Causation, Unification, and the Adequacy of Explanations of Facts

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ABSTRACT: Pluralism with respect to the structure of explanations of facts is not uncommon. Wesley Salmon, for instance, distinguished two types of explanation: causal explanations (which provide insight in the causes of the fact we want to explain) and unification explanations (which fit the explanandum into a unified world view). The pluralism which Salmon and others have defended is compatible with several positions about the exact relation between these two types of explanations. We distinguish four such positions, and argue in favour of one of them. We also compare our results with the views of some authors who have recently written on this subject.

Keywords: Causal explanation, explanatory pluralism, unification.

1. Introduction

In the literature on scientific explanation, there is a classical distinction between explanations of facts and explanations of laws. This paper is about explanations of facts. While in the 1980s several protagonists in the domain (e.g. Salmon 1984; Kitcher 1981, 1989) argued that all explanations of facts can be fitted into one model that describes their aim and structure, the 1990s gave rise to pluralistic stances. Wesley Salmon, for instance, put forward the idea that explanations of facts can serve different aims and therefore can have different structures (see e.g. Salmon 1993, 1998). He distinguished two types of explanation: causal explanations (which provide insight in the causes of the fact we want to explain) and unification explanations (which fit the explanandum into a unified world view).

The pluralism which Salmon and others have defended is compatible with four positions about the exact relation between these two types of explanations. These four positions are conjunctions of the following claims or their negations:

(A) Some explanations are purely causal (non-unificatory).

(B) Some explanations are mixed, i.e. they are both unificatory and causal.

(C) Some explanations are purely unficatory (non-causal).

By conjoining these claims or their negations, we can obtain four pluralistic positions:

(I) Some singular explanations are mixed, others are purely causal (non-unificatory). Unificatory explanations that are not causal, do not exist. (A&B&not-C)

(II) Some singular explanations are mixed, others are purely unificatory (non-causal). Causal explanations that are not unificatory, do not exist. (not-A&B&C)

(III) The two types are exclusive: some explanations are purely causal (non-unificatory), others are purely unificatory (non-causal). Mixed ones do not exist. (A&not-B&C).

(IV) The two types occur in a pure form but also in a mixed form. (A&B&C)

Obviously, (IV) is the most liberal form of pluralism, while (I)-(III) are more restricted.

The main aim of this paper is to defend (I). The structure of our argument is straightforward: In Section 4 we argue for A, in Section 5 we argue for B, and in Section 6 we argue against C. If these sections are convincing, the conclusion — position (I) — follows logically. In Section 7 we compare our results with the views of some authors who have recently written on this subject. Before we engage in all of this we clarify our assumptions and method (Section 2) and explicate what we mean with causal explanation and unification (Section 3).

2. A Pragmatic Approach to Explanation: Assumptions and Method

First of all, we want to mention a convention that we will use. It is common to use the term "understanding" to cover whatever scientists want to achieve by formulating explanations. We will also use the term "understanding" in this way. As a consequence of this terminological convention, the claim that explanation aims at understanding is trivially true.

However, we also have some substantial assumptions. We will assume that there is a variation in the aims that scientists want to achieve by formulating explanations. In other words: there is a variety of types of understanding. We will assume — without actually giving any historical or empirical evidence — that the history of science and descriptive analyses of contemporary science support this claim. Our position here is identical to the one taken by Henk de Regt (2006). In commenting on Salmon's later views on explanation and understanding, he writes:

> This view implies that also criteria for scientific understanding are objective and universal, not amenable to change. But this is in conflict with the actual variation in scientists' criteria for understanding that is exhibited by the history of science. A viable philosophical account of scientific understanding should accommodate this variation, and the associated complementarity thesis cannot be based on a notion of superunderstanding that is insensitive to such contextual variation. (pp. 141-142)
>
> If we do not want to brush away the opinions of scientists (past or present) as irrelevant, we should acknowledge contextual variation in criteria for understanding and, accordingly, in the ideal explanatory text. (p. 142)

We call an approach to explanation pragmatic if it acknowledges this contextual variation (this is the basic assumption of a pragmatic approach) and investigates how this variation in types of understanding leads to variation in types of explanation and variation in criteria for evaluating the explanations (this is the main methodological guideline of a pragmatic approach). Our approach will be pragmatic in this sense[1].

3. Causation, Causal Explanation, and Unification

3.1 A causal explanation is an explanation which somehow refers to the causes of the event to be explained. In Section 3.3 we discuss the structure of causal explanations. In this section and in Section 3.2 we focus on what causation is.

Ned Hall has recently argued that causation, understood as a relation between events, comes in at least two basic and fundamentally different varieties:

> Events can stand in one kind of causal relation — *dependence* — for the explication of which the counterfactual analysis is perfectly suited [namely, had *c* not occurred, *e* would not have occurred] (...). And they can stand in an entirely different kind of causal relation — *production* — which requires an entirely different kind of causal analysis [namely, *c* produces *e*] (...). (Hall 2004, p. 226, cf. pp. 252-257; emphasis added)

If we put his view into a definition of causation, we get:

> C causes E, if and only if, [E counterfactually depends on C] or [there is a causal mechanism by which C produces E].

Hall argues that in some cases a reading in terms of production is required, in yet some others a reading in terms of dependence, and, in most cases, a reading in terms of both. Let us start with a quintessential example from Hall, which is intended to give an example of a case where only dependence is required:

> Suzy and Billy have grown up, just in time to get involved in World War III. Suzy is piloting a bomber on a mission to blow up an enemy target, and Billy is piloting a fighter as her lone escort. Along comes an enemy fighter plane, piloted by Enemy. Sharp-eyed Billy spots Enemy, zooms in, pulls the trigger, and Enemy's plane goes down in flames. Suzy's mission is undisturbed, and the bombing takes place as planned. If Billy hadn't pulled the trigger, Enemy would have eluded him and shot down Suzy, and the bombing would not have happened. (Hall, 2004, p. 241)

Billy's pulling the trigger *did not produce* the bombing, rather it neutralized a state-of-affairs that would have prevented the effect from occurring. The occurrence of the bombing *was dependent* on Billy's pulling the trigger, but not produced by it. In this example, the effect counterfactually depends on the cause, but there is no mechanism linking cause and effect. Counterfactual dependence "seems to be the only appropriate causal relation for such "negative events" to stand in" (ibid., p. 256).

In other cases there is a causal mechanism but no counterfactual dependence. Suppose that Billy and Suzy are engaged in a competition to see who can shatter a target bottle first. Suppose further that Suzy throws her rock a split second before Billy. Suzy's throw is spatiotemporally connected to the shattering in the right way, but Billy's is not:

[1] As one of the referees pointed out, we could also label our approach "contextualist". We prefer the label "pragmatic" because there are links with pragmatist views on the aims of science; these links cannot be further explored here.

> Suzy's throw is a cause of the shattering, but Billy's is not. Indeed, every one of the events that constitute the trajectory of Suzy's rock on its way to the bottle is a cause of the shattering. But the shattering depends on none of these events, since had they not occurred the bottle would have shattered anyway, thanks to Billy's expert throw. (Ibid., p. 235)

3.2 Hall himself indicates that dualism might not be enough. He gives the following counterexample to his own theory:

> [T]here are certain kinds of cases that we have some inclination to call cases of causation, but that also elude classification in terms of production or dependence. Here is an example, a slight variation on the story of Billy, Suzy and Enemy: This time, there is a second fighter plane escorting Suzy. Billy shoots down Enemy exactly as before, but if he hadn't, the second escort would have. (Ibid., p. 271)

This example is an instance of pre-empted double prevention; in this case it is no longer true that the bombing wouldn't have happened if Billy hadn't pulled the trigger. Hall admits that one will nonetheless be inclined to grant Billy some causal responsibility for the success of the bombing, just as when there was no second escort. Hall sees this as "a piece of unfinished business that affects my account of causation" (ibid., p. 272). Cases like this one can be easily dealt with by means of probabilistic causation. We will use here the definitions of Giere (1997, p. 204):[2]

> C is a *positive causal factor* for E in the population U whenever $\mathbf{P}_X(E)$ *is greater than* $\mathbf{P}_K(E)$.
>
> C is a *negative causal factor* for E in the population U whenever $\mathbf{P}_X(E)$ *is less than* $\mathbf{P}_K(E)$.
>
> **C** is *causally irrelevant* for **E** in the population U whenever $\mathbf{P}_X(E)$ *is equal to* $\mathbf{P}_K(E)$.

Though it can be extended to other types of variables, Giere considers only binary variables. So in his definitions, **C** is a variable with two values (C and Not-C); the same for **E** (values E and Not-E). X is the hypothetical population which is identical to U, except that each individual exhibits the value C of the causal variable **C**. K is the analogous hypothetical population in which all individuals exhibit Not-C.

Let us apply these definitions to Hall's example. Suppose we have a group of experienced army pilots which we ask to simulate some fights (like they would do during ordinary training sessions). First, we have 500 control trials in which there is only a pilot playing the role of Suzy, and one playing the role of Enemy. Suzy is virtually shot down 450 times before she can drop her bomb (so her success rate is 10%). Then we have a first set of 500 experimental trials, with one escort fighter (playing the role of Billy) also present. Enemy is shot down in time 450 times. He shoots Suzy only 50 times, and succeeds in shooting her down 45 times. Suzy's success rate is much higher now: 91%. In the second series of 500 experimental trials we also add Second Escort. Billy misses Enemy 50 times, Second Escort shoots 50 times (i.e. whenever Billy misses) and misses 5 times. Enemy shoots only 5 times, and doesn't miss. Suzy's success rate is 99%. If we assume that the pilots are assigned randomly to the different

[2] We think that Giere's theory is superior to other theories of probabilistic causation. See Weber (2009) for this.

trials and roles, this experiment is good evidence for the claim that the presence of a second escort is a positive causal factor for the success rate of bombing raids (the same goes for the presence of a first escort).

On the basis of these considerations, we add a third relation, viz. positive probabilistic causal relevance to Hall's definition. That results in the following definition:

> C causes E, if and only if, [E counterfactually depends on C] or [there is a causal mechanism by which C produces E] or [there is a positive probabilistic causal relevance relation between C and E].

This is how we conceive causation in this paper. However, we want to stress that nothing we will say in the next sections depends on the "only if" in the definition: if we add a fourth, fifth, ... relation, our arguments remain valid.

3.3 In our view not much can be said about the general structure of causal explanations, because they can have very different formats. This view is developed and defended at length in Weber, Van Bouwel & Vanderbeeken (2005) and Weber & Van Bouwel (2007). Here we confine ourselves to one point, viz. the fact that we can ask different explanation-seeking questions about facts. Suppose we have observed that John has stolen a bike and Peter has stolen a cd-player. We can ask why John stole a bike rather than something else. Or we can ask why John stole something rather than nothing. These are examples of contrastive questions. The importance of contrastive questions has been stressed by e.g. Bas van Fraassen (1980) and Peter Lipton (1990, 1993). We can also ask why John stole a bike. This is an example of a question about a plain fact. These questions are at the focus of most classical accounts of explanation, including Hempel's, Salmon's and Kitcher's. We can also ask why both John and Peter stole something. This is an example of a comparative question. These questions are largely neglected in the literature on explanation (we will discuss them in Section 5).

The fact that we can ask different types of questions about facts is one of the reasons why causal explanations have different formats and thus that no general account of their structure can be given. However, there are three requirements that every causal explanation must satisfy. The first is trivial: a causal explanation must refer to the causes of the explanandum, i.e. claim to provide causes of the explanandum in some way. The second requirement is that causal explanations must be accurate in the facts they use: an explanation is acceptable only if the events it claims to have happened, really took place. This second requirement can be called "factual accuracy". The third requirement is "causal accuracy". A causal explanation must use causal knowledge which is backed up by sufficient (scientific or other) evidence. For instance, if we explain the collapse of a bridge by referring to an earthquake, this explanation is acceptable only if the earthquake really took place and if it is established that bridges of the type considered collapse when exposed to earthquakes of a certain strength.

3.4 The term *unification* will also be used in a broad sense here. Kitcher (1981) claims that besides what he calls Hempel's "official" position with respect to what understanding is (in which understanding is identified with *expectability*, see e.g. Hempel 1965, p. 337), there is an "unofficial" one:

> What scientific explanation, especially theoretical explanation, aims at is not [an] intuitive and highly subjective kind of understanding, but an objective kind of insight that is achieved by a systematic unification, by exhibiting the phenomena as manifestations of common underlying structures and processes that conform to specific, testable basic principles. (Hempel 1966, p. 83; quoted in Kitcher 1981, p. 508).

Kitcher ascribes to Hempel the view that, besides expectability, explanations can confer a second intellectual benefit upon us: unification. Whether or not this ascription is correct does not matter here. What we need here is the idea of unification: unifying events/phenomena consists in showing that two or more different events/phenomena are instances of the same (set of) law(s) of nature. This broad idea can be elaborated in different ways (see e.g. Kitcher, 1981, 1989; Schurz, 1999; Weber, 1999). For our purposes, it is not important how the idea of unification is filled in, but there is one restriction: we have to allow that the laws of nature are non-causal. In this way, it remains possible that there are explanations that unify but are non-causal.

4. Causal Explanations Without Unification

4.1 In this section we want to argue for the following claim:

(A) Some explanations are purely causal (non-unificatory).

What does it mean to apply a pragmatic approach to this issue? We will try to show that there are contexts in which the type of understanding scientists are looking for *does* require that the explanation is causal, but *does not* require that the explanation has unificatory power.

Before we start, we have to introduce some terminology. In this section, we will refer to three types of questions:

(E) Why does x have property P, rather than the expected property P′?

(I) Why does x have property P, rather than the ideal property P′?

(I′) Why does x have property P, while y has the ideal property P′?

P and P′ are mutually exclusive properties. An E-type question compares an actual fact with one that we expected. For instance, we can try to explain why only 61 % of the Belgian population (between the age of 15 and 64) was working in 2006 (according to Eurostat), while we expected 64,4% (the average of the European Union). An I-type question compares an actual fact with an ideal one (one we would like to be the case). For instance, we can try to explain why only 61 % of the Belgian population (between the age of 15 and 64) was working, while the ideal put forward by the European Union is 70%. An I′-type question does basically the same, but a different object in which the ideal situation is realised is used to emphasise that the ideal is not unrealistic. For instance, we can try to explain why only 61% of the Belgian population (between the age of 15 and 65) was working in 2006, while in the Netherlands 74,3% was working. The three types of questions we consider here are contrastive. Non-contrastive questions will come up in Sections 5 and 6.

E-type questions are obviously motivated by surprise: things are otherwise than we expected them to be, and we want to know where our reasoning process failed (which causal factors did we overlook?). Contrastive questions of type (I) and (I′) are motivated by a therapeutic or preventive need: they request that we isolate causes which help us to reach an ideal state that is not realised now (therapeutic need) or to prevent the occurrence of similar events in the future (preventive need).

4.2 I- and I′- type questions as characterised in Section 4.1 can provide a first type of cases in which the type of understanding scientists are looking for does require that the explanation is causal, but does not require that the explanation has unificatory power. We use a fictitious but realistic (because it is based on real causal knowledge) example. Two neighbouring cities, Koch City and Miasma City, have a history of simultaneous cholera epidemics: every ten years or so, after excessive rainfall, cholera breaks out in both cities. Suddenly, in the year X, the population of Koch City remains healthy after a summer with lots of rain, while Miasma City is hit by cholera again. Explaining the difference can help Miasma City in the future (therapeutic function).

Let us consider the following explanation of the contrast:

> There was a cholera outbreak in Miasma City because:
>
> (a) there was a lot of rainfall; and
>
> (b) Miasma City had no sewage system.
>
> There was no cholera outbreak in Koch City, despite the fact that
>
> (a′) there was a lot of rainfall, because
>
> (b′) Koch City started building a sewage system after the previous outbreak, and this system was ready now.

The explanation refers to a difference between the cities that is the result of a human intervention that was present in one case, but absent in the other. Moreover, the difference is causally relevant for the difference in the effect. These are the reasons why it can serve a therapeutic function. An answer to an I- or I′-type question is adequate only if (i) the difference that is singled out is in some way manipulable, and (ii) there is a causal relation between the difference that is singled out in the explanation and the difference that is to be explained. In the example the value of the explanation lies in the fact that Miasma City also could have built a sewage system, and that the sewage system is causally relevant for the outbreak of cholera. With respect to causal relevance, it is useful to repeat what we said in Section 3.3: an explanation is acceptable only if we have sufficient evidence for the causal claims it contains. In this case, the causal relevance of sewage systems should be established before giving the explanation, or be backed up with evidence after presenting it. The observed difference between the cities is certainly not enough to establish the causal relation (not all differences are causally relevant).

Manipulability and causal relevance are minimal conditions of adequacy for explanations in the context we are discussing here. However, high probability values are also important. If a sewage system is the only causally relevant factor (i.e. if cities with sewage system are never struck by cholera, cities without a sewage system always after a certain amount of rainfall), the explanation above is perfect: it describes the only possible therapy, and this therapy is 100% efficient. The value of an answer to an I- or I′-type question depends on manipulability and causal relevance, but also on the degree of efficiency and indispensability of the therapeutic measure it suggests.[3]

One crucial question remains: is unification a desideratum in these contexts? Obviously not: the similarities between the cities (e.g. the heavy rainfall) are irrelevant in these contexts.

4.3 E-type questions as characterised in Section 4.1 can also provide cases in which unification is irrelevant, while causation is relevant. Our example is taken from the work of the famous sociologist Robert Merton. During World War II, the American government asked Merton to analyse the success and failure of propaganda campaigns (see Merton 1957, chapter 14). In his analysis, Merton takes individual propaganda documents (e.g. a movie, a pamphlet, a radio speech) as units. Each propaganda document has a specific aim, viz. to convince the reader/viewer/listener to adopt a specific role in the war machine. One of Merton's most interesting examples is a pamphlet that was meant to convince Afro-Americans to volunteer for the army, i.e. to adopt the role of soldier. The pamphlet was a complete failure. It increased the self-confidence of Afro-Americans, but did not convince them to go to the army. So the following E-type question arose:

> Why did this pamphlet increase the self-confidence of its Afro-American readers, rather than convince them to become a soldier?

Merton's method for answering this question (and similar ones) was to divide the document into items. The pamphlet contained two kinds of items: text paragraphs and pictures accompanied by captions. The unsuccessful pamphlet contained, according to Merton's analysis, 198 items. Items were compared with the messages the writers wanted to communicate to their readers or audience. The aim of the pamphlet was twofold:

(1) to convince the readers that, while Afro-Americans still suffer from discrimination, great progress has been made; and

(2) to convince that these attainments are threatened if the Nazis win the war.

Some of the items were designed to communicate the first message, others to communicate the second message. In general, the items of a propaganda document can be grouped according to the specific message they want to communicate. In Merton's view, a pamphlet will be successful if and only if the items of each group are sufficient for communicating the corresponding message to the audience or readers.

[3] Suppose that both cities had an equally good sewage system and that the difference is due to a geological event that changed a fact about the groundwater in one city but not in the other. Then the correct answer would contain a factor that is not manipulable. This means that in some sense the explanation failed (the aim of finding a therapy or preventive measure is not reached) but in another sense the explanation succeeded (the explanation tells us that there is nothing we can do).

The reason why the pamphlet failed was that the authors tried to communicate the second message mainly by text items. The — mostly lower educated — Afro-Americans did not read the text, they just looked at the pictures (behind this lies a causal claim about the relationship between educational level and what people do when they are handed over propaganda documents; according to what we said in Section 3.3, this causal claim must be backed up with evidence in order to make the explanation acceptable). Most of the pictures related to the first theme: they featured Afro-Americans that occupied important positions in the American society. The result was that their self-confidence increased, but they did not conclude from the pamphlet that their attainments were in danger. Hence, they did not volunteer for military service.

An answer to an E-type question must show what was wrong in the line of reasoning that led to the wrong expectation; it has to point at a hidden or forgotten fact which is causally relevant. This is what Merton does: he shows that the authors neglected the fact that the average degree of schooling of Afro-Americans was low, and that this fact is causally relevant. This leads them to having the wrong expectation that their pamphlet would work. Unification is irrelevant in Merton's example, because he is interested in why one particular pamphlet failed; the explanatory information required is adequately provided by the (non-unificatory) causal explanation. This holds for answers to E-type questions in general, because they always relate to one particular failed expectation.

4.4 We have argued that E-type, I-type and I'-type questions can be successfully answered by causal explanations as answers, but that unification is not a desideratum in answering questions of these types. This entails claim (A): some explanations are purely causal (non-unificatory). In order to avoid misunderstandings, we want to stress that not all contrastive questions fit into one of the three types we have used here. So we have certainly *not* shown that unification is irrelevant for *all* contrastive explanations. However, for our purposes (i.e. for establishing (A)) it suffices that unification is irrelevant for answers to *some* types of contrastive questions. This is what we have argued for in 4.2 and 4.3.

Let us briefly return to the overall argument of our paper. Everyone who accepts that our arguments for claim (A) are convincing, has to reject position (II) *Some singular explanations are mixed, others are purely unificatory (non-causal). Causal explanations that are not unificatory, do not exist. (not-A&B&C).* The three other ones are still possible. In other words: one rival down, two to go.

5. Causal Explanations With Unification

5.1 In this section we argue for the following claim:

(B) Some explanations are mixed, i.e. they are both unificatory and causal.

What does it mean to apply a pragmatic approach to this issue? We will try to show that there are contexts in which the type of understanding scientists are looking for *does* require that the explanation is causal, and, on top of that, *also* requires that the explanation has unificatory power.

5.2 The material we use is taken from an article of Michael Taylor on revolutionary collective action (Taylor, 1988) which discusses Theda Skocpol's classic *States and Social Revolutions* (Skocpol, 1979). By using comparative methods, Skocpol has formulated a so-called "structural" explanation for three successful modern social revolutions in agrarian-bureaucratic monarchies (the French, Russian and Chinese revolution). The structural conditions that, in her view, make a revolution possible (the revolutions can be successfully mounted only if these structural preconditions are met), relate to the incapacitation of the central state's machineries, especially the weakening of the state's repressive capacity. This weakening is caused by external military (and economic) pressure: because of the backward agrarian economy and the power of the landed upper class in the agrarian-bureaucratic monarchy, the attempt to increase the military power leads to a fiscal crisis. Escalating international competition and humiliations particularly symbolized by unexpected defeats in wars (which inspired autocratic authorities to attempt reforms) trigger social revolutions. The foreign military and economic pressure that triggered the respective social revolutions, were:

(1) Bourbon *France* (1787-89): financially exhausted after the War for American Independence and because of the competition with England in general.

(2) Manchu *China* (1911-16): the Sino-Japanese War (1895) and the Boxer debacle (1899-1901).

(3) Romanov *Russia* (1917): massive defeats in World War I.

Skocpol's theory gives adequate answers to several contrastive questions, for instance:

Why did the French revolution start in 1789, rather than in 1750?

The answer is that the pressure was not big enough in 1750.

However, in this section we focus on non-contrastive questions, for instance:

> Why was there a revolution in Bourbon France, Manchu China *and* in Romanov Russia?

This is a request for the explanation of a set of similar facts. If we ask questions like this, the underlying aim is a type of unification: we want to know what is *common* in the causal ancestry of the different phenomena. In the example, we want to know what the causal mechanisms that led to these three revolutions have in common. Skocpol gives a part of the answer: She endorses the following principle:

> External military/economic pressure is a necessary cause of social revolutions.

According to Michael Taylor there is another causal factor which the revolutions have in common, viz. a strong sense of community among the peasants:

> When the peasant community was sufficiently strong, then, it provided a social basis for collective action, including revolutionary collective action and rebellions and other popular mobilizations. (1988, p. 68)

Taylor shows how the participation of vast numbers of peasants in collective action could be explained by using *the logic of collective action* advanced by Mancur Olson — which implies the use of economic incentives and selective social incentives, because without incentives to motivate participation, collective action is unlikely to occur even when large groups of people with common interests exist — adding his own theory of conditional cooperation. Using this account of collective action, Taylor argues that peasant collective action in revolutions was based on community (as many historians have argued) and that this is mainly why the large numbers of people involved were able to overcome the free-rider problem familiar to students of collective action and opted for conditional cooperation.

Taylor's idea can be summarized in the following principle:

> A strong sense of community is a necessary cause for social revolutions to occur.

This does not contradict Skocpol's principle: they are different but compatible claims about factors that occur in the causal ancestry of all social revolutions (see also Van Bouwel & Weber 2008).

5.3 In Section 4 we have used three types of explanation-seeking questions. Here we introduce a fourth type:

(U) Which factors occur in the causal ancestry of all the events x_1, ..., x_n.

We call this U-type questions because they ask for factors that are common in the causal ancestry and therefore unify the mechanisms that led to the events. Note that U-type questions are non-contrastive (this is one of the features that distinguishes them from E-, I- en I′- type questions). That U-type questions require causal explanations as answers follows from the way we have characterised them: they ask for factors in the causal ancestry of events. That unification is a desideratum in answering U-type questions also follows from the way we have characterised them: we are looking for factors that are common in the causal ancestry of the events involved. This means that *if* scientists regularly ask U-type questions and succeed in answering them, there are indeed contexts in which the type of understanding scientists are looking for requires that the explanation is causal, and also requires that the explanation has unificatory power. Our example in Section 5.2 shows that the condition is satisfied: scientists ask U-type questions and try to answer them. So we have an argument for claim (B): some explanations are mixed, i.e. they both unificatory and causal.

To conclude this section, let us go back to the overall argument. Everyone who accepts that our arguments for claim (B) are convincing, has to reject position (III) *The two types are exclusive: some explanations are purely causal (non-unificatory), others are purely unificatory (non-causal). Mixed ones do not exist. (A&not-B&C).* Combined with the results of Section 4 this means: two rivals down, one to go.

6. Unification Without Causation?

6.1 Eliminating the last rival is the toughest task, for purely formal (logical) reasons. In order to reject position (IV), we have to argue *against* the following claim:

(C) Some explanations are purely unficatory (non-causal).

In Sections 4 and 5 we used examples of real explanations to support our claims. That was a good strategy because we wanted to argue in favour of an existentially quantified generalization. Now we want to argue against such a generalisation, so examples will not help. All we can do is rebut the arguments of people who have argued in favour of (C) by means of examples (which we do in Sections 6.2 and 6.3) and show that some plausible routes for finding purely unificatory, non-causal explanations don't work (we do that in Sections 6.4 and 6.5).

6.2 Kitcher (1989) contains a section on 'Are There Noncausal Explanations of Singular Propositions?' (see pp. 422-428). After a digression into the difference between explanatory and non-explanatory proofs of mathematical theorems (which is irrelevant for our and his purposes, because the theorems cannot be formally expressed without quantifiers, and thus are not singular propositions) Kitcher gives two examples which are relevant: one about a party trick an one about sex-ratios at birth. The example of the party trick goes as follows:

> There is a party trick in which someone "knots" a telephone cord around a pair of scissors. In fact, no genuine knot is produced, and the scissors can easily be removed (and the cord returned to its standard configuration) if the victim makes a somewhat unobvious twist at the start. Those who do not make the right initial twist can struggle for hours without getting anywhere. What explains their failure? In any such case, we could, of course, provide the causal details, showing how the actions actually performed lead to ever more tangled configurations. But this appears to omit what should be central to the explanation, namely the fact that the topological features of the situation allows for disentanglings that satisfy a specifiable condition, so that sequences of actions which do not satisfy that condition are doomed to failure. We need to know the topological structure that lies behind the vicissitudes of the particular attempt and the particular failure. (1989, p. 426)

In our view, Kitcher overestimates the argumentative power of this example. The conclusion he wants to draw from it (that there are contexts in which a non-causal explanation of a singular fact is better than a causal explanation) follows from two premises:

(1) The topological explanation is better than the causal-mechanical one describing all the particular moves.

(2) The topological explanation is not a causal explanation.

We endorse the first premiss, but the second must be rejected. To see this, consider the following question:

> Why did A manage to unravel knot *x* easily, but not knot *y*?The topological answer (which Kitcher favours) is that *x* had the typical party trick topological structure, while *y* was a real knot. The topological structure is a cause of success or failure in unravelling in a probabilistic sense, and also in a counterfactual sense (cfr. our threefold definition of causation in Section 3). We elaborate this for the probabilistic case. If we apply Giere's definitions to Kitcher's example, X is the hypothetical state where everyone would be asked to unravel a party knot (within, let us say, 10 seconds), K a state where everyone would be asked to unravel a real knot within the same time limit. The topological structure is a cause of success/failure if and only if (as it is plausible to assume) more people in X than in K manage to unravel the knot within 10 seconds.

Given that the topological structure is a cause of success or failure in the probabilistic sense, the claim that the topological explanation is a non-causal explanation must be rejected. Kitcher fell victim of a tacit and unwarranted identification he has made, viz. that all causal explanations are causal-mechanical in Salmon's sense. Or, what amounts to the same: he tacitly identifies causation with one of the three relations (the production relation) distinguished in Section 3. Kitcher's example shows that there are cases in which causal-mechanical explanations are inferior to *other causal* explanations. It does *not* show that there are cases in which a non-causal explanation is better than a causal explanation, for the simple reason that his example is a causal explanation (contrary to what he thinks).[4]

6.3 Ruth Berger, in her 1998 paper, tried to offer examples that are similar to Kitcher's party knot, but are taken from population biology. Her main example is about Dungeness crabs. The explanandum consists in great fluctuations in the crab population: the number of crabs harvested varies drastically from year to year, and after adjusting for the level of fishing effort the researchers conclude that there are large fluctuations in the actual crab population (1998, pp. 313-314). According to Berger, the explanations that population biologists give for this phenomenon are not causal. She discusses the explanation developed by Alan Hastings and Kevin Higgins, of which the crucial element is that Dungeness crabs lay their eggs along an extremely thin strip of coastline (1998, p. 315). Note that this explanation uses a biological/physical fact (a spatial distribution of eggs) and that this fact is certainly a cause (on a probabilistic or counterfactual account of causation) of the population cycles. In a population of crabs that lay their eggs randomly, the effect would be absent. So the explanations Berger discusses do not constitute evidence in favour of (C), because they are causal explanations.

The basic problem with Berger's paper is its ambiguity. The title ("Understanding Science: Why Causes Are not Enough") suggests that the paper will argue against the claim that all singular explanations are causal. This impression is reinforced by the first sentence of the abstract:

> This paper is an empirical critique of causal accounts of scientific explanation. (p. 306)

This looks quite clear, but when we read on, we see different, non-coextensive characterisations of what a causal account is:

> Causal accounts appeal to the intuitive idea that to explain something is to tell what caused it to happen. (p. 307)

and

[4] Kitcher's examples do show something important, viz. that explanation and understanding do *not always* presuppose insight into underlying causal mechanisms. In our view, there are contexts in which explanation requires underlying mechanisms and contexts in which explanation does not require mechanisms (just as unification is sometimes required, sometimes not). We cannot discuss this issue in detail here, because we focus on unification. However, Kitcher's example (and the example of Berger in 6.3) would be useful to support this pluralistic stance towards mechanisms.

> Causal accounts are often associated with "bottom" up explanations because causal theorists argue that we gain understanding of phenomena terms of their constituent entities, processes, and interactions. (p. 308)

Humphreys (1989) and Hausman (1998) (see Section 7.3) are well-known examples of causal accounts of explanation fitting the first description, but not the latter. The examples which Berger offers constitute evidence against causal accounts of the latter type (causal-mechanical accounts) but not against causal accounts in general: she has shown that not all causal explanations are causal-mechanical, not that there are non-causal explanations. Like in Kitcher's case, the underlying problem is that causation is narrowed down to one specific relation (production) while the others (probabilistic dependence and counterfactual dependence) are neglected.

6.4 A common domain in which people tend to look for non-causal explanations is quantum mechanics. We don't think that is a viable strategy because the problems in the quantum domain relate to explanations of laws, rather than to explanations of singular events. James Cushing (1994, pp. 9-17) clarifies the challenge posed by EPR correlations by comparing them with Kepler's laws and Boyle's laws.

Cushing distinguishes three possible goals of scientific inquiry: empirical adequacy, formal explanation and understanding. Empirical adequacy is achieved when we are able to reproduce observed data (1994, p. 10). This aim can be reached without theories: we only need phenomenological laws. Kepler's laws, Boyle's law and a purely phenomenological representation (in the form of joint probabilities) of results of EPR-like experiments are examples of this. Formal explanation is explanation in the sense of Hempel's covering law model. Formal explanation provides unification by deriving a law from a more general framework (1994, pp. 10-11). For instance, Newton's theory allows a formal explanation of Kepler's laws (and other laws), statistical mechanics allows a formal explanation of Boyle's law. In the same way, the formalism of quantum mechanics allows a formal explanation of EPR correlations. However, understanding is a different matter:

> [U]*nderstanding* of physical processes involves a story that can, in principle, be told on an event-by-event basis. This exercise often makes use of picturable physical mechanisms and processes. (1994, p. 11)

Understanding of Boyle's law is provided by the kinetic theory of gases. Understanding of Kepler's law is provided by general relativity:

> In a sense, Einstein's general theory of relativity provided an understandable (picturable) causal explanation in terms of a curved space-time background (whose specific structure is determined by the distribution of masses) through which gravitons (or gravitational waves) propagate to transmit physical influences of one mass upon another. (1994, p. 13)

The challenge posed by EPR correlations is that understanding of this type seems impossible. However, this does not entail that there are singular events for which it is impossible to give a causal explanation.

6.5 What can we learn from Sections 6.2-6.4? First, once we take into account the fact that causal-mechanical explanations are only a subclass of all possible causal explanations, it is not easy to find examples in common scientific practice or in everyday life of non-causal explanations of facts. Second, quantum mechanics will not provide examples to support the claim that there are non-causal explanations of facts, because the cases it can provide are about explanations of laws.

However, there is one further route we can explore: explanations in terms of an earlier effect of a common cause. Let us clarify what we mean by means of an example. Suppose that John has blue eyes, and the following explanation is offered:

C_1: The mother of John has blue eyes

C_2: The father of John has blue eyes.

L: Children of two parents with blue eyes have blue eyes.

E: John has blue eyes.

This explanation is not causal: the law it uses describes correlated effects of a common cause. The phenotypes (blue eyes) of the parents and of the children are non-simultaneous effects of the same cause, viz. the genotype of the parents. If we regard this example and others with the same structure (a common cause relation where the effect that occurs first is used to explain the effect that occurs later) as adequate explanations, then there are a substantial number of non-causal explanations while explanation is still asymmetrical (there is a time order). The trouble is that explanations with this structure are intuitively unacceptable. Explaining a storm by means of a drop of the barometer (a classical counterexample to Hempel's deductive-nomological model with the same structure) is not acceptable. Personality psychology can provide further examples. Suppose that I commit a violent crime, and I have been previously diagnosed as an extremely aggressive person by means of the answers I gave in certain psychological tests. Explaining my crime by invoking the test results would not be a good explanation, even though there is a common cause of the test results and the crime (my aggressive personality) and the time order is appropriate.

7. Some Comparisons

7.1 The views that we have been developing are compatible with some accounts of unification that have emerged in the last decade as reaction to Kitcher's account. Take for instance the idea of "pervasive mechanisms" as developed by Robert Skipper:

> I have provided the foundations of an alternative to Kitcher's way of understanding explanatory unification. Kitcher claims that unification is the reduction of types of facts scientists must accept in expressing their world view, and it proceeds through derivation of large numbers of statements about scientific phenomena from economies of argument schemata. I suggest that it is very much worth exploring whether unification can be conceived as the reduction of types of mechanism scientists must accept as targets of their theories and explanations, and whether it proceeds through the delineation of pervasive causal mechanisms via mechanism schemata. (1999, pp. S207-S208)

Pervasive causal mechanisms are exactly what is required in order to answer U-type questions. So Skipper's idea can be integrated in our framework.

7.2 Our position is incompatible with monistic unificationist views as e.g. defended in Schurz (1999). On Schurz' view, there are four elements involved in every explanatory process. There is a why-question ("Why P?"), the cognitive state C of the questioner, the answer A, and the expanded or revised cognitive state C + A after receiving the answer. To distinguish genuine explanations he imposes further constraints. (i) A must be of the form: "P because of the reasons *Prem*" (i.e. explanations must give reasons of being for the explanandum); (ii) Prem must be *true*; (iii) the inference Prem Þ P must be correct in a broad sense (i.e. a deductive or probabilistic inference) — the inference then establishes a partial *assimilation* of P to Prem; (iv) the resulting cognitive state C + A must be *more unified* than C. To make this last condition more clear he introduces a measure for unification that defines a partial order relation between cognitive states. For the technical details we refer the reader to Schurz' article; for our purposes it is enough to remark that this measure essentially has to do with the level of coherence of a cognitive corpus. It is clear that (iv) is a *global* feature that cannot be defined by referring to P and A only. Schurz stresses that this needn't be problematic since the three other conditions do concern local features.

The main motivation for constraint (iv) is summed up in the following condition U, which he claims to be a necessary condition for explanation, missing in most traditional accounts.

> The explanatory premises Prem must be *less in need of explanation* (in C + A) than the explanandum P (in C). (1999, p.97)

The italicized part is analysed in terms of coherence, thus leading to constraint (iv). In this way he also claims that unification is necessary to safeguard the relation between explanation and understanding.

As explained in Section 5, we think there are contexts in which unification is a desideratum for adequate explanations. However, there are also contexts in which unification is not required or desirable (see Section 4). So we reject the monism that is inherent in Schurz' view.[5]

7.3 Our position is also incompatible with monistic causalist views as e.g. defended in Humphreys (1989) and Hausman (1998). According to Humphreys, singular explanations have a the following canonical form:

Y in S at t (occurred, was present) because of φ, despite ψ.

Here φ is a (nonempty) list of terms referring to contributing causes of Y, ψ a (possibly empty) list of terms referring to counteracting causes of Y (his definition of causation is a probabilistic one, see his 1989, p. 74). Of course, we do not deny that explanations can, in some contexts, have this format. However, Humphreys claims that all causal explanations have this format, thereby neglecting contrastive cases (cf. Section 4) and U-type questions (cf. Section 5).

After describing some standard counterexamples to Hempel's DN account of explanation (examples relating to irrelevant premises and the asymmetry of explanation), Daniel Hausman writes:

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[5] A consequence of this is that — contrary to what unificationists assume — understanding does not always depend on global features of a belief system.

> The most plausible diagnosis of these cases of DN arguments that are not explanations is that the premises in these arguments fail to focus on the *causes* of the phenomena described in their conclusions (1998, p. 157)

To see what he means, let us consider one of the standard counterexamples, Bromberger's flagpole:

> *Question 1*
>
> Why does this flagpole have a shadow of 10 metres long?
>
> *Answer 1*
>
> The flagpole is 10 metres high. The sun is at 45° above the horizon.
>
> Because light moves in a straight line, we can derive (by means of the Pythagorean Theorem) that the flagpole has a shadow of 10 metres long.
>
> *Question 2*
>
> Why is this flagpole 10 metres long?
>
> *Answer 2*
>
> The flagpole has a shadow of 10 metres long. The sun is at 45° above the horizon.
>
> Because light moves in a straight line, we can derive (by means of the Pythagorean Theorem) that the flagpole is 10 metres high.

The problem is that only the first argument is an intuitively acceptable explanation, while both answers are DN explanations in Hempel's sense. According to Hausman, only the first answer is an adequate explanation, because in that derivation the premises describe causes of the fact described in the conclusion. So Hausman's solution for the problems Hempel faces is straightforward: only derivations from causes (causal derivations) are explanatory, derivations from effects are not explanatory. Note that Hausman holds on to the idea that all explanations are arguments. He simply adds a causality requirement to the covering law model.[6] For our purposes, the most important aspect is that Hausman is monistic about this: all scientific explanations fit this format. In making this claim, he neglects contrastive cases (see Sections 3 and 4). Note that we do agree that in some contexts, explanations fit Hausman's format (see Weber & Van Bouwel 2007 for examples).

7.4 According to Jim Woodward, causal explanations should exhibit systematic patterns of counterfactual dependence. In this way, they not only show that the explanandum was to be expected, but also how it would change if the initial conditions were

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[6] Hausman acknowledges that other people have given the same diagnosis. He mentions a.o. Wesley Salmon, Peter Railton, James Woodward and Clark Glymour (see Hausman 1993, pp. 227-228). His contribution consists in giving an elaborate defence of this solution in terms of the crucial explanatory virtues which arguments not satisfying this requirement lack.

different (2003, p. 191). Woodward does not claim that he has a theory about all explanations: he claims to have a general theory about causal explanations, and leaves open the possibility that there are non-causal explanations (p. 187). This means that he is pluralistic in one sense (he does not exclude the possibility of non-causal explanations) but monistic in another sense (in his view all causal explanations have the same format). This monism brings him into trouble. There are cases in which explanation requires *more* than Woodward acknowledges (e.g. mechanisms on top of dependencies, see footnote 5). There are cases in which explanation requires *less* than Woodward requires (only a part of the counterfactual dependencies, see Section 4; or only a derivation and no answers to contrastive questions, see Hausman). And there are cases in which explanation requires something *completely different,* e.g. a narrative in terms of causal processes and interactions; or a common causal factor, see Section 5.

7.5 Finally, we want to make some comments on Michael Strevens' attempt to reconcile causal and unification approaches. In his 2004 paper, he writes:

> The kind of explanation I have in mind is that in which the causal details are either omitted or distorted. The unificationist is able to handle such cases easily, by showing that omission or distortion of the details enables a far greater degree of unification than would otherwise be possible. The causalist is embarrassed, because giving the correct causal details is, on the causal approach, just what explanation is supposed to be. (2004, p. 156)

Strevens defines a causal approach as follows:

> On the causal approach, what explains an event is the event's causal history (2004, p. 155)

Given this definition, he is right in saying that causalists will be embarrassed by the cases he is considering. However, his definition excludes most causal approaches (pluralist approaches like ours, but also monistic causal approaches like Humphreys' and Hausman's). Apart from causal-mechanicists like Salmon, causalists will not be embarrassed at all by omission and distortion of causal details.

Furthermore, unification is certainly not the only possible motivation for omission or distortion. In contrastive explanations, we leave out information that is irrelevant because it is common to both events. The information that is singled out in such cases is the one that divides or separates rather than the one that unifies. Strevens assumes that there is only one perspective from which we can select explanatory relevant information from the available causal knowledge about an event. Our contrastive cases in Section 4 show that there is at least one more perspective, that pulls in an opposite direction (i.e. leads to the selection of different causes as explanatorily relevant).

8. Conclusion

In Sections 4 and 5 we have argued for the following claims:

(A) Some explanations are purely causal (non-unificatory).

(B) Some explanations are mixed, i.e. they are both unificatory and causal.

Taken together these claims shed light on the value of unification in singular causal explanations: in some contexts (certain comparative questions) unification is important for having good explanations, while in other contexts (certain contrastive questions) it is not a required. In Section 6 we have argued against the following claim:

(C) Some explanations are purely unficatory (non-causal).

In this way, we hope to have convinced the reader to adhere to the following position:

(I) Some singular explanations are mixed, others are purely causal (non-unificatory). Unificatory explanations that are not causal, do not exist. (A&B&not-C)

The pluralistic rivals of this position (positions (II)-(IV) must be rejected if one accepts the three steps of our argument.

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