Causality in medicine, and its relation to action, mechanisms, and probability.

Donald Gillies. *Causality, Probability, and Medicine*. Abingdon, Routledge. 2018. £29.99.

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Medical researchers want to find out the causes of disease, and they want to find out what works to prevent or cure those diseases. A good deal of recent work in the philosophy of medicine has therefore been concerned with the issue of working out exactly what sort of evidence is required to establish a causal hypothesis in medicine (Russo and Williamson 2007, Howick 2011, Parkkinen, et al. 2018, Clarke, et al. 2014). One way to make progress on this epistemological issue is to first work out the correct metaphysical theory of causality for medicine. In this book, Donald Gillies supports a particular theory of generic causality for theoretical medicine by testing it against detailed historical case studies in medicine. He then investigates the implications of such a theory for the epistemology of medicine.

The book comes in three parts. In the first part, Gillies proposes a version of a so-called *action-related* theory of deterministic causality, where an action-related theory stresses the connection between causal laws and interventions. He argues that this theory compares favourably to

alternative action-related theories of causality advocated by Gasking (1955), Menzies and Price (1993), and Woodward (2003). Gillies responds to the main objections to an action-related theory of causality, including the infamous worry that some causes cannot be manipulated. His idea is that causal laws involving non-manipulable causes can still be the basis of *avoidance* actions. Indeed, medicine is typically more interested in such avoidance actions, because it is interested in avoiding disease. He develops these ideas by appealing to a detailed and insightful discussion of Koch's efforts to establish the comma bacillus as the cause of cholera.

	Observational	*Interventional*
Statistical Evidence	Epidemiological surveys	Clinical trials
Evidence of Mechanism	Autopsies	Laboratory experiments on animals, tissues, cells, etc.

Figure 1: Table showing the two by two classification of types of evidence in medicine.

The second part of the book is more epistemological in that it discusses the different types of evidence needed to confirm causal laws in medicine. Gillies applies the well-known distinction between *interventional* and *observational* evidence to the more recent distinction between *statistical evidence* and *evidence of mechanism* to produce a two by two classification of types of evidence (Figure 1). He argues that strong confirmation of a causal hypothesis in medicine requires the combination of these different types of evidence. In particular, Gillies advocates *the evidential principle of strength through combining*, which is a principle based upon the work of Phyllis Illari (2011):

> "Each type of evidence will naturally have strengths and weaknesses. Suppose, however, that the weaknesses of evidence of type α are compensated for by the strengths of evidence of type β, and vice versa. Then the combination of evidence of

> type α with evidence of type β will give an overall confirmation to the hypothesis H much greater than would be obtained by a comparable amount of evidence just of type α or a comparable amount of evidence just of type β." (130)

His argument here appeals to a detailed case study of the research into the causes of coronary heart disease. Among other things, Gillies argues that the *interventional* evidence of mechanisms from cholesterol-fed rabbits was complemented by the *observational* evidence concerning the mechanisms of atherosclerosis in humans.

Gillies then considers a thesis stronger than but related to the principle of strength through combining, namely, the Russo-Williamson thesis: 'A causal hypothesis in medicine can be established only by using both statistical evidence and evidence of mechanism' (133). The idea here is that the strengths of statistical evidence overcome the weaknesses of evidence of mechanisms, and vice versa (Russo and Williamson 2007, Illari 2011). Gillies argues that the streptomycin trial and the thalidomide disaster provide good reasons to accept the Russo-Williamson thesis. However, Gillies prefers a weak version of the thesis, which requires statistical evidence and evidence only of a *plausible* rather than *confirmed* mechanism (cf. Illari (2011) and Wilde and Parkkinen (2017)). His argument here appeals to a case study on the health effects of tobacco smoking: in order to establish that smoking was a cause of heart disease it was necessary to have at least evidence of a plausible mechanism; in order to establish that smoking was a cause of lung cancer it was sufficient to have statistical evidence and evidence only of a plausible mechanism. Gillies then provides a sustained defence of his weak version of the Russo-Williamson thesis in light of a bunch of putative counterexamples. His defence introduces a number of modifications to the thesis. In particular, Gillies argues for a more inclusive understanding of statistical evidence, as well as the caveat that it can be justified

to adopt a medical intervention provisionally in the absence of evidence of a mechanism. He thinks that this is the correct way to respond to the case of Ignaz Semmelweis (Broadbent 2011, Howick 2011).

Importantly, Gillies argues that his action-related theory of causality motivates *the principle of interventional evidence*: 'A causal law cannot be taken as established unless it has been confirmed by some interventional evidence' (24). One way to advance the debate here may be to consider possible counterexamples to this principle of interventional evidence. In particular, it might be argued that observational statistical evidence is in some cases enough to establish a causal hypothesis in medicine, so long as the observed correlation exhibits certain characteristics, for example, a consistent dose-response curve. Of course, the problem with this argument is that there may still exist alternative non-causal explanations of the observed correlation. One strategy for dealing with this problem is to attempt to disconfirm these alternative non-causal explanations. Gillies calls this *strategy one*. He provides a nice example of the strategy in his case study of the correlation observed between saturated fat and heart disease (115-118). However, Gillies thinks that strategy one is insufficient to properly establish a causal hypothesis because it does not require interventional evidence. He prefers a strategy of gathering evidence of a mechanism that can explain the extent of the observed correlation. He thinks that this mechanistic strategy satisfies the principle of interventional evidence because mechanisms are to be defined in terms of his action-related theory of causality. This is an ingenious move, but it might complicate the two by two classification of types of evidence given in Figure 1. According to this classification, it is possible to get *observational* evidence of a mechanism. Given this, it looks like observational evidence can itself meet the principle of interventional evidence. It is therefore no longer clear that strategy one fails to satisfy the principle of interventional evidence, so long as disconfirming non-causal explanations of an

observed correlation is a way of confirming that a mechanism explains the correlation. One way to deal with these complications may be to more explicitly distinguish between the objects of evidence and the methods by which that evidence is gathered (Illari 2011).

In the third part of the book, Gillies extends his action-related theory of deterministic causality in order to also provide a theory of indeterministic causality. His idea is to appeal to the mathematical theory of probability. Of course, there have been many failed attempts to define causality in terms of probability by appealing to the guiding intuition that a cause raises the probability of its effects. A nice overview of the major attempts has been provided by Jon Williamson (2009). One problem here is the Hesslow counterexample (Hesslow 1976): Although it is known to be a cause of thrombosis, taking the contraceptive pill may in fact lower the probability of thrombosis, since it lowers the probability of pregnancy, which is another cause of thrombosis. Gillies wants a way to relate causality and probability that saves the guiding intuition from this Hesslow counterexample. His approach is to argue that the truth of a causal claim is relative to a reference class by appealing to a propensity theory of probability, according to which the probability of an event is its propensity from within a reference class: Although taking the contraceptive pill does not raise the probability of thrombosis relative to the reference class of all women, it may still be a cause of thrombosis relative to the classes of both pregnant and non-pregnant women, since it may still raise the probability of thrombosis in each of these reference classes. An alternative approach is to relate causality and probability in a more sophisticated manner by appealing to causal models such as Bayesian networks, which are made mathematically tractable with the help of the causal Markov condition (Pearl 2000). However, Gillies argues that such Bayesian networks are not empirically well-corroborated, because some causal structures in medicine are best modelled by *multi-causal forks*, and these multi-causal forks do not satisfy the causal Markov condition.

His example involves a detailed case study of the research into the multiple causes of coronary heart disease. Of course, there is then a worry about the mathematical tractability of these non-Markovian models. Gillies argues that non-Markovian models can be made mathematically tractable by appealing to some theorems by Aidan Sudbury. He thinks that these models are both empirically well-corroborated in medicine and mathematically tractable.

Although the book often deals with quite technical and complicated material, it remains accessible throughout because the written expression is characteristically clear and engaging. All of the mathematical details are confined to a couple of appendices, which sit alongside a helpful glossary of medical terms. The book is also an excellent example of an approach in the philosophy of science that draws philosophical conclusions on the basis of a close examination of historical examples from actual scientific practice. Gillies says that 'one must study history and philosophy of science, and not philosophy of science without the history. Only the history of science can provide the variety of examples needed for philosophy of science' (21). This historical approach allows him to make a number of important contributions, which further present debates about evidential pluralism in medicine, the nature of causality and its relationship to both actions and causal mechanisms, the propensity interpretation of probability and its relationship to indeterministic causality, and the application of causal networks in medicine. It is therefore essential reading for anyone working in the history and philosophy of science and in particular the philosophy of medicine.

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