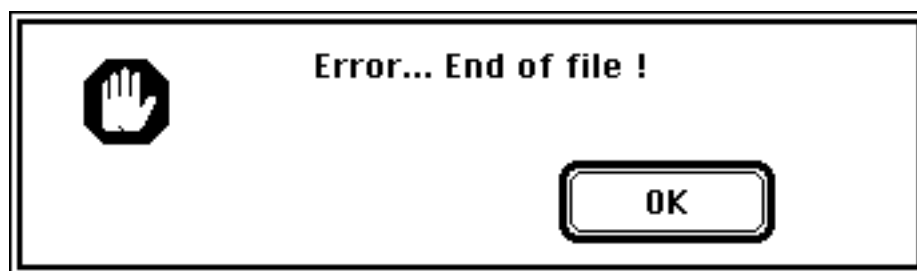


Figure 2.8:
End of the file warning box.

The contents of the output file is thus undetermined...

Transfo. BIN -> TEXT

This command corresponds to the inverse transformation of the preceding one: it transforms a binary file created by GraphMu (or MacMul, or ADECO), into a text file which can be used in word processing or spreadsheets. The text file obtained has a point (not a comma) as decimal symbol. It will thus only be compatible with

non-French versions of spreadsheets (or with French versions which accept the decimal point). GraphMu asks the user to indicate the number of columns of the binary file (figure 2.9). The maximum authorised number is 256. Here one can give a number different from the number of columns declared when the file was created, but be careful with the structure of the output file in this case.

Figure 2.9:
Dialog box for binary to text transformation.

An important difference compared to the corresponding command in MacMul is that here one can specify an output format different from the standard one. In this case a FORTRAN writing format may be indicated, which allows "fixed format" files to be obtained. This is useful for certain programs. The syntax of this format is not checked, apart from the presence of external brackets, which are added if they are not specified. If the syntax is incorrect, an error may occur during transformation. In this format, one can specify the tabulation character to obtain files compatible with spreadsheets by typing the **option-t** character.

MVC File

This command allows construction of an MVC file (binary file with 5 columns: moy.1, moy.2, var.1, cov.1-2 and var.2) to draw ellipses or Gauss curves from a file of row factor coordinates and the initial data file (CA) or the complete disjunctive table (PCA or MCA). The initial CA file and the disjunctive file must be binary. Figure 2.10 shows the corresponding dialog box.

In MCA, the first column of the output file (MVC file) will contain the mean of the input file variable (factor coordinates) indicated in field "Var. 1". The second column will contain the mean of the variable indicated in field "Var. 2". Columns 3 and 5 will contain the corresponding variances and column 4 will contain the covariances. These means, variances and covariances are calculated for all the individuals (rows) belonging to each category indicated in the complete disjunctive file (01DI file). The MVC file will thus have a number of **rows** equal to the number of **columns** of the complete disjunctive file (equal to the total number of categories of the MCA qualitative variables).

In PCA, the principle is identical, but in this case the disjunctive file no longer represents the categories of several qualitative variables, but a division of the set of individuals into several groups. One thus obtains the means, variances and covariances calculated within these different groups.

Coordinates file: Initial file (AFC) or 01DI (ACM):

Columns: Rows:

Var. 1: Columns:

Var. 2:

Output file (MVC):

Figure 2.10:

Main dialog window of the "MVC File" command of GraphMu. The MVC file obtained ("chatMVC" here) is a binary file which can be used directly to draw ellipses or Gauss curves.

In CA, the parameters are calculated in the same way, but one introduces the initial data file of the analysis instead of the disjunctive file, so one obtains as output in the MVC file the conditional means, variances and covariances of factor coordinates (Thioulouse and Chessel, Ecology, in press).

01DI File

This command allows construction of the complete disjunctive table associated with a file of qualitative variables. This operation is necessary before using the "MVC File" command in MCA or in PCA.

The calculation principle is the following (example with 4 individuals and 3 variables) :

Variable 1:	2 categories
Variable 2:	4 categories
Variable 3:	3 categories

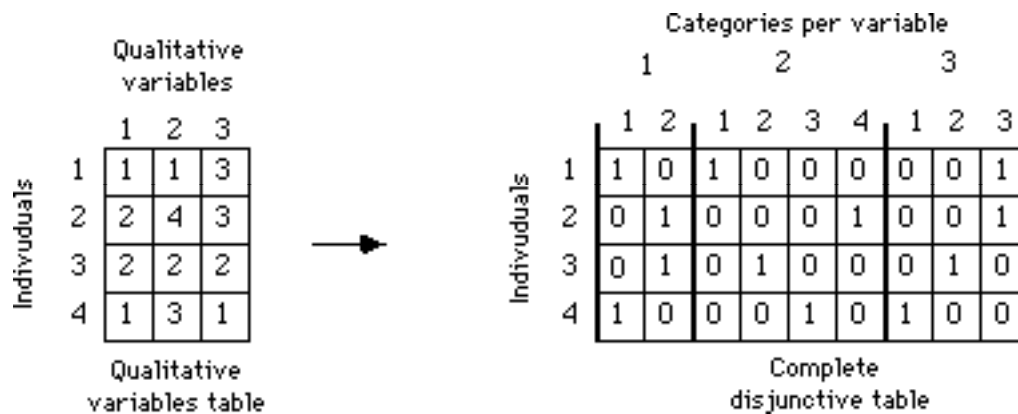


Figure 2.11:

Principle of the transformation from a qualitative table to a complete disjunctive table.

In the first table, each column corresponds to a qualitative variable and each line corresponds to an individual. The values contained in this table are the categories to which belong each individual for all the variables.

In the complete disjunctive table, the lines also correspond to individuals, but each column corresponds to a category of one of the variables (there is thus a number of columns equal to the sum of the number of categories of all the variables). The values contained in this table are either 1 or 0, depending on whether the individual belongs to the category considered or not.

List BIN file

Displays on the screen the contents of a binary file (this avoids having to transform it into text file and using a text editor to check the values it contains). It uses the scientific format with 4 figures after the comma (example: 0.6544E-01, or -.5792E+03). The window width only allows 7 numbers to be displayed per line; if the lines contain more than 7 numbers, they are displayed on the following lines. The display is by groups of 20 lines and for files with many columns the first line may not be visible. The "Next" and "Stop" buttons allow passing to the following group of 20 lines or stopping the display and returning to the main GraphMu window respectively.

Number of rows & columns

Allows consultation or changing of the number of rows and columns of a binary file. This command does not modify the file contents or structure, but just modifies the information concerning it (this information is stored in the resource part of the file, and is displayed when the file is used with GraphMu). The binary files of factor coordinates created by MacMul (version 2.14 or later) automatically contain their line and column number, so that they do not have to be remembered.

Digitization

Digitizes an image: this command allows two files to be obtained from one image: an "XY"-type file and a "G"-type file, which can be used with the "Digitized maps"

command of the "Graphics" menu. The XY file contains the coordinates of the digitized points and the G file contains a 1 or a 0 depending on whether the corresponding point must be joined to the previous by a line or not. This allows the drawing of map backgrounds on which the figures drawn by GraphMu can be superimposed.

The first stage consists in obtaining a "Bitmap" image (i.e. a "MacPaint"-type file) from a drawing program or a scanner. This image must then be saved in a PICT file with MacDraw II, being careful to indicate the real size of the image with the "Document size" command of the "Page" menu. One can then use the "Digitization" command. GraphMu first asks the user to specify the two output files (files XY and G, the names proposed by default are "XY.file" and "G.file"). The following stage consists in choosing whether a map background is to be used for the digitization or not (figure 2.12).

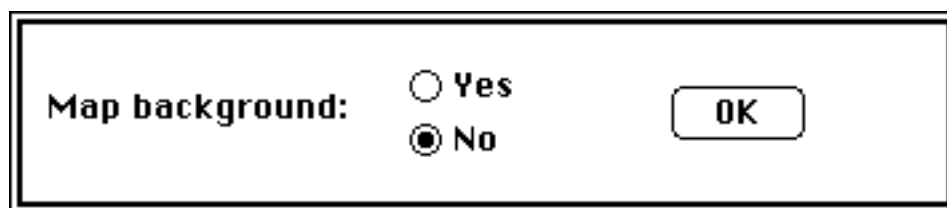


Figure 2.12:
Dialog box to choose whether a map background is to be used for the digitization.

If yes, one can then choose the map background file (PICT file created with MacDraw II above). The program then asks for the choice of framework dimensions within which the digitization will be made. These values are expressed in pixels (figure 2.13).

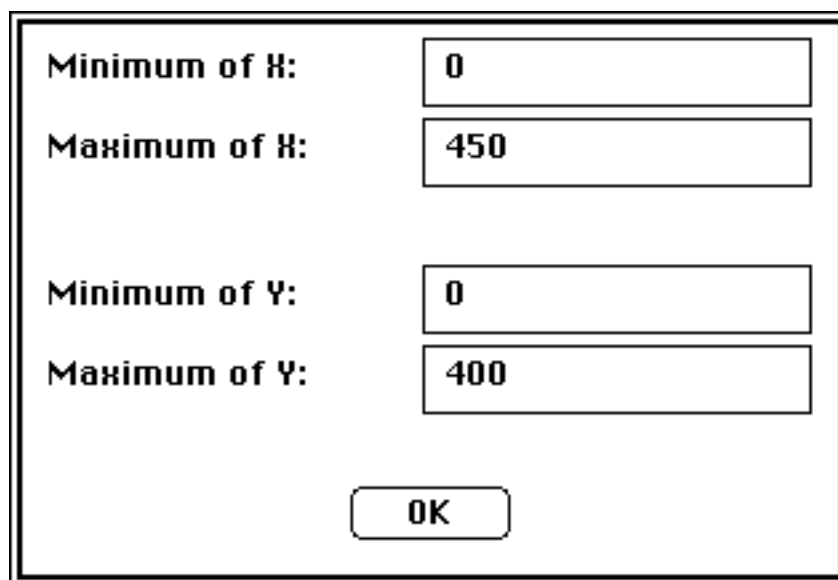


Figure 2.13:
Dialog box for the choice of the digitization zone.

In the same way, one must then indicate the dimensions of the real space corresponding to the digitized zone; its height/width ratio must be equal to that of the digitization framework (figure 2.14). The values saved in the XY file will be included in this space (expressed, e.g., in kilometres).

Min. abscissa:	-1.000
Max. abscissa:	1.000
Min. ordinate:	-.8889
Max. ordinate:	.8889
OK	

Figure 2.14:
Dialog box of the choice of real space corresponding to the digitization zone.

A new window then appears (figure 2.15), with a framework drawn to delimit the digitization zone and three buttons.

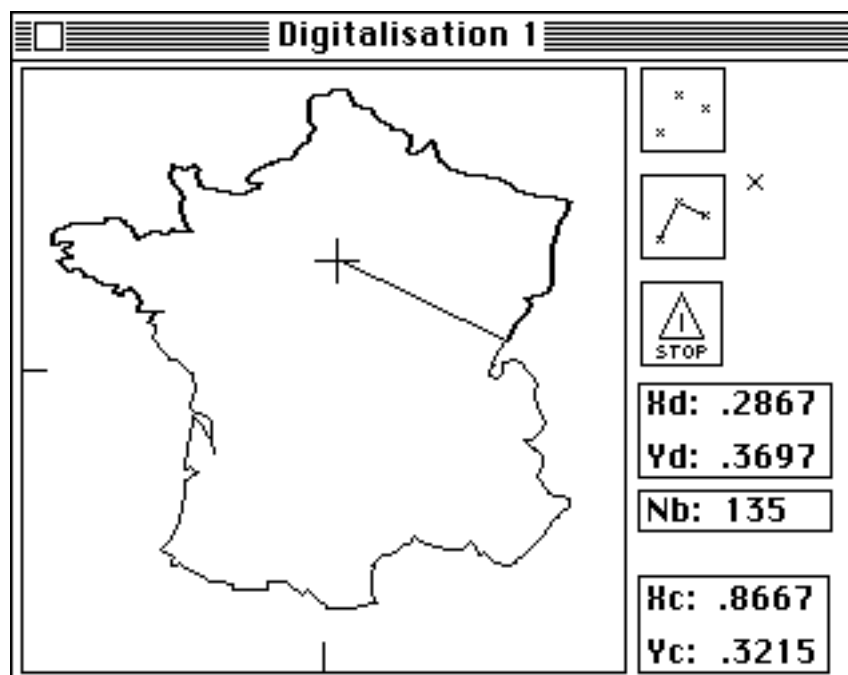


Figure 2.15:
Digitization window.

The three buttons are used to stop the digitization and pass to "Draw" or "Move" state. The "Move" state is used to change the position of the current point without drawing a line (a 0 is written in the G file), while the "Draw" state is used to draw a straight line between the successive digitized points (a 1 is written in the G file). Below the buttons appear the X and Y coordinates of the cursor controlled by the mouse and, with each mouse click, the X and Y coordinates of the digitized point,

with its number. The digitization then occurs by clicking with the mouse on the different points to be digitized. At each click, the cursor coordinates (X_c , Y_c) are written in the coordinates of the digitized point (X_d , Y_d) and the number of digitized points (N_b) is increased by 1.

A simplified example is given in figure 2.16.

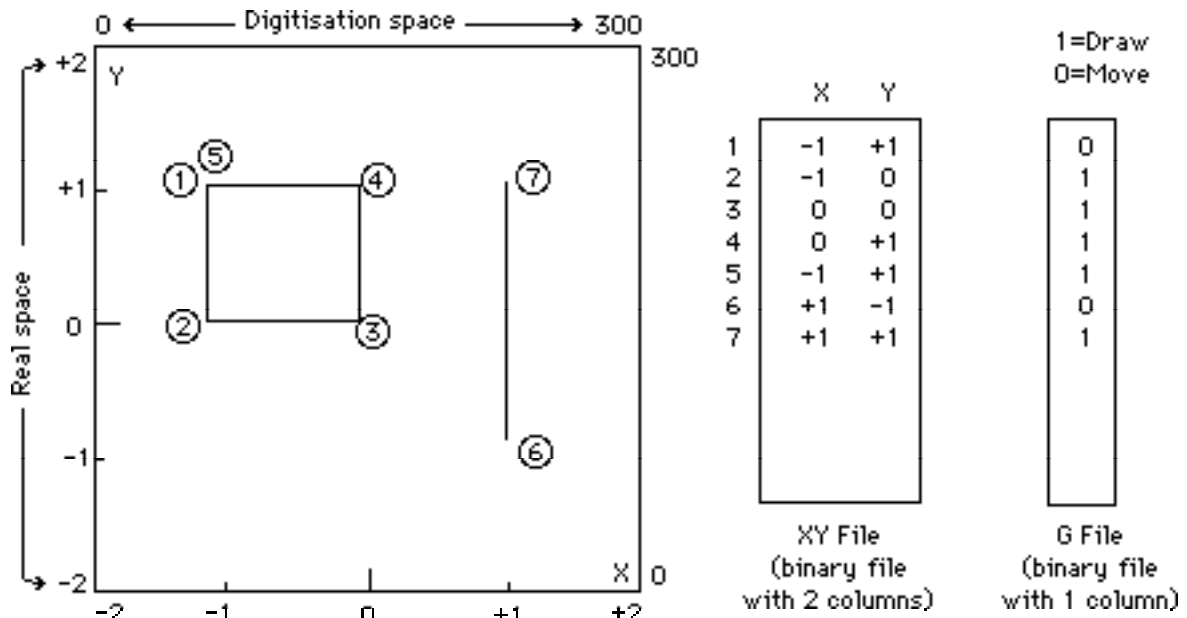


Figure 2.16:

Files created during digitization. The XY file contains the coordinates of the digitized points and the G file contains a 1 or a 0 depending on whether the corresponding point must be joined to the preceding by a straight line or not. The mouse clicks are numbered from 1 to 7.

When all the needed points have been digitized, just click the "Stop" button and close the digitisation window by clicking in its close box.

Cross rows & cols.

This command is used to draw graphical representations of data tables. Starting from two files containing row and column coordinates (for example factor coordinates coming from a multivariate analysis), it builds one file containing the coordinates of each cell of the initial data table.

Transpose file

This command allows transposition of a file (the rows of the initial file become the columns of the new file). One must indicate the number of rows and columns of the file to be transposed. The name proposed for the transposed file is formed by adding the extension ".tn" to the name of the initial file.

Screen size

This command changes the "GraphMu" window size (and that of all the later windows). One may have a window bigger than the screen: only the center of the window will be displayed, but the drawings will effectively have the same size as the window. This is practical on the Mac Plus and the SE to produce large drawings, or to obtain better printing quality by using a reduction factor when printing (particularly for ellipses and Gauss curves).

On a Mac Plus or SE, the default dimensions are 300 by 450 (figure 2.17). On a Mac with a bigger screen, they are 400 by 600. In both cases the width/height ratio is 3/2.

If the window size is changed with the mouse, the changes are taken into account: the modified value is displayed in the dialog box (figure 2.17).

Screen size	882	×	1152
Available space:	842	×	1132
Used space:	400	×	600
OK			

Figure 2.17:

Dialog box to adjust the drawing window size. The first line indicates the total dimensions of the screen, the second corresponds to the available space (taking account of the title bar ...) and the third indicates the current values and allows changing them.

Transfer

This command passes directly to another application without returning to the Finder.

MacMul

Allows passing directly to MacMul without returning to the Finder and without changing the work folder. If GraphMu does not manage to locate MacMul (e.g. if MacMul has been moved, or during the first use of GraphMu on a Mac), a dialog box can be used to specify the complete access path (figure 2.18).

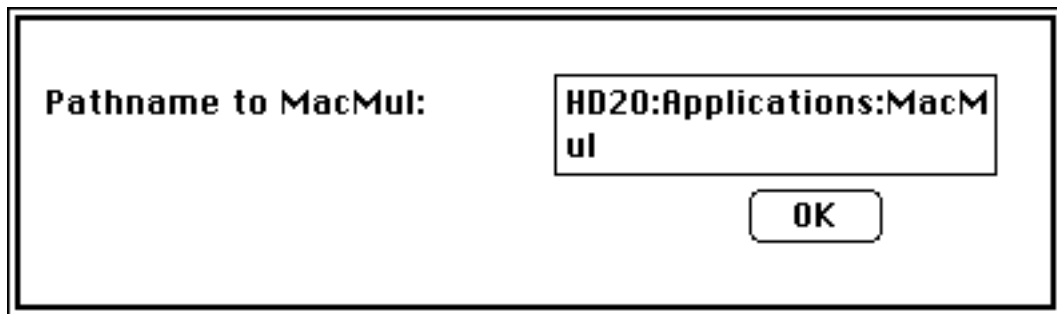


Figure 2.18:
Dialog window used to indicate the access path to MacMul.

This path will be written in the GraphMu resources and can then be used later: it must be given under the form "d.dur:1-Applications:MacMul" for example (first the disk name, then the folder name(s) separated by a colon (":") and last the program name MacMul).

This command **does not work** when using the MultiFinder.

Quit

Allows quitting GraphMu and returning to the Finder.

Edit menu

The three usual commands (Cut, Copy and Paste) can be used to handle the graphics drawn by the program (figure 2.19). It is, e.g., possible to copy an image, then call MacDraw and paste it in this program. Within GraphMu, one can also copy an image, paste it in a new window, then paste one or several other images above to make overlays.

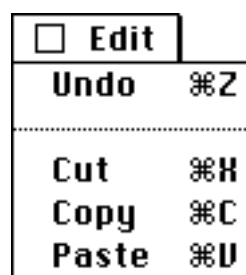


Figure 2.19:
GraphMu "Edit" menu

The "Undo" command is not used in GraphMu. It is only present for compatibility with the desk accessories.

3 - GRAPHICS MENU

The first 5 commands of the Graphics menu are used to draw different types of curve. The following 5 correspond to maps and the last 2 to graphic models (figure 3.1). For each command, an icon symbolises the corresponding type of drawing.

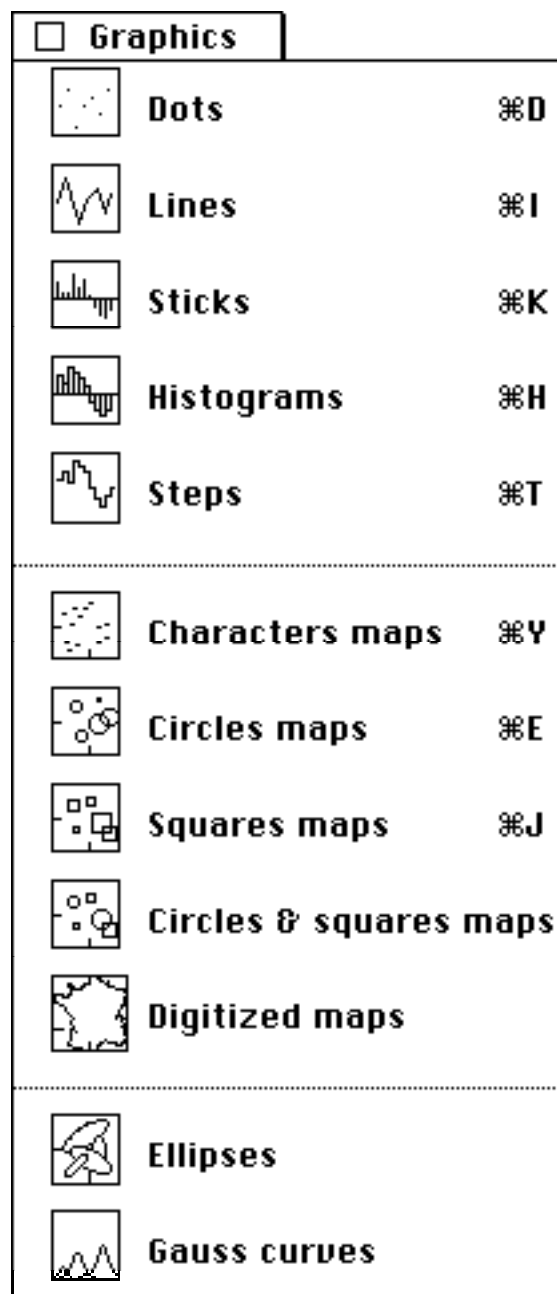


Figure 3.1:
GraphMu "Graphics" menu.

Curves

For the 5 types of curves, the first dialog window is the same (figure 3.2).

File X:		File G:	
Rows:	0	Rows:	0
Columns:	0	Columns:	0
N° column X:	0	Cols. used:	
Selection of rows: ☒ All ☐ Keyboard ☐ File			
Cancel		OK	

Figure 3.2:
Main dialog window for the 5 "Curve" commands of the "Graphics" menu.

The buttons "File X" and "File G" may be used to select the corresponding files with the standard file selection window. It is also possible to use the keyboard and type the file names in the corresponding fields. If one uses the buttons, the fields "Rows" and "Columns" are automatically filled with the appropriate values, provided that the information is stored in the resource part of the data files (see the "Number of rows & cols." command).

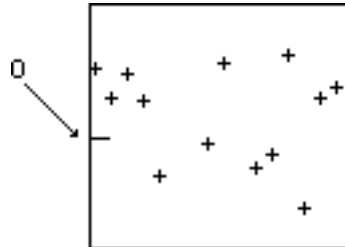
The X file must contain the abscissae of all the points of the curves for all graphics. It must be a binary file and may have several columns, but only one column will be used (the one selected in the "N° column X" field). This X file is optional : if no file is selected, abscissae will be automatically equal to 1, 2, 3, ... up to the number of rows of the G file. This is valuable for curve with regularly spaced abscissae. In this case, one needs not to fill the remaining fields ("Rows", "Columns", and "N° column X") for this file.

The G file must contain the ordinates of all the points of the curves for all graphics. In the case of histograms, it must contain the **area** under the histogram bars. It must be binary and may have several columns. Each selected column will correspond to one or more graphics (one graphic for each group of rows selected and for each column). Columns are selected by typing their number in the corresponding field ("Cols. used"), cf p. 9. One must also choose the row selection method, or, by default, select all the rows.

Curves with dots

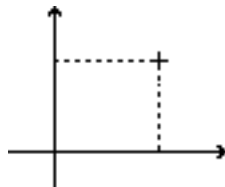
In the case of curves by points, only the curve peaks are represented and a character (which can be chosen at will) is placed at each of these peaks.

Example of a curve by points with the character "+":

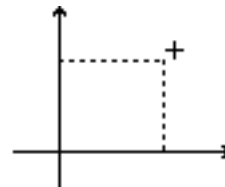


For curves with dots the center of the character is positioned in the drawing. For character maps, the lower left corner of the character is positioned in the drawing.

Curves with points:



Characters maps



The character to figure at each peak of the curves is chosen in the same window than the number of horizontal and vertical graphics (figure 3.3.).

Horizontal graphics:	3
Vertical graphics:	3
Character:	+
Drawing: ☒ Square ☐ Rectangular	Frame: ☒ Yes ☐ No
Min. & max. of absc. & ordin.:	
Comput.: ☒ Yes ☐ No	Modif.: ☒ Yes ☐ No
OK	

Figure 3.3:

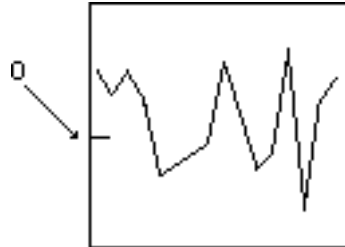
Dialog box of the main drawing parameters in the case of curves with dots.

When display of the minimum and maximum of the abscissae and ordinates is requested (by checking "Yes" for the "Modif." button, in the lower right part of the window), one obtains a dialog window similar to that of figure 2.14, which also allows changing the values calculated and displayed by the program.

Curves by lines

This type of graphic is similar to the preceding one, but instead of displaying a character for each point of the curve, one obtains here lines which link the curve peaks together.

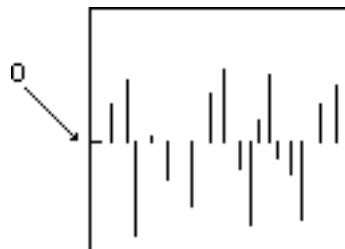
Example of curve by straight lines:



The dialog zone to choose the number of horizontal and vertical graphics does not propose choice of a character.

Curves with bars

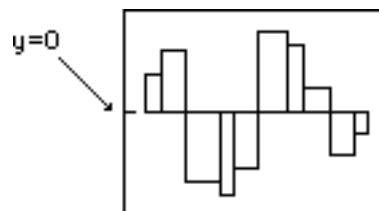
The principle is also similar to that of the preceding, but at each point a vertical line is drawn, which height is proportional to the value contained in the G file.



Histograms

For this type of curve, the X file must contain one more value than the G file. If the classes are of equal width, the X file is optional. If the classes are of variable amplitudes, the X file must contain the class boundary values.

Example of a histogram:



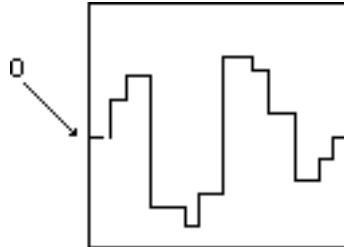
It should not be forgotten that GraphMu does **not** itself compute the histogram from the data file. It considers that the calculations have already been performed and that the G file contains directly the **number of individuals** belonging to each class.

When the classes are of variable width, the **area** under the histogram bars drawn by GraphMu is proportional to the values of the G file. When the classes are of constant width, either the **height** or the bar **area** are proportional.

Step curves

The principle is similar to that of the histograms (file X contains the step boundary values and must therefore have one more value than file G), but the height of the curve steps is proportional to the data and not their area.

Example of step curve :



Maps

For the 5 types of maps, the first dialog window which appears is the following (figure 3.4):

File XY:		File G:	
Rows:	0	Rows:	0
Columns:	0	Columns:	0
N° column X:	0	Cols. used:	
N° column Y:	0		
Selection of rows: ☒ All ☐ Keyboard ☐ File			
Cancel		OK	

Figure 3.4:
Main dialog window for the "Map" commands.

The "File XY" and "File G" buttons allow, as in the curve commands, specification of the corresponding files and automatic filling of the associated fields ("Rows", and "Columns" fields). The XY file must contain the coordinates (abscissae and ordinates) of the points and file G contains, depending on the case, character strings (for character maps) or the size of the circles or squares to be drawn on the map. For digitized maps, file G contains the values 1 or 0 depending on whether the current point of the map must be joined to the preceding by a line or not.

Character maps

For this type of map, the G file must contain the character strings which will be displayed at each point of the map (i.e. the labels corresponding to each individual or variable). This file must not be binary, but of text type. It can be constructed with any word processing program being careful to save it in "Text only" or "ASCII" format. Moreover it must have a strictly constant number of characters per line for all the lines. This number of characters per line must be declared in the first dialog window ("Chars./row" field, see figure 3.5) which is, for this reason, slightly different from that of the other maps.

File XY:		File G:	
Rows:	0	Rows:	0
Columns:	0	Chars./row:	0
N° colonne X:	0		
N° colonne Y:	0		
		Selection of rows:	
		☒ All	
		☐ Keyboard	
		☐ File	
Cancel		OK	

Figure 3.5:
Main dialog window of the Character map command.

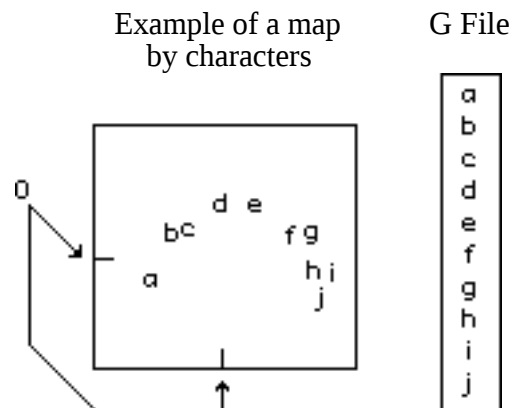
For the same reason, the dialog window of the general graphic parameters is also slightly different. One must specify the size of the characters (in points) which will be drawn on the graphic (figure 3.6).

Horizontal graphics:	1
Vertical graphics:	1
Character size:	9
Drawing: ☒ Square	Frame: ☒ Yes
☐ Rectangular	☐ No
Min. & max. of absc. & ordin.:	
Comput.: ☒ Yes	Modif.: ☒ Yes
☐ No	☐ No
OK	

Figure 3.6:
Dialog box of the main drawing parameters for Character maps.

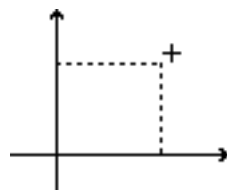
As for the other types of graphics, one can then request display (with possibility of changing) of the minimum and maximum of the abscissae and ordinates (figure 1.3).

The diagram below shows an example of a map by characters, with the associated G file.

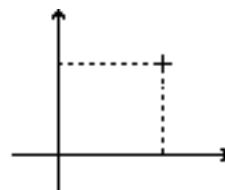


Finally we remember that for maps by characters, the lower left corner of each character is positioned on the map at the coordinate point (x,y).

Map by characters:



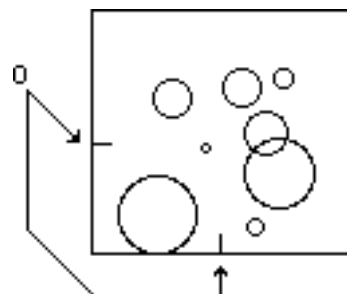
Curves by points:



Circle maps

With a map by circles, the XY file contains the coordinates of each point on the map. The size of the circles to be drawn at each of these points is proportional to the values contained in the G file. These two files must be binary. The columns of file G are selected by typing their number in the corresponding field "Cols. used" (figure 3.2).

Example of a map by circles:



For the map by circles, by squares and by circles plus squares, an extra dialog window allows changing the proportionality factor, so that the values of the G file are proportional to the diameters of the circles, to their radius, to their area, etc. (figure 3.7).

Factor G:

Largest element: .8548

Smallest element: -.4885

Power factor:

Multiplic. factor:

Sign (+/-): ☒ **Yes** ☐ **No**

Objects: ☒ **Pict** ☐ **Dash**

Figure 3.7:
Dialog box of the parameters of factor G

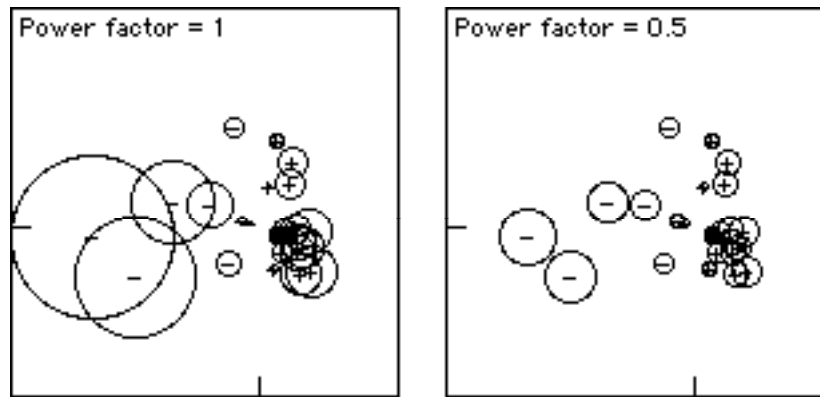
This box displays the largest and the smallest value found in the selected part of the G file. Two fields allow the choosing of a value for the "Power factor" and for the "Multiplication factor". The relationship between the circle diameter (or the square side) and the values in file G depends on these two factors. The relationships may be written:

$$\Phi = m \times x^p$$

with:

Φ = circle diameter (or square side)
 m = multiplication factor
 p = power factor
 x = value read in the G file

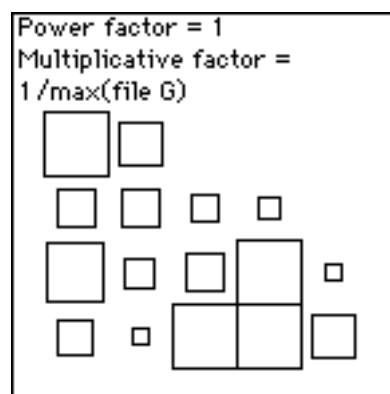
Power factor: With value the 0.5, it is the diameter of the circles (or the side of the squares) which is proportional to the values of the G file. With the value 1, it is the area of circles (or squares) which is proportional.



High values of the power factor therefore tend to increase the differences between the file G values. Low values tend to reduce the differences, and make the data appear more homogeneous.

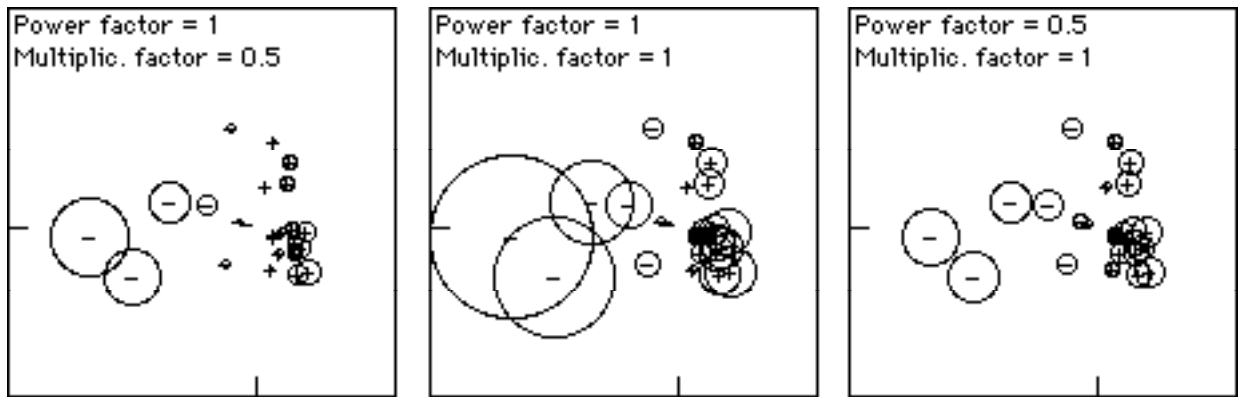
Multiplication factor: With value 1, the size of the circles or squares is directly proportional to the G file values. For different values, their size is uniformly increased or reduced by a factor equal to the multiplication factor.

When the points of the map are spread over the nodes of a regular mesh, if one chooses the ratio of the mesh size over the largest value of the G file (in absolute value) as value of the multiplication factor, one obtains graphics such that two neighbouring circles or squares of maximum size are tangents (see example below).



For this map by squares, the distance between two nodes (equal to 1) divided by the highest value of the G file was chosen as multiplication factor, so that two neighbouring squares of maximum size are (at most) touching.

The diagram below shows some examples of graphics illustrating the effect of different power factor and multiplication factor values. For the three maps by circles, the data of the XY and G files are identical; only the values of the m and p factors have varied. The reduction of the power factor (at the right) leads to a reduction of the differences in the circle sizes (i.e. big circles are more affected), while the variations in the multiplication factor (at the left) maintain the ratios between the sizes of the different circles and decreases all circles uniformly.



For $p = 1$ and $m = 1$, the minimum and maximum abscissae and ordinates automatically calculated by GraphMu are such that the circles or squares are completely included inside each graphic and the outermost is tangent to the frame. If one changes these values, the circles or square may protrude outside the frame. In this case, we recommend choosing "Dash" objects instead of "Pict" objects (figure 3.7) so that the lines stop exactly at the intersection of the circle and the graphic frame.

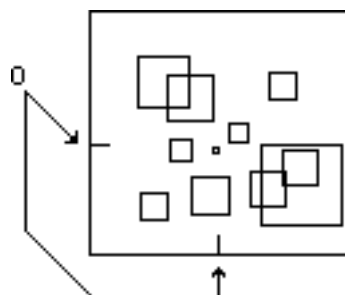
The same dialog box allows indication of whether the value sign of the G file should appear on the graphic. If "Yes" is clicked, a "+" sign will be placed at the center of the circles or squares corresponding to the positive G file values and a "-" sign will be placed for negative values.

The difference between the "Pict" objects and the "Dash" objects is as follows: in the output file (or in the clipboard if the drawings are copied) the Pict objects are true "whole" objects which can easily be handled with the mouse. the "Dash" objects are instead formed of small juxtaposed straight segments which are more difficult to handle.

Square maps

The principle of this type of graphic is the same as that of maps by circles.

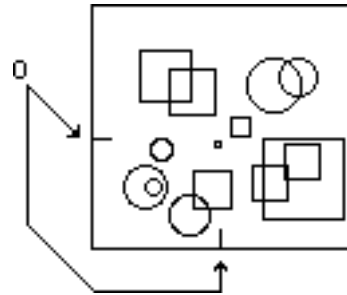
Example of a map by squares:



Circle and square maps

The principle of this type of graphic is the same as that of the two preceding, but here the negative values are represented by circles and the positive values by squares. One may always add the sign "+" or "-" at the centre of the circles or squares.

Example of a map with circles and squares:

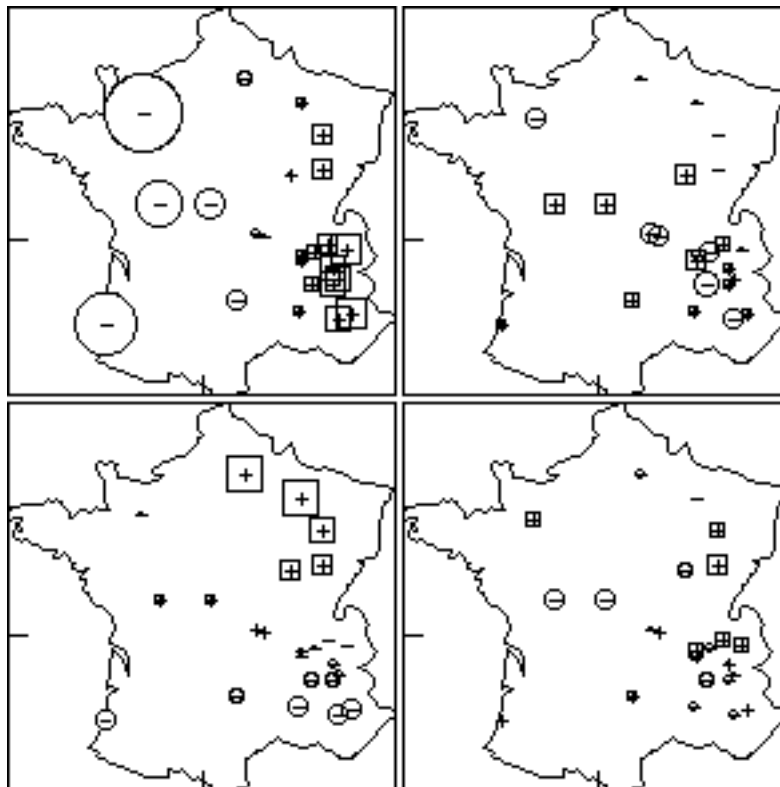


Digitized maps

This command draws maps from XY and G files created by the "Digitization" command of the "File" menu or by other programs (particularly ADECO). One can thus obtain map backgrounds which can be overlaid on maps by squares or by circles.

For this command, there is obviously no dialog window for the "G Factor".

The figure below is an example of a graphic obtained by overlaying a collection of digitized maps of France and a collection of maps by circles + squares. In this case the G file contains only one column; just select it several times (4 times in this example) by typing 1;1;1;1 as number of columns to obtain the 4 maps of France.



Another example of superimposition of a map by circle plus squares and of a digitized map will be studied in greater detail in chapter 5 of this manual.

Models

Ellipses

This type of representation allows study of the relationships between various groups of individuals, by using the means, variances and covariances for two variables measured in these groups. One thus quickly obtains an idea of the dispersion of individuals within and between the considered groups.

Figure 3.8
Main dialog window of the "Ellipses" command of the "Graphics" menu

The "File of Means-Variances-Covariances" button selects an MVC file and automatically fills the corresponding fields. The number of rows of the MVC file corresponds to the total number of ellipses for all the graphics. One must indicate the number of variables on which the MVC file has been calculated (generally 2, which corresponds to 5 columns) and the number of the 2 variables to be used to draw the ellipses.

The other dialog windows are identical to those of the preceding commands, apart from the enlargement factor, corresponding to the "G factor" window for the maps. It also allows a choice between Pict objects or dashes and is represented in figure 3.9.

This enlargement factor increases or reduces the size of the ellipses. In the case of inertia ellipses, the following values may be used to draw the ellipses enclosing a certain percentage of individuals: 2.15 = 90%; 2.45 = 95%; 3.03 = 99%. The value 2 corresponds to 86% and 1 to 39%.

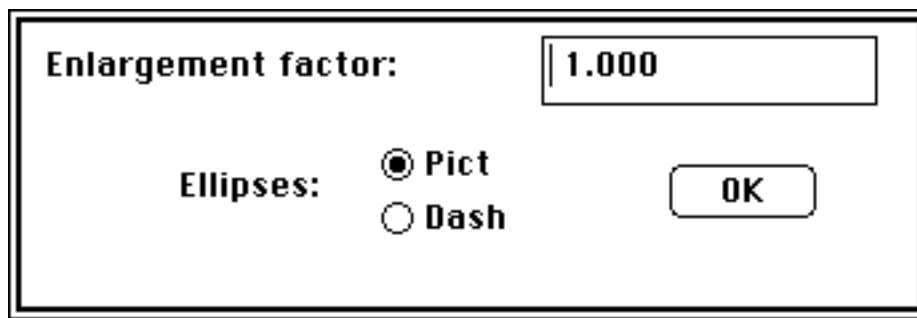
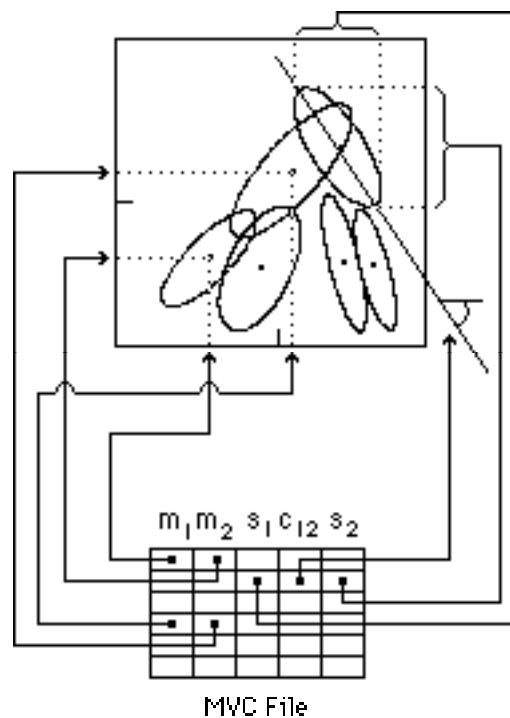


Figure 3.9
Dialog box for the ellipse enlargement factor.

The example below explains the organisation of MVC files for displays by ellipses.

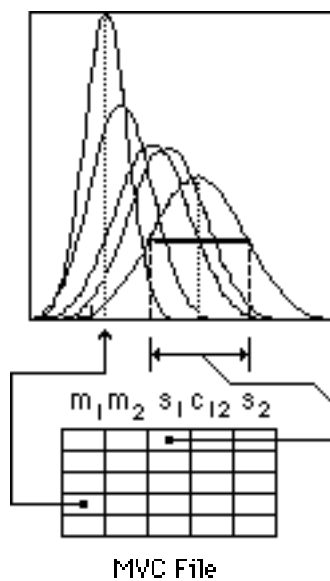


The means of the two variables correspond to the abscissae and ordinates of the ellipse centers. The variances correspond to their horizontal and vertical magnitudes and the covariance gives the slope of each ellipse.

Gauss curves

This type of representation allows study of the relationships between several groups of individuals, by using the mean and variance of a variable measured in these groups.

The means of the variable in the different groups correspond to the position of the means of the Gauss curves. The variances correspond to the variance of each Gauss curves (width of the curve), see the example below.



File of Means-Variances-Covariances:

Number of rows:

0

Number of variables concerned:

0

Number of variable used:

0

Selection of rows:

☒ All
☐ Keyboard
☐ File

Cancel

OK

Figure 3.10
Main dialog window of the "Gauss curves" command of the "Graphics" menu

For the Gauss curves one selects only one variable in the MVC file (figure 3.10). As the enlargement factor is not relevant here, there is just a choice between "Pict" or "Dash" objects (figure 3.11).



Figure 3.11

Dialog window to choose between "Pict" or "Dash" objects for Gauss curves

4 - MODIFICATIONS MENU

This menu allows quick change of certain parameters of a graphic and redrawing it without having to pass through all the dialogs.

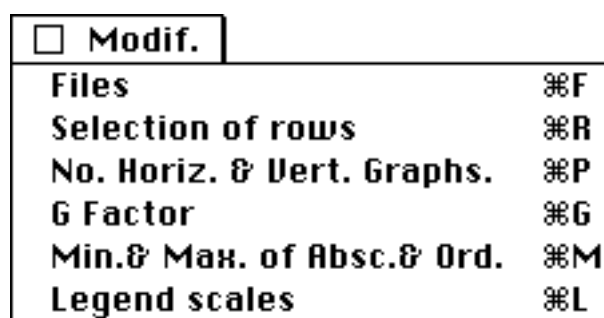


Figure 4.1:
GraphMu "Modifs." menu.

Files

This command is used to change the files used to draw the graphics, or simply the characteristics of these files: number of rows and columns, number of columns selected. Depending on the last type of graphic which was drawn, it will involve the X and G files (curves, fig. 3.2), the XY and G files (maps, fig. 3.4) or the MVC files (ellipses, fig. 3.8 and Gauss curves, fig. 3.10). The drawing is redrawn as soon as the user clicks the OK button.

Row selection

This command changes the numbers of lines and groups of lines associated with each graphic. if the selection was made previously using a selection file, the dialog concerning this file is called (figure 1.5). If not, the line selection window is called (figure 1.4).

No. Horiz. & Vert. Graphs

This command allows changing the number of horizontal and vertical graphics and the character to use for the curves by dots, or the character size for the maps by characters. It also allows choosing between a rectangular or square drawing, between drawing a frame around each graphic or not and between automatic search of minimum and maximum abscissae and ordinates or use of preceding values (cf figure 1.2).

G Factor

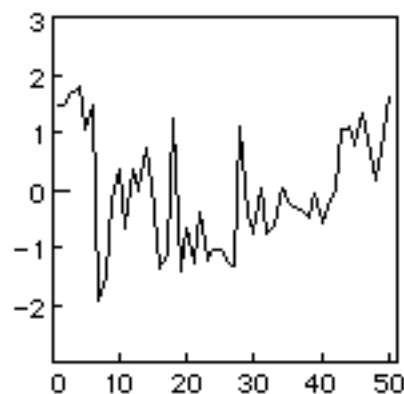
This command displays the minimum and maximum of the values found in the G file and proposes values for the power factor and the multiplication factor (1 by default). It also specifies whether a sign (+ or -) must appear in the center of each circle or square, depending on the sign of the value in the G file, and if the objects are to be "Pict" or "Dash" (figure 3.7).

Min. & Max. des Absc. & Ord.

This command is used to check and if necessary to modify the values of the minimum and maximum abscissae and ordinates used previously (figure 1.3).

Legend scales

This command adds scale legends on a graphic. The scales are represented by graduations drawn on the edges of each graphic of a drawing (along the frame). The values corresponding to each graduation may be displayed or not. One can choose the minimum and maximum of the values covered by the scale and the number of graduations.



The corresponding dialog box (figure 4.2) allows the user to specify whether the graduations are to appear along the axes (the dashes are all of equal length, apart from that corresponding to the zero value, which is slightly longer) and, independently, the values corresponding to these graduations (the figures are all written in 9-point Monaco).

Four fields fix the minimum and maximum values which will be used to calculate the scales. By default these are the extreme values found for the abscissae and the ordinates, but these values can be changed depending on whether one wants to make them appear on the graphic or not. The program automatically rounds the values to the nearest integers (wholes, tens, hundreds, etc.).

The number of scale graduations can also be fixed (by default, 10). This value can be changed, but we recommend choosing only the values 2, 4, 5 or 10 and multiples of 10, so that the values corresponding to the graduations are round numbers. The number of graduations effectively drawn may be different from that requested here because the program can change them to improve the arrangement of figures on the scales and use only round figures.

Horizontal axis:		Vertical axis:	
Graduations:	☒ Yes ☐ No	Graduations:	☒ Yes ☐ No
Values:	☒ Yes ☐ No	Values:	☒ Yes ☐ No
Minimum:	0.0000	Minimum:	0.0000
Maximum:	10.0000	Maximum:	10.0000
Nb. grad.:	10	Nb. grad.:	10
Cancel		OK	

Figure 4.2:
Dialog box used to parametrise the scale legend drawing command.

The example below shows certain possibilities of this command, with curves by bars and trigonometrical functions.

