Book Review of

"Causation in Decision, Belief Change and Statistics"

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Reviewed by

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This collection of papers is the second volume of the proceedings of a Conference on Probability and Causation held at Irvine, California in 1985. Contributors include famous names in probability theory such as E. Adams, H. Kyburg and I. Levi. The contents are divided into three parts reflecting the three topics that appear in the title in relationship to causation. The first part, about decision and games, basically deals with so-called "causal decision theory" after Lewis [1]. The aim of these contributions is to discuss decision analysis cases "where an act counts as evidence for a desired state even through the agent knows his choice of that act cannot causally influence whether or not the state obtains" (to quote Harper's excellent introduction). For instance assume that both, smoking and cancer in humans are caused by some gene. Then probability P(Cancer | Smoking) is high not because smoking causes cancer but because they are simultaneously consequences of the gene. However, when someone smokes, people think it increases his chances to get cancer. In order to compute the utility of smoking, such causal shemes must be taken into account. In his contribution, Armendt proposes a representation theorem for causal expected utility ; then Harper argues that causal theory is useful to discuss some foundamental problems in game theory, because situations of causal independence that go along with epistemic dependence are often found in this field. Adams discusses the ideas that relative frequencies are the best possible degrees of belief to used for long-run decision under uncertainty, and comments on Ramsey's views of this question. However he claims that the one-step decision case cannot be treated this way due to ignorance of the relevant conditional probabilities. Kyburg argues that causality is but sheer superstition when construed as the powers of inaminate objects ; causality should refer to the powers of individuals, i.e. involves acts. Probabilistic causality is a matter of choosing a reference class. Kyburg insists that free acts should not be regarded as evidentially relevant, while past acts can be. Hence if I decide to smoke, this should not incrase my belief in getting cancer while if somebody sees me smoking it might increase his own belief due to the observed simultaneity between cancer and smoking.

Part 2 of the book deals with belief updating and is at first glance very heterogeneous. Gärdenfors develops a theory of rational belief change for epistemic states described by probability measures. This theory parallels the one he has himself proposed for epistemic states described by logical theories (Gärdenfors [2]). He focuses on contractions of probability measures, viewed as the operation inverse to conditioning, by which a piece of evidence is forgotten. Spohn proposes a rational theory of belief change for non Bayesian qualitative belief states described by so-called "ordinal conditional functions". His approach is formally related to Zadeh's possibility theory and for that reason is more precisely discussed below. Lastly Burks deals with the problem of automated learning computer programs. His representation framework is the one of rule-based systems. Burkes distinguishes two levels of learning, one where rules are attached relevance weights which evolve until a problem has been solved in a satisfactory way (only useful rules eventually get significant weights) and another one where weak rules are eliminated, and new ones are created by so-called genetic algorithms. The last part of the book contains 2 papers about statistics. Levi discusses the presence of causality in statistical explanation. Glymour presents an artificial intelligence program for model selection, that overcomes the combinatorial problem of choice between linear causal models, a choice which is usually performed by researchers guided by their experience of the process under study. The computer program improves on models proposed by researchers.

On the whole the book may be of interest to people working in the field of artificial intelligence, namely the section on decision theory is closely related to belief networks and influence diagrams that are presently very popular in the U.S. community of uncertainty in Artificial Intelligence. Also very relevant to Artificial Intelligence researchers are the papers of Burks and Glymour. For fuzzy set-theoretists the most intriguing paper is certainly the one on ordinal conditional functions by Spohn. His setting is basically a Boolean algebra $\mathfrak{B}$ of propositions and a function from $\mathfrak{B}$ to the set of ordinals, such that $k(\mathbf{a} \vee \mathbf{b}) = \min(k(\mathbf{a}), k(\mathbf{b}))$ (the latter is only a consequence of the formal setting, but it is simpler to start from it in this discussion). $k(\mathbf{a})$ is interpreted as a degree of disbelief in **a**. The choice of the set of ordinals as a valuation set for k emphasizes the qualitative flavor of the theory. Practically we can choose a valuation set the set of natural integers. The fundamental property of k points out the formal links to possibility theory. Namely, letting $\Pi(\mathbf{a}) = 10^{-k(\mathbf{a})}$ it is easy to see that Π is a possibility measure, with the special property that $\Pi(\mathbf{a}) \neq 0$, $\forall\ \mathbf{a} \in \mathfrak{B}$ (except the bottom element of $\mathfrak{B}$, i.e. the contradiction symbol). Of most interest is an updating rule for ordinal conditional functions which can be translated back to possibility theory, and that corresponds to Dempster rule of conditioning when updating upon a sure event **a**. This rule is extended to the updating of an ordinal conditional function in the face of evidence described by another such function. But once translated into the setting of possibility theory, it is not Dempster rule of combination that is obtained, but one that yields a possibility distribution again. This is enough to be said in order to show the potential interest of Spohn's contribution for fuzzy set people ; more discussions can be found in Dubois and Prade [3].

A last note on ordinal conditional functions. Spohn's interpretation of his theory does not refer to possibility theory (Zadeh is not mentioned in his paper, and Shackle's conditioning rule for degrees of surprize [4] is critically assessed), but to probability theory. Namely Spohn's views ordinal conditional functions as models for infinitesimal probabilities. Namely, if P(**a**) is $0(10^{-n})$, and P(**b**) is $0(10^{-m})$ then P(**a** $\vee$ **b**) is $0(10^{-\min(m,n)})$, i.e. k(**a**) is the exponent in P(**a**). The question of assimulating degrees of possibility ($\Pi(\mathbf{a}) = 10^{-k(\mathbf{a})}$ as pointed out above) as infinitesimal degrees of probability has never been envisaged in fuzzy set theory, although it is undoubtedly a way of justifying the axioms of possibility theory, and may be its usefulness for handling rare events.

References

[1] Lewis D. Causal decision theory. Australian Journal of Philosophy, 59, 5-30, 1989.

[2] Gärdenfors P. Knowledge in Flux. MIT Press, Cambridge, Mass., 1988.

[3] Dubois D., Prade H. Updating with belief functions ordinal conditional functions and possibility measures. Proc. of the 6th Inter. Conf. on Uncertainty in Artificial Intelligence, Cambridge, Mass., 1990, pp. 307-315.

[4] Shackle G.L.S. Decision Order and Time in Human Affairs. Cambridge University Press, U.K., 1969.