range (I have fewer of those). This is not the source for information on programs – I would have preferred more comments on desirable attributes – the programs change so rapidly that all have been upgraded by the time any book is printed.

There are some missing references (Begg and Berlin, from page 39), some typos (missing denominators, etc.) but the production is generally well done. Some statistical jargon appears (for example, what's a 2 × 2 crossover design, if you have never run into one?) as does varying mathematical levels. These are minor problems which can be overcome easily. A useful adjunct might be some signposting of the level of the text and of the references. It does vary, and readers could be forewarned.

To summarize, this book covers a lot of territory in a few pages. It is clearly written, has lots of examples, and can often serve as an introduction to a topic for non-statisticians.

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CAUSAL INFERENCE. Kenneth J. Rothman (ed), Epidemiology Resources Inc., Mass., U.S.A., 1988. No. of pages: 207. Price: $21

This book starts with an implied pretentiousness, namely, a title that is all embracing but an application which is entirely epidemiological. Is it the case that causal inferences only happen in epidemiology? Of course not, and hence some mention on the cover that this is an epidemiological book would, perhaps, be more honest. Indeed, glancing through the chapter headings in the Contents would also be misleading until the seventh entry, at which point the casual reader might think that some special logical considerations for epidemiology were to be discussed.

In fact this book is about Karl Popper and A.B. Hill and how their thoughts can be applied successfully to epidemiological inference. In a way it is a more philosophical treatment but nonetheless a sequel to Susser's 'Causal thinking in the Health Sciences' published in 1973.[1] I cannot remember any books like this published in the interim. There was, of course, Hacking's book[2] on the logic of statistical inference, but that was published in 1965 (and cost 40s. net, I note), and is not mentioned in this book. This is odd, since it is still entirely relevant.

This book consists essentially of the proceedings of a meeting of the Society for Epidemiological Research held in 1985. There are four substantive, and not unanimous, essays by Susser and others (including one philosopher) on how one should make causal inferences in epidemiology, and then several authors comment on these contributions in writing at some considerable length. At the end the first contributors are allowed to defend themselves, which they do with varying degrees of vigour.

The substance of the book really revolves around the extent to which inductive inference is or is not misleading in epidemiological research and hence the role and importance of falsification. On top of and orthogonal to this there is a discussion in various guises of the relative importance of Bradford Hill's criteria for judging causality.

The trouble with it is that in epidemiology the context is all important, and really this receives scant attention. Unlike much in the social sciences, for which causal inferences are also essential, epidemiology has a strong theory which is independently verifiable, namely the biological sciences (however one would like to define them). This is extremely important, for while we are all conscious that plausible theory can be manufactured out of thin air, what we believe in the end depends on the biological justification or refutation of the epidemiology. Thus, in other words, the extent of causation in observational empirical association is always judged by its scientific context. Hill's rules implicitly formalize this process, but the main point should not be obscured.

Also the role of experimentation in epidemiological inference is not sufficiently exploited. It seems that this provides the possibility of some validation of the philosophy. There are many associations for which observational epidemiology has in fact led to strong support for particular hypotheses and simultaneously the ethical justification for experimentation. In these circumstances the examination of the differences between the results and their implications should provide valuable information and empirical validation.

Then the utility of these rules and the scientific logic depends on the actual degree of understanding of the theory, and on the extent to which the *known* theory can or cannot discriminate between

causation and association attributable to chance or artefact, such as confounding and selection. In particular the inferential role of refutation and/or induction does not have general utility, in my view; rather it depends on what else we know.

This leads me to an overall view on this book and perhaps explains why there have been so few on this topic. First, it is interesting to hear the arguments rehearsed by different exponents and relearn the importance of the contributions of Russell, Kuhn, Popper and so on, but in the end the interest is historical. Most of these discussions are overplayed and provide little useful insight into the treacherous business of making reliable sense of contemporary epidemiology. For most of the important unsolved questions we face massive uncertainties about causation combined with an urgent need for answers, but these will not come from philosophy any more; they require well designed epidemiological studies and hard work to eliminate bias.

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2. Hacking, I. *Logic of Statistical Inference*, Cambridge University Press, Cambridge, 1965.

COMPUTER INTENSIVE METHODS FOR TESTING HYPOTHESES. Eric W. Noreen, Wiley, New York, 1989. No. of pages: ix + 229. Price: £31.80

This is not a conventional textbook, with just over half the contents comprising computer program listings plus associated notes. The format is as follows: pages 1–92 normal text; pages 93–195 computer programs; pages 196–222 statistical tables; pages 223–229 references and index.

The five chapters in the first half of the book are as follows:

Chapter 1. Introduction. This contains an exposition of the general ideas behind significance tests of hypotheses, plus an introduction to the types of problem to be tackled by computer-intensive methodology.

Chapter 2. Approximate Randomization Tests. The basic ideas underlying randomization tests (more commonly referred to as permutation tests by statisticians in my experience, see footnote 2 on page 12) are first set out, 'exact' and 'approximate' randomization are contrasted, and some examples are treated in detail. Appendix 2A reports the results of some numerical experiments on the power of the tests conducted by the author, together with some reinforcement of general points.

Chapter 3. Monte Carlo Sampling. The simulation of random samples from hypothesised distributions, and the consequent generation of the null distribution of a test statistic, are described. Examples are given, with plenty of discussion. Appendix 3A explains the notion of the 'validity' of a test, 3B explains 'confidence levels' for computer-intensive tests, and 3C discusses their power.

Chapter 4. Bootstrap Resampling. Four bootstrap-based methods are described, two in the chapter proper, and a further two in the Appendix. One section is given over to a lengthy discussion of the reliability of bootstrap methods, together with some advantages and disadvantages, and incorporating the author's own numerical experiments. A short example is also given.

Chapter 5. Conclusion. This is almost a rerun of chapters 2, 3 and 4 in summary form. The methods previously presented are described and discussed again, and compared with conventional parametric tests again. The emphasis here, though, is more on the choice of method for the data at hand, and recipe tables and flow charts are used for guidance on this choice.

Appendices A, B and C. The computer program listings are given in BASIC (Appendix A), FORTRAN (Appendix B) and PASCAL (Appendix C).

One could say that the book covers little ground for its length, even counting only the first 92 pages of normal text. However, the material is vitally important in statistics, representing the fundamental ideas of significance testing, and the uncompressed treatment may be just what is needed for non-specialists. The author has taken a great deal of care to explain in detail what is going on,