Scientific Explanation And The Causal Structure Of The World

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in Networks Perceived Causal Structure and Attributional Reasoning *Wesley C. Salmon Wesley C. Salmon Gjalt de Jong Richard P. Scheines Peter Kenneth Lunt Alison Gopnik Clark Glymour Wenyu Chen Richard Paul Scheines Daphna Buchsbaum Steven Sloman Jesus M. Cortés Charles H. Pence Thomas S. Richardson Leif K. Ervik Jeremy Gunawardena David B. Malament James Clough Peter Kenneth Lunt*

the philosophical theory of scientific explanation proposed here involves a radically new treatment of causality that accords with the pervasively statistical character of contemporary science wesley c salmon describes three fundamental conceptions of scientific explanation the epistemic modal and ontic he argues that the prevailing view a version of the epistemic conception is untenable and that the modal conception is scientifically out dated significantly revising aspects of his earlier work he defends a causal mechanical theory that is a version of the ontic conception professor salmon s theory furnishes a robust argument for scientific realism akin to the argument that convinced twentieth century physical scientists of the existence of atoms and molecules to do justice to such notions as irreducibly statistical laws and statistical explanation he offers a novel account of physical randomness the transition from the reviewed view of scientific explanation that explanations are arguments to the causal mechanical model requires fundamental rethinking of basic explanatory concepts

long term supply relationships are of crucial importance in industrial organization the present r evolution in information and communication technology such as e business is proof of the increasingly dynamic environment in which firms operate as a result firms have to focus on their core competencies and obtain complementary ones from partner firms to be able to survive this can hardly be realized without having long term supply relationships in the past decades research on strategic alliances the class of interfirm arrangements to which long term supply relationships belong mushroomed many ofthe empirical studies in the alliance literature focus on a single variable that is then explained by a set of independent variables for example for international joint ventures the level of commitment interdependence asymmetry and dedicated investments explains the development of trust by itself there is nothing wrong in this approach on the contrary because of all these studies we now have some knowledge about the reasons why firms enter in alliances and why some alliances are more successful than others in fact one of our first studies also belonged to this research tradition

understanding causal structure is a central task of human cognition causal learning underpins the development of our concepts and categories our intuitive theories and our capacities for planning imagination and inference during the last few years there has been an interdisciplinary revolution in our understanding of learning and reasoning researchers in philosophy psychology and computation have discovered new mechanisms for learning the causal structure of the world this new work provides a rigorous formal basis for theory theories of concepts and cognitive development and moreover the causal learning mechanisms it has uncovered go dramatically beyond the traditional mechanisms of both nativist theories such as modularity theories and empiricist ones such as association or connectionism

discovering causal structure artificial intelligence philosophy of science and statistical modeling provides information pertinent to the fundamental aspects of a computer program called tetrad this book discusses the version of the tetrad program which is designed to assist in the search for causal explanations of statistical data or alternative models this text then examines the notion of applying artificial intelligence methods to problems of statistical model specification other chapters consider how the tetrad program can help to find god alternative models where they exist and how it can help detect the existence of important neglected variables this book discusses as well the procedures for specifying a model or models to account for non experimental or quasi experimental data the final chapter presents a description of the format of input files and a description of each command this book is a valuable resource for social scientists and researchers

directed graphical models are commonly used to model causal relations between random variables and to understand conditional independencies in their joint distributions we focus on the crucial task of structure learning which aims to recover graphical structures using observational data sampled from distributions that obey certain underlying graphical model a common challenge in structure learning is the computational and statistical cost of learning large graphs or using high dimensional data in this dissertation we study four cases where the efficiency of structure learning could be improved over existing methods we propose new algorithms and provide theoretical consistency guarantees first we study a simple setting of linear structural equation model sem with equal error variances it is known that in this setting the dag can be uniquely identified from observational data we proposed in chapter 2 a simple yet state of the art procedure that sequentially estimates the causal ordering of the random variables this procedure is consistent and readily extendable to high dimensional setting we provided theoretical guarantees as well as simulation results to demonstrate the efficiency in chapter 3 we consider the problem of structure learning in sparse high dimensional settings that may be subject to the presence of unmeasured confounders as well as selection bias based on the structure found in common families of large random networks and examining the representation of local structures in linear sem we propose a new local notion of sparsity for consistent structure learning in the presence of latent and selection variables and develop a new version of the fast causal inference fci algorithm with reduced computational and sample complexity which we refer to as local fci lfci the new notion of sparsity allows the presence of highly connected hub nodes which are common in real world networks but problematic for existing methods our numerical experiments indicate that the lfci algorithm achieves state of the art performance across many classes of large random networks containing hub nodes in dags directed paths represent causal pathways between the corresponding variables the variable at the beginning of such a path is referred to as an ancestor of the variable at the end of the path in chapter 4 we investigate the graphical characterization of ancestral relations via cpdags and d separation relations we propose a framework that can learn definite non ancestral relations without first learning the skeleton we demonstrated that this framework yields structural information that can be used in both score and constraint based algorithms to learn causal dags more efficiently in chapter 5 we consider an intermediate problem in dag learning where a partial causal ordering of variables is available we discuss a general estimation procedure for discovering dags with arbitrary structure from partial orderings we also present efficient estimation algorithms for two popular classes of high dimensional sparse directed acyclic graphs namely linear and additive structural equation models

a major challenge children face is uncovering the causal structure of the world around them previous research on children s causal inference has demonstrated their ability to learn about causal relationships in the physical environment using probabilistic evidence however children must also learn about causal relationships in the social environment including discovering the causes of other people s behavior and understanding the causal relationships between others goal directed actions and the outcomes of those actions in addition many of the causal relationships children experience do not occur in the physical world at all but instead occur in richly causal imaginary worlds in this dissertation we argue that social reasoning and causal reasoning are deeply linked both in the real world and in children s minds children use both types of information together and in fact reason about both physical and social causation in fundamentally similar ways we suggest that children jointly construct and update causal theories about their social and physical environment and that this process is best captured by probabilistic models of cognition we also argue that causal pretense may serve as a form of counterfactual causal reasoning allowing children to explore causal what if scenarios in alternative imaginary worlds and suggest a theoretical link between the development of an extended period of immaturity in human evolution and the emergence of powerful and wide ranging causal learning mechanisms we investigate the complex and varied ways in which children learn causal relationships through three primary lines of research each of which extends probabilistic models beyond reasoning about purely physical causes while also characterizing the distinctive aspects of causal pretense and social causal reasoning in the first set of studies we examine how causal learning can influence the understanding and segmentation of action and how observed statistical structure in human action can affect causal inferences we present a bayesian analysis of how statistical and causal cues to segmentation should optimally be combined as well as four experiments investigating human action segmentation and causal inference we find that both adults and our model are sensitive to statistical regularities and causal structure in continuous action and are able to combine these sources of information in order to correctly infer both causal relationships and segmentation boundaries the second line of work examines how the social context influences children s causal learning focusing particularly on children s imitation of causal actions we define a bayesian model that predicts children will decide whether to imitate part or all of an action sequence based on both the pattern of statistical evidence and the demonstrator s pedagogical stance we conducted an experiment in which preschool children watched an experimenter repeatedly perform sequences of varying actions followed by an outcome children s imitation of sequences that produced the outcome increased in some cases resulting in production of shorter sequences of actions that the children had never seen performed in isolation a second experiment established that children interpret the same statistical evidence differently when it comes from a knowledgeable teacher versus a naive demonstrator suggesting that children attend to both statistical and pedagogical evidence in deciding which actions to imitate rather than obligately imitating successful action sequences the final line of work explores the relationship between children s understanding of real world causal structure and their pretend play we report a study demonstrating a link between pretend play and counterfactual causal reasoning preschool children given new information about a causal system made very similar inferences both when they considered counterfactuals about the system and when they engaged in pretend play about it counterfactual cognition and causally coherent pretense were also significantly correlated even when age general cognitive development and executive function were controlled for these findings link a distinctive human form of childhood play and an equally distinctive human form of causal inference we speculate that during human evolution computations that were initially reserved for particularly important ecological problems came to be used much more widely and extensively during the long period of protected immaturity

human beings are active agents who can think to understand how thought serves action requires understanding how people conceive of the relation between cause and effect between action and outcome in cognitive terms how do people construct and reason with the causal models we use to represent our world a revolution is occurring in how statisticians philosophers and computer scientists answer this question those fields have ushered in new insights about causal models by thinking about how to represent causal structure mathematically in a framework that uses graphs and probability theory to develop what are called causal bayesian networks the framework starts with the idea that the purpose of causal structure is to understand and predict the effects of intervention how does intervening on one thing affect other things this is not a question merely about probability or logic but about action the framework offers a new understanding of mind thought is about the effects of intervention and cognition is thus intimately tied to actions that take place either in the actual physical world or in imagination in counterfactual worlds the book offers a conceptual introduction to the key mathematical ideas presenting them in a non technical way focusing on the intuitions rather than the theorems it tries to show why the ideas are important to understanding how people explain things and why thinking not only about the world as it is but the world as it could be is so central to human action the book reviews the role of causality causal models and intervention in the basic human cognitive functions decision making reasoning judgment categorization inductive inference language and learning in short the book offers a discussion about how people think talk learn and explain things in causal terms in terms of action and manipulation

the aim of this research topic is to discuss the state of the art on the use of information based methods in the analysis of neuroimaging data information based methods typically built as extensions of the shannon entropy are at the basis of model free approaches which being based on probability distributions rather than on specific expectations can account for all possible non linearities present in the data in a model independent fashion mutual information like methods can also be applied on interacting dynamical variables described by time series thus addressing the uncertainty reduction or information in one variable by conditioning on another set of variables in the last years different information based methods have been shown to be flexible and powerful tools to analyze neuroimaging data with a wide range of different methodologies including formulations based on bivariate vs multivariate representations frequency vs time domains etc apart from methodological issues the information bit as a common unit represents a convenient way to open the road for comparison and integration between different measurements of neuroimaging data in three complementary contexts structural connectivity dynamical functional and effective connectivity and modelling of brain activity applications are ubiquitous starting from resting state in healthy subjects to modulations of consciousness and other aspects of pathophysiology mutual information based methods have provided new insights about common principles in brain organization showing the existence of an active default network when the brain is at rest it is not clear however how this default network is generated the different modules are intra interacting or disappearing in the presence of stimulation some of these open questions at the functional level might find their mechanisms on their structural correlates a key question is the link between structure and function and the use of structural priors for the understanding of the functional connectivity measures as effective connectivity is concerned recently a common framework has been proposed for transfer entropy and granger causality a well established methodology originally based on autoregressive models this framework can open the way to new theories and applications this research topic brings together contributions from researchers from different backgrounds which are either developing new approaches or applying existing methodologies to new data and we hope it will set the basis for discussing the development and validation of new information based methodologies for the understanding of brain structure function and dynamics

recent arguments concerning the nature of causation in evolutionary theory now often known as the debate between the causalist and statisticalist positions have involved answers to a variety of independent questions definitions of key evolutionary concepts like natural selection fitness and genetic drift causation in multi level systems or the nature of evolutionary explanations among others this element offers a way to disentangle one set of these questions surrounding the causal structure of natural selection doing so allows us to clearly reconstruct the approach that some of these major competing interpretations of evolutionary theory have to this causal structure highlighting particular features of philosophical interest within each further those features concern problems not exclusive to the philosophy of biology connections between them and in two case studies contemporary metaphysics and philosophy of physics demonstrate the potential value of broader collaboration in the understanding of evolution

abstract this paper is concerned with the problem of making causal inferences from observational data when the underlying causal structure may involve feedback loops in particular making causal inferences under the assumption that the causal system which generated the data is linear and that there are no unmeasured common causes latent variables linear causal structures of this type can be represented by non recursive linear structural equation models i present a correct polynomial time on sparse graphs discovery algorithm for linear cyclic models that contain no latent variables this algorithm outputs a representation of a class of non recursive linear structural equation models given observational data as input under the assumption that all conditional independencies found in the observational data are true for structural reasons rather than because of particular parameter values the algorithm discovers causal features of the structure which generated the data a simple modification of the algorithm can be used as a decision procedure whose runtime is polynomial in the number of vertices for determining when two directed graphs cyclic or acyclic entail the same set of conditional independence relations after proving that the algorithm is correct i then show that it is also complete in the sense that if two linear structural equation models are used as conditional independence oracles for the discovery algorithm then the algorithm will give the same output only if every conditional independence entailed by one model is entailed by the other and vice versa another way of saying this is that the algorithm can be used as a decision procedure for determining markov equivalence of directed cyclic graphs if the conditional independencies associated with two cyclic graphs result in the same output from the algorithm when used as input then the two graphs are equivalent

we make use of the logical approach to causality in which a general event structure is interpreted as a logical automaton arising from a particular logic of causality by choosing a different logic we can define a class of generalized event structures we introduce a new causal logic and associate a corresponding logical automaton to any finite safe petri net our main result is that the domain of configurations of this generalized event structure is isomorphic to the muller unfolding of the net

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