ISS, NEWCASTLE UNIVERSITY

Getting Started With IBM SPSS Statistics for Windows

A Training Manual for Beginners

Dr. S. T. Kometa

Getting Started with SPSS
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Table of Contents

Contents **Page**

1 Aims and Objectives

1.1 Learning outcomes (Aims and Objectives of course)

This course gives a quick overview of the essentials of SPSS. After completing this course you should:

- understand some common statistical terms
- be able to create an SPSS data file from scratch (coding a questionnaire)
- be able to carry out some simple analyses on the data file
- be able to present some of the data graphically
- open an Excel file in SPSS
- be able to interpret the output from the analyses
- be able to use SPSS with a degree of confidence

1.2 Some Basics

1.2.1 Scale of Measurement

- **Nominal** (categorical) e.g. race, colour, sex, job status, etc.
- **Ordinal** (categorical) e.g. the effect of a drug could be none, mild and severe, job importance (1-5, 1 being not important and 5 very important), etc.
- **Interval** (continuous, covariates, scale, metric) e.g. temperature (in Celsius), weight (in stones or Kg), height (in inches or cm), etc.

1.2.2 Summarising Data

- Frequency Table
  - Frequency (counts) number of occurrences of a given value
  - Percentages and cumulative percentages
- Charts
  - Pie charts
  - Bar charts
  - Histograms
- Central measure
  - Mean is sum of all values divided by the number of values, written as:

    $$\bar{x} = \frac{x_1 + x_2 + x_3 + ... + x_n}{n}$$

    where x_1, x_2, etc. are the individual values and n the number of values. (What is the mean of the following values: 22, 13, 10, 4, 13 and 30?)
  - Median is the value which lies half-way along a series if a set of values are arranged in ascending or descending order of size. When there are an even number of values in the set the median is found by taking the mean of the middle two values. What is the median of the numbers above?
  - Mode is the most frequently occurring data value. Associated to mode we have **unimodal**, **bimodal**, and **multimodal**.
  - Percentile (most common are 25% (Q1), 50% (Q2 same as median), & 75% (Q3)). The 25th percentile is that value such that 25% of the

observations have value less than or equal to it. You can use the quartile values to regroup values into low and high values.

1.2.3 Measure of Variability

- Range is maximum value minus minimum value, i.e. Range = Max - Min
- Interquartile range is 75th percentile minus 25th percentile, i.e. InterQ = Q3 – Q1
- Variance
- Standard Deviation (σ)

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

1.2.4 Some Common Statistical Terms

In order to use any statistical package (SPSS, Minitab, SAS, etc.) successfully, there are some common statistical terms that you should know. These terms serve as a useful conceptual interface between methodology and any statistical data analysis technique. Irrespective of the statistical package that you are using, it is important that you understand the meaning of the following terms.

1.2.5 Variables

Most statistical data analysis involves the investigation of some supposed relationship among variables. A variable is therefore a feature or characteristic of a person, a place, an object or a situation that the experimenter wishes to investigate. A variable comprises different values or categories and there are different types of variables.

1.2.5.1 Quantitative variables

Quantitative variables are possessed in degrees. Some common examples are height, weight and temperature.

1.2.5.2 Qualitative variables

Qualitative variables are possessed in kind. Some common examples are sex, blood group, and nationality.

1.2.6 Hypotheses

Often, statistical data analysis wishes to test a hypothesis. A hypothesis is therefore a provisional supposition among variables. It may be hypothesized, for example, that tall mothers give birth to tall children. The investigator will have to collect data to test the hypothesis. The collected data can confirm or disprove the hypothesis.

1.2.7 Independent and dependent variables

The independent variable has an effect upon another, the dependent variable. In the example hypothesized above, the height of mothers is the independent variable while the height of children is the dependent variable. This is so because a child's height is supposed to depend upon the height of their mother.

1.2.8 Kinds of data

There are basically three kinds of data:

1.2.8.1 Interval data

These are data taken from an independent scale with units. Examples include height, weight and temperature.

1.2.8.2 Ordinal data

These are data collected from ranking variables on a given scale. For example, you may ask respondents to rank some variable based on their perceived level of importance of the variables.

1.2.8.3 Nominal data

Merely statements of qualitative category of membership. Examples include sex (male or female), race (black or white), nationality (British, American, African, etc.).

It should be appreciated that both Interval and Ordinal data relate to quantitative variables while Nominal data refers to qualitative variables.

1.2.9 Some cautions in using statistical packages

The availability of powerful statistical packages such as SPSS, Minitab, and SAS has made statistical data analysis very simple. It is easy and straightforward to subject a data set to all manner of statistical analysis and tests of significance. It is, however, not advisable to proceed to formal statistical analysis without first exploring your data for transcription errors and the presence of outliers (extreme values). The importance of thorough preliminary examination of your data set before formal statistical analysis can not be overemphasized.

1.2.10 The Golden Rule of Data Analysis

Know exactly how you are going to analyse the data before you even begin to think about to collect it. Ignoring this advice could lead to difficulties when analyzing your data.

1.2.11 Introducing SPSS: A Typical SPSS Session

A typical SPSS session involves starting SPSS, opening an SPSS data file, requesting an analysis or building a chart and then leaving SPSS.

Starting SPSS

To start SPSS within the Windows operating system follow these instructions:
Choose **Start -> Programs -> Statistical Software**. The available statistical software will be displayed, choose **IBM SPSS Statistics -> SPSS 19.0 for Windows**. Click **Cancel**.

Opening An SPSS Data File

Click **File -> Open -> Data** (or click the open File button). Within the SPSS directory look for and open the file called **Employee.sav**.

Running An Analysis

Click **Analyze -> Descriptive Statistics -> Frequencies…**
Click on ***Employment Category [jobcat]***, then click the **arrow (>)** to place it on the **variable(s)** list. Click ***Minority Classification [minority]*** and then click the **arrow (>)** button. Click **OK** to run the frequencies analysis.

Building A Chart

Click **Graphs -> Legacy Dialogs -> Interactive -> Line…**
Drag and drop ***Current Salary [salary]*** to the **vertical axis** list box.
Drag and drop ***Beginning Salary [salbegin]*** to the **horizontal axis** list box.
Click **OK** to produce the chart.

Leaving SPSS

Click **File -> Exit**. Click the **No** button in the Save Contents alert box

Summary

You have seen a typical SPSS session, been introduced to the primary windows within SPSS, and used dialogue boxes to produce frequency tables and a chart.

1.2.12 The SPSS Help System

SPSS has a comprehensive help system. This is very useful to both experienced and new users of SPSS. This course covers the following:

Click **Help -> Topics**. There are fours tabs here: **Contents**, **Index**, **Search** and **Favorites**. Briefly explore them. Then close the window.
Click **Help -> Tutorial:** This is SPSS online tutorial. You are strongly encouraged to go through this tutorial. It helps you to learn SPSS by yourself. Click on **Introduction** and use the arrows at the bottom of the screen to navigate through the tutorial.

Statistics Coach: Helps you to select a suitable analysis for your data by asking you to answer a series of questions. It is located at **Help -> Statistics Coach**. Select **What do**

you want to do? from the available choices. You are encouraged to have a look at the example output by clicking on **Show examples output**.

Case Studies: Case Studies provide hands-on examples of how to create various types of statistical analyses and how to interpret the results. These examples assume you are already familiar with the basic operations of SPSS. If you want to perform any advanced procedure it is recommended that you go through a case study first via **Help -> Case Studies…** Then look for procedure of interest. You can also access a case study through **Analyze** menu. For example select **Analyze -> Regression -> Linear… -> Help**. Then click on **Show Me**.

2 Getting Started with SPSS for Windows

2.1 Assumptions

This course assumes that you know the basics of using a computer such as:

1. How to start applications
2. How to use your mouse
3. How to move and close windows.
4. How to save and open a file.

2.2 Essential steps for data analysis in SPSS

SPSS is a powerful computer package that can be used to carry out a wide range of statistical analysis. Before carrying out any formal statistical analysis, users are encouraged go through a preparatory first step.

It is important to ensure that the data has been correctly entered into the Data Editor of SPSS. Errors during data entry will result to misleading conclusions. It is very tempting to proceed to formal statistical analysis after ensuring that the data has been correctly entered. Not a good thing to do.

The procedure for data analysis using SPSS and indeed any other statistical package should be thought of as a two step process:

1. The exploration and description of the data to examine the main characteristics.
2. The formal statistical analysis to confirm some characteristics of the data.

If you embark immediately on formal statistical analysis, you may miss the most important feature of your data. Also, formal statistical analyses assumed some characteristics about your data. If these assumptions are wrong, the results of statistical analysis may be quite misleading.

2.3 Exploratory data analysis in SPSS

Many Exploratory Data Analysis (EDA) techniques are available in SPSS. These include: ***Frequencies***, ***Descriptives***, ***Explore***, ***Crosstabs***, ***Case summaries***. These are located under ***Analyze -> Descriptive Statistics*** on the main menu bar. This document demonstrates the proper use of these facilities.

2.4 Starting SPSS

Start SPSS and reproduce the results of the typical session.

Introduction

SPSS has two main windows: The **Data Editor** window and the **Viewer** window. The **Data Editor** window is in turn divided into the **Data View** and the **Variable View** windows.

The **Data View** window is simply a grid with rows and columns. The rows represent subjects (cases or observations) and columns represent variables whose names should appear at the top of the columns. In the grid, the intersection between a row and a column is known as a cell. A cell will therefore contain the score of a particular subject (or case) on one particular variable. This window displays the contents of data file. You create new data files or modify existing ones in this window. This window opens automatically when you start an SPSS session. See Figure 1 for a brief annotation of this window.

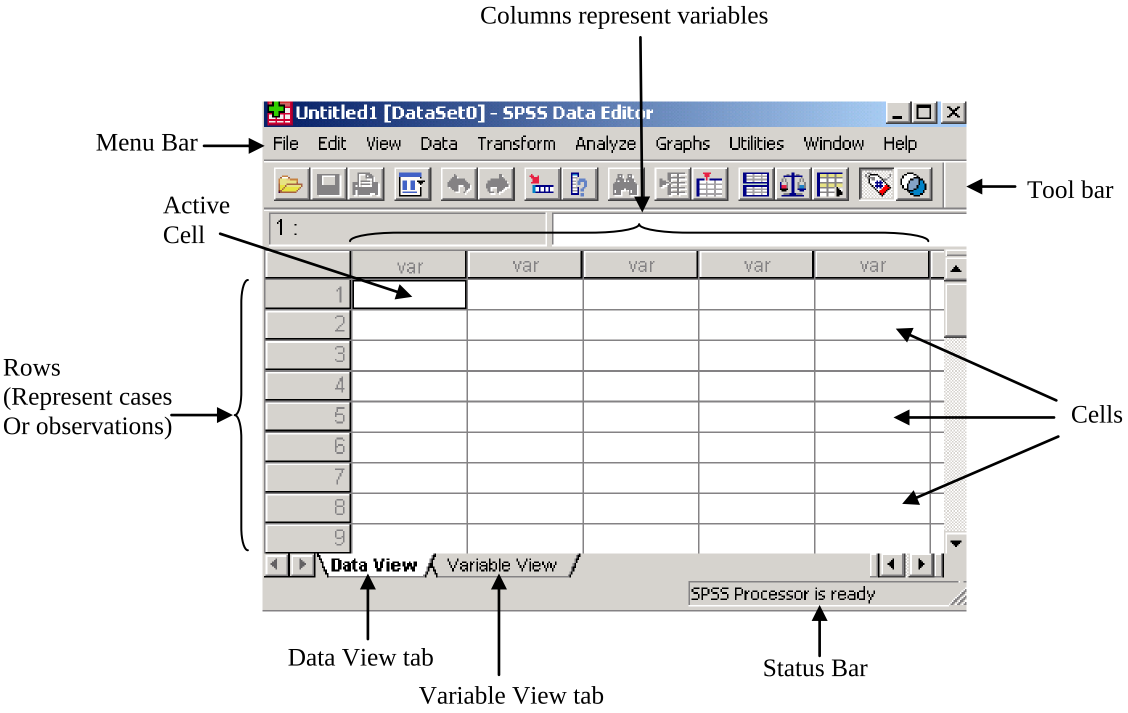
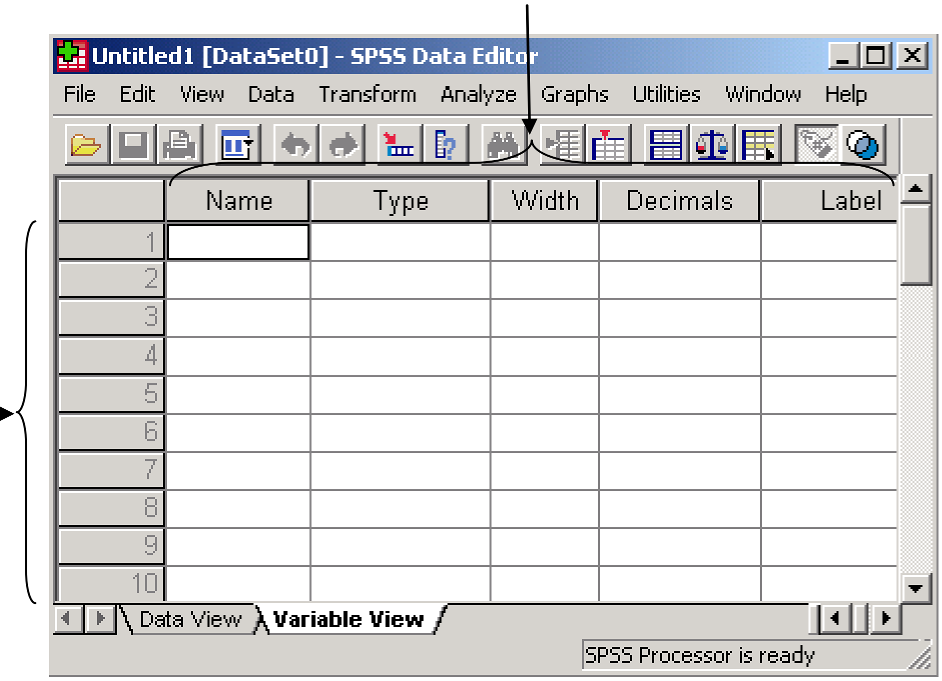

Columns represent variables
Untitled1 [DataSet0] - SPSS Data Editor
Menu Bar
File Edit View Data Transform Analyze Graphs Utilities Window Help
Tool bar
Active Cell
1 :
var var var var var
1 2 3 4 5 6 7 8 9
Rows (Represent cases Or observations)
Cells
Data View Variable View
SPSS Processor is ready
Data View tab
Variable View tab
Status Bar

Fig. 1 Data View Window

The **Variable View** window is also a simple grid with rows and columns. This window contains descriptions of the attributes of each variable that make up your data set. In this window, rows are variables and columns are variable attributes. You can make changes to variable attributes in this window such as add, delete and modify attributes of variables. There are ten columns altogether namely: **Name**, **Type**, **Width**, **Decimal**, **Label**, **Value**, **Missing**, **Columns**, **Align**, and **Measure**. See Fig. 2 for more information. As you define variables in this window, they are displayed in the **Data View** window. The number of rows in the **Variable view** window corresponds to the number of columns in the **Data view** window.

Columns represent attributes of variables

Rows represent variables

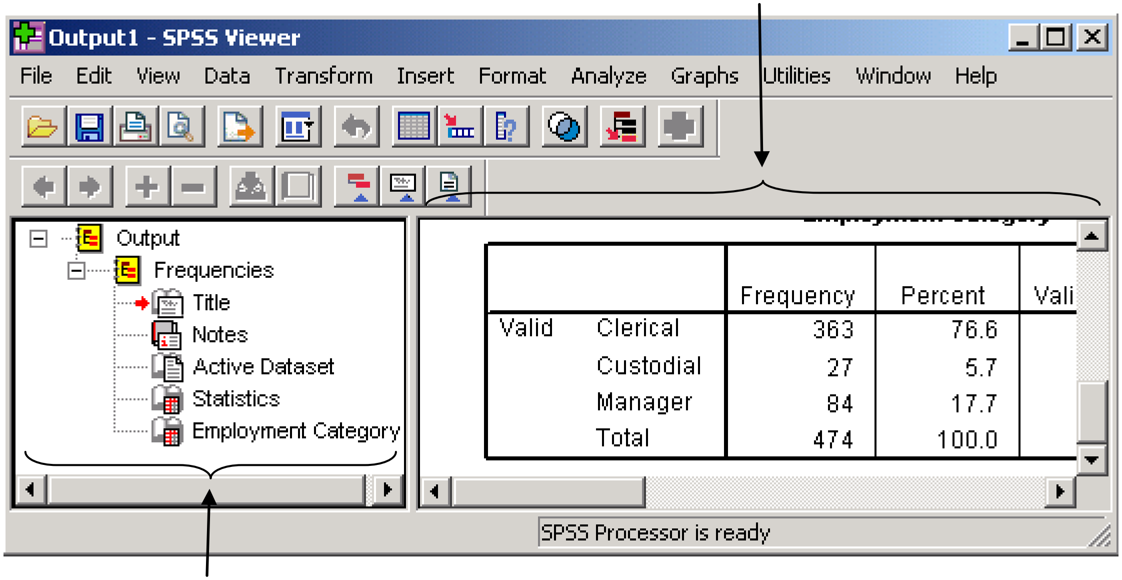


SPSS Processor is ready

Fig. 2 Variable View Window

The **Viewer** window is where results are displayed after a statistical procedure has been performed. It is divided into two main sections: the left pane contains an outline view of the output contents and the right pane contains statistical tables, charts, and text output. You can edit the output in this window and save it for later use. This window opens automatically the first time you run a procedure that generates output. See Fig. 3 for details.

Right pane contains statistical tables, charts and text output



		Frequency	Percent	Vali
Valid	Clerical	363	76.6	
	Custodial	27	5.7	
	Manager	84	17.7	
	Total	474	100.0	

SPSS Processor is ready

Left pane contains outline
view of the output contents

Fig. 3 Viewer window

2.5 Finding your way round...

Menus

The menu bar contains menus for opening files, calculating statistics, and creating charts. It also provides access to most SPSS features, from modifying data values to changing fonts. Each window has its own menu bar and toolbar. The diagrams for some menus and how to access them are shown below.

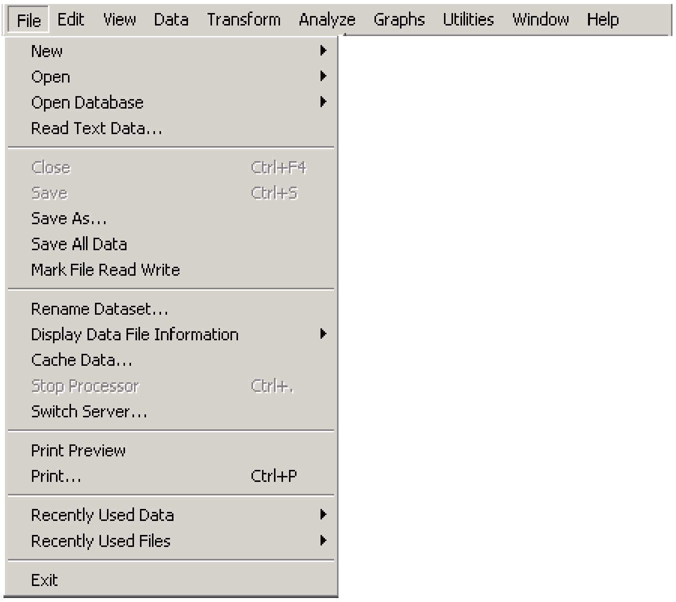


Fig. 4 File drop-down menu

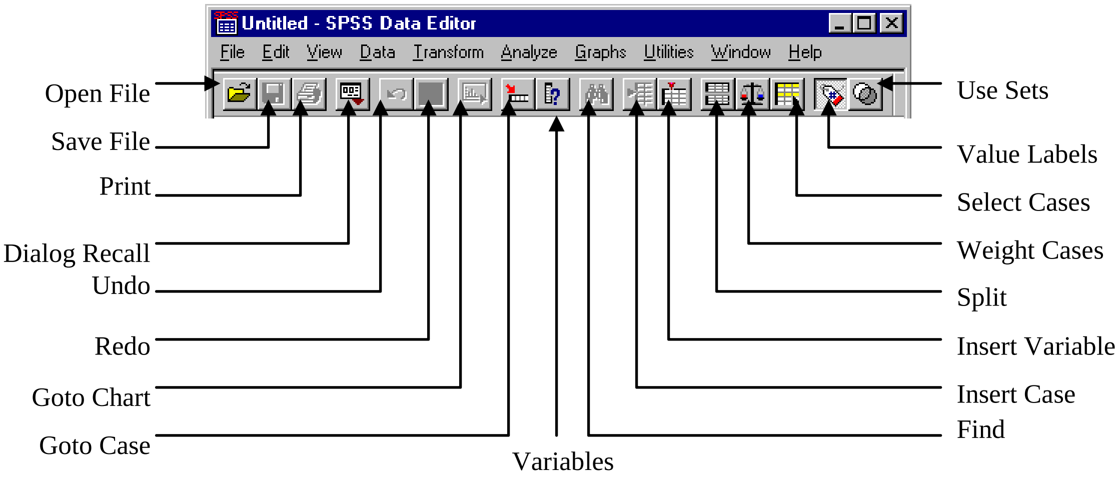


Fig. 5 Main Menu and Toolbar in SPSS

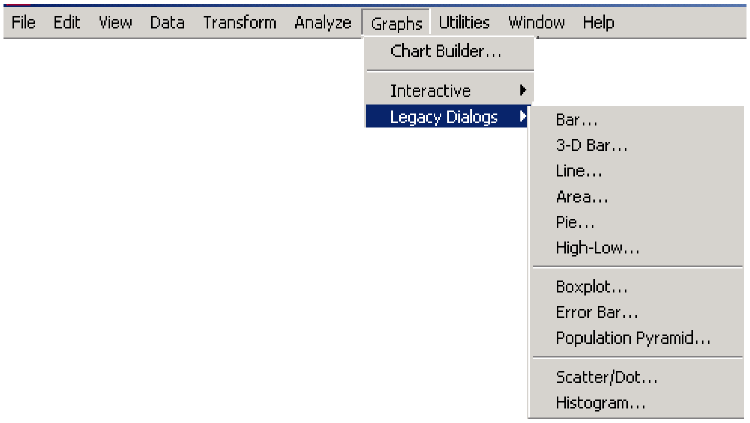


Fig. 6 The Graph drop-down menu

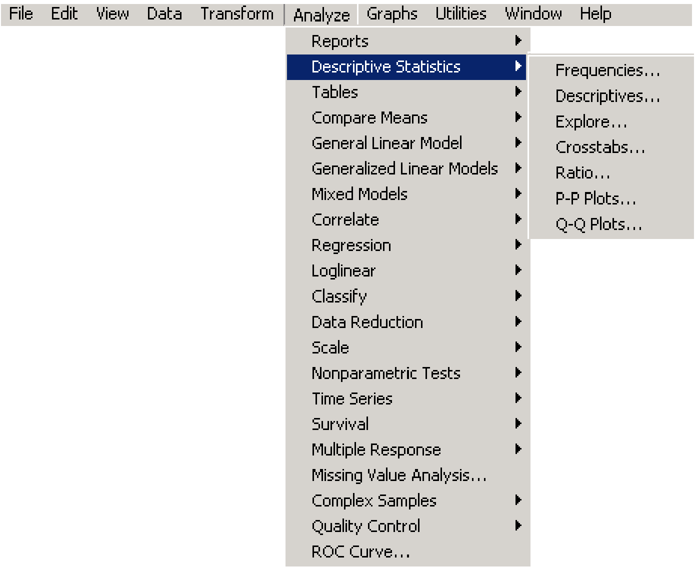


Fig. 7 The Descriptive Statistics drop-down menu

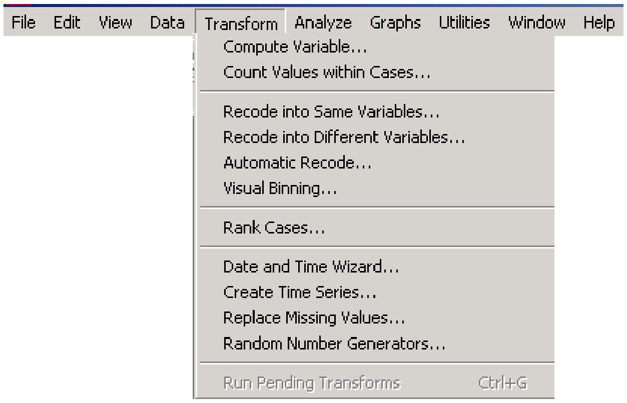


Fig. 8 The Transform drop-down menu

Toolbars

Each window has its own toolbar. When you put the mouse cursor on a tool, a brief description of the tool pops up.

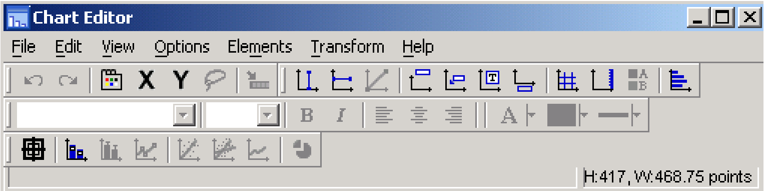


Fig. 9 The Chart Editor Menu and Toolbar

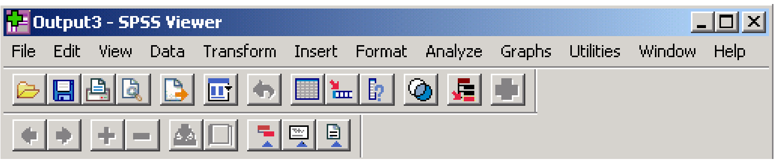
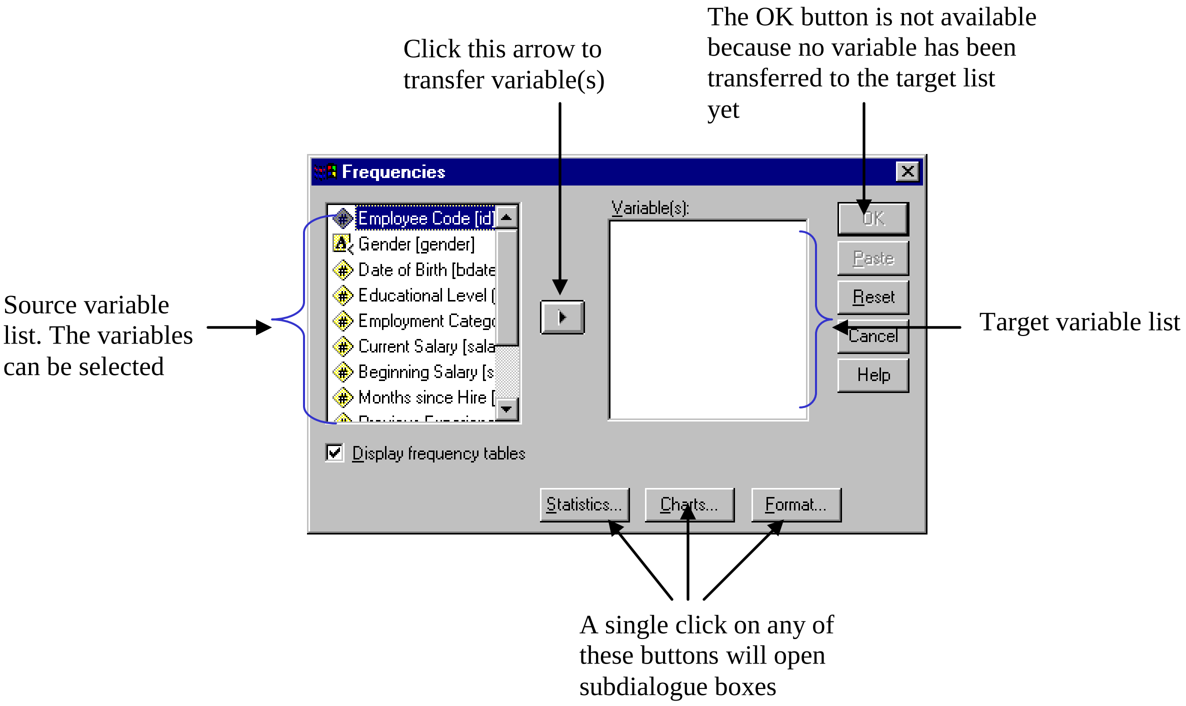


Fig. 10 The Viewer menu and Toolbar

2.6 Dialogue boxes

You use dialogue boxes to select variables and options for statistics and charts. You select variables for analysis from the **source** list. And you use the arrow button to move the variables into the **target** list. Dialogue box buttons with an ellipsis (...) open subdialogue boxes for optional selections. There are five standard buttons on most dialogue boxes (**OK**, **PASTE**, **RESET**, **CANCEL**, and **HELP**). You see some diagrams of some dialogue boxes as you progress through this document. The Frequency dialogue box is shown in Fig. 11.



Click this arrow to transfer variable(s)

The OK button is not available because no variable has been transferred to the target list yet

Source variable list. The variables can be selected

Target variable list

A single click on any of these buttons will open subdialogue boxes

Fig. 11 Frequency dialogue box

2.7 Status Bar

The status bar at the bottom of each SPSS window is divided into sections which provides the following information: OMS (Output Management System), Case counter area, Filter/Use area, Weight area, and Split file area.

2.8 Opening a Data File

SPSS can open many types of files such as Excel, dBase, Lotus 1-2-3, SYLK, SYSTAT, SAS, etc. and of course the SPSS files format. SPSS data file has the extension **.sav**, the output file **.spo** (old version), **.spv** (new version) and the syntax file **.sps**. To open a data file follow these instructions:

2.8.1 File -> Open -> Data...

Note you have to tell SPSS the type of file you want to open via **Files of types:**.

2.8.2 Saving a New Data File or Save Data in a Different Format

To save a file:

1. Make sure the **Data Editor** is active.
2. **File -> Save AS..**.
3. Select a file type from the drop-down list.
4. Enter a file name for the new data file.
5. Click **Save**.

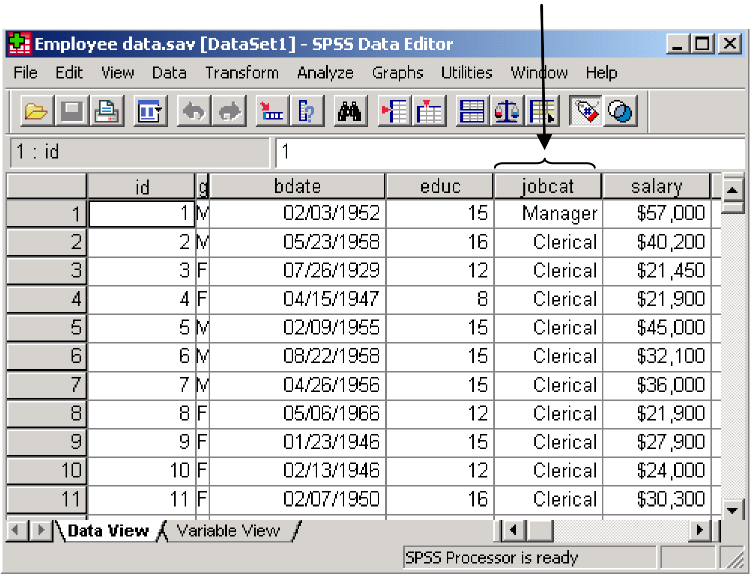
2.9 Basic data file structure

The Data Editor reflects the basic structure of an SPSS data file. Each row is a single case (observation). For example, each person in a survey is a case. Each column is a single variable. For example, each question in a survey is a variable. You can enter and edit data in the **Data Editor**. You can't perform calculations or enter formulas in the **Data Editor** as is common in other spreadsheets, e.g. Microsoft Excel. There are other ways of doing this in SPSS through the **Transform -> Compute** menu.

Note that the columns named *id*, *educ,* and *jobcat* contain **Numeric** data, the one named *gender* contains **String** data, the one named *bdate* contains **Date** data, and the one named *salary* contains **Dollar** data.

This is a single variable

This is a single observation or case


Employee data.sav [DataSet1] - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Window Help
1 : id
1
Data View
Variable View
SPSS Processor is ready

	id	g	bdate	educ	jobcat	salary
1	1	M	02/03/1952	15	Manager	$57,000
2	2	M	05/23/1958	16	Clerical	$40,200
3	3	F	07/26/1929	12	Clerical	$21,450
4	4	F	04/15/1947	8	Clerical	$21,900
5	5	M	02/09/1955	15	Clerical	$45,000
6	6	M	08/22/1958	15	Clerical	$32,100
7	7	M	04/26/1956	15	Clerical	$36,000
8	8	F	05/06/1966	12	Clerical	$21,900
9	9	F	01/23/1946	15	Clerical	$27,900
10	10	F	02/13/1946	12	Clerical	$24,000
11	11	F	02/07/1950	16	Clerical	$30,300

Fig. 12 The basic data file structure

2.10 Types of Data

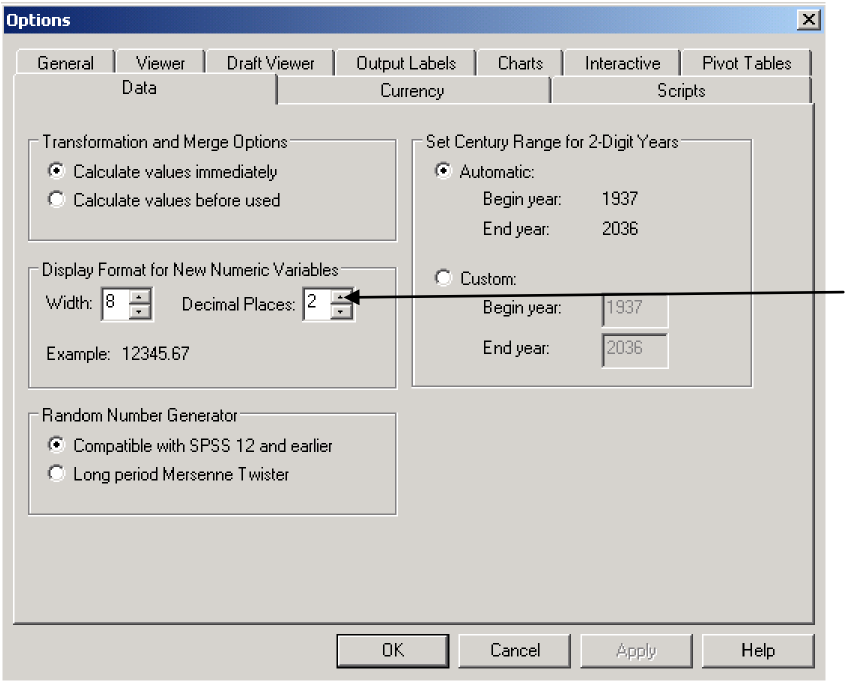
SPSS accepts the following types of data:

Numeric (This is the default)
Comma
Dot
Scientific notation
Date
Dollar
Custom currency
String

2.11 Number of decimal places to display values

It is always a good idea to specify a default format to which values should be displayed in the data editor window. This can subsequently be over-ridden for specific variables only. Follow these steps to specify the number of decimal places:

From the main menu bar select **Edit -> Options**. SPSS Options dialog box appears. From the dialog box select **Data**. Now specify the number of decimal places and click **OK**.



Transformation and Merge Options

● Calculate values immediately

○ Calculate values before used

Display Format for New Numeric Variables

Width: 8 Decimal Places: 2

Example: 12345.67

Random Number Generator

● Compatible with SPSS 12 and earlier

○ Long period Mersenne Twister

Set Century Range for 2-Digit Years

● Automatic:

Begin year: 1937

End year: 2036

○ Custom:

Begin year: 1937

End year: 2036

Specify the number of decimal places you want here

Fig. 13 Options: Data Dialogue box

This decimal place will apply to the whole data set. The decimal place for a specific column could be changed later.

2.12 Variable names and value labels

2.12.1 Variable names

Always give meaningful names to all your variables. If you do not, SPSS will name the variables for you, calling the first variable var00001, the second var00002 and so on. There are six specific rules that you should follow when selecting variable names. A variable name:

1. must not exceed 32 characters. (A character is simply a letter, digit or symbol).
2. must begin with a letter.
3. could have a mixture of letters, digits and any of the following symbol: @, #, _, $.
4. must not end with a full stop.
5. must not contain any of the following: a blank, !, ?, *.
6. must not be one of the keywords used in SPSS (e.g. AND, NOT, EQ, BY, and ALL)

2.12.2 Value labels

With **Value labels** you assign names to arbitrary code numbers. For example, you may want to perform a statistical procedure on two groups that have been given arbitrary code numbers of 1 and 2. You can give **Value labels** to these code numbers. Follow these instructions:

With the **Define Value** labels dialogue box on the screen, type the lowest code number 1 into the **Value** text box. In the **Value label** text box type the label for the code number e.g. *group 1*. The **Add** button will become active. Click the **Add** button and the following will appear in the lowest box: 1="group 1". Repeat the procedure to label value *2* so that the lowest box will contain the following:

1="group 1"
2="group 2"

After completing the value labels click **OK**.

2.13 Data entry using the keyboard

When the **Data Editor** window is accessed for the first time, the top cell of the leftmost column will be highlighted (i.e. thickened black borders round the cell). This is the active cell. You can make any cell active by moving your mouse to the required cell and then clicking the left mouse button. Notice that as you change the active cell, the cell editor on the left, track the location of the active cell. A value typed in from the keyboard will appear in the cell editor and can be transferred to the active cell by pressing **return** or **enter** key on the keyboard. You can change position of the active cell in grid by using the cursor keys (i.e. the up, down, right and left arrows on the keyboard). You can now enter data into any cell.

2.13.1 Editing data on the grid

The editing functions found in most applications are available in SPSS for Windows. You can copy, cut, and paste in SPSS. The block-and-paste technique can also be used. To delete the values in a cell (or block), highlight the required area and press **shift delete** or the **back space** key. To delete the values of an entire row, click on the grey area containing the row number followed by delete. Similarly, to delete the values of an entire column, click on the grey area containing the name of the column followed by delete.

2.14 Exercise

Now that the basics of SPSS for Windows have been covered, attempt the following exercise. To do the exercise you must start SPSS for Windows if you have not already done so.

2.14.1 Exercise 1a – Sample Questionnaire and Coding, Variable Labels, Value Labels and Data entry

In this exercise, you will learn how to code a questionnaire, label variable and value, and enter data into SPSS Data Editor.

Sample Questionnaire

1. What is your gender? Please tick 1: Male Female

2. What is your date of birth? ……………………

3. What is the total number of years you completed in an educational establishment? …….

4. Which employment category do you belong to? Please select one:
   Manager
   Clerical
   Custodial

5. What is your current salary? ……………….

6. What was your beginning salary …………..

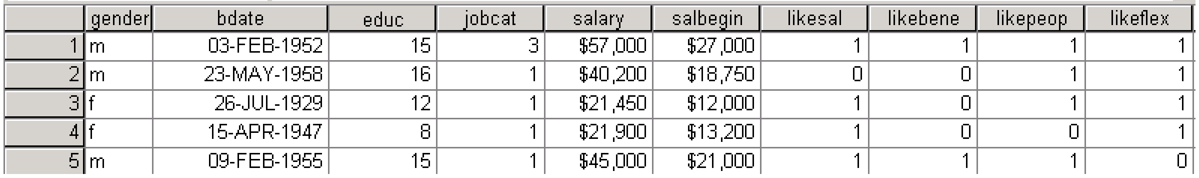
7. What do you like about your current job? Select all that applies:
   Salary Benefits
   People I work with Flexible Hours

Go to the **Variable View** window and code each question using the information shown on the table below:

Coding of Questionnaire

Questions (Variable Name)	Type	Description (Variable Label)	Code (Value and Value Label)
gender	String	Respondent's sex	m=male, f=Female
bdate	Date	Date of birth	
educ	Numeric	Educational level	
jobcat	Numeric	Employment category	1=Clerical, 2=Custodial, 3=Manager
salary	Dollar	Current salary	
salbegin	Dollar	Beginning salary	
likesal	Numeric	Like the salary	1=Yes, 0=No
likebene	Numeric	Like the benefits	1=Yes, 0=No
likepeop	Numeric	Like people I work with	1=Yes, 0=No
likeflex	Numeric	Like the flexible hours	1=Yes, 0=No

Go to the **Data View** and type in the data shown on the table below:



	gender	bdate	educ	jobcat	salary	salbegin	likesal	likebene	likepeop	likeflex
1	m	03-FEB-1952	15	3	$57,000	$27,000	1	1	1	1
2	m	23-MAY-1958	16	1	$40,200	$18,750	0	0	1	1
3	f	26-JUL-1929	12	1	$21,450	$12,000	1	0	1	1
4	f	15-APR-1947	8	1	$21,900	$13,200	1	0	0	1
5	m	09-FEB-1955	15	1	$45,000	$21,000	1	1	1	0

Save the file, give it a suitable name and save it in a folder of your choice (if you like you can save it under **H:\**). You have now successfully created and saved your first data set in SPSS. Congratulations!

2.14.2 Exercise 1b – Read an Excel Data file into SPSS

The file is stored in this location **\\campus\software\dept\spss**. It is called **Gss91Sm.xls**. Before you open the file in SPSS it is a good idea to open it first in Excel, have a look at it. Close the file in Excel. Now open this file in SPSS following these instructions:

1. **File -> Open -> Data…**
2. Under **Files of type:** using the drop-down arrow select **Excel (*.xls, *.xlsx, *.xlsm)**
3. Under **File name:** type **\\campus\software\dept\spss** and click **Open**
4. Select **GSS91Sm.xls** and click **Open**
5. Make sure **Read variable names from first row of data** is checked
6. Using the drop down arrow select the worksheet to open
7. Under **Range** type **A6:F506** and click **OK**

You can now modify and save the file as an SPSS data file.

2.15 Exercise 2 - How to conduct an Exploratory Data Analysis - Quantitative Variable

Now that we have successfully entered and saved data into SPSS, it is time to perform some statistical data analysis procedures. However, it is advisable to conduct an Exploratory Data Analysis (EDA) before carrying out any formal data analysis. Why not attempt some Exploratory Data Analysis using the following: **Explore**, **Descriptives**, and **Frequencies**. Follow these instructions:

2.15.1 The Explore Procedure

1. Start SPSS if you have not already done so and open the data set file called **employee data** in the usual way. That is **File -> Open -> Data**. Select the file and click **Open**. Study this data file. The file is located at **C:\Program Files\SPSS**.
2. Select **Analyze -> Descriptive Statistics -> Explore...**. The **Explore** dialogue box will appear on the screen. Highlight the variable *Current Salary [salary]* by clicking on it once using your mouse left button and transfer it to the **Dependent List** box by clicking the top arrow. Highlight the variable *Employment Category [jobcat]* and transfer it to the **Factor List** box by clicking the middle arrow.
3. Click on **Plots…** to open the **Explore:Plots** dialogue box and deselect the **Stem-and-Leaf** check box in the **Descriptive** group. If **Stem-and-Leaf** is already deselected click on **Continue**.
4. Click on **OK** to run the procedure. The result of this procedure will be displayed on the **Output Viewer** window. Examine and try to interpret the result.

2.15.2 The Descriptives Procedure

With **Descriptives** you can quickly generate summary statistical measures such as *mean*, *standard deviation*, *variance*, *maximum* and *minimum* values, *range* and *sum* for a given variable. Follow these instructions:

1. From the menu bar, select **Analyze -> Descriptive Statistics -> Descriptives...**. The **Descriptives** dialogue box will appear on the screen.
2. Transfer the variable *Current Salary [salary]* into the **Variable(s)** box.
3. Select the **Options** pushbutton. The **Descriptives: Options** dialogue box will appear on the screen. Notice that **Mean**, **Std. deviation**, **Minimum** and **Maximum** have already been selected for you. These are the default statistics.
4. Also select these statistical measures: **Variance**, **Range**, **Sum**, and **S.E mean**. To select an item click on the check box once. To deselect it click on it again once.
5. Select **Continue** to return to the **Descriptives** dialogue box.
6. Select **OK** to run the procedure.

Examine and attempt to interpret the output.

What are the main differences between the output from the **Descriptives Procedure** compare to the output from the **Explore Procedure**?

2.15.3 The Frequencies Procedure

With the Frequencies procedure you can also generate summary statistical measures for a given variable. **Frequencies** gives frequency distributions for all types of data (nominal, ordinal and interval). This example concentrates on the quantitative variable *Current Salary [salary]*. An example involving qualitative variables will be carried out in Exercise 3. Follow these instructions:

1. From the menu bar, select **Analyze -> Descriptive Statistics -> Frequencies...**. The Frequencies dialog box will appear on the screen. You my need to click on the **Reset** button if this dialogue box has been used before.
2. Highlight the variable *Current Salary [salary]* and then click on the arrow pushbutton to transfer it into the **Variables(s)** box.
3. Click on the **Charts** pushbutton to open the **Frequencies: Charts** dialogue box. Click on the **Histogram** and click on **With Normal Curve** button in the **Chart Type** group and then click on **Continue**.
4. Click on the **Statistics** pushbutton to open the **Frequencies: Statistics** dialogue box.
5. Select these statistics: **Quartiles**, **Mean**, **Median**, **Mode**, **Sum** and click on **Continue**.
6. Click on **Display frequency tables** to deselect it. It is not appropriate to produce a frequency table for interval (continuous) variable.
7. Click on **OK** to run the procedure.

Examine and interpret the output.

2.16 Exercise 3 - How to conduct an Exploratory Data Analysis - Qualitative Variable

The data file used in this example is stored **\\campus\software\dept\spss**. Follow these instructions to open this file:

1. **File -> Open -> Data**…
2. In the text area for **File name:** type **\\campus\software\dept\spss**.
3. Click on **Open** and select the file called **bloodtype.sav**.
4. Click **Open**.

Study this file.

The most commonly used SPSS procedures for describing qualitative data are **Frequencies** and **Crosstabs**. To conduct an exploratory data analysis on the data follow these instructions:

2.16.1 The Frequencies Procedure

1. From the menu bar, select **Analyze -> Descriptive Statistics -> Frequencies...**. The Frequencies dialogue box will appear on the screen.
2. Highlight the variables *Blood Type [bloodtyp]* and *Gender [gender]* then click on the arrow pushbutton to transfer them into the **Variables(s)** box.
3. Click on the **Charts** pushbutton to open the **Frequencies: Charts** dialogue box. Click on the **Histogram** and click on **With Normal Curve** buttons within the **Chart Type** group and then click on **Continue**.
4. Click on **OK** to run the procedure. Examine and interpret the output.

2.16.2 The Crosstabs Procedure

This procedure is used to generate contingency tables from qualitative data. To carry out this procedure follow these instructions:

1. From the menu bar, select **Analyze -> Descriptive Statistics -> Crosstabs...**. The **Crosstabs** dialogue box will appear on the screen.
2. Highlight the variable *Gender [gender]* and click on the arrow pushbutton to transfer it to the **Row(s)** text box.
3. Highlight the variable *Blood Type [bloodtyp]* and click on the arrow pushbutton to transfer it to the **Column(s)** text box.
4. Click on **OK** to run the procedure. Examine and interpret the output.

To use the Chi-Square test and find out if *gender* is associated with *blood type*, the contingency table must satisfy these assumptions:

- No cell should have expected value (count) less than 0, and
- No more than 20% of the cells have expected values (counts) less than 5

In order to perform the test we need to state the null and alternative hypotheses:

Null (H_o): There is no association between *gender* and *blood type*.
Alternative (H_1): There is an association between *gender* and *blood type*.

To perform the test, follow these instructions:

1. Recall the **Crosstabs** dialogue box via **Analyze -> Descriptive Statistics -> Crosstabs...**.
2. Click **Cells…** Under **Percentage** select **Row** and click **Continue**
3. Click **Statistics…** Select **Chi-square** and click **Continue**
4. Click **OK** to run the procedure.

Examine and interpret the output. Will you accept or reject the null hypothesis? What will you conclude?

3 Menu and Toolbar in SPSS:

Selecting Cases / Variables

Example data set: **Employee data.sav**

The following tools on the **TOOLBAR** are used often:

3.1 Select Cases: Helps you to subset your data file and work with specific cases only. Example, select case if *gender='f' & jobcat=3*. That is, we are interested in only female managers. To set the conditions, follow these instructions:

1. From the menu bar select **Data -> Select Cases….**
2. Click on **If Condition is Satisfied**. Click on **If….**
3. Click on *Gender* [*gender*] and click on the arrow. Type equal sign (=) using your keyboard or select it from the dialogue box.
4. Type *'f'*. Type *&* or select it from the dialogue box.
5. Click on *Employment Category* [*jobcat*] and click on the arrow. Type equal sign (=) using your keyboard or select it from the dialogue box.
6. Then type *3* or select it from the dialogue box. The complete expression should look like this *gender='f' & jobcat=3*.
7. Click on **Continue**. Click on **OK**.

Notice that in your **Data View** window some row numbers are crossed out. These are the cases that have not satisfied the condition. Also note that a new variable called '*filter_$*' is added to your data set.

Now do a descriptive procedure on *current salary*. Use your output to answer this question.

How many female managers work for this company? What is their average *current salary*?

3.2 Split File: Helps you divide a file based on a given condition. Example split the employee data file into (a) the different *gender* and (b) the different job categories (*jobcat*). Follow these instructions:

1. From the menu bar select **Data -> Split File…**.
2. Click on **Organize output by groups**. This option gives you a different table for each combination of factor while **Compare groups** give you a single table.
3. Select *Gender* [*gender*] and click on arrow.
4. Select *Employment category* [*jobcat*] and click on arrow.
5. Click **OK**.

Notice the changes that have taken place in the Data View window. First the data is sorted alphabetically according to *gender*. Then within gender, it is sorted in ascending order according to *Employment category* [*jobcat*].

Do a descriptive procedure on current salary and see how the output is displayed. Use the output to answer the following questions.

How many female clerical employees work for this company? What is their average current salary?

How many male clerical employees work for this company? What is their average current salary?

How does the average current salary for female clerical employees compares to that of male clerical employees?

3.3 Dialogue Recall: Helps you to recall the most recently used dialogue boxes. From the tool bar select the fourth tool from your left (). You can now select any of the dialogue by a single click. It is a fast way to gain access to a previously used dialogue box.

3.4 Menu and Toolbar in SPSS:

Data Manipulation

3.4.1 Data -> Sort: Helps you sort a data set based on a given variable. You can sort in ascending or descending order. Example, sort the data set using 'gender' in ascending order.

3.4.2 Transform: This menu helps you create new variables and as well as many other tasks. For example: there is an increase of 3% on current salary for all employees. Create a new variable to represent this. Call this variable *salinc*.

If we wish to create a new grouping for *salary*, that is,

Salary less than $20,750=Low Income (1)
Salary between $20,751 and $50,000=Medium Income (2)
Salary greater than $50,001=High Income (3)

To create the new category of salary based on these conditions, follow these steps carefully:

1. From the menu bar select **Transform->Recode Into Different Variables…**
2. Select *current salary* [*salary*] and click on the arrow
3. In the **Output Variable** area under **Name:** type *salacate*; under **Label** type *Salary Category*
4. Click on **Change**. Click on **Old and New Values…**
5. In the **Old Value** area, select **Range, LOWEST through value:** and type *20750*.
6. In the **New Value** area, select **Value** and type *1*.
7. In the **Old->New:** area click on **Add**.
8. In the **Old Value** area, select **Range**: type *20751* and *50000* in the boxes respectively.
9. In the **New Value** area, select **Value** and type *2*.
10. In the **Old->New:** area click on **Add**.
11. In the **Old Value** area, select **All other values**.
12. In the **New Value** area, select **Value** and type *3*.
13. In the **Old->New:** area click on **Add**.
14. Click on **Continue**. Click on **OK**.

Notice that the new variable (*salacate*) has been added to the **Data Editor** and **Variable View** windows. Select the **Variable View** window and specify these **Values** and **Labels** for the variable: *1=Low Income*, *2=Medium Income* and *3=High Income*.

Find out how many female/male employees fall into this new category of salary by doing a crosstabs. Also show the percentages.

3.5 Calculating age using Date and Time Wizard

1. From the menu bar select **Transform -> Date and Time Wizard….**
2. Select **Calculate with dates and times** and click **Next**.
3. Select **Calculate the number of time units between two dates (e.g. calculate an age in years from birthdate and another date)** and click **Next**.
4. Select *Current date and time* [*$TIME*] and click on the arrow next to it.
5. Select *birthdate* [*bdate*] and click on the active arrow. Make sure that under **Units:** *Years* is selected. Click on **Next**.
6. Under **Result Variable:** type *age*. Under **Variable Label**: type *Age of respondent*. Click **Finish**.

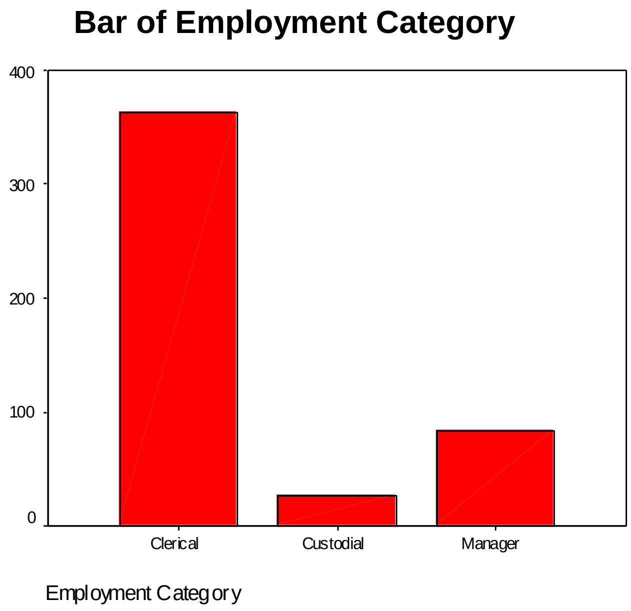
Notice that the new variable (*age*) has been added to the **Data Editor** and **Variable View** windows.

What is the minimum, maximum, average, and modal age? What is the 95% confidence interval of the average age? What is the 1%, 25%, 75% and the 99% of age? How would you interpret the 1% of age?

4.0 Graphical Presentation of Data (Data Visualisation)

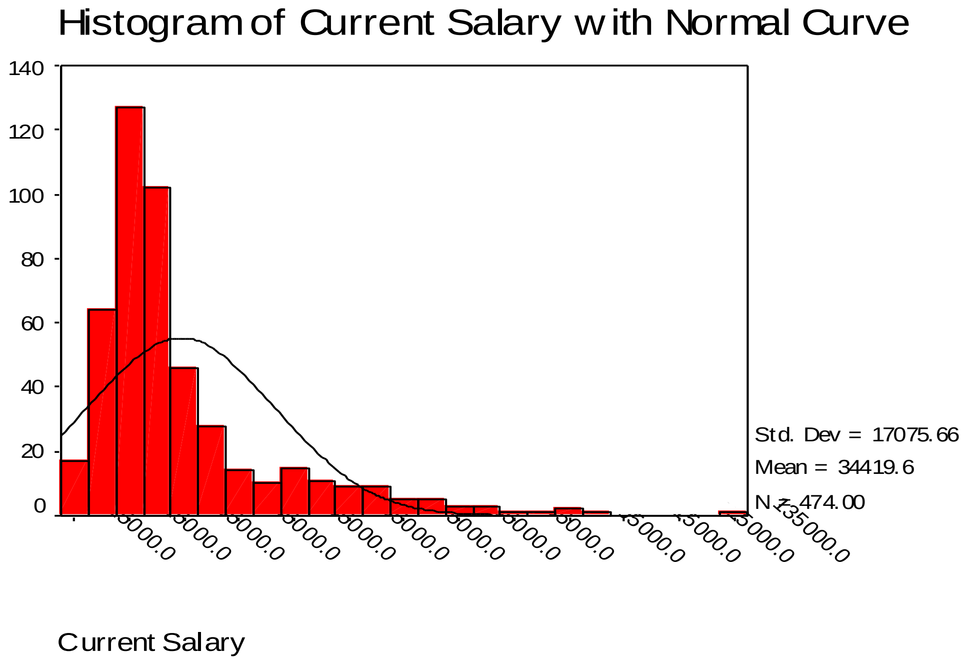
4.1 Bar Chart

To produce the **Bar of Employment Category**. From the menu bar select
Graphs ->Legacy Dialogs -> Bar…click on **Simple**, click on **Define**
From the variables list, select *Employment Category [jobcat]* click the arrow (>) to transfer it under **Category Axis:**. Then click **OK** to generate the graphic.



4.2 Histogram

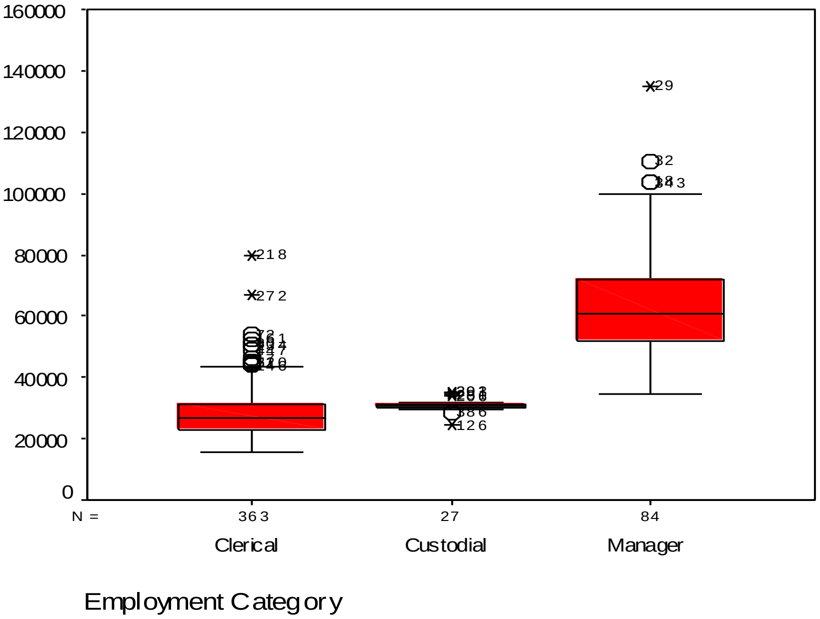
To produce a **Histogram of Current Salary with Normal Curve** - from the menu bar select **Graphs -> Legacy Dialogs -> Histogram…**
From the variables list, select *Current Salary [salary]* click the arrow (>) to transfer it under **Variable:**. Select **Display normal curve** by a single click on the check box. Then click **OK** to generate the graphic.



4.3 Boxplot

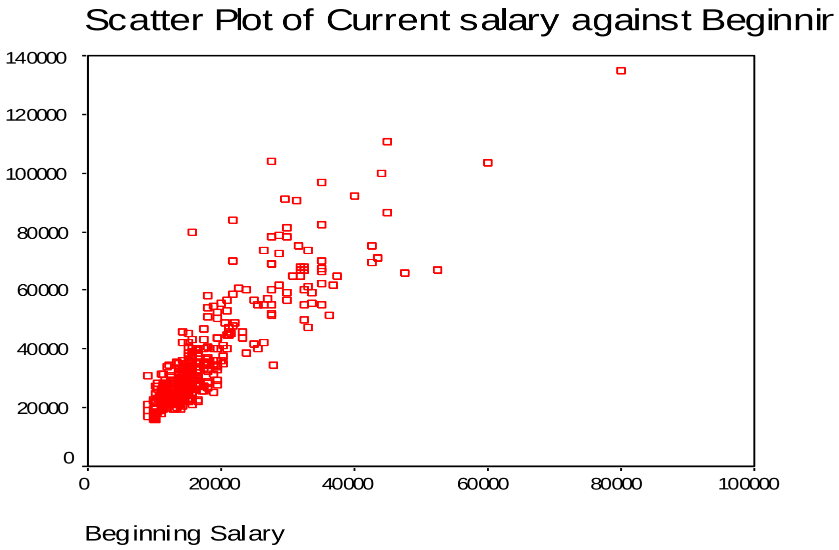
To produce **Boxplot of Current salary across Employment**. From the menu bar select **Graphs -> Legacy Dialogs -> Boxplot**… click on **Simple**, click on **Define**
From the variables list, select *Current Salary [salary]* click the arrow (>) to transfer it under **Variable:**. From the variable list again, select *Employment Category [jobcat]*, click the arrow (>) to transfer it under **Category Axis:**. Then click **OK** to generate the graphic.

Boxplot Current Salary across Employment category



4.4 Scatter Plot

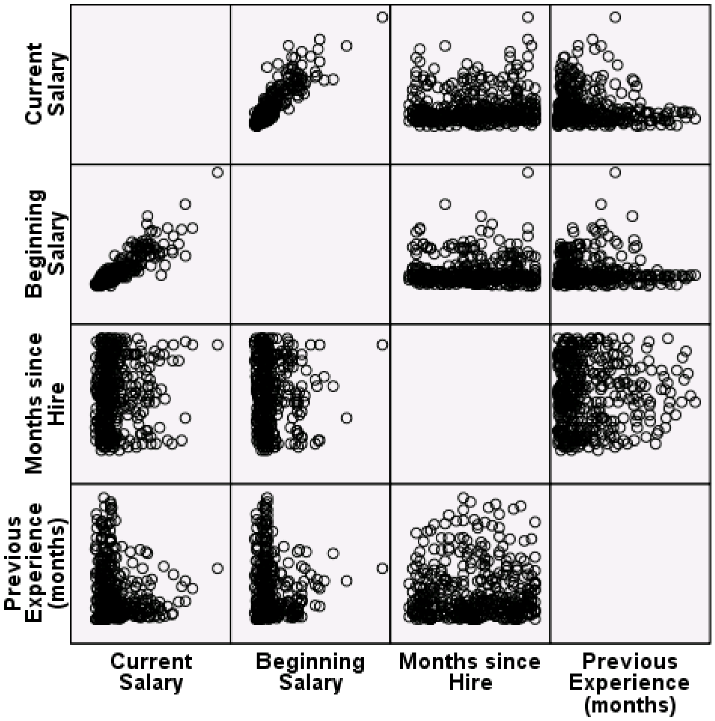
To produce **Scatter Plot of Current Salary against Beginning Salary**. From the menu bar select **Graphs -> Legacy Dialogs -> Scatter/Dot… ->** click on **Simple**, click on **Define**. From the variables list, select *Current Salary [salary]* click the arrow (>) to transfer it under **Y Axis:**. From the variable list again, select *Beginning Salary [salbegin]*, click the arrow (>) to transfer it under **X Axis:**. Then click **OK** to generate the graphic.



4.5 Matrix Scatter Plot

Why not attempt to produce **Matrix Scatter Plot** on your own! The variables you need are shown on the matrix. Can you interpret the Matrix Scatter Plot?

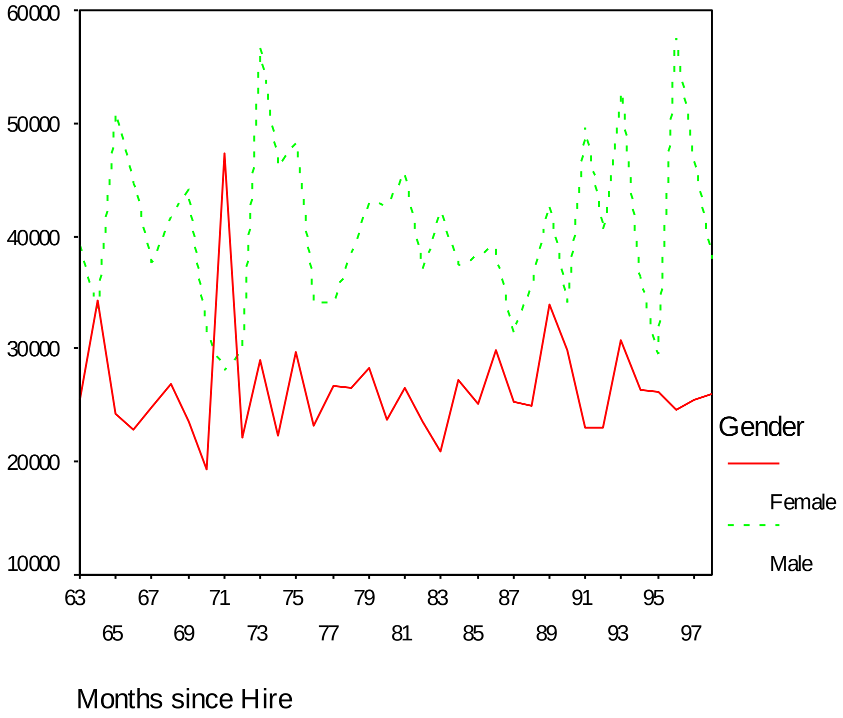
Matrix Scatter Plot



4.6 Line Graph

To produce **Graph Showing the Relationship between Mean Current Salary against Months Since Hire for a different Gender**. From the menu bar select
Graphs -> Legacy Dialogs -> Line… click on **Multiple**, click on **Define**. Select **Other Statistics (e.g. mean)** by a single click on the radio button.
From the variables list, select *Current Salary [salary]* click the arrow (>) to transfer it under **Variable:**. From the variable list again, select *Months since Hire [jobtime]* click the arrow (>) to transfer it under **Category Axis:**. From the variable list again select *Gender [gender]* click on the arrow (>) to transfer it under **Define Lines by:**. Then click **OK** to generate the graphic.

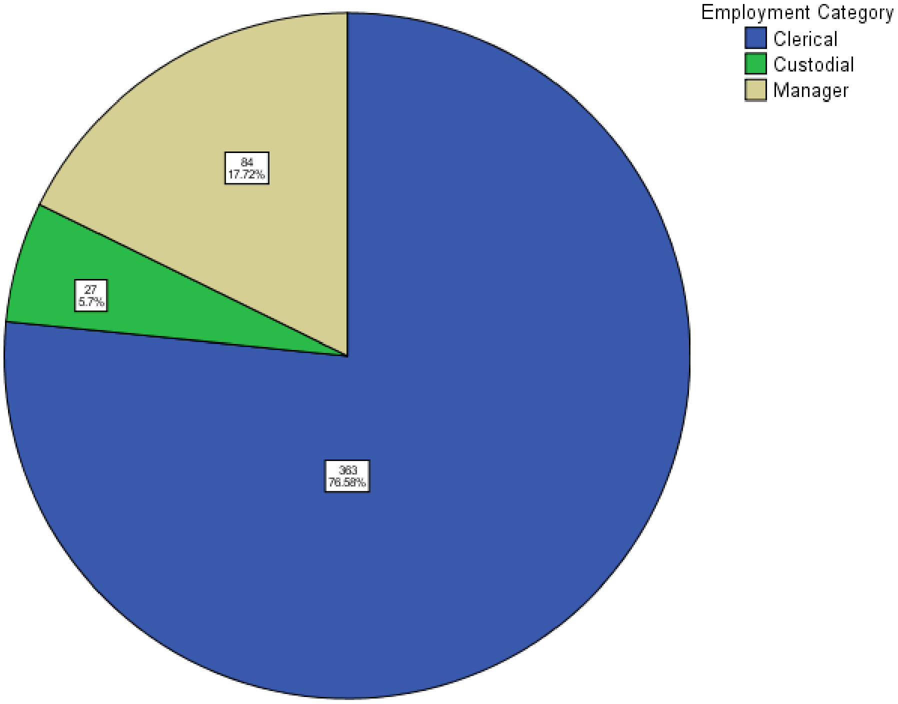
Graph Showing the Relationship between *Mean Current Salary* against *Months Since Hire* for a different *Gender*



4.7 2D Pie Chart

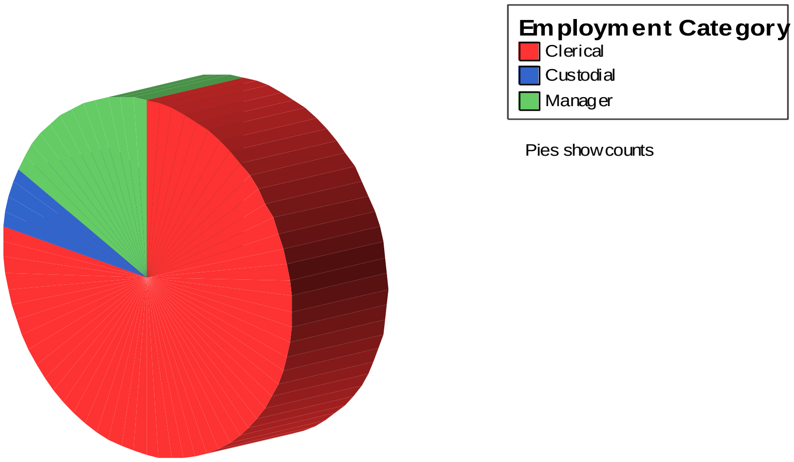
To produce **2D Pie Chart**. From the menu bar select **Graphs -> Legacy Dialogs -> Pie**…Select **Summaries for groups of cases** by a single click on the radio button. Click on **Define**. From the variables list, select *Employment Category [jobcat]* click the arrow (>) to transfer it under **Define Slices by:**. Then click **OK** to generate the graphic. Double-Click on the Pie in quick succession to make it editable. (the pie will be displayed in the **Chart Editor** window). In this Window select **Elements -> Show Data Labels**. Select **Percent (or Count)** from the displayed dialogue box. Click on the green arrow on the right. Still on the dialogue box, click **Apply** and then **Close**. You will now be back on the Chart Editor window, from the menu bar select **File -> Close**.

2D Pie Chart



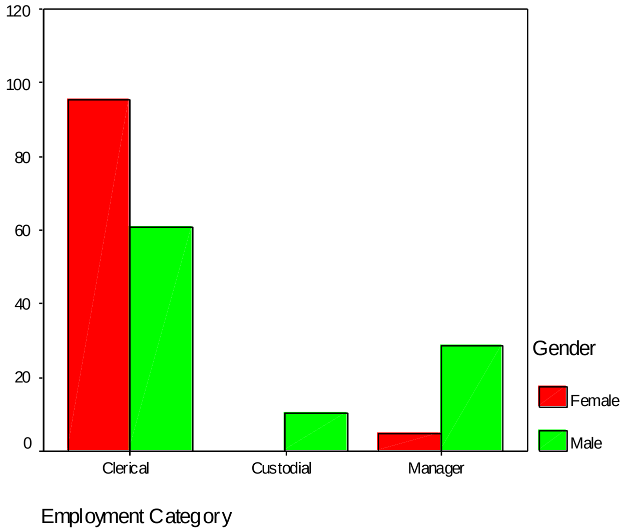
4.8 3D Pie Chart

To produce **3D Pie Chart**. From the menu bar select **Graphs -> Interactive -> Pie -> Simple**… Click the downward pointing arrow at the top right hand corner of the dialogue box and select **3D Effect**. From the variables list, select *Employment Category [jobcat]* drag and drop it under **Slice By:**. Then click **OK** to generate the graphic. Double-click on the graph to make it interactive. Explore some of the features by trial and error. When you have finished, click anywhere outside the plot to leave the interactive mode.



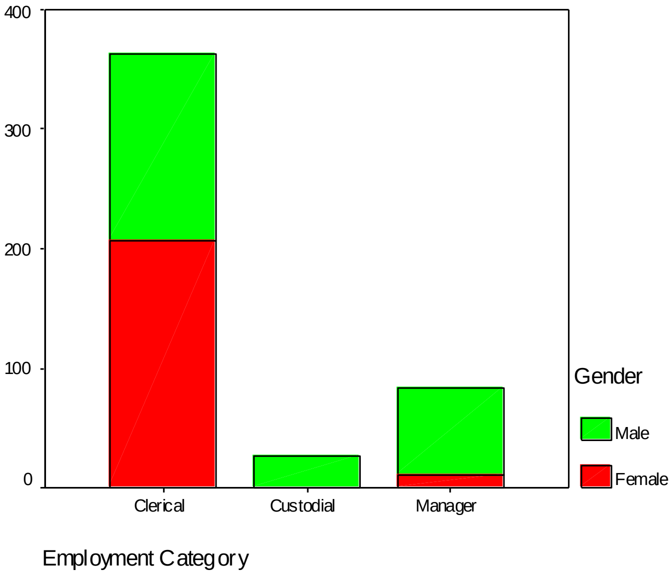
4.9 Clustered Bar Charts

Why not attempt to produce the Clustered Bar Chart.
Hint: Graphs ->Legacy Dialogs -> Bar -> Clustered -> Define. **Category Axis:** *Employment Category [jobcat]***. Define Clusters by:** *Gender [gender]*



4.10 Stacked Bar Charts

Why not attempt to produce the Stacked Bar Chart.
Hint: Graphs -> Legacy Dialogs -> Bar -> Stacked -> Define. **Category Axis:** *Employment Category [jobcat]***. Define Stacks by:** *Gender [gender]*



5 Statistical Significance and Inference

5.1 Samples and Random Sampling

The main idea of sampling is to reduce cost and save time. However, you have to make sure that your sample is a good representation of the population. If resources were not limited, we would study the whole population. This would give us an accurate estimate of whatever we are studying. To get a good representation of the population, you would have to collect a random sample. Usually, the size of a sample does not depend on the size of the population but on the accuracy you require and the resources you are willing to allocate to data collection. A large sample will give a more accurate result than a small sample, but would need more time and resource to collect.

5.2 Populations and Samples

Population refers to the entire number of things you want to study. In other words, the totality of the potential units for observation. It could be the population of a given country, the number of houses in a given area, number of insects on a single tree, the number of companies with turnover of £1b, the number of teachers in a given county, and so-on. A sample is a selection of individual items or members of the population.

5.3 Units

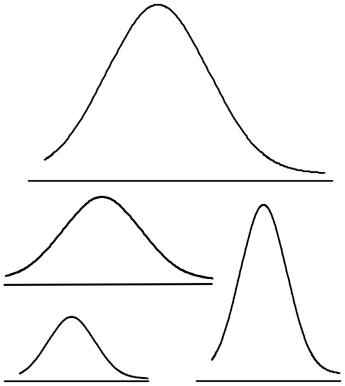
In case of the population of given country, the sampling unit will be a single individual. For number of houses in an area, it would be a single house. For insects, it would be a single insect. Note that a sampling unit can also refer to more than one item, for example, a classroom in a school could be a sampling unit from which pupils are selected to take part in a survey.

5.4 Sampling Frames

Sampling frame simply refers to the record from which a sample can be selected. In the case of teachers, a list with the local councils, register of professional bodies, or a list of occupation register kept by some agency would be a suitable sampling frame.

5.5 Normal Distribution

Normal distribution is a theoretical concept that is symbolised by the familiar bell-shaped curve. It is really a family of distribution. See diagram below. It plays an important role in statistical inference. Some statistical procedures in SPSS assume that your data is normally distributed. That is, your data is taken from a normal population.



A standard normal distribution is a normal distribution with a mean of zero and a standard deviation of one. A normal distribution score can be easily converted into a standard normal distribution (standardised or z) score using the following simple formula.

$$\text{Standard Score} = \frac{\text{Score - Mean}}{\text{Standard Deviation}}$$

5.6 Hypothesis testing, one and two tail tests, type I and type II errors

5.6.1 Hypothesis testing

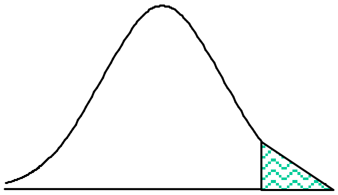
1. Set up a null hypothesis (H_0) and an alternative hypothesis (H_1) about the population or populations. For example: H_0: There is no difference between the mean of two populations. H_1: There is a difference between the mean of two populations.
2. Set up an alpha level. An alpha level is the probability level you view as low enough to constitute evidence that there is a contradiction between the data and the assumption that the null hypothesis is true in the population (often alpha is set at .05).
3. Gather sample data from the population.
4. Compute the value of a test statistic based on the sample data.
5. Compute the probability of the value of the test statistic in Step 4 under the assumption that the null hypothesis is true.
6. If the probability in step 5 is less than alpha selected in step 2, then conclude that there is an inconsistency between the null hypothesis and the data. You can then reject the null hypothesis in favour of the alternative hypothesis and state that the results are statistically significant.
7. If the probability is greater than the alpha level, then conclude that the sample data is consistent with the null hypothesis. You must accept the null hypothesis and state that the results are not statistically significant.

Note that statistical significance is not the same as practical significance. Rejecting this null hypothesis only indicates that the sample data imply that there is some difference in the population; however, that difference may be small and unimportant.

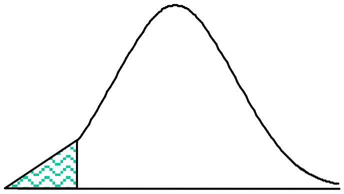
5.7 One- and Two-tailed tests

One-tailed test applies in situation where the experimenter knows the direction the results should point. For example, when testing a new drug against a placebo, an experimenter would want to know whether the new drug is better than the placebo. On a family of normal distribution curves a one-tailed test can be in one direction only, positive or negative (see diagram).

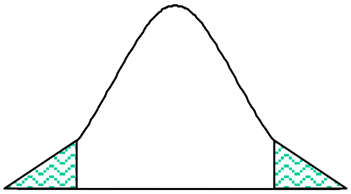
Two-tailed test applies in situation where the experimenter does not know or is interested in both directions of the results. The two-tailed test is more commonly use than the one-tailed test. See diagram below for graphical representation.



Positive one-tailed test



Negative one-tailed test



Two-tailed test

5.8 Type I and Type II Errors

These are errors that are made in significance testing. On the one hand, Type I error is the probability of rejecting the null hypothesis when it is in fact true. When you reject the null hypothesis, you accept the alternative hypothesis. Thus, you draw the wrong conclusion that your result is significant, when in fact it is not. This is a very serious error to make.

On the other hand, the Type II error is the probability of accepting the null hypothesis when it is in fact not true. In other words, you conclude that your result is not significant when in fact it is.

You can calculate these errors by performing a power and sample size analysis, which is outside the remit of the course!

5.9 Student's t-test for independent samples and for matched samples

There are basically three types of t tests. We are going to look at each one in turn, that is, how to perform and interpret the output. The three types are:

5.9.1 Independent-samples t test (two-sample t test)

This is used to compare the means of one variable for two groups of cases. As an example, a practical application would be to find out the effect of a new drug on blood pressure. Patients with high blood pressure would be randomly assigned into two groups, a placebo group and a treatment group. The placebo group would receive conventional treatment while the treatment group would receive a new drug that is expected to lower blood pressure. After treatment for a couple of months, the two-sample t test is used to compare the average blood pressure of the two groups. Note that each patient is measured once and belongs to one group.

5.9.2 Paired-samples t test (dependent t test)

This is used to compare the means of two variables for a single group. The procedure computes the differences between values of the two variables for each case and tests whether the average differs from zero. For example, you may be interested to evaluate the effectiveness of a mnemonic method on memory recall. Subjects are given a passage from a book to read, a few days later, they are asked to reproduce the passage and the number of words noted. Subjects are then sent to a mnemonic training session. They are then asked to read and reproduce the passage again and the number of words noted. Thus each subject has two measures, often called before and after measures.

An alternative design for which this test is used is a matched-pairs or case-control study. To illustrate an example in this situation, consider treatment patients. In a blood pressure study, patients and control might be matched by age, that is, a 64-year-old patient with a 64-year-old control group member. Each record in the data file will contain responses from the patient and also for his matched control subject.

5.9.3 One-sample t test

This is used to compare the mean of one variable with a known or hypothesised value. In other words, the One-sample t tests procedure tests whether the mean of a single variable differs from a specified constant. For instance, you might be interested to test whether the average IQ of some 50 students differs from 125; or how the average salary in Newcastle compares to the national average.

5.10 Assumptions underlying the use of t test

Before we look at the details of how to perform and interpret a t test, it is good idea for you to understand the assumptions underlying the use of t test. The assumptions are:

- your data is normally distributed
- the variances between the groups are equal
- the sample size is adequate (at least 30 cases per group)

So, before you carry out any t test, you must check to make sure that your data satisfy all these assumptions. However, if your data seriously violates any of these assumptions then Non-parametric tests should be used. Non-parametric tests do not carry specific assumptions about population distributions, variance and sample size.

5.11 The p-value

In the interpretation of the t statistics, we will be looking at its p-value. Generally, there are three situations where you will need to interpret the p-value:

1. If the p-value is greater than 0.05, the null hypothesis is accepted and the result is not significant.
2. If the p-value is less than 0.05 but greater than 0.01, the null hypothesis is rejected and the result is significant beyond the 5 percent level.
3. If the p-value is smaller than 0.01, the null hypothesis is rejected and the result is significant beyond the 1 percent level.

5.12 Exercise

Perform an independent-samples t test (two-sample t test) on the data on Table 1. This data file is stored in this location **\\campus\software\dept\spss** and is called **high blood pressure.sav**.

Table 1: Patients with high blood pressure

Group	Blood pressure
1=placebo	90
1	95
1	67
1	120
1	89
1	92
1	100
1	82
1	79
1	85
2=new drug	71
2	79
2	69
2	98
2	91
2	85
2	89
2	75
2	78
2	80

You need to first check the two assumptions: i) whether blood pressure is normally distributed and ii) whether the variance is equal between the two groups (Homogeneity of variance test). Write down the null and alternative hypotheses for the normality test:

Null Hypothesis (H_o): Blood pressure is normally distribution.
Alternative Hypothesis (H_1): Blood pressure is not normally distribution.

5.12.1 Normality Test

Follow these steps to perform the normality test:

1. From the menu bar select **Analyze -> Descriptives Statistics -> Explore…**.
2. Transfer *blood pressure* [*bloodpres*] to **Dependent List:**.
3. Transfer *Group Membership* [*group*] to **Factor List:**.
4. From **Display** click on **Plots**. Then click on **Plots…**.
5. Under **Descriptive** deselect **Stem-and –leaf**.
6. Select **Normality plots with tests**.
7. Click on **Continue**. Click on **OK**.

Examine the result on the table Tests of Normality. For a small sample size (n≤50) use the Shapiro-Wilk statistic. For large sample size (n>50) use the Kolmogorov-Smirnov statistic.

Is blood pressure from the placebo group normally distributed? Why?
Is blood pressure from the new drug group normally distributed? Why?

Overall, what would you conclude?

Notice that as part of the output some graphs (charts) are also produced. The Normal Q-Q plots and Detrented Normal Q-Q plots. The Normal Q-Q plots also helps you decide if the data is normally distributed or not. For a normal distribution, all the dots should be closed to (or be on) the straight line of the Normal Q-Q plots. Ignore the Detrented Normal Q-Q plots.

Write down the null and alternative hypotheses for the Homogeneity of variance test:

Null Hypothesis (H_o): The variance is equal between the two groups.
Alternative Hypothesis (H_1): The variance is not equal between the two groups.

5.12.1 Homogeneity of variance test

Follow these steps to perform the homogeneity of variance test:

1. Select **Analyze -> Compare Means -> One-Way ANOVA…**.
2. Transfer *blood pressure* [*bloodpres*] to **Dependent List:**.
3. Transfer *Group Membership* [*group*] to **Factor**.
4. Click on **Options** and select **Homogeneity of variance test**.
5. Click **Continue** and click **OK**.

Examine the table **Test of Homogeneity of variance**. What would you conclude? Ignore the table **ANOVA** which is also produced as part of this procedure.

5.12.3 Independent Samples T Tests

Since blood pressure passed the two assumptions, that is, blood pressure was normally distributed and the variances between the two groups are equal, we have to perform a parametric t test.

Write down the null and alternative hypotheses for the Independent Samples T Tests:

Null Hypothesis (H_o): The average blood pressure is the same between the placebo group and new drug group.
Alternative Hypothesis (H_1): The average blood pressure is different between the placebo group and new drug group.

Follow these steps to perform the test:

1. Select **Analyze -> Compare Means -> Independent-Samples T Test….**
2. Transfer *blood pressure* [*bloodpres*] to **Test Variable(s):**.
3. Transfer *Group Membership* [*group*] to **Grouping Variable:**.
4. Click on **Define Groups**. Beside **Group 1:** type *1*. Beside **Group 2:** type *2*.
5. Click on **Continue** and click on **OK**.

Examine the output. Notice that two tables are produced. Using the table **Group Statistics** answer these questions.

What is the average blood pressure for the placebo group?
What is the average blood pressure for the new drug group?
Which of these two averages is more variable and why?

Using the table **Independent Sample Test**, answer these questions. Notice that in this table two rows of figures are given, use the first row.

What is the difference in the averages between the two groups?
Is this difference statistically significant and why?
What is the 95% Confidence Interval of the average difference between the two groups? How is this related to the p-value?
Will you accept or reject the null hypothesis? Why?

5.13 Exercise

Perform a Paired-samples t test (dependent t test) on the data on Table 2. This data file is stored in this location **\\campus\software\dept\spss** and is called **b4_after training words.sav**.

Table 2: Number of words recalled

Before mnemonic training	After mnemonic training
204	223
393	412
391	402
265	285
326	353
220	243
423	443
342	340
480	582
464	490

You need to check whether the number of words recalled before training and after training are normally distributed.

Why do you think in this case it not necessary to perform the homogeneity of variance test?

Write down the null and alternative hypotheses for the Paired-samples t test (dependent t test):

Null Hypothesis (H_o): There is no difference in the average number of words recalled before and after training.
Alternative Hypothesis (H_1): There is a difference in the average number of words recalled before and after training.

5.13.1 Normality Test

Follow these steps to perform the normality test:

1. From the menu bar select **Analyze -> Descriptives Statistics -> Explore….**
2. Transfer *number of words recalled before training* [*words_b4*] to **Dependent List:**.
3. Transfer *number of words recalled after training* [*words_af*] to **Dependent List:**.
4. From **Display** click on **Plots**. Then click on **Plots….**
5. Under **Descriptive** deselect **Stem-and –leaf**.
6. Select **Normality plots with tests**.
7. Click on **Continue**. Click on **OK**.

Examine the output. What would you conclude?

5.13.2 Paired Samples T Test (Dependent T Test)

Since *number of words recalled before training* [*words_b4*] was normally distributed and *number of words recalled after training* [*words_af*] was also normally distributed, we need to perform a parametric paired samples t test. There was not need to homogeneity of variance test because we are dealing with the same group. To do the actual test, follow these steps:

1. From the menu bar select **Analyze -> Compare Means -> Paired Samples T Test….**.
2. Click on *number of words recalled before training* [*words_b4*] and click on the arrow.
3. Click on *number of words recalled after training* [*words_af*] and click on the arrow. Click **OK**.

Use the output to answer these questions.

Using the table **Paired Sample Statistics** what is the average value of the *number of words recalled before training* [*words_b4*]? What is the average value of the *number of words recalled after training* [*words_af*]? Which of these two averages is more variable?

Using the table **Paired Samples Test**, what is the mean difference between the two averages? Is this difference significant? Why? Will you accept or reject the null hypothesis? Why?

5.14 Exercise

Perform a One-sample t-test on the data on Table 3. Is the IQ of 10 students shown on the table different from an IQ of 125? This data file is stored in this location **\\campus\software\dept\spss** and is called **iqs.sav**.

Table 3: IQs of students

IQs
128
134
134
131
134
126
140
133
127
131

This test assumes that the data are normally distributed; however, this test is fairly robust to departures from normality. This probably explains why SPSS does not provide a non-parametric equivalent of this test. You have no option but to proceed with the parametric test.

Write down the null and alternative hypotheses for the One-sample t test:

Null Hypothesis (H_o): The IQ from the ten students is not different from an IQ of 125.
Alternative Hypothesis (H_1): The IQ from the ten students is different from an IQ of 125.

5.14.1 One-Sample T Test

To do the actual test, follow these steps:

1. From the menu bar select **Analyze -> Compare Means -> One-Sample T Test….**
2. Select *Intelligence Quotient* [*iq*] and click on the arrow.
3. Type *125* besides **Test Value:**.
4. Click **OK**.

Use the output to answer these questions.

What is the average *Intelligence Quotient* [*IQ*] from the ten students? Is this average significantly different from an *IQ* of 125? Why? Will you accept or reject the null hypothesis? Why?

5.15 Confidence Intervals

We have discussed hypothesis above; it should be appreciated that it is only one form of statistical inference. There would be situation that you will not be interested in testing hypotheses. You may only be interested in obtaining an estimate of a parameter. For example, we usually use the sample mean as an estimate of the population mean.

However, we are quite certain that the population mean will not be equal to the sample mean due to sampling and data collection errors. It is therefore important to present our estimate within a given range to address these errors. This is where confidence interval is important. *A confidence interval is therefore an estimated range of values with a given high probability of covering the true population value*.

Note, you can calculate the confidence interval of other parameters.

6 Correlational Analysis

6.1 Introduction

Correlation analysis is use to measure the association between two variables. A **correlation coefficient** (**r**) is a statistic used for measuring the strength of a supposed linear association between two variables. The most common correlation coefficient is the **Pearson** correlation coefficient, use to measure the relationship between two interval variables. Generally, the correlation coefficient varies from -1 to +1.

After completing this session you should be able to do the following:

- Conduct and interpret a correlation analysis using interval data.
- Conduct and interpret a correlation analysis using ordinal data.
- Conduct and interpret a correlation analysis using categorical data (crosstabs).

6.2 Scatterplot

The existence of a statistical association between two variables is most apparent in the appearance of a diagram called a scatterplot. A scatterplot is simply a cloud of points of the two variables under investigation. The diagram below shows the scatterplots of sets of data with varying degrees of linear association.

Scatterplots of sets of data with varying degrees of linear association

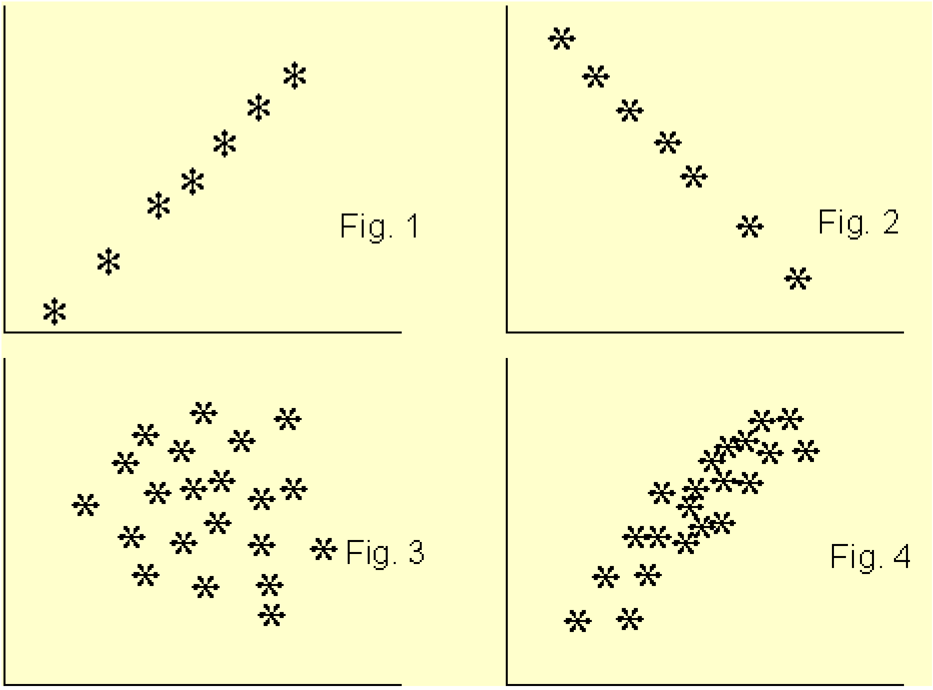


Figure 1 clearly shows a linear association between the two variables and the coefficient of correlation r is +1. For Figure 2, r is -1. In Figure 3, the two variables do not show any degree of linear association at all, r = 0. The scatterplot of Figure 4 shows some degree of association between the two variables and r is about +0.65. From the scatterplot, we can see very clearly whether there is a linear association between the two variables and guess the value of the correlation coefficient. It is a good idea to produce the scatterplot between two variables before conducting a correlation analysis. From the correlation coefficient alone, we can not say much about the linear association between the two variables.

6.3 How to conduct and interpret a correlation analysis using interval data

Suppose you are interested in finding whether there is an association between people's monthly expenditure and income. To investigate this, you collected data from ten subjects as shown in Table 1 below. Perform the correlation analysis. This data file is stored in this location **\\campus\software\dept\spss** and is called **income_expend.sav**.

To conduct the correlation analysis, it is advisable to produce a scatterplot of the two variables first.

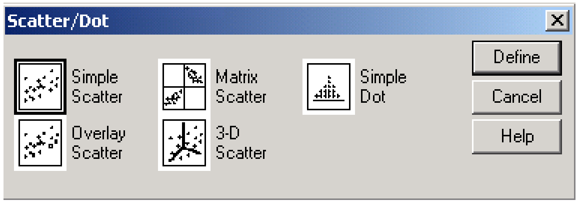
Table 1: Set of paired data

Income / month (£)	Expenditure / month (£)
4000	4000
4000	5000
5000	6000
2000	2000
9000	6000
4000	2000
7000	5000
8000	6000
9000	9000
5000	3000

To produce the scatterplot choose:
Graphs -> Legacy Dialogs
Scatter/Dot…

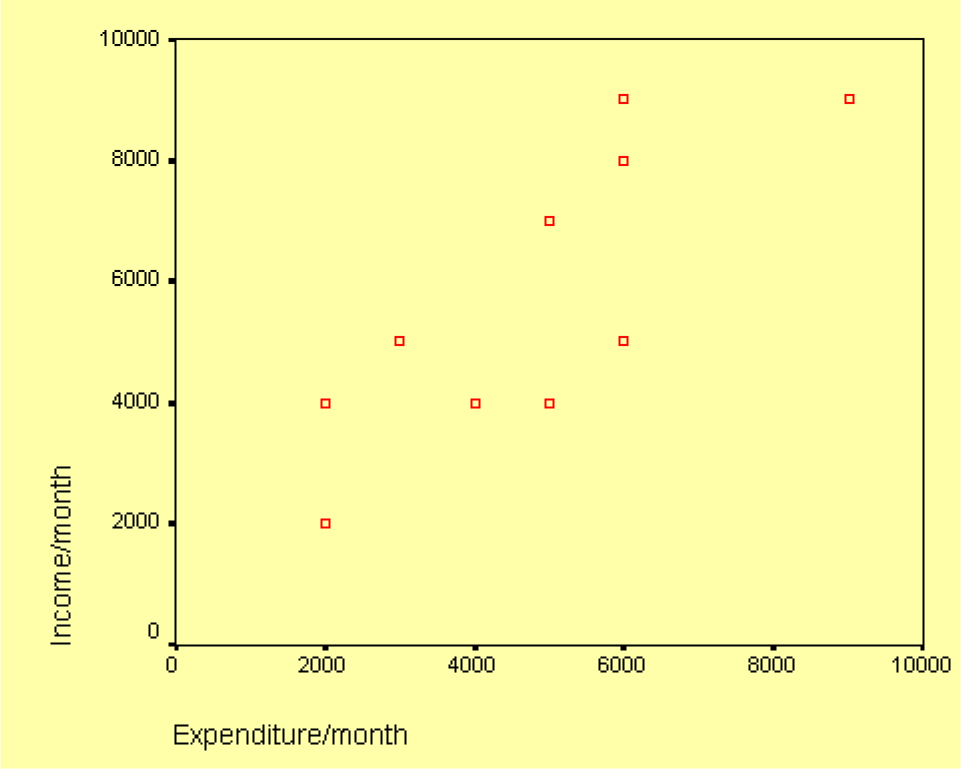
The **Scatterplot** selection box will be loaded to the screen as shown below, with **Simple** scatterplot selected by default. Click on **Define** to specify the axes of the plot. Enter the variables names *income* and *expend* into the **y-axis** and the **x-axis** box, respectively. Click on **OK**.

The Scatterplot selection box



The scatterplot is shown below and it seems to indicate a linear association between the two variables.

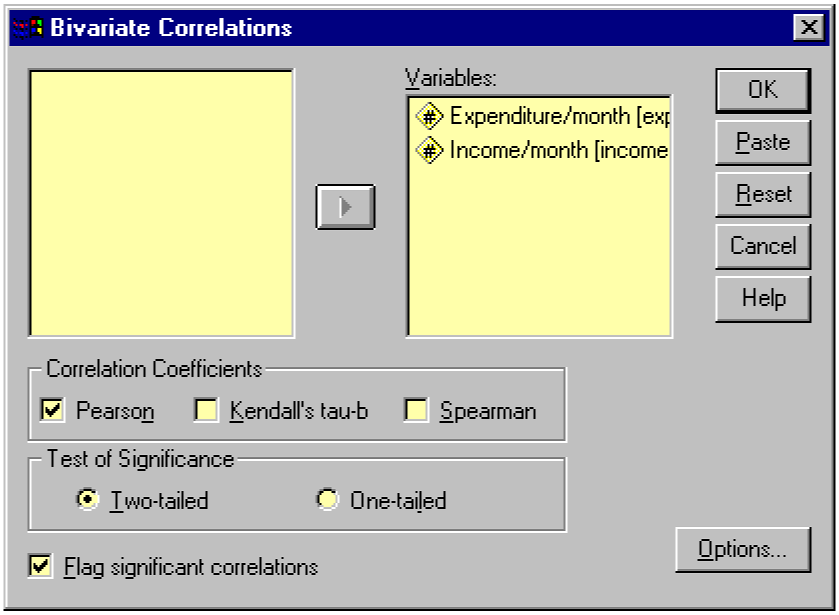
Scatterplot Income/month against Expenditure/month



To produce the correlation analysis choose:
Analyze
  Correlate
    Bivariate…

This will open the **Bivariate Correlation** dialog box as shown below. Transfer the two variables to the **Variables** text box.

The Bivariate Correlation dialog box



Variables:
- Expenditure/month [exp
- Income/month [income

Correlation Coefficients

☑ Pearson ☐ Kendall's tau-b ☐ Spearman

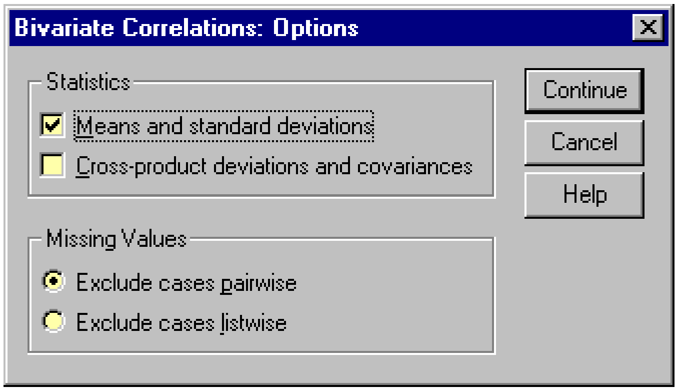
Test of Significance

● Two-tailed ○ One-tailed

☑ Flag significant correlations

Click on **Options** and the **Bivariate Correlation: Options** dialog box will be loaded on the screen as shown below. Click on the **Means and Standard Deviations** check box. Click on **Continue** and then **OK** to run the procedure.

The Bivariate Correlation: Options dialog box



Statistics

☑ Means and standard deviations

☐ Cross-product deviations and covariances

Missing Values

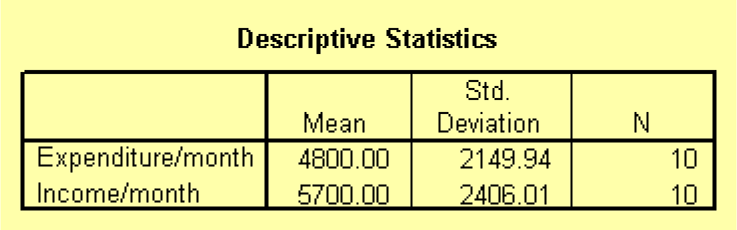
● Exclude cases pairwise

○ Exclude cases listwise

Let us now look at the output listing.

6.3.1 Output Listing of Pearson Correlation Analysis

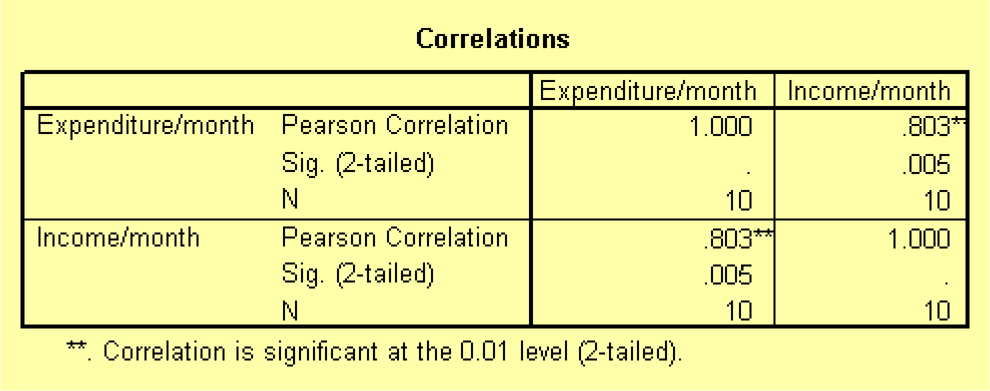
The output listing starts with the means and standard deviation of the two variables as requested under the **Options** dialog box. This result is shown on the table below.



Descriptive Statistics

	Mean	Std. Deviation	N
Expenditure/month	4800.00	2149.94	10
Income/month	5700.00	2406.01	10

The next table from the output listing shown below gives the actual value of the correlation coefficient along with its p-value. It also gives the number of cases with non missing values. The correlation coefficient is 0.803 and the p-value is 0.005. From these values, it can be concluded that the correlation coefficient is significant beyond the 1 per cent level. The significance means that the two variables are linearly related.



Correlations

		Expenditure/month	Income/month
Expenditure/month	Pearson Correlation	1.000	.803**
	Sig. (2-tailed)	.	.005
	N	10	10
Income/month	Pearson Correlation	.803**	1.000
	Sig. (2-tailed)	.005	.
	N	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

6.4 How to conduct and interpret a correlation analysis using ordinal data

The **Pearson** correlation analysis as demonstrated above is only suitable for interval data. With other types of data such as ordinal or nominal data other methods of measuring association between variables must be used. Ordinal data are either ranks or ordered category membership and nominal data are records of qualitative category membership. A brief introduction of types of data has already been covered.

Suppose you are a psychology student. Twelve books dealing with the same psychological topic have just been published by 12 different authors. You and a friend were asked to rank the books in order depending on how well the authors covered the topic. The ranking is show on Table 2 below. Is there any association of the ranking by the two students?

Table 2: Ranks assigned by two students to each of twelve books

Books	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Student 1	1	2	3	4	5	6	7	8	9	10	11	12
Student 2	1	3	2	4	6	5	8	7	10	9	12	11

This data file is stored in this location **\\campus\software\dept\spss** and is called **books ranking.sav**

To obtain the correlation coefficient follow these instructions:

Choose
Analyze

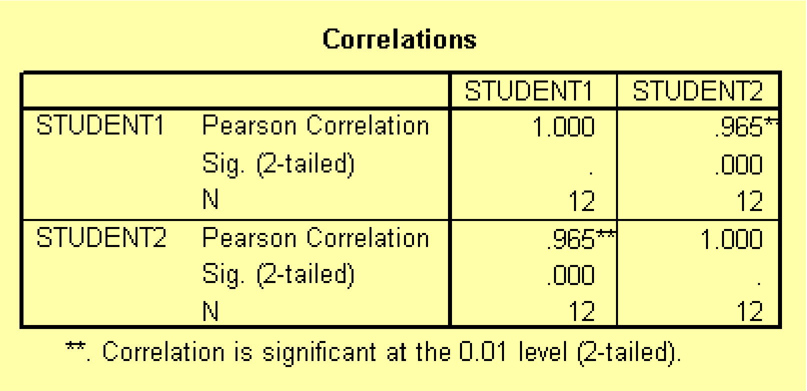
Correlate
Bivariate…

This will open the **Bivariate Correlation** dialog box. Transfer *Ranking from student1 [student1]* and *Ranking from student2 [student2]* under **Variables:**. Select the **Kendall's tau-b** and the **Spearman** check boxes. Notice that by default the **Pearson** box is selected. Click on **OK** to run the procedure.

6.4.1 Output Listing of Spearman and Kendall rank correlation

The two tables from the output listing are shown below. Notice that both the **Pearson** and the **Spearman** correlation coefficient are exactly the same 0.965 and significant beyond the 1 per cent level. The **Kendall** correlation coefficient is 0.848 and also significant beyond the 1 per cent level. The different between the **Spearman** and the **Kendall** coefficients is due to the fact that they have different theoretical background. You should not worry about the difference.

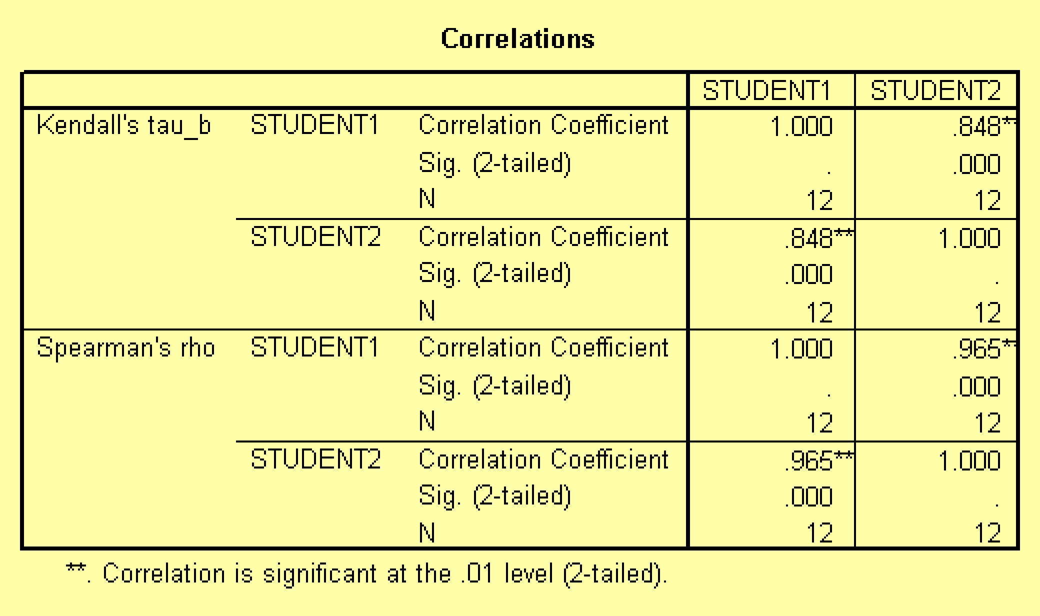
The association between the two ranks is significant indicating that the two students ranked the twelve books in a similar way. In fact, close examination of the data on Table 2 shows that, at most, the ranks assigned by the students differ by a single rank.



Correlations

		STUDENT1	STUDENT2
STUDENT1	Pearson Correlation	1.000	.965**
	Sig. (2-tailed)	.	.000
	N	12	12
STUDENT2	Pearson Correlation	.965**	1.000
	Sig. (2-tailed)	.000	.
	N	12	12

**. Correlation is significant at the 0.01 level (2-tailed).



Correlations

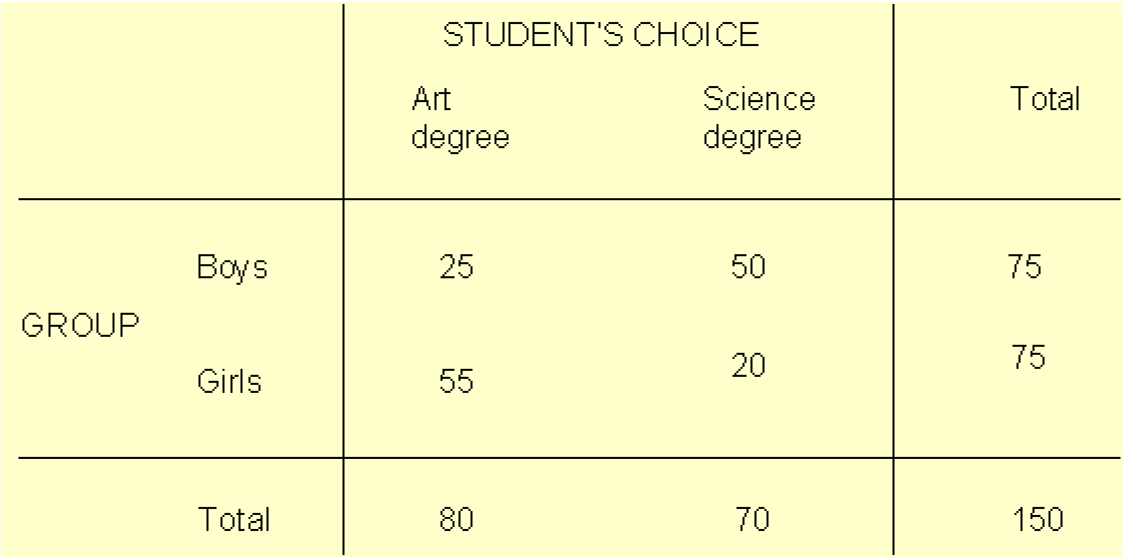
			STUDENT1	STUDENT2
Kendall's tau_b	STUDENT1	Correlation Coefficient	1.000	.848**
		Sig. (2-tailed)	.	.000
		N	12	12
	STUDENT2	Correlation Coefficient	.848**	1.000
		Sig. (2-tailed)	.000	.
		N	12	12
Spearman's rho	STUDENT1	Correlation Coefficient	1.000	.965**
		Sig. (2-tailed)	.	.000
		N	12	12
	STUDENT2	Correlation Coefficient	.965**	1.000
		Sig. (2-tailed)	.000	.
		N	12	12

**. Correlation is significant at the .01 level (2-tailed).

6.5 How to conduct and interpret a correlation analysis using categorical data

Suppose that 150 students (75 boys and 75 girls) starting at a university are asked to show their preference of study by indicating whether they prefer arts or science degrees. We can hypothesise that boys should prefer science degree and girls arts. There are two nominal variables here *group* (boys or girls); and *student's choice* (arts or science). The null hypothesis is that there is no association between the two variables. State the alternative hypothesis. The table below shows the students' choices.

Table 3: A contingency table

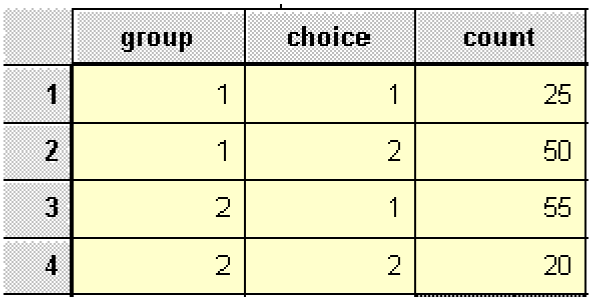


		STUDENT'S CHOICE		
		Art degree	Science degree	Total
GROUP	Boys	25	50	75
	Girls	55	20	75
	Total	80	70	150

Close examination of Table 3 indicate that there is an association between the two variables. The majority of the boys chose science degree while the majority of the girls chose arts degree.

This data file is stored in this location **\\campus\software\dept\spss** and is called **weighting3_Cases&crosstabs.sav.**

Showing coding of data in Data Editor



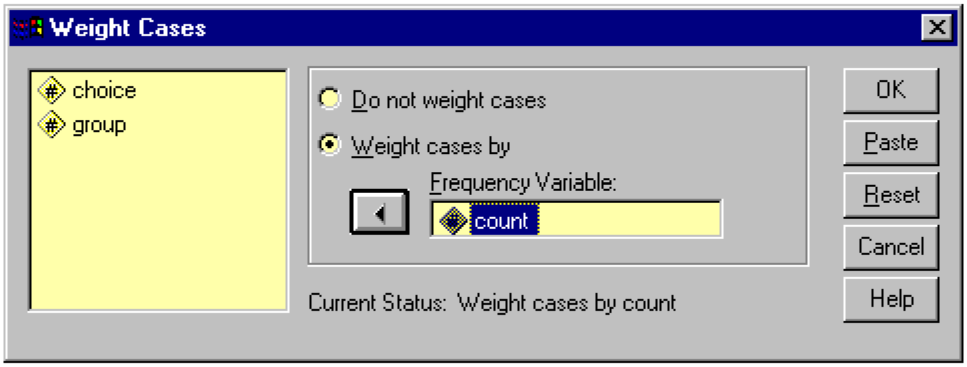
	group	choice	count
1	1	1	25
2	1	2	50
3	2	1	55
4	2	2	20

Before we can proceed, we need to tell SPSS that the data in the count column represent cell frequencies of a variable and not actual value. To do this, follow these instructions.

Choose
Data
  Weight Cases

The **Weight Cases** dialog box will be loaded on the screen as shown below. Select the item **Weight cases by**. Click on the variable *count* and on the arrow (>) to transfer it into the **Frequency Variable** text box. Click **OK**.

The Weight Cases dialog box



○ Do not weight cases

● Weight cases by

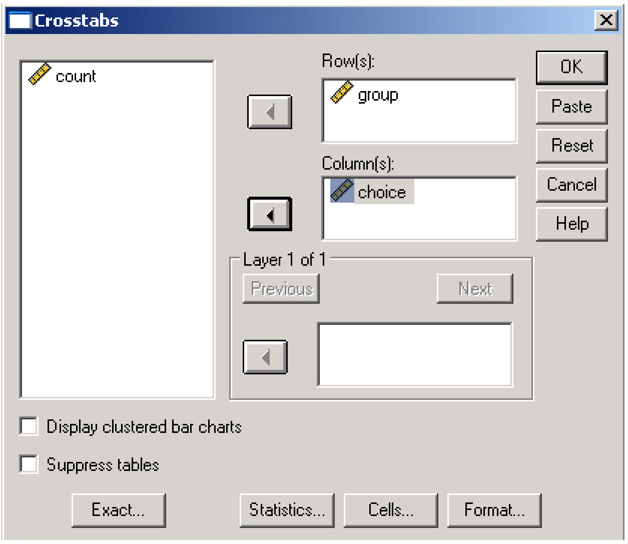
Frequency Variable: count

Current Status: Weight cases by count

To analyse the contingency table data, choose
Analyze
  Descriptive Statistics
    Crosstabs

The **Crosstabs** dialog box will be loaded on the screen as shown below. Click on the variable *group* and on the top arrow (>) to transfer *group* into the **Row(s)** text box. Click the variable *choice* and then on the middle arrow (>) to transfer *choice* into the **Column(s)** text box.

The completed Crosstabs dialog box



Row(s): group

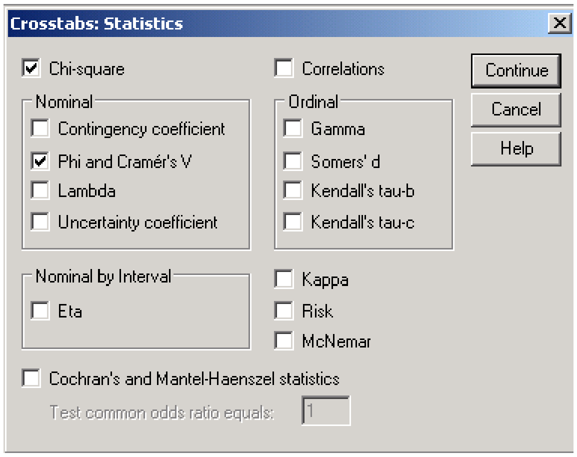
Column(s): choice

□ Display clustered bar charts

□ Suppress tables

Click on **Statistics** to open the **Crosstabs: Statistics** dialog box. See diagram below. Select the **Chi-square** and **Phi and Cramer's V** check boxes. Click on **Continue** to return to the **Crosstabs** dialog box.

The completed Crosstabs: Statistics dialog box



Crosstabs: Statistics

☑ Chi-square
☐ Correlations

Nominal
☐ Contingency coefficient
☑ Phi and Cramér's V
☐ Lambda
☐ Uncertainty coefficient

Ordinal
☐ Gamma
☐ Somers' d
☐ Kendall's tau-b
☐ Kendall's tau-c

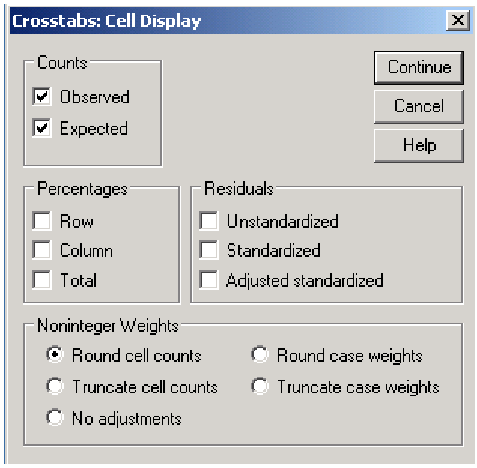
Nominal by Interval
☐ Eta

☐ Kappa
☐ Risk
☐ McNemar

☐ Cochran's and Mantel-Haenszel statistics
Test common odds ratio equals: 1

Click on **Cells** at the foot of the **Crosstabs** dialog box to open the **Crosstabs: Cell Display** dialog box. See diagram below. Select the **Expected** check box. Click on **Continue** and then **OK** to run the procedure. We have computed the cell frequencies to ensure that the prescribed minimum requirements for the valid use of chi-square have been fulfilled, i.e. a cell frequency should not be less than 5.

The Crosstabs: Cell Display dialog box



Crosstabs: Cell Display

Counts
☑ Observed
☑ Expected

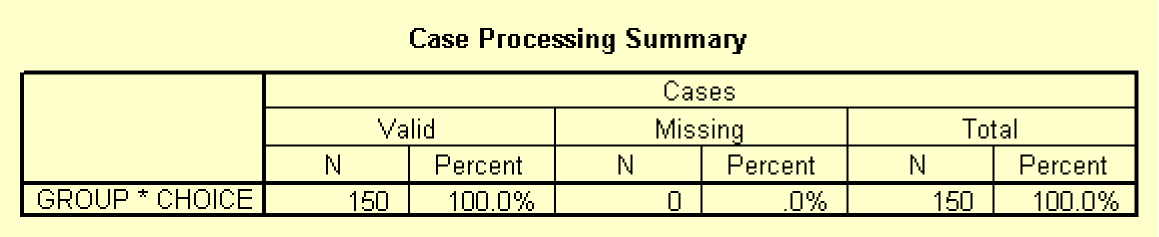
Percentages
☐ Row
☐ Column
☐ Total

Residuals
☐ Unstandardized
☐ Standardized
☐ Adjusted standardized

Noninteger Weights
● Round cell counts
○ Round case weights
○ Truncate cell counts
○ Truncate case weights
○ No adjustments

6.5.1 Output Listing for Crosstabulation

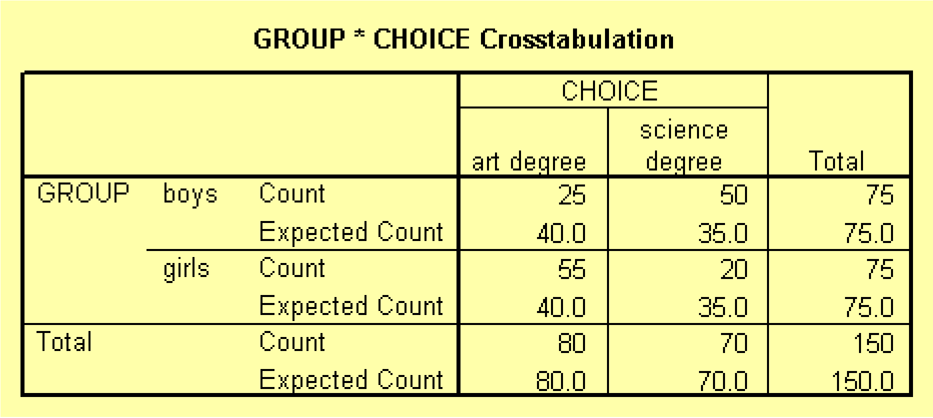
The first table from the output listing shown below gives a summary of variables and the number of cases.



Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
GROUP * CHOICE	150	100.0%	0	.0%	150	100.0%

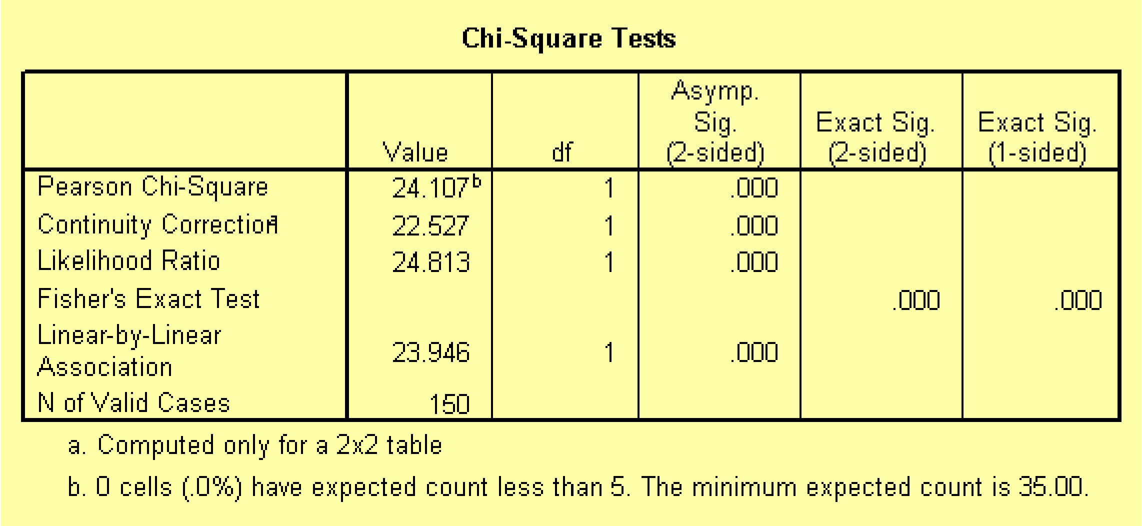
The table below shows the observed and expected frequencies as requested in the **Crosstabs: Cell Display** dialog box. Notice that none of the expected frequencies is less than 5.



GROUP * CHOICE Crosstabulation

			CHOICE		
			art degree	science degree	Total
GROUP	boys	Count	25	50	75
		Expected Count	40.0	35.0	75.0
	girls	Count	55	20	75
		Expected Count	40.0	35.0	75.0
Total		Count	80	70	150
		Expected Count	80.0	70.0	150.0

The table below gives the Chi-square statistics for the contingency table. It can be concluded that there is a significant association between the variables *group* and *choice*, as shown by the p-value (less than 0.01).



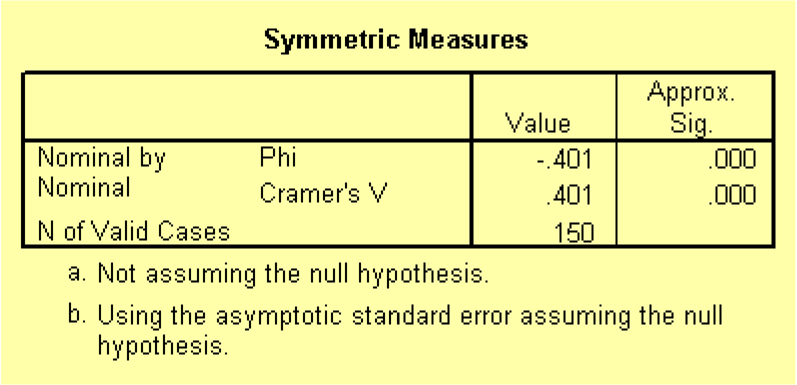
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	24.107[b]	1	.000		
Continuity Correction[a]	22.527	1	.000		
Likelihood Ratio	24.813	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	23.946	1	.000		
N of Valid Cases	150				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 35.00.

The **Phi** and **Cramer's V** coefficients (shown on the table below) of 0.401 gives the strength of the association between the two variables. This shows a fair to moderate strength.



Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.401	.000
	Cramer's V	.401	.000
N of Valid Cases		150	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

You should now be able to perform and interpret the results of correlational analysis using SPSS for interval, ordinal and categorical data.

7 Measures of Association and Analysing Data from more than two groups

7.1 Simple One-Way Analysis of Variance (ANOVA)

ANOVA is concerned with the testing of hypotheses about means. It is very similar to t-test. In fact, for an experiment involving two groups, output from ANOVA and t-test will be the same. However, t-test can not be used to test hypothesis on three or more groups. So, if there are just two groups use t-test. If there are three groups or more use ANOVA.

The assumptions stated earlier that need to be satisfied before proceeding with a t test are also applicable to ANOVA. Can you remember the three assumptions?

Carry out a simple one-way ANOVA on the employee data set using the variable *current salary* as dependent list and *employment category* as factor. Note you have to test these assumptions before you proceed. This will help you decide whether you perform a parametric or nonparametric ANOVA.

To select one-way ANOVA from the menu bar choose **Analyze -> Compare Means -> One-Way ANOVA**.

Note that ANOVA can only tell us if there is a difference between the three groups or not. It does not justify us saying that any particular comparison is significant or not. In other words, in cases where there is significance, ANOVA does not tell us where the significance lies.

A planned comparison of means is known as **a priori** comparisons and unplanned is known as **post-hoc** comparisons. Two post-hoc comparisons test in SPSS are **Tukey's Honestly Significant Difference** (**HSD**) and **Scheffe's test**. After performing an ANOVA, to find where the differences lies between the groups, you need to carry out a post-hoc test. If the result from the ANOVA is not significant, there will be no need to perform a post-hoc test.

Look at your output and try to interpret it by answering the following questions. Is the ANOVA test significant? If so where does the difference lie? That is:

- Is the Manager group different from the Clerical group?
- Is the Manager group different from the Custodial group?
- Is Clerical group different from Custodial group?

7.2 Kruskal-Wallis test (Non-parametric equivalent to ANOVA)

If your data is not normally distributed, you should consider the use of non-parametric test such as Kruskal-Wallis. Note that with Ordinal data you can't use parametric ANOVA.

To open the **Tests for Several Independent Samples** dialogue box from the main menu bar choose **Analyze -> Nonparametric Tests ->Legacy Dialogs -> K Independent Samples**.

8 Introduction to Non-Parametric Statistics

In most statistical packages and in SPSS in particular it is assumed that the data has been derived from a population with normal distribution. When this is not the case, non-parametric test should be used instead.

SPSS provides a variety of non-parametric tests in the **Non-parametric Tests** submenu within the **Analyze** menu in the main menu bar. The **Sign** and **Wilcoxon** tests are the equivalent to the paired samples t-test. The **Mann-Whitney** test is the equivalent to the independent samples t-test.

Most non-parametric tests use measures that are resistant to outliers and skewness, for instance median.

8.1 Mann-Whitney U Test

Use this test to compare two independent samples. Choose **Analyze -> Nonparametric Tests -> Legacy Dialogs -> 2 Independent Samples…**.

Wilcoxon Signed Ranks test for two correlated samples

Use this test to compare two related or paired samples. Choose **Analyze -> Nonparametric Tests -> Legacy Dialogs -> 2 Related Samples…**.

9 Hands-on Exercises

9.1 Exercise 1: Opening an Excel File into SPSS

The file is stored in this location \\campus\software\dept\spss. It is called Gss91Sm.xls. Open this file in SPSS.

Background Information for Exercises 2, 3 and 4

The data file used for exercises contains demographics, salary and job information of the employees of a company. We are interested in understanding the employees in terms of demographics (gender, minority classification, education) and employment measures (job position, beginning and current salary). We are also interested in the relationship between demographics and salary. Finally we want to represent our findings graphically. You are not expected to perform the definitive study on this data, but rather make a start in terms of describing the employees and take a preliminary look at how the measures interrelate.

The data are stored as an SPSS file. In the course of performing the exercises you will read this data, perform several statistical analyses, modify the data and create several charts.

9.2 Exercise 2: Examining Summary Data for Individual Variables

In this exercise we ask you to begin analysing the employee data by producing some descriptive summaries on both the demographic and salary variables. These will provide summaries useful in describing the employees and serve as a check on the data values; for example, are the maximum and minimum values of education, months since hire and salary reasonable?

1. Open the data file *employee data*.

2. Run Frequencies on the variables *jobcat* (employment category), *minority* (minority classification), and *gender* (employee gender), requesting mode, plus barcharts. Examine the bar charts to better understand the distributions of these variables. Which job category had the greatest number of employees, and which had the fewest?

3. Run Frequencies for *salbegin* (beginning salary) and *salary* (current salary), requesting summary statistics, and a histogram for each variable with a superimposed normal curve. **Suppress the display of the frequency table**. Do you think that the salaries are normally distributed? If not, why?

4. Produce a frequency distribution of *educ* (educational level) showing the table in descending order of frequency (use the **format** pushbutton). You may need to reset the frequency dialogue box.

9.3 Exercise 3: Modifying Data Values

In this exercise we will look at salary information in several different ways, which require some modification of data. First we will group employees into several salary categories and see how many employees fall into each category. Next we will study the difference between current and beginning salary across employees.

1. Open the data file *employee data* if you have not already done so.

2. Use **Recode Into Different Variables** under the Transform menu to create a new variable that groups *salbegin* (beginning salary) into 3 categories (call this new variable *salcate* and labelled it salary category). Use these cut off points:

Range	Category
Salary up to $13,500	Low salary
$13,501 - $15950	Medium salary
$15,951+	High salary

3. After the recode is complete, check your work by running frequencies of *salcate*.

4. Use **Compute** under the **Transform** menu to create a new variable that contains the difference between current and beginning salary. Call this new variable *saldiff* (salary difference)

5. Run Descriptives on this new variable to see summary information. Can you tell whether anyone has a current salary lower than their beginning salary? What was the largest salary change?

6. Save the modified data file under Drive C: in the temporary (temp) folder.

7. Use the variables *jobtime* (months since hire) and *prevexp* (previous experience) to create a new variable that measures the total time (in months) each employee has been working. Examine summary information (i.e. mean, mode, median, standard deviation, range, minimum, maximum values) of the new variable.

8. Create a new variable that divides the *saldiff* (salary difference) by *jobtime* (months since hire). This will produce a salary difference adjusted for the number of months in the current position. Run the Descriptives procedure on this new variable.

9.4 Exercise 4: T-test

Is there any statistical significance difference between the average salary of male and female employees on current salary?