

Chapter 2

The Ranking-Theoretic Account of Causation

Abstract A notion of causation based on the ranking functions of degrees of belief is presented in this chapter. The notion of cause is identified with the notion of a reason, which is defined in terms of a conditional ranking function. On these grounds, an epistemic theory of causation can be developed. It will be shown that the epistemic aspect of this account permits clarifying overdetermination cases in a novel way. A comparison of the ranking-theoretic approach to causation with the counterfactual analysis of causation and with the causal modelling account is also conducted.

Keywords Ranking function • Sufficient cause • Necessary cause • Supererogatory cause • Direct cause • Causal model

2.1 Ranking Functions

Wolfgang Spohn (2006) has developed a theory of causation based on a certain way of measuring the strength of belief. This theory has important similarities with the causal modelling account and with the counterfactual account of causation. More importantly, his theory accounts for our intuitions in overdetermination cases.

The notion of disbelief is characterised by a ranking function κ , a function from a set of propositions to the natural numbers (Spohn 2009). The ranking function represents the strength of disbelief, assigning numerical values to sets of propositions. In principle, ranking functions could meet their arguments to the real interval between 0 and ∞ , but for the sake of simplicity we will treat ranking functions as mappings to the natural numbers, including infinity. Besides simplicity, there is another reason for considering natural numbers as the values assigned by the ranking function: that for any proposition, there is a minimum value that we can assign to it.

The ranking function κ with regard to a given proposition assigns a certain degree of disbelief to that proposition (Spohn 2012, p. 70), on the ground of the following conditions:

- (i) $\kappa(\emptyset) = \infty$
- (ii) $\kappa(A \cup B) = \min \{ \kappa(A), \kappa(B) \}$

A characterisation of how ranking functions express disbelief can be presented as follows.

2.1.1 Negative ranking function.

- (i) $\kappa(A) > 0$ means that proposition A is disbelieved to some degree.
- (ii) $\kappa(A) = 1$ means that proposition A is disbelieved to the least degree.
- (iii) $\kappa(A) = \kappa(\neg A)$ means neutrality with regard to A .
- (iv) $\kappa(\neg A) > 0$ means that proposition A is believed to some degree.

There is a corresponding positive ranking function β , where for any proposition A , $\beta(A) = \kappa(\neg A)$. Using both ranking functions, we can introduce the two-sided function τ .

2.1.2 Two-sided function. $\tau(A) = \beta(A) - \kappa(A)$

Suppose, for instance, that R represents the proposition that it will rain tomorrow and that $\kappa(R) = 2$. This indicates disbelief that it will rain tomorrow. Suppose further that $\kappa(\neg R) = 0$ —i.e. it is not disbelieved that it will not rain tomorrow. Then, $\beta(R) = 0$ and $\tau(R) = -2$. Using the two-sided ranking function, we say that it is believed to a negative degree that it will rain tomorrow.

Regarding the two-sided ranking function, proposition A is believed to some degree when $\tau(A) > 0$ and A is disbelieved when $\tau(A) < 0$. There is neutrality with respect to A when $\tau(A) = 0$.

Originally, Spohn's uses ranking functions to develop a theory of belief change. The key concept of belief change is the concept of conditional belief, which can be expressed by the different conditional ranking functions (Spohn 2012, p. 78), such that:

$$\begin{aligned}
 \kappa(B \mid A) &= \kappa(A \cap B) - \kappa(A) && \text{(Conditional negative rank)} \\
 \beta(B \mid A) &= \beta(\neg A \cup B) - \beta(\neg A) && \text{(Conditional positive rank)} \\
 \tau(B \mid A) &= \kappa(\neg B \mid A) - \kappa(B \mid A) && \text{(Conditional two-sided rank)}
 \end{aligned}$$

Given the definition of a conditional τ function, we can explain, in Spohn's terms, the concept of a reason between propositions, which is simply defined as follows (Spohn 2012, p. 107).

2.1.3 Reasons. Proposition A is a reason for B regarding τ if and only if the degree of belief in B , given A , is higher than the degree of belief in B , given $\neg A$: $\tau(B \mid A) > \tau(B \mid \neg A)$.

We might interpret $\tau(B \mid A)$ as the belief about the world being such that B holds, given the belief that A holds (Spohn 2012, p. 78). On the grounds of the notion of a reason, different types of reasons can be characterised as follows (Spohn 2012, p. 107).

Types of Reasons Proposition A is a:

Supererogatory reason	for B , if and only if	$\tau(B \mid A) > \tau(B \mid \neg A) > 0$
Sufficient reason	for B , if and only if	$\tau(B \mid A) > 0 \geq \tau(B \mid \neg A)$
Necessary reason	for B , if and only if	$\tau(B \mid A) \geq 0 > \tau(B \mid \neg A)$
Weak reason	for B , if and only if	$0 > \tau(B \mid A) > \tau(B \mid \neg A)$

Consider the following example of a *weak reason*. Suppose that we want to know whether the bottle will be shattered (B). Someone gives us a weak reason by saying that there are some rocks near the bottle (A). It is more believable that it will be shattered, given the presence of rocks near the bottle, than given the absence of rocks around it. That is, $\tau(B \mid A) > \tau(B \mid \neg A)$. The presence of rocks near the bottle is somehow a reason to believe that the bottle will be shattered. However, we might disbelieve that the bottle will be shattered given just the fact that there are some rocks around the bottle. That is, $0 > \tau(B \mid A)$. This makes A a weak reason for B .

Now consider an example of a *necessary reason*. Suppose that we want to know why a house burnt down (B) and someone says that there was oxygen in the atmosphere (A). The presence of oxygen can be regarded as a reason for the house burning down because $\tau(B \mid A) > \tau(B \mid \neg A)$. But it is also a necessary reason. If we believed that there was no oxygen in the atmosphere, we would not believe that the house burnt down—i.e. $0 > \tau(B \mid \neg A)$. We may believe that the house burnt down, if we believed that there was oxygen in the atmosphere. But we might also remain neutral about it, since the presence of oxygen is still not a sufficient reason for the house's burning. That is, $\tau(B \mid A) \geq 0$.

Now consider an example of a *sufficient reason* for the fact that the house burnt down (B). Someone gives us a sufficient reason by mentioning a set of conditions (A), including, among other facts, that there was oxygen in the atmosphere and a description of the house's materials, including the proposition about a lightning bolt that struck the house. Proposition A can be regarded as a reason for the house's burning, because $\tau(B \mid A) > \tau(B \mid \neg A)$. It is also a sufficient reason: We would not believe that the house burnt down if A were not true. However, we might also remain neutral about it, since we could replace the description of the lightning bolt by the description of a short circuit occurring inside the house. Thus, $0 \geq \tau(B \mid \neg A)$.

Consider now an example of a *supererogatory reason*. We want to know why the house burnt down (B) and someone describes to us a set of conditions including, among other facts, the presence of oxygen, the materials of the house, the occurrence of a lightning bolt striking the house, and the occurrence of a short circuit inside the house (A). Proposition A can be regarded as a reason for B , since $\tau(B \mid A) > \tau(B \mid \neg A)$. However, A is more than a sufficient reason for B ; it is a supererogatory reason. We may negate the occurrence of the short circuit and we would still have a sufficient reason for the house's burning down. We may still believe that the house burnt down if A were not true. That is, $\tau(B \mid A) > \tau(B \mid \neg A) > 0$.

These different concepts of a reason will be applied to some difficult cases of causation. As we will see, the notion of a supererogatory reason will be particularly helpful in cases of overdetermination.

2.2 Direct Causation

The ranking-theoretic account of causation considers propositions as causal relata. Based on the concept of a reason, we can define the concept of a direct cause as follows (Spohn 2012, p. 356).

Definition. Proposition C is a direct cause of E if the following conditions hold:

- (i) C and E are true.
- (ii) The event represented by C temporally precedes the event represented by E .
- (iii) C is a reason for E .

In contrast to Lewis's counterfactual account of causation, the temporal asymmetry of cause and effect is assumed. Like Lewis's notion of causal dependence, direct causation is not a transitive notion. According to Spohn's account, causation is the transitive closure of direct causation.

On the grounds of this definition of the concept of a direct cause, we can consider different types of causes, given the corresponding types of reasons characterised above. For example, the true proposition C is a sufficient cause for the true proposition E if and only if the realisation of C precedes E , and if C is a sufficient reason for E .

2.3 Ranking Theory and Overdetermination

Consider the cases of overdetermination discussed so far. Cases of early preemption are well clarified by fine-graining the effect. Cases of late preemption, as we have seen, can be considered as cases of early preemption. Spohn agrees on this (2006, p. 111). Thus, in both cases of preemption, Suzy's throw is regarded as the cause of the bottle's shattering: The propositions describing these events are true—Suzy's throw temporally precedes the bottle's shattering and there is a transitive chain of reasons from Suzy's throw to the bottle's shattering.

In cases of symmetric overdetermination, Spohn (2012, p. 364) uses the strategy of *fine-graining the theory* (rather than fine-graining the events or the chains), by considering several concepts of causation. In particular, the concept of a supererogatory cause helps to clarify these cases.

Let ST be the proposition describing Suzy's throw, BT the proposition representing Billy's throw and BS the proposition representing the bottle's shattering. These may be the degrees of belief for the conditional two-sided ranking function in a case of symmetric overdetermination.

2.3.1 Symmetric overdetermination.

$\tau(\text{BS} \mid \cdot)$	BT	$\neg\text{BT}$
ST	2	1
$\neg\text{ST}$	1	-1

The proposition about the shattering of the bottle (BS) would be believed with a higher degree, given both throws ($ST \cap BT$), than given just one. Of course, it would be disbelieved, given that neither Suzy nor Billy had thrown ($\neg ST \cap \neg BT$). Thus, considering the different types of causes characterised above, each throw is taken to be a necessary and sufficient cause in the absence of the other. However, each throw is, in the presence of the other, a supererogatory cause (Spohn 2012, p. 366).

Spohn argues that we should take symmetric overdetermination at face value and rejects the idea of event fine-graining. Instead, he considers an entirely different notion of causation—the notion of a supererogatory cause—to clarify our intuitions in these cases.¹ According to Spohn (2012, p. 366), this strategy is not available to realistic theories of causation—e.g. to Lewis’s account of causal dependence. It is possible to clarify symmetric overdetermination only in an epistemic account of causation, such as the ranking account.

Let us consider late preemption. In cases of late preemption, Suzy’s throw hits the bottle first and shatters it, and Billy’s rock flies an instant later through the space where the bottle had stood. The ranking-theoretic account of causation must only describe that Suzy’s throw is a reason for the shattering of the bottle, while Billy’s is not. These may be the values for the two-sided ranking functions.

2.3.2 Late preemption.

$\tau(\text{BS} \mid \cdot)$	BT	$\neg\text{BT}$
ST	1	1
$\neg\text{ST}$	-1	-1

The proposition about the bottle’s shattering (BS) would be believed with the same degree given Suzy’s throw alone as given both throws. That is, given Suzy’s throw, Billy’s throw does not count as a reason for the bottle’s shattering. Thus, a relevant inequality that characterises late preemption cases is the following:

¹It is possible that the fine-graining of the theory depends somehow on the event fine-graining or on the choice of the event set. Whether an event is, for instance, a supererogatory cause depends on the degree of belief we assign to the occurrence of its effect, given not only the occurrence of that event, but also given the occurrence of other events. A supererogatory cause cannot be regarded as such alone. Thus, the solution of the ranking-theoretic account of causation is still based on how the set of events is fine-grained. The advantage of the account is rather that one does not have to consider a finer, different description of the events in order to clarify overdetermination cases, once one is confronted with them.

$$\begin{aligned}\tau(\text{BS} \mid \text{ST} \& \text{BT}) &= \tau(\text{BS} \mid \text{ST} \& \neg\text{BT}) > \tau(\text{BS} \mid \neg\text{ST} \& \text{BT}) \\ &= \tau(\text{BS} \mid \neg\text{ST} \& \neg\text{BT})\end{aligned}$$

Consider now the case of trumping preemption. Let *OC* be the proposition of the officer ordering the soldiers to advance, *SC* the proposition representing the sergeant doing the same, and *SA* the proposition representing the soldiers advancing. The situation may be described with the following values of the two-sided function.

2.3.3 Trumping preemption.

$\tau(\text{SA} \mid .)$	SC	$\neg\text{SC}$
OC	2	2
$\neg\text{OC}$	1	-1

Supposing that the officer shouted the order, the degree of belief about the soldiers advancing (*SA*) remains the same regardless of whether the sergeant gave the order or not. However, given that the sergeant shouted his command alone ($\neg\text{OC} \cap \text{SC}$), the degree of belief about the soldiers' marching is lower than in the case in which both ordered the soldiers to advance ($\text{OC} \cap \text{SC}$). And of course, it is no longer believed that the soldiers will march, given that neither the officer nor the sergeant has given any orders ($\neg\text{OC} \cap \neg\text{SC}$).

2.4 Ranking Theory and Counterfactual Dependence

There seem to be some similarities between the ranking account of causation and the counterfactual account. But what are these exactly? Franz Huber (2011) shows that Lewis's concept of causation based on counterfactual dependence is a special case of Spohn's concept of causation. Recall that the two conditions of Lewis's notion of causal dependence (1973) for two occurring events, a cause *c* and an effect *e*, are the following:

- (1) If *c* occurred, *e* would occur.
- (2) If *c* had not occurred, *e* would not have occurred.

As Huber explains (2011, p. 208), these two conditions can be described using ranking functions as follows, with proposition *C* describing the cause and proposition *E* describing the effect. Let us call this characterisation 'Lewis causation'.

2.4.1 Lewis causation.

- (1') $\kappa(\neg E \mid C) > \kappa(E \mid C)$
- (2') $\kappa(E \mid \neg C) > \kappa(\neg E \mid \neg C)$

According to the first condition, the effect's occurrence is believed with a higher degree than its absence, given that the cause occurs. According to the second condition, when the cause does not occur, it is believed with a higher degree that the effect does not occur either. The occurrence of the effect in the latter case would be disbelieved to a higher degree.

2.4.2 Spohn causation. Consider Spohn's Inequality (Huber 2011, p. 209), which expresses the notion of a reason as defined in (2.1.3).

Spohn's Inequality. $\kappa(\neg E \mid C) - \kappa(E \mid C) > \kappa(\neg E \mid \neg C) - \kappa(E \mid \neg C)$

In order to understand that this inequality is equivalent to the definition of the notion of a reason already given, consider the definition of the two-sided conditional rank for C and E :

$$\tau(E \mid C) = \kappa(\neg E \mid C) - \kappa(E \mid C)$$

Considering this, Spohn's Inequality regarding C and E is equivalent to the definition of the notion of a reason using two-sided ranks, according to which C is a reason for E just in case $\tau(E \mid C) > \tau(E \mid \neg C)$. Thus, C is a direct cause of E in Spohn's sense just in case C and E are true, the event represented by C precedes the event represented by E , and Spohn's Inequality holds.

Huber argues that this inequality captures the conditions of Lewis's concept of causation expressed with ranking functions as a special case. In order to show this, consider a simple example in which Suzy's throwing a rock, described by proposition C , causes the bottle's shattering, described by E . Lewis's conditions translated into ranking theory may hold for the following assumed values:

$$(1') \quad \kappa(\neg E \mid C) [= 2] > \kappa(E \mid C) [= 0]$$

$$(2') \quad \kappa(E \mid \neg C) [= 1] > \kappa(\neg E \mid \neg C) [= 0]$$

Spohn's inequality also holds for the assumed values:

$$\begin{aligned} \kappa(\neg E \mid C) - \kappa(E \mid C) &> \kappa(\neg E \mid \neg C) - \kappa(E \mid \neg C) \\ 2 - 0 &> 0 - 1 \end{aligned}$$

For the particular values assumed, the case of Lewis causation is also a case of Spohn causation. When there is counterfactual dependence between cause and effect, there is also direct causation in Spohn's sense. Notice that the left-hand side of the inequality is positive, while the right-hand side is negative. This is always the case when we have Lewis causation. This is because when a situation that turns out to be a case of Lewis causation is also described in terms of Spohn causation, the left side of Spohn's inequality must be positive, given condition (i) of Lewis causation. Given condition (ii) of Lewis causation, the right-hand side of the inequality must be negative.

Thus, counterfactual dependence implies direct causation (Huber 2011, p. 209). But the converse is not true: Direct causation (Spohn causation) does not imply

counterfactual dependence (Lewis causation). Consider a case of symmetric overdetermination for C describing one of the redundant causes, E describing the effect, and with the following values for the ranking function:

$$\kappa(\neg E | C)[= 2] - \kappa(E | C)[= 0] > \kappa(\neg E | \neg C)[= 1] - \kappa(E | \neg C)[= 0] \\ 2 - 0 > 1 - 0$$

This time, both sides of the inequality are positive. For these values, the second condition of the counterfactual dependence account does not hold:

$$\begin{array}{ccc} \kappa(E | \neg C) & > & \kappa(\neg E | \neg C) \\ 0 & < & 1 \end{array}$$

The second condition required for Lewis causation does not hold. Thus, direct causation does not imply counterfactual dependence (Huber 2011, p. 209).

2.5 Ranking Theory and Causal Models

Let us now consider the similarities and differences between the ranking theory of causation and the theory of causal models. Spohn (2010) considers different points of comparison between his theory and the account of causal models.

2.5.1 Examples. A first point of comparison is related to how both theories handle difficult examples—like overdetermination cases—a point about which, according to Spohn, discussion may turn out to be futile:

No theory, though, will reach a perfect score, all the more as many examples are contested by themselves, and do not provide a clear-cut criterion of adequacy. And what a ‘good score’ would be cannot be but vague. Therefore, I shall not even open this unending field of comparison regarding the two theories at hand. (Spohn 2010, p. 512)

I have already considered the most difficult overdetermination cases in the light of both theories and both deliver *prima facie* plausible results. However, as Spohn says, this is an unending field of comparison. We will not study it in further depth.

2.5.2 Applicability. Another important point of comparison is the applicability of both theories to scientific practice. Regarding this, the theory of causal models seems to have an advantage over the ranking-theoretic approach (RT):

Structural modeling is something many scientists really do, whereas ranking theory is unknown in the sciences and it may be hard to say why it should be known outside epistemology. [...] Still, I tend to downplay this criterion, not only in order to keep the RT account as a running candidate. The point is rather that the issue of causation is of a kind for which the sciences are not so well prepared. (Spohn 2010, p. 513)

Thus, according to Spohn, even if some theory of causation may not be visible in the scientific practice, it might still offer new insights on causal relation. This is why the point of comparison should focus on the theory, more than on the applications.

2.5.3 Singular variables. One important theoretical similarity is that both accounts work with the notion of a variable. However, the ranking approach to causation distinguishes between generic and singular variables:

A variable may vary over a given population as its state space and take on a certain value for each item in the population. E.g. size varies among Germans and takes (presently) the value 6' 0" for me. This is what I call a *generic variable*. Or a variable may vary over a set of possibilities as its state space and take values accordingly. For example, *my* (present) size is a variable in this sense and actually takes the value 6' 0", though it takes other values in other possibilities; I might (presently) have a different size. I call this a *singular variable* representing the possibility range of a given single case. (Spohn 2010, p. 513)

As Spohn argues, an important difference between generic and singular variables depends on the domain over which these range. Generic variables range over a population and singular variables range over a set of possibilities. While the ranking-theoretic account of causation explicitly uses only singular variables, the distinction in the terminology of the causal modelling account is not as clear. However, since the choice of a model depends on its contextualisation to a given scenario, the variables in the theory of causal models can also be considered as singular variables (Spohn 2010, p. 514).

2.5.4 Analytic policy. An important difference between the ranking theory of causation and the theory of causal models is related to the kind of definitions they propose for the concept of causation. The ranking-theoretic approach defines the concept of direct causation *reductively* on the basis of ranking functions and without presupposing other notions of cause. This is not the case in the account of structural causal models (SM):

The SM approach proceeds in the opposite direction. It presupposes an account of general causation that is contained in the structural equations, transfers this to causal dependence between singular variables [...], and finally arrives at actual causation between facts. The claim is thereby to give an illuminating analysis of causation, but not a reductive one. (Spohn 2010, p. 516)

Spohn here reminds the reader that the definition of the concept of actual causation given by the causal modelling account is based on the structural equations and characterised by causal graphs, which are supposed to describe a certain causal dependence between the variables.

2.5.5 Causal relevance. As I have shown, the ranking theory of causation can give different definitions for different concepts of causation—such as supererogatory, sufficient, necessary and weak causes. By contrast, the theory of causal models provides a definition of only one type of causation, namely, actual causation, which is clearly based on the cause being necessary for the occurrence of the effect: If the

value of the variable regarding the cause changed, the value of the variable regarding the effect would also change. Spohn counts this as an advantage for the ranking-theoretic approach:

So, roughly, in SM terms, the only ‘action’ a cause can do is making its effect necessary, whereas ranking theory allows many more ‘actions’. This is what I mean by the SM approach being poorer. (Spohn 2010, p. 518)

Spohn uses the concept of the ‘action’ of a cause on its effect to characterise *how* causes are relevant for their effects in many ways. In the ranking approach, we can distinguish many types of causes, while the theory of causal models seems to recognise only necessary causes.

2.5.6 Context dependence. As I have shown, the causal modelling account and the ranking account of causation clearly exemplify the main idea of this work—namely, that the evaluation of causal claims like ‘*c* causes *e*’ depends on the epistemic context of the subject that evaluates it. Both accounts start working within a *frame*, a set of variables. This set of possibilities is similar to the set from which one starts when one wants to evaluate causal dependence according to the counterfactual account of causation. It is the context of causal inquiry. Thus, the concept of causation is frame-relative, where the frame represents a context. But we can be fairly sure that in any realistic epistemic context there are unknown facts. So the presence or absence of causal relations within a frame can be due to incomplete knowledge. Thus, the causal relations defined within a frame seem to be an unreliable guide to real causation. Spohn is nevertheless highly optimistic:

In fact, any rigorous causal theorizing is thereby frustrated in my view. For, how can you theoretically deal with all those don’t-know-what’s? For this reason, I always preferred to work with a fixed frame, to pretend that this frame is all there is, and then to say everything about causation that can be said within this frame. This procedure at least allows a reductive analysis of a frame-relative notion. (Spohn 2010, p. 520)

Thus, the best that one can do is to support an epistemic notion of causation. Every case must be considered based on a set of variables that should receive values depending on what we know and what we want to know. I agree with this general strategy and would like to give further support to make it clearer through the remainder of this work.

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