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Book review

Clark Glymour (2001). The mind's arrows. Bayes nets and graphical causal models in psychology. Cambridge, MA: MIT Press.

In the past 15 years a small group of philosophers, statisticians, and computer scientists have laboured to set up a consistent formal syntax and semantics for causal statements and inference. Together with Richard Scheines, Peter Spirtes and Judea Pearl, Clark Glymour is among the prominent proponents of this framework. In his latest book, *The Mind's Arrows*, Glymour connects his work on causality to psychology, most notably to human development, cognitive neuroscience, and social psychology. The book contains 14 chapters, which are divided in four parts: Developmental psychology and discovery, adult judgments of causation, inference and explanation in cognitive neuropsychology, and psychometrics and social psychology.

The first part of the book is about human development. In Chapter 2, Glymour launches one of the main hypotheses of the book: Not only are graphical causal models methodologically useful, but the model and associated search algorithms yield an accurate description of causal learning in human beings. This bold hypothesis is put forward persuasively, in a chapter that is exceptionally clear and witty. Chapter 3 starts off with a related topic, the Frame problem, and raises the question how infants solve it: How do they decide which features of a given situation are relevant with respect to a given action, and which are irrelevant? How do they decide which part of their knowledge structure should be updated upon receiving a given piece of evidence? Glymour suggests that the answer may be found in the inference rules used in causal Bayes nets. According to Glymour, these models solve certain aspects of the Frame problem more or less automatically. This feature of causal models is adduced as evidence for the thesis that the developing mind operates according to the principles of causal models.

The second part of the book is about adult judgments of causation. Specifically, Glymour compares the Rescorla–Wagner learning model to an account based on causal Bayes nets. In Chapters 4 and 5, Glymour discusses the results of a psychological experiment on causal inference and possible explanations for these results. The main hypothesis here is that human judgments of causal relations are accurately described by means of causal Bayes nets, which can be used to explain the experimental results involved. Chapter 6 shows that the Monty Hall problem (also known as 'quizmaster-problem' and 'goat-problem') can be represented in a collider structure, and proposes an experiment to decide between the Rescorla–Wagner model for learning, and the causal Bayes net model. Chapter 7 discusses Cheng models, and Glymour again suggests a number of interesting psychological experiments.

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Chapter 8 evaluates the computational complexities of various learning models, among which is the causal Bayes net. Here, Glymour finally discusses a problem that has been lingering from the beginning: It is unlikely that human causal reasoning is governed by integrating probability densities, or iterative minimalization procedures, techniques that are common in the scientific application of causal models. Glymour suggests that humans may bypass these problems by using various heuristics. In Chapter 9, Glymour shows that at least some causal models, in contrast to the Rescorla–Wagner model, entail backward blocking (a process whereby the causal force of a characteristic is estimated as lower, if the causal force of another characteristic has been previously reinforced). Backward blocking has been reasonably well established in the experimental literature, so this is an important finding because it supports the causal Bayes net model over the Rescorla–Wagner model.

The third part of the book is about inference and explanation in cognitive neuropsychology. Chapter 10 is a description of two theories of cognitive design (Freud's and Farah's, respectively). Chapter 11 provides a discussion of how graphical models may be of assistance in determining which profiles of cognitive deficits are entailed by different cognitive architectures. Chapter 12 extends this work to group data by showing how different cognitive structures predict different frequency distributions of cognitive deficits in group data. Chapter 13 is about neural networks, and deals with the criticism that neural networks are unfalsifiable, because they can account for any type of abnormal functioning through appropriate lesioning. Glymour refutes this objection by reformulating some neural networks as graphical models, showing that these networks imply several conditional independencies, and arguing that they will continue to imply these independencies irrespective of lesioning.

Part 4 of the book contains one chapter, which deals with *The Bell Curve* (Herrnstein & Murray, 1994). Glymour discusses the limitations of two common psychological procedures which are the cornerstones of that book: Factor analysis and regression analysis. Glymour's objection to factor analysis is that the method is, in his terms, unreliable: Exploratory factor models are not good at recovering the true number of latent variables. The objection to regression analysis is that it more often than not fails to recover the correct causal structure, and easily leads to erroneous conclusions regarding that structure. Neither conclusion will come as a surprise to those familiar with the statistical literature, but the discussion may be a healthy antidote against the belief that such methods as exploratory factor analysis and stepwise regression could possibly justify the sort of conclusions we find in *The Bell Curve*.

The Mind's Arrows is, for the most part, an entertaining book. Glymour is a competent writer who launches his bold hypotheses in a style that is generally accessible and clear. The book contains many illuminating analyses of psychological problems involving causality, and proposes so many experiments that it will undoubtedly prove a goldmine for experimental psychologists in a creative dip. However, the book is not advisable for those allergic to unlimited speculation, because Glymour builds his theory of causal reasoning in humans on meagre empirical evidence. The few instances of experimental evidence that he does discuss seem carefully selected for the purpose of supporting his theory, and as a result his account is largely

based on post hoc considerations. I also found that Glymour was very mild on himself in discussing theoretical arguments against his theory. For example, if Glymour is correct in stating that there is a causal modeling routine implemented in my brain, I should be completely at ease with the kind of probabilistic conditional independence relations on which such a causal model operates. But if conditional independence is such a natural concept, basic to all causal reasoning in humans, I wonder why I have to spend hours trying to get the very concept of conditional independence into students' heads. If the brain comes hardwired with a causal modeling routine, if I have a maximum likelihood estimation algorithm in my left temporal cortex and an iterative proportional fitting routine in my right, recognizing conditional independencies should be as easy as recognizing faces. Why is this not the case?

Such rather obvious objections to Glymour's hypotheses do not receive a sufficiently detailed treatment in *The Mind's Arrows*, which makes the book somewhat more superficial than it could have been. However, there is no doubt that recent work on causal modeling represents one of the better ideas in the past 20 years of methodology, and Glymour convincingly shows the conceptual power of this framework, especially in the second half of the book. Together with its relatively nontechnical character and Glymours accessible style, this makes the book suited for psychologists interested in causality.

Reference

Herrnstein, R. J., & Murray, C. (1994). *The Bell Curve: intelligence and class structure in American life*. New York: Free Press.

Denny Borsboom
Department of Psychology, University of Amsterdam
Roetersstraat 15, 1018 WB
Amsterdam, The Netherlands
Tel.: +31-20-525-6876
Fax: +31-20-639-0026
E-mail address: ml_borsboom.d@macmail.psy.uva.nl