Workshop: Causality in complex systems (scientific goal)

Scientists and philosophers have arrived at a fairly good understanding of what a complex system is. They often rehearse the insight that there is no universally agreed upon definition of ‘complex system’ (cf. Rickles 2009, p. 86; Hooker 2011, p. 20), and many of them doubt that there will ever be such a definition (or single such definition). But they usually agree on a set of features that they think most complex systems exhibit: on features like numerosity, feedback, nonlinearity, spontaneous order, and adaptivity. While hardly any of them believes that these features (or conjunctions of them) are sufficient for the complexity of a system, some of them think that they are necessary (cf. e.g. Ladyman and Wiesner 2020, chap. 3).

Scientists and philosophers have also arrived at a fairly good understanding of (efficient) causality. They defend a variety of accounts of causality, but three of these accounts prove to be especially important for scientific practice: the first (the probability account) defines causality in terms of probabilistic dependence and temporal asymmetry (Granger 1969, 1980), the second (the process or conserved quantity account) in terms of transmissions of nonzero amounts of conserved quantity (Salmon 1998), and the third (the interventionist account) in terms of invariance under interventions (Woodward 2003).

But scientists or philosophers have not yet arrived at a satisfactory understanding of the conceptual or inferential connections between causality and complexity. Complexity science is relatively new, and philosophers account for causality primarily in the context of non-complex systems. They rarely consider the applicability of these accounts to complex systems, and whenever they do, they even complain that these accounts are difficult to square with important complexity features. Bishop (2011, p. 125), for instance, maintains that the process account is difficult to reconcile with the nonlinearity of complex systems. In a similar vein, Mitchell (2009, p. 82) argues that the interventionist account cannot be reconciled with the complexity feature of feedback.

The general goal of the workshop is to better understand the conceptual and inferential connections that obtain between (specific) accounts of causality and (specific) features of (specific) complex systems. Plausible candidates for complex systems are condensed matter, the universe, the climate, eusocial animals, the economy, the world wide web, and the (human) brain. Plausible candidates for complexity features include numerosity, disorder, feedback, non-equilibrium, nonlinearity, spontaneous order, robustness, nested structure, and adaptivity. Specific accounts of causality include the accounts of efficient causality mentioned above. But it might also be worth the effort to consider the applicability of accounts of material, final or formal causation.

One more specific goal is to analyze cases, in which complexity features and accounts of causality go together well. Order can be measured in terms of covariance or mutual information, and perhaps the relation between values of variables can be understood as causal in the sense of the probability account if these variables covary. Numerosity and feedback relate to interactions between system components (i.e. to direct exchanges of matter or energy), and perhaps these interactions can be interpreted as causal in the sense of the conserved quantity account. Perhaps any relation between system components can be interpreted as causal in the sense of the interventionist account if it remains invariant under interventions. And so on.

Another specific goal of the workshop is to analyze cases, in which complexity features and accounts of causality come apart. Causal inference faces problems when the underlying system is (nonlinear in the sense of being) extremely sensitive to initial conditions, or when an upper-level variable, on which a lower-level variable is believed to causally depend fails to screen off that variable from some of the lower-level variables that constitute the upper-level variable. Do these problems imply that (specific) accounts of causality cannot be reconciled with complexity features like nonlinearity or feedback as a matter of principle?

A third specific goal is to debate whether we should be monists or pluralists about the type of causality that operates in complex systems. Philosophers often suggest that the position to be adopted is one of monism: that there can be only one (true) account of causality. But perhaps the position that practicing scientists should (and perhaps unwittingly do) adopt is one of pluralism: perhaps the different accounts point to different features of a system that are more precisely described with thick causal terms than with the loose and multi-faceted term “cause” (Cartwright 2007: chap. 2), or perhaps different types of causal knowledge can be exploited for different purposes (perhaps knowledge that is causal in the sense of the probability, conserved quantity, and interventionist accounts can exploited for purposes of prediction, physical explanation, and control and non-physical explanation, respectively).

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