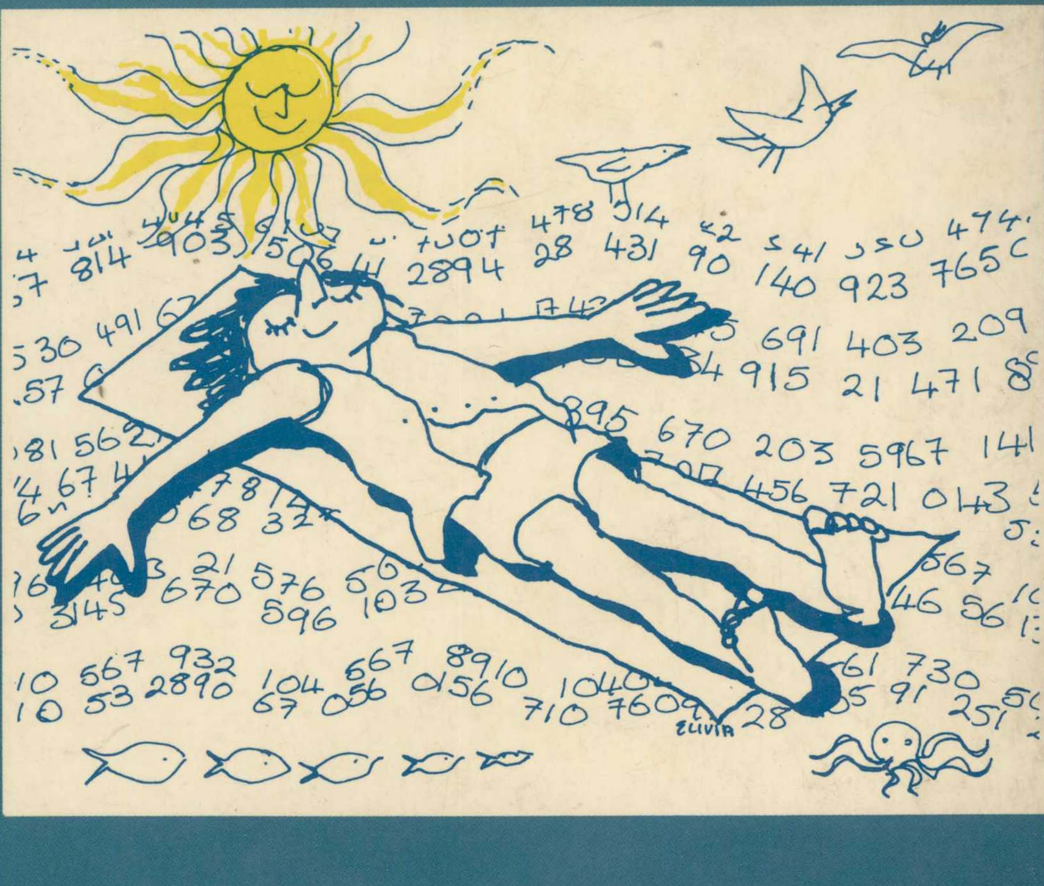
SIMPLE STATISTICS

A course book for the social sciences



FRANCES CLEGG

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A course book for the social sciences

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Acknowledgements

Like many other teachers of introductory statistics, I felt a need to supplement the available textbooks with my own handouts. When time permitted I compiled these into a single manual; at that point, thanks to illustrations drawn by Chris Hinds and Patrick Sammon, the project took on a life of its own. I still remember with gratitude the ideas, the time for discussion and the support which Chris and Patrick gave to me. It was quite a challenge to turn a statistics manual – potentially the dreariest and most off-putting kind of book – into something which students might positively enjoy using. However, the response to the manual was very encouraging and the book you are now looking at is, I hope, an improved version which retains the early spirit. If you can suggest further improvements, I will be pleased to receive your comments and ideas for further amendments.

The original illustrations have now been replaced by Elivia Savadier's skilfully drawn cartoons. The debt to Patrick and Chris remains – but Elivia has also succeeded in making another valued contribution to the finished product. I must also thank Dodie Masterman, a leading authority on Tennyson's poem 'Maud', for providing the lovely little illustration on page 180.

Several members of the Psychology and Mathematical Statistics Department at Hull University also gave me advice and help. Professor A. D. B. Clarke and Dr Ann Clarke, Dave and Jean Williams and Lorraine Hudson must be named in particular. More recently I have valued the enthusiasm and patient comments I have received from Graham Hart, Sue Glover and Marcus Askwith at Cambridge University Press. It will be largely due to their efforts that the book has improved over the two-year interval. Needless to say, any errors which remain are due to my own misjudgements and oversights, and should not be associated with anyone else who has been involved in the book's production.

I am constantly amazed by the great tolerance shown to me by the members of my family; without their understanding and assistance I doubt that I could have written the book. I must thank my husband, Brent Elliott, in particular, for he has helped me considerably with many aspects of the final manuscript preparation.

Finally I would like to acknowledge the role of all the A-level students I taught at Hull College of Further Education – and who were exposed to much of the written material in 'live' form! It was their needs and responses which inspired my first attempts to teach statistics, and from them I started not only to learn how to do it, but also to appreciate the value of humour in the classroom.

As a nonstatistician I feel some trepidation in producing a statistics textbook.

Acknowledgements

Ironically though, it seems that people who are less expert in statistics are better able to understand the problems that students (and particularly those who label themselves 'non-numerate') encounter when starting the subject, and are thus in a position to cover the ground more gently. If you are about to embark on statistics, then I hope that I manage to explain clearly what the subject is all about. When you have finished this book you will then be in a position to turn to standard textbooks for further information – and I will consider that I have truly succeeded in my aim if you are able to do this with interest and pleasure.

Frances Clegg

THOSE OF YOU WHO APPROACH STATISTICS WITH FEAR AND FOREBODING...

CONTENTS

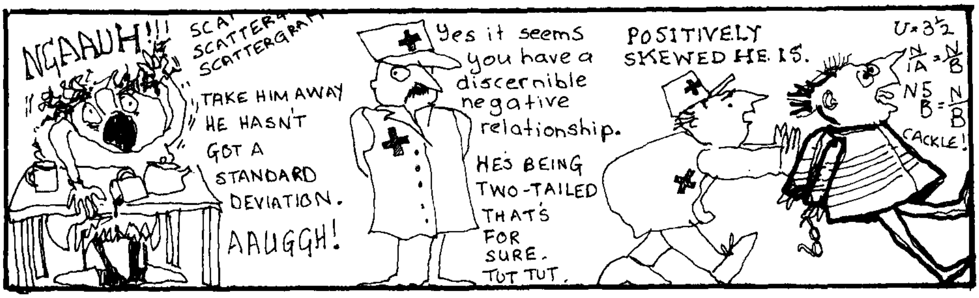
The drawings and cartoons on the cover and within this book were drawn by Elivia Savadier.

The report 'Some observations on the diseases of Brunus edwardii (species nova)' by D. K. Blackmore, D. G. Owen and C. M. Young first appeared in *The Veterinary Record*, 1 April 1972. The extracts from it on pages 148–52 are reproduced with permission from the journal's editor, Edward Boden.

Table S2 is based on table 2 of *Some rapid approximate statistical procedures* by F. Wilcoxon and R. A. Wilcox (1964, New York: Lederle Laboratories) and is reproduced with the permission of the American Cyanamid Company.

Tables S4 and S7 are from tables C.7 and C.6 of *The numbers game: statistics for psychology* by Joan Gay Snodgrass (1978, New York: Oxford University Press). Table S4 draws on table 11.4 of *Handbook of statistical tables* by D. B. Owen (1962, Reading, Mass.: Addison Wesley) and on D. Auble's article 'Extended tables for the Mann-Whitney statistic', *Bulletin of the Institute of Educational Research at Indiana University*, vol. 1, no. 2, 1953.

1 Why do we need statistics?



Perhaps when you began your course in one of the life sciences, you felt dismayed to discover that you would have to start doing statistics. You wouldn't be the first person to feel like this! Understandably, many students imagine that the new syllabus will concentrate entirely on aspects of behaviour or mental processes shown by living organisms, and that knowledge of maths will not be needed. So why is it your bad luck that you now have to start statistics – just when you thought that at last you would be able to devote all your attention to a really *interesting* subject? In the next sections I shall outline the main uses of statistics in the life sciences, and conclude the chapter by considering the matter of just why it is that so many students dislike the subject and find it difficult.

Statistics for description

In the social and biological sciences, although we are very happy to be able to understand precisely what makes one living organism 'tick', at the same time, our overall aim is to be able to comprehend the mechanics which underlie the behaviour of an entire species. Then we can use our knowledge to make predictions about individuals or groups of individuals which we have not previously encountered or studied. Thus in our studies of living beings and their activities, we will often be working with several individuals at any one time. In surveys, the numbers may run into thousands, but there will normally be smaller numbers in the more carefully controlled experimental type of investigation. Inevitably our efforts will reward us with sets of data which usually, although not always, take the form of numbers. It is in conveying information about, and trying to interpret, these large sets of numbers in an efficient and convenient manner that we really need *descriptive* statistics. An example will make this clear.

Suppose someone was studying road accidents, with a view to making road safety recommendations. The first thing to discover is when, where, and under what circumstances accidents occur. We will look at 'when' in more detail. The times of road accidents can easily be obtained from police records, and the researcher could find out how many accidents occur each year, month, week, day, and even hour. The data could be put into the form of daily tables. Well, here it is, looking very impressive, but taking up an awful lot of space! Constantly wading through sheets of daily accident tables is not going to be particularly useful, either, until some kind of overall picture or summary can be gleaned. A good starting point would be an indication of the 'normal', or 'usual', number of accidents per year, month, week, etc., these figures being called *averages*. You all know, even if only vaguely, what an average is. Our researcher might say:

'On average, there are about 100 accidents per week in Dodge City,'

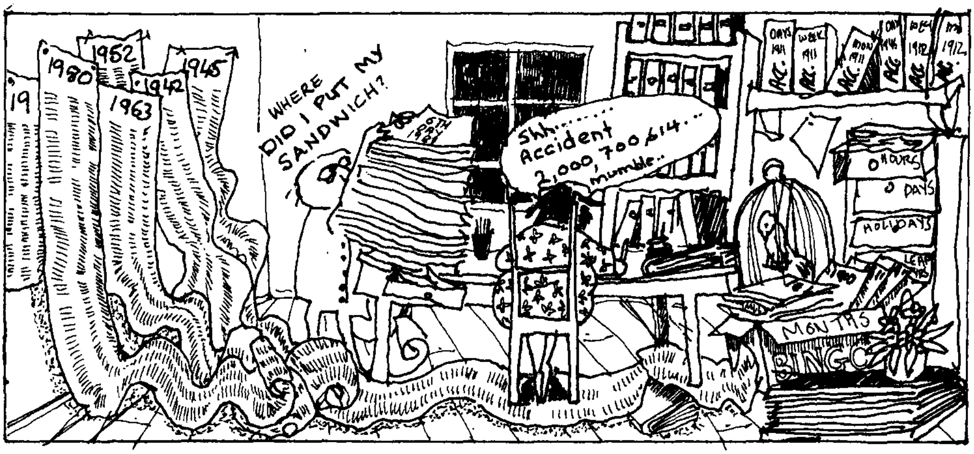
using as his basis the fact that 10 000 accident reports came in over a two-year period. Notice the word 'about'. It indicates that you would not expect precisely 100 accidents to occur each week, but that some variation around the figure of 100 is to be expected. The researcher might then go on to give more specific details . . .

'Usually, most of the accidents involving other cars occur between 10.30 pm and midnight on Fridays and Saturdays. Of the accidents involving children and pedestrians, which comprise about 40 each week, roughly an eighth happen between 8 and 9 am, Mondays to Fridays, a quarter on the same days, but between 3.30 and 6.30 pm, and the remainder during the weekend daylight hours.'

These sentences describe briefly, yet fairly accurately, the wealth of information contained in the 10 000 reported incidents. But no one is yawning, or feeling the minor panic induced in the researcher when confronted with the original data – in twenty cardboard boxes! The *average* is one kind of descriptive statistic. It is a number which indicates a 'typical' or 'central' figure for a group of numbers, and is officially called a *measure of central tendency*. From the example just given, averages could be quoted for any of the groups of numbers comprising yearly, weekly, daily or hourly accident rates.

Another type of descriptive statistic is used to qualify the word 'about', as in the sentence 'There are *about* 100 accidents per week.' Clearly, there is a difference between a town in which anything from 50 to 150 accidents is usual, and one where no less than 98 and no more than 103 accidents occur in any single week. Although both towns might have an average of 100 accidents each week, 'about' signifies that there may be a very large departure from the average in the first town, but only two or three more or less than the average in the second. Used on its own the word 'about' is far too vague, and we need some means of giving more details about the variation which occurs. The solution is to use the kind of descriptive statistic which is called a *measure of spread*, or sometimes, a *measure of dispersion*; it simply indicates just how much the word 'about' means for a particular set of figures.

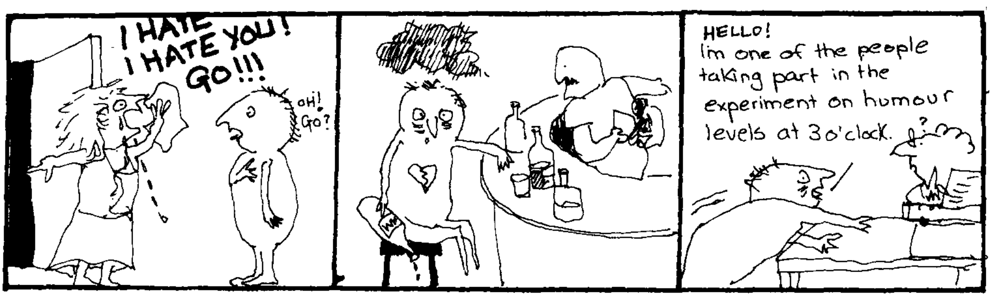
As living creatures show the most tremendous variety in their attributes, behaviour, and just about every characteristic you care to name, variation is an inescapable fact of life. On the whole, the simpler the organism, the less variation it will display; but most readers of this book will be especially interested in studying the behaviour of mammals – the most complex animals – and man in particular – the most complex of the lot! If humans were fairly similar in their behaviour and characteristics, then we would not need to study so many of them to be able to make statements about mankind as a whole. As it is, humans vary tremendously, not only on a world-wide scale, and with regard to cultural differences and appearance but also within cultures, and, as we all know, within nations and families. Even identical twins, who have the same genetic make-up, are not entirely alike, due to the effect of the different experiences they have had from conception onwards. In other words, living organisms are unique entities, and the more complex the organism, the less likely it is to behave in the same way as its neighbour. So we often need statistics to describe adequately the large numbers of people, other animals, or events which we are studying, both in terms of *typical* patterns and the *variation* which we might expect.



Statistics for drawing conclusions

The other main use of statistics is in making decisions about situations where you are not entirely confident that the 'truth' has been revealed. In an experiment certain events take place (hopefully, ones which are more or less anticipated by the experimenter!), changes are recorded, and the findings, which will usually comprise numbers of some sort or another, are used as a basis for drawing conclusions about the underlying events. Statistics used in arriving at conclusions in this way are called *inferential* statistics. Think about the following example.

Suppose you gave two people of similar age and intelligence a long list of words to read, and asked them to recall the words later. Despite their similarity as humans, and in age and intelligence, their recall of the information would undoubtedly differ – or show variability. No doubt you can think of several reasons why this should be so. They may have concentrated to different extents whilst reading the words; some of the words might have conjured up strong association or visual images for either of the learners; one of them might have been very anxious about the purpose of the reading task, whilst the other took it more light-heartedly; one of the learners might have spent the immediate pre-learning period propping up a nearby bar . . . These, or a score of other factors, could have influenced the learners' recall.



WE MUST SOMETIMES BEAR IN MIND PRE-EXPERIMENTAL EVENTS...

Why do we need statistics?

Suppose that you have just invented a new memorising technique, and you wish to find out whether it works as well as you hope. Common-sense will tell you that you must try out your technique on more than one person, and also that you must compare the technique in actual use with memorisation which is carried out by another, similar, group of people who have not had the benefit of your wisdom. If you didn't have such a group (called a *control* or *control group*), then you would have no idea what sort of aid your technique is providing. For all you know, it might turn out to make recall harder, rather than easier! So you must have this other group of memorisers acting under identical conditions to those using the new method, except that they are not actually using the new technique.

If the group using the new method comprised people who had good memories, whilst the other group was made up of poor memorisers, then the comparison would hardly be a fair one. But although it is easy to see *why* the two groups should be similar to each other, in practice it is often difficult to achieve complete similarity, as you might have guessed. We shall return to this topic later in the book. Meanwhile, a set-up like the one just described is called an *experiment*. When it has been completed the investigator will be the proud owner of sets of scores (the *results*, which in this case represent success in memorising), obtained from the victims, who are usually referred to as *subjects*. Another piece of jargon used in experimental work is the verb used to describe the participation of subjects in an experiment. We say that they *ran* in an experiment, and also talk of experimenters *running* either subjects or experiments.

Let's return to the memory experiment, in which two groups have participated and provided us with recall scores. Suppose that *all* the people who used the new technique recalled the same words correctly, and that these were 80% of the total number of words on the list, whilst the unaided group, the control subjects, recalled the same kinds of words, but only 40% of the list. Doubtless you would hurry off to patent your new memory technique! This is not a plausible situation though, is it? It would be much more likely that the aided group got *about* 80% of the words right, and the unaided group *about* 40%. Probably the words recalled would also be different for each person. A different, but even more realistic, outcome would be the aided group getting *about* 60% of the words correct, and the unaided group *about* 50%. Would you be so certain now that your technique was an improvement? Let's consider again the word 'about'. It describes a scattering of result scores which will occur over and over again in experimental work. With the last set of results mentioned for the memory experiment, it could have been that the lowest score in the aided group was 45% and the highest 70%; in the unaided group, the lowest 30% and the highest 80%. In other words, some people in the unaided group did *better* than some in the aided group. The overlap of scores is presented visually in figure 1.

It is this problem of overlapping sets of scores which creates the need for statistical analysis – and inferential techniques in particular. The overlapping is largely due to the following factors. Notice that the first two are a direct result of the natural variation which occurs in complex organisms.

1 We can never match our comparison (control) group *exactly* with the experimental group on every single relevant attribute (e.g. age, intelligence, motivation, previous experiences, family background, personality, etc.).
2 There are dimensions of personality or experience which we *should* match on, but

we may not be able to, because our methods of assessment are not sophisticated enough. Some of the ways in which we measure personality and intelligence are still very crude. There may be other aspects of organisms which we should consider, but our lack of knowledge means that we have not yet learned the importance or relevance of these features, and so we ignore them.

3 Even when we have matched the groups soundly, our experimental efforts may still not result in their presenting scores which are clearly different, because our understanding of the phenomenon under consideration was too limited. Put another way, the experiment didn't 'work'!

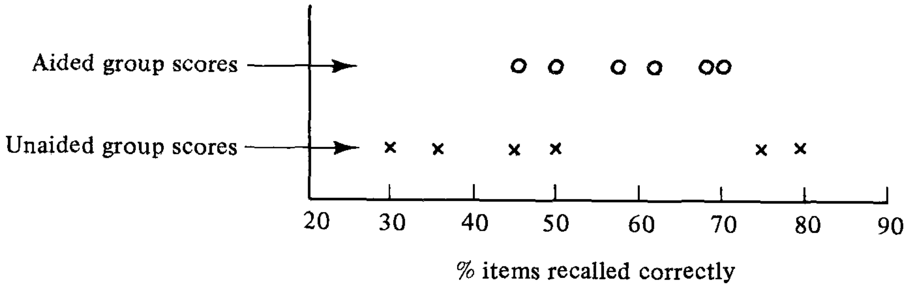


Figure 1. Overlap of scores in a memory experiment

These factors will become very real to you when you actually start to carry out experiments – situations in which we change something and then try to decide whether our change brought about other changes. *Surveys* provide another way of gathering information about organisms or events. Our role is less active than in experiments however, for here we draw data from groups already occurring naturally, and don't actually induce any changes. When it comes to analysing the results though, just as with experiments, we find that our data may not indicate clearly distinguishable groups, but ones with a certain degree of overlap. Once more, inferential statistics come to our aid in helping us decide the extent to which the groups really differ.

Exercise

1 The results of four memory experiments are shown in table 1. Study the numbers and decide for yourself which experiments suggest that the memory technique being tried out actually does help people to memorise better. Answers are given at the end of the book.

Table 1. Results from four separate memory experiments

Experiment 1		Experiment 2		Experiment 3		Experiment 4	
Aided	Unaided	Aided	Unaided	Aided	Unaided	Aided	Unaided
55	30	50	40	50	45	30	50
60	35	55	45	55	50	40	52
65	40	60	50	60	55	50	58
70	45	65	55	65	60	52	60
75	50	70	58	70	65	54	65
80	55	75					70

Why do we need statistics?

You probably found that it was most difficult to decide whether the memory technique worked in experiments 2 and 3. This is why we need inferential statistics – or the dreaded statistical tests! When we can merely glance at sets of scores, as in experiments 1 and 4, and see immediately that they are different, we call this, jokingly, the 'eye-ball' test. Unfortunately, we are not able to get away with this test very often. It is far more typical to obtain scores which need careful analysis in order to find out whether one of the groups is *really* different from the other; that is to say, when our experimental conditions have not created a sufficient difference for us to be able to easily distinguish the two sets of scores.

Another explanation for the failure to show a clear difference in the sets of scores lies in an element of luck. Our memory technique might be a perfectly good one, but just through bad luck, the items listed for recall might have given rise to particularly strong visual images or associations for members of the unaided group, thus making that set of scores as a whole higher. It might have been the other way round in experiments 1 and 2. Chance factors may have made it *seem* as though our memory aid groups were better, though we would find, if we used different subjects, that really the technique isn't as good as the two sets of results led us to believe initially. Unfortunately, this element of luck can never be completely ruled out; even after we have carried out a statistical analysis, we usually feel that we cannot state our conclusions with complete confidence, but must qualify them according to the role we think that chance may have had. The qualifications we make – our cautiousness in concluding whether an experiment 'worked' or not – are built into the statistical analysis techniques, and so at the end of our calculations we are able to estimate precisely the part we consider chance factors (or luck!) to have played. Note that although I have attributed results to luck, or been forced to consider that an element of luck is involved, what has happened is that we haven't really known enough about our subjects' memories, personalities, etc., to be able to control these variabilities precisely. If we knew all that there was to know, then of course we could choose our subjects with exact precision, and would not be left with quite such a hard task of deciding whether or not our new technique had altered events.

So, one of the main uses of statistics in biological and social sciences is to decide whether a particular treatment (e.g. using a new memory aid; seeing whether a certain mineral affects plant growth; trying out a new drug; looking for links between housing conditions and delinquency) causes one group under study to obtain scores which are *really* different from a comparable group or groups. The statistical techniques used for this are called inferential, because on the basis of the scores which we obtain and analyse, we make inferences (or inspired guesses!) about what has been happening to the groups of subjects or materials which we are studying.

Statistics in practice

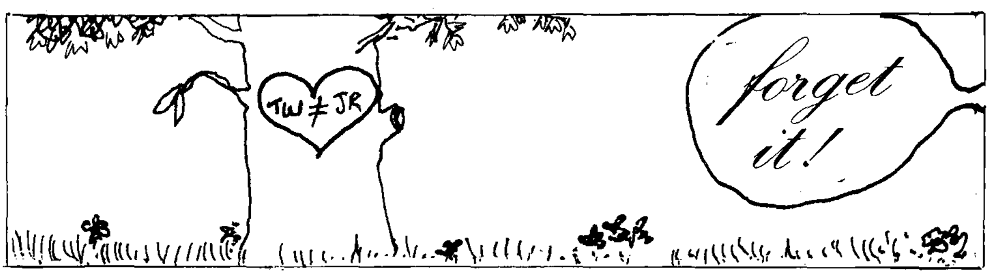
Using statistics is rather like using a tool box. Certain jobs have to be done, and in order to do them, you must select from the tool box implements which are appropriate. If your dentist kept a handyman's drill amongst his or her instruments, no doubt you would hope that you never needed a filling! Equally, you would be a little surprised to see a joiner attempting to cut a plank with a scalpel, or a decorator putting plaster on with a ruler. Instead, decorators, joiners, dentists, and everyone else who needs to use tools for particular tasks, will select instruments appropriate for the job. Appropriateness will be decided on the basis of the particular materials involved and the degree of precision sought. Think of statistics in the same way. The 'job' we undertake is to describe events and attempt to draw conclusions from them; the 'tools' are the various statistical techniques which are available. In order to pass statistics exams you will need to know something about certain techniques (the tools), and, of course, how to use them.

If you asked a driver how the engine of his car worked, he would probably be able to describe the basic principles and name and locate the main parts. However, it is unlikely that he would be able to identify the causes of, or rectify, an engine failure other than a simple one. Most people who use engines and tools are similar in this respect. They know *how* to use the instrument, *when* to use it, and when *not* to use it, but have only a rough idea of how it actually works. The same is true of statistics. You are only required to have a rough idea of how the techniques work – more detailed knowledge and understanding is the province of the mathematical statistician. Like engineers, statisticians are constantly devising new techniques and modifying existing ones, and it is their expertise which filters down to the many people who use statistical techniques in their daily work. The workmen themselves are not expected to understand in great detail how the tools work, or to carry out modifications or improvements.

Learning about statistics is also like being a workman in another respect. Although you may learn about the theoretical aspects of statistical techniques – uses of tests, their strengths and weaknesses, etc. – your knowledge would not be entirely complete if it did not include a certain amount of practice at using the various procedures. So it is necessary to practise using the tools. There are several things to be gained: better learning and retention through the *active* use of information; a good understanding of the contexts in which certain techniques can be appropriately used; first-hand knowledge of the various problems arising with statistical techniques and data analysis; and through the computational steps carried out, an appreciation of the principles which underlie the techniques. As a final bonus, you begin to see that even *you* can do statistics! For these reasons, many exercises are included in this text.

But I'm hopeless at maths!

If you are a typical social science student, you probably dislike maths and feel that it is one of your weakest subjects. You may also feel anxious or inferior because of this very fact. Let's look at these sources of worry – and I hope that I can offer some reassurance to those of you who are approaching statistics with fear and foreboding!



AN EVERYDAY USE OF SYMBOLS

Why do we need statistics?

First, statistics is *not* maths. True, it is a branch of mathematics, but it only involves the simplest of arithmetical operations. I expect that you will have the use of a calculator, and so these days you can study statistics and escape doing even basic arithmetic. Both maths and statistics rely heavily upon the use of symbols, and this is possibly responsible for the confusion – and also, for the dislike and dread which the subjects seem to generate.

We all use symbols a great deal. You are now reading symbols – i.e. the letters of the alphabet which have been strung together to make the words written on this page. However, are you experiencing difficulty and distaste over the act of reading them? Of course not. You have been reading for long enough, and frequently enough, to do it 'automatically'. No doubt a seven year old child would find these pages a little heavy going. You could imagine the youngster struggling to read and pronounce the words 'arithmetic' or 'enough', and perhaps wondering what 'symbol' means. These difficulties are quite reasonable, for seven year old children do not normally have an adult vocabulary at their command, and there are many abstract concepts which are completely beyond their experience. Well, you are the equivalent of a seven year old child as far as mathematical symbols go!

You may be quite happy about the symbols

$+$ and $-$ and $=$,

perhaps scratch your head over

$<$ and $\pm$ and $\neq$,

and definitely start to stammer when you see

$\bar{X}$ and Σ.

Yet you are already familiar with the *operations* which all these symbols refer to, and may in fact use the concepts involved quite frequently, if only you knew it!

Other concepts, such as those expressed by the symbols

$\hat{\sigma}$ and χ^2,

are a little more specialist, and it is unlikely that you will have needed to use them in your everyday (non-statistical) life.

Remember though:

SYMBOLS ARE NOT IMPOSSIBLE TO UNDERSTAND!

What you must understand is that it takes thought and patience and time and practice . . . and yet more practice, to become familiar and at ease with symbols. It is quite possible to acquire a working knowledge of statistics without knowing much about the symbols which could be used to describe the various arithmetical operations involved. In the operational schedules included in this book I will tell you how to carry out the various statistical procedures in words, and through worked examples *show* you what to do. Ideally, you will get the background knowledge from the text. In the schedules I have also included the symbols for the various techniques or formulae, and for two reasons. First, so that you gain familiarity – even if only a vague familiarity – with them, and secondly because there may come a day when you actually find it easier to work from statistical steps as summarised in a single formula, rather than from a verbal description, which may involve many small steps. At the moment you may well feel that *you* will never achieve such dizzy heights of competence, but all I can say is that it has been known for so-called 'innumerate' people to come to prefer symbols to words!

The arithmetic you need for statistics is hardly mind-boggling. Basically you will need to add, subtract, multiply, use brackets, understand what squaring means, and know what a square root is. These operations are usually covered in the first few pages of introductory arithmetic books. Of course calculators can carry out all these operations for you, but there are two things which they can't cope with. Calculators can't think on your behalf, neither can they count. Statistics involves both thinking and counting now and again, I'm afraid!

The maths language

No doubt you have at some time picked up a book printed in a foreign language, noted fairly rapidly that it was not written in a language with which you were familiar, and replaced it on the shelf before looking for a book which you could understand. When you looked at the first book, did it make you entertain serious doubts about your intellectual ability?

What if you saw

ولم تكن مناهج العلوم والرياضيات ، في الأرد

These symbols don't make you feel inadequate, or worried about your intelligence either, do they? You recognise immediately that you don't understand what the heiroglyphics stand for (unless you have recently been doing Arabic at night classes!); you don't feel threatened by them.

Now let's take another language:

$$t = \bar{d} \div \sqrt{\left(\frac{\Sigma d^2 - (\Sigma d)^2/n}{n(n-1)}\right)}.$$

I expect that feelings of anxiety and inadequacy will promptly be aroused in most of you! Is this reasonable, do you think? Why are you somehow expecting that you should be able to make sense of these symbols – and maybe also thinking that you 'never will' manage them, when you face the Arabian squiggles quite unruffled? What has happened to make you feel like this? Possibly a sequence of events, not uncommon, which took place in the murky past of your school days. Let's look at the maths language in a little more detail.

Maths symbols are just like those used in any language. They stand for something else – in this case, operations with numbers – and unless you are familiar with what they stand for, of course you can't translate them. The snag is that fluency in another language takes time and effort and continuous practice – yet this is *all* that is needed to master mathematical notation. There are no mystical skills or insights available only to a few lucky geniuses – and denied to you. Maths is like any other language; given work and practice, anyone can become reasonably fluent. Unfortunately, many maths teachers fail to appreciate that they are using a foreign language. They rattle on at a fair to moderate speed, leaving the average pupil floundering, simply because the learner needs more time to interpret the symbols than the teacher (who has been speaking the language for years – if not decades) realises. The more time the pupil needs for translation, the further he or she gets behind; the further behind, the more *new* information is not coped with, and the more *extra* time is needed for translation and thought. This extra time is not forthcoming, usually. I am sure that you get the picture. The poor pupils slowly sink into a mire of incomprehension, frustration, fear, and finally, hatred of maths. The circle is complete when a person actively avoids contact with the subject, and we have another self-confessed failure at maths on our hands. It is very sad that such 'failures' tend to blame themselves, rather than perceive that they are reasonably competent intelligent people, who have simply been exposed to a disastrous teaching programme. What lessons can be learned from this analysis of an unfortunately common situation then?

The first one is: don't blame yourself for the nasty experiences you have had with maths in the past, but try to forget them and make this a fresh start. In other words, stop thinking and worrying over the fact that you are 'hopeless' at maths. With careful effort, you too can pass statistics exams!

Secondly, for success, you must regard maths as a language, and be prepared for continuous practice. Would you go to a French class once a week, fail to do the set homework, fail to speak in the language or listen to it between sessions, and expect to make progress? I doubt it. You know as well as I do that halfway through the week you would probably have forgotten nearly all the things you learned in the lesson, and during the first part of the next class you would be struggling to get back into the swing of things. The same is true of maths. If you don't practise pretty regularly, you'll rapidly forget what it's all about, and so will always need extra time for thought and translation. So do try to work at statistics, the branch of maths central to this book, frequently. Plenty of exercises are included to help you in this respect. Don't ignore them, or just glance at them without making any effort to work through them. They not only give you a chance to think about and apply new techniques, but they also make you more fluent in your new language.

You would also do well to follow the advice given over a century ago by the old school master Bartle Massey, in George Eliot's novel *Adam Bede*. He urges his pupils of accounts to make up and work through examples of their own devising whilst their hands are occupied but their minds are free.

> 'There's nothing you can't turn into a sum, for there's nothing but what's got number in it – even a fool. You may say to yourselves, "I'm one fool, and Jack's another; if my fool's head weighed four pound, and Jack's three pound three ounces and three-quarters, how many penny-weights heavier would my head be than Jack's?" A man that had got his heart in learning figures would make sums for himself, and work 'em in his head; when