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PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, Vol. 1986, Volume One: Contributed Papers. (1986), pp. 59-65.

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Thu Mar 2 13:51:58 2006

Reichenbach, Causation, and Explanation

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Theories of scientific explanation have taken different forms, but many philosophers are adopting models of explanation in which causation plays a central role. The intuition behind this idea is that we explain the occurrence of an event by displaying its causal history, or by listing its causes. As natural as this may seem, problems arise when we attempt to use this model of explanation with a system that is indeterministic. If we want to give a causal explanation of an event that is not causally determined, then we need a theory of causation which allows for causation in indeterministic systems. Although Hume discussed something like indeterministic causation under the topic of reasoning from contrariety, Reichenbach was the first modern philosopher to develop a theory of indeterministic causation. Reichenbach's first attempt at developing a theory of indeterministic causation is found in his 1925 article, "The Causal Structure of the World and the Difference Between Past and Future." Although this is a modern discussion of indeterministic causation, a much more developed theory is found in The Direction of Time, which was published in 1956. This later work contains two fundamentally different analyses of indeterministic causation which Reichenbach believed were extensionally equivalent. These two analyses of causation form the basis for most current theories of indeterministic causation. In this paper I will first show that Reichenbach's analyses of causation are not extensionally equivalent, and then I will discuss the relation of these analyses to scientific explanation.

Reichenbach's first analysis of causation relies upon the close connection between causal sequences and the ability to transmit a mark. A mark is simply a modification of a sequence; if the modification appears in later parts of the sequence we say that the mark was transmitted. Reichenbach's idea was that genuine causal sequences can transmit marks, but that pseudo-processes cannot transmit a mark. This intuition is captured more formally in Reichenbach's first analysis of causation:

> If a mark made in an event C shows in an event E, then C is a cause of E (1956, p.290).[1]

We will call this analysis of causation the 'mark analysis of causation'. This analysis of causation has many problems, because it does not specify what counts as a mark, nor does it incorporate any counterfactual requirements. A much more sophisticated version of the mark

PSA 1986, Volume 1, pp. 59-65
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analysis of causation is defended by Wesley Salmon (1984).

Reichenbach's other analysis of causation is based upon probability relations among events. It is well known that two effects of a common cause may be statistically relevant to each other, even though they are not genuine causes of each other. The earlier event is a spurious cause of the later event, and is not a genuine cause of it. Reichenbach's second analysis of causation is founded on the intuition that spurious causes are predictively uninformative, once we have knowledge of a genuine cause. In other words, once we know that a cause of E occurred, additional knowledge about spurious causes is uninformative. Central to the concept of being predictively informative is the concept of <u>screening off</u>, which we can define as follows:

Event C screens off event B from event A if and only if P(A/B&C) = P(A/C).

If C screens off B from A, then B does not help predict the occurrence of A, once it is known that C has occurred. The screening off relation determines whether an event is predictively informative. Given these ideas, we can characterize Reichenbach's second analysis of causation as follows:

Event C is a cause of event E if and only if P(E/C) > P(E) and there exists no event B which is earlier than or simultaneous with C such that B screens off C from E.

We will call this analysis the 'probability analysis of causation'. In this analysis positive relevance is included to insure that we have a positive cause and not a negative cause, and the screening off requirement insures that we have a genuine cause and not a spurious cause. This analysis of Reichenbach's is the basis for all theories of causation that define the causal relation in terms of probability relations.

1. Reichenbach's Argument

Reichenbach believed that the above two definitions of causation were extensionally equivalent. He claims that we have observed that any cause according to the probability analysis is also a cause according to the mark analysis. This is not logically necessary, but rather it is an empirical fact about the world. Reichenbach also believed that we could prove that all causes according to the mark analysis were also causes according to the probability analysis. His proof is based upon two assumptions:

Assumption 1: If a mark made in A shows in B, then P(B/A) > P(B). (1956, p. 201).

Assumption 2: If C screens off B from A, and if a mark made in B shows in A, then it also shows in C. (1956, p. 202).

Reichenbach reasons as follows. Suppose that C is causally relevant to E according to the mark analysis; hence it is possible to transmit a mark from C to E. From assumption 1, it follows that P(E/C) > P(C). This is half of the probability analysis. Now suppose that B is some event that is earlier than or simultaneous with C. We can then derive that B cannot screen off C from E. Suppose that B screens off C from E. Assumption 2 implies that a mark made in C that shows in E must also appear in B. But a mark made in C cannot appear in event B, because a mark always travels forward in time, and event B is not later than C. Thus, contrary to our supposition, there can be no event B which screens off C from E. This is the second requirement of the probability analysis, and completes Reichenbach's proof that the analyses are equivalent.

I believe that there are two problems with Reichenbach's argument that the two analyses are extensionally equivalent. The first problem concerns whether it is possible for events in a causal chain to be negatively relevant to later events in the causal chain. This issue has been debated at length, and there is no consensus on this issue.[2] If it is possible for some events in a causal chain to be negatively relevant to later events in that chain, then assumption 1 would be false. It would then be possible for some causes according to the mark analysis to not be causes according to the probability analysis.

The second problem with Reichenbach's argument is that it does not seem true to claim that it is an empirical fact that all causes according to the probability analysis are causes according to the mark analysis. I believe that there are genuine causes according to the probability analysis in which it is not possible for a mark to be transmitted from the cause to the effect. Consider the following simple example. Suppose that a fire begins in a house and that the fire department is called. On the way to extinguish the fire, the fire engine gets a flat tire. As a result of the flat tire, the fire engine does not arrive at the house before it is completely destroyed. In this example, the fire engine getting a flat tire is positively relevant to the house burning down. Furthermore, there is no earlier event which screens off the flat tire from the destruction of the house. Hence the flat tire is a cause of the house burning down according to the probability analysis. However, I do not believe that the flat tire is a cause of the house burning down according to the mark analysis. It does not seem possible for a mark to be transmitted from the flat tire to the destruction of the house, because there are no causal processes that link the flat tire with the destruction of the house. Hence, not all causes according to the probability analysis are causes according to the mark analysis. Reichenbach's claim that it was an empirical fact that the analyses of causation are extensionally equivalent appears to be false.

Let us also consider an example in the honorable tradition of billiard balls. Suppose that the cue ball, the eight-ball, and the corner pocket are in a straight line. It is your turn, and you decide to take the easy shot of placing the eight-ball in the corner pocket. Just as you strike the cue ball, I lift the eight-ball off the table, and as a result the cue ball falls in the corner pocket. In this example, my removing the ball from the table raises the probability of the cue ball falling in the pocket, and it is not screened off from that effect by any earlier event. Hence my raising the ball is a cause of the cue ball falling in the pocket according to the probability analysis of causation. However, the mark analysis gives a different result. It is not possible for a mark to be transmitted from my removing the ball to the cue ball falling in the pocket. Thus, according to the mark analysis, my removing the ball is not a cause of the cue ball falling in the pocket. In this situation the earlier event is a cause according to the probability analysis, but not according to the mark analysis. Many other examples could be given to support the claim that these analyses of causation are not extensionally equivalent.

One important feature of these examples is that they do not depend upon any particular formulation of the analysis in terms of mark transmission or of the analysis in terms of probability relations. Both of the analyses offered by Reichenbach have been improved by recent philosophers, but I do not think that any minor modifications will solve the present difficulty. The two analyses of causation are fundamentally different, and the fact that they are not extensionally equivalent is not because one of the analyses has a minor flaw. I think the analyses pick out different conceptions of causation, and thus it is incorrect to think that the lack of equivalence is due to some error in one of the analyses. Even if both analyses were improved to the point where there were no problems with either of them, they would not be equivalent. The probability analysis recognizes events not connected by a causal process as being causally related, whereas the mark analysis excludes this possibility.

2. Significance of the Above Examples

Reichenbach viewed the causal structure of the world as a "causal net" consisting of various events connected by causal processes. Causal influence is transmitted by causal processes, which intersect with other processes. The causal net of the world displays the causal processes and their intersections, which constitute the means by which events and processes are produced and modified. The mark analysis of causation is founded upon the idea that causes and effects are events in the causal net linked together in an appropriate way. As the above examples show, the mark analysis does not recognize any connection between events or processes which are not connected by a genuine causal process. If two events or processes do not intersect or are not connected by some other causal process, then the one event or process cannot causally influence the other event or process. In the above example, the fire engine getting a flat tire was not connected to the house burning to the ground, and so the flat tire was not a cause of the house being destroyed. In the causal net there is no process connecting the flat tire and the destruction of the house.

In contrast to the mark analysis, the probability analysis of causation picks out events which may not be connected in the causal net. Since an event may affect the probability of another event occurring without being connected to it by a causal process, according to Reichenbach's second analysis a cause need not be connected to its effect by a causal process. If assumption 1 is correct, then the causes picked out by the mark analysis of causation will be a proper subset of the causes picked out by the probability analysis of causation. The disagreement between these two analyses is over whether the causal relation requires a causal process to connect the cause and the effect.

It appears that the probability analysis is closer to our use of the term 'causation' in ordinary language. Most people would not hesitate to blame the fire engine's flat tire for the destruction of the house. They believe that the flat tire is a cause of the house burning down, even though there is no causal process linking the flat tire with the fire. The reason the flat tire is a cause of the house burning down is because the flat tire prevented the occurrence of a negative cause of the house burning down: the arrival of the fire engine. An event can be a positive cause of another event by preventing the occurrence of a negative cause of that later event, even if the first event is not connected by a causal process with the later event. For similar reasons we would say that the cue ball fell in the corner pocket because I lifted the eight-ball off the table. However, even though I believe that the probability analysis is closer to our ordinary understanding of causation, it does not follow that it is the appropriate analysis of causation to use in scientific explanation.

The difference between the two analyses of causation is particularly important for scientific explanation. A model of scientific explanation which uses the mark analysis to identify causes will be different than a model of scientific explanation which uses probability relations to identify causes. These models will have different conceptions concerning what events are to be part of a scientific explanation, since the analyses are analyses of different causal concepts. In the above example, one model of scientific explanation would explain the destruction of the house in terms of the fire starting, the presence of combustible material, etc. Since the fire engine getting a flat tire is not part of the causal net which is able to transmit a mark to the house burning down, it is not included in a scientific explanation of that event. In contrast to that explanation, the model of scientific explanation based on probability relations would include all of the factors that the other explanation listed, but in addition it would include factors such as the fire engine getting a flat tire, the sprinkler system malfunctioning, etc. This model of explanation allows the explanans and explanandum to be unconnected in the causal net.

The crucial question is which of these models of scientific explanation is correct, or at least a step in the right direction. That question is dependent upon whether events which are causes according to the probability analysis but not according to the mark analysis are to be included in a proper scientific explanation of an event. Does a correct scientific explanation only display the relevant portion of the causal net, or does it also include considerations relevant to what usually occurs and considerations relevant to why certain events failed to occur? If an event prevents a negative cause from being successful, is that event a cause of the later event? These are difficult questions, and I am not sure what the correct answers are. Salmon's original work on explanation was based upon statistical relevance, but in recent years Salmon has decided that a correct scientific explanation should be based upon the relation of mark transmission. I hope to have shown that there is a substantive difference between these two models of scientific explanation, beyond the difficulties in formulating each concept of causation. Formulating an analysis of causation does not solve the problem of scientific explanation, because there are different conceptions of causation.

Although this article is not the appropriate place to argue in favor of one of these models of scientific explanation, a few comments about the procedure to be followed is in order. I have already mentioned that I do not believe that the issue can be settled by appealing to our ordinary use of the term 'causation'. Furthermore, I think that the procedure must be inductive; the issue should not be settled by any demonstration from a priori principles. In deciding between these two analyses of causation, I propose that we examine many examples of what we consider to be good scientific explanations to see which of the above conceptions of causation is used. If we can find good scientific explanations which appeal to causes that are not connected to their effects by causal processes, then we would have evidence that the mark analysis of causation is not the one to be used in a model of scientific explanation. Scientific explanation would be more than just exhibiting the relevant portion of the causal net. If we find that in all good scientific explanations causes are connected to their effects by causal processes, then we would have evidence that the mark analysis is to be used in scientific explanation. Of course, the choice of an initial class of good scientific explanations will be extremely important to this method. But that characteristic is common to most philosophical problems.

Notes

[1] Reichenbach's analysis differs from the one presented here in that instead of an analysis of causation, Reichenbach was giving an analysis of an event being causally relevant to another event. For our present purposes this simplification is not important, and thus we will ignore this difference.

[2] Salmon (1984) contains a thorough discussion of this issue.

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