

chapter, a weakness in the editing, which did at least allow my own performance on the purely logical form of the task to reach perfection by the last chapters.

A second empirical test examines the possibility that people have a module for calculating probabilities based on an assessment of the frequency of different outcomes in previously experienced similar situations. In Chapters 5 and 6, Over, the editor of this volume, deconstructs this argument, suggesting that many situations concern decisions where frequency information about past outcomes is unavailable. To make a sensible decision we need to consider all the available evidence and make a context-independent judgement.

The final chapter highlights the difference between ultimate and proximate goals, and argues that human rationality has evolved to a point where we are able to override our tendency to act in the best interests of our genes, and can instead act in the best interests of our own bodies. The use of contraception is perhaps one of the more obvious examples. This debate draws on Dawkins' concepts of memes and replicators (Dawkins 1982), but the longer-term implications of such a dissociation between the interests of the individual and the individual's genes, particularly should such human rationality have a strongly heritable component, were not examined in detail.

The book is almost exclusively concerned with human psychology so the animal welfare implications are certainly not explicit. I suppose that if one accepted the MMH then one could initiate experiments to determine whether animals possessed each specialised module. Since it has been proposed that modules for emotions such as jealousy may have evolved, it could, in theory, be possible to say whether given species possessed given emotions. This would undoubtedly have welfare implications. In the area of social cognition, work along these lines is already being done — experiments on primates and other species are targeted at questions such as “Do they have a theory of mind?” “Are they able to deceive?” “Are they able to detect cheaters?” Mapping any such modules to physical brain structures might then enable us to use neuroanatomy to classify species into groups that did or did not possess each type of module. This seems neat but harsh. The problem of the level of analysis is important — an animal of a given species may fail a cheater detection test because it has different building blocks underpinning its module, perhaps using olfactory rather than visual cues. It also ignores the possibility that an animal may have evolved a functionally similar module based on different neuro-anatomical structures.

The other animal welfare implication that I drew was to do with the fairness of the cognitive tests we impose on animals. If human performance on essentially the same test can vary from 15% correct to 70% correct depending on subtle contextual cues, we should be very humble when our animals ‘fail’ the tests we devise. A capacity to solve the task may be revealed using just a slight shift in protocol.

I enjoyed reading the book, and taking the psychological tests (!), although found some of the chapters far too verbose. I appreciated being drawn into an interesting debate

but by the end of the book I remained sceptical about the MMH hypothesis. I accepted much more easily the idea of a general connectionist network, providing flexible solutions to a variety of different problems, underpinned by some biologically predisposed biases, particularly for species that live in complex and changeable environments (horses, dogs). Perhaps this is because such domestic animals seem to adapt so well to a huge variety of arbitrary and artificial situations for which they clearly could not have evolved very narrow and specific rules. For species that have evolved in highly specialised constant environments (worms living in horses or dogs), the evolution of correspondingly specialised modules might be easier to accept.

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Statistics for the Behavioural Sciences: An Introduction

R Russo (2003). Published by Psychology Press Ltd, 27 Church Road, Hove, East Sussex BN3 2FA, UK; <http://www.psypress.com>. 242 pp. Paperback (ISBN 1 84169 320 0). Price £9.95.

Statistics is a difficult subject to teach students of the life-sciences. Many students seem to have a natural aversion to mathematics, while others have difficulty in relating the academic subject of statistics to their future needs as citizens and research workers. Indeed, in most life science disciplines little or no attempt is made to teach the subject to undergraduates, and, as there is little formal teaching of graduate students in the UK, it is possible to obtain a PhD and become a full time research worker with little, if any, exposure even to quite simple statistical methods. As a result, the quality of research is often not as high as it might be, and where it involves research on animals there may be serious ethical implications. Clearly, experiments that use animals and reach the wrong conclusions as a result of either faulty design or incorrect statistical analysis, not only waste those animals but also may lead to a waste of additional animals used in trying to repeat the results. However, psychologists are an honourable exception. In order to join professional associations of psychologists it is necessary to have done a degree that includes a substantial amount of teaching of statistical methods. As a result, many basic statistical texts are aimed at students of psychology, although the statistical

methods are universal, and the textbooks can be used by students in any life science discipline. This is such a book.

There are likely to be serious time constraints in teaching statistics to undergraduates. Only so many hours are available, and a choice must be made as to whether to give a solid and rigorous background with a limited range of methods, the more traditional approach, or to give a more general overview of the subject with a problem-solving approach in the hope that when students need some of the more advanced methods they will be able to read up about them and/or consult a statistician provided they understand the basic principles.

This book is firmly in the traditional camp, with chapters on descriptive statistics, an introduction to probability, probability distributions, continuous random variables and the normal distribution, the chi-squared distribution and the analysis of categorical data, statistical tests on proportions, the sampling distribution of the mean and its use in hypothesis testing, comparing a pair of means using the *t*-test, non-parametric statistics, correlation, regression and an introduction to power analysis. Unfortunately, it stops short of introducing the analysis of variance, which is a pity. In my experience easily the most common statistical mistake in published papers is the inappropriate use of the *t*-test in trying to analyse complex experiments with more than two groups.

A useful first chapter starts by discussing a hypothetical experiment to assess whether listening to classical music helps students to learn. It goes on to discuss descriptive and inferential statistics, "The main aim of descriptive statistics techniques is to extract useful information from unorganised data." Inferential statistics on the other hand "provides those techniques that allow us to infer the characteristics of a population from the sample data." While this is perfectly orthodox statistics, it does become a little academic when the population is largely hypothetical. An experiment using strain X specific pathogen-free female mice housed in a particular type of cage with specified bedding material in a particular animal house is capable of drawing inferences about the hypothetical population of such mice, but in practice scientists really only want to know if the treated and control groups differ, and then tend to extrapolate to a wider population than the one that they actually used in their experiments. Even with clinical experiments, patients will usually only be accepted into a study if they fit certain pre-defined characteristics, so that the 'population' is always somewhat hypothetical.

Chapter 2 is devoted entirely to descriptive statistics; covering frequency distributions and histograms, stem-and-leaf diagrams, measures of central tendency (the mode, median and mean), and measures of variability such as the inter-quartile range and the variance and standard deviation. The latter two are introduced using simple formulae using the Σ (summation) notation. Although this is quite nicely done, I do question the need to derive the formula for the manual calculation of the standard deviation. A standard deviation function is available on even quite cheap calculators, and everyone doing any serious statistics should be encouraged to use one of the widely respected statistical packages.

Chapter 3 is an introduction to probability. Unfortunately, it is not particularly well written. For example the sentence, "It is now important to make clear that the use of probability is at the heart of inferential statistics." could have been written without the first eight words. On the next page the author states, "It is however important to keep in mind that", another nine redundant words. A good editor could have reduced such wordiness and made the text easier to read. However, this does seem to be a reasonably comprehensive account of probability using Venn diagrams and the concepts of union, intersection and the addition and multiplication rules of probability, and ending up with Bayes theorem.

Chapter 4 deals largely with the binomial distribution, starting with examples of coin tossing and the rolling of dice. Interestingly, the null hypothesis is introduced here on p 71 although in the index the first mention of it is on p 88. An example is given of the use of the binomial distribution in testing whether a new treatment for phobic symptoms in which 13 out of 15 patients improved can be considered superior to the standard method where the rate of improvement is 60%. This makes use of an equation "calculated using the equation defining the binomial distribution" given two pages earlier. It would have been helpful to have the equations numbered so that they could be referred to more easily in the text as it may not be obvious to many students just which equation was used for this example; particularly as the equation in question does look rather frightening, and no simple numerical example of its use is given.

It is probably not worth going into details of the following chapters because I am not at all sure that this book is suitable as a general textbook for people doing animal experiments. It seems to me to be directed at undergraduate psychology students who will be examined on the subject as part of their psychology degree, and it probably covers a defined syllabus that the students must study. It makes no real attempt to 'sell' the subject to research workers who are wanting to improve their statistical skills, do not expect to be examined on the subject, but want to know what statistics can do for them. It only briefly covers experimental design, and it stops short of introducing the analysis of variance, which is generally far more useful than Student's *t*-test. Indeed, a text that I can strongly recommend, written jointly by the same author, and which I personally use in my statistical teaching is 'A student's guide to the Analysis of Variance' by MJ Roberts and R Russo (1999, Routledge, ISBN 0 415 16565 2). This covers basic statistical methods briefly and succinctly in such a way that the material can be expanded upon in lectures, but also deals very effectively with designed experiments and the analysis of variance. Of course, it does not cover the analysis of categorical data, correlation or regression, so it is not a sufficient textbook on its own; but for teaching the analysis of variance it would be difficult to beat.

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