Analysing Causation in Light of Intuitions, Causal Statements, and Science

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1. Overview

The aim of this paper is to provide an account of causation that is compatible with both common sense intuition and science. In the next section, I briefly rehearse the most important philosophical strategies for analysing the concept of causation. Then I investigate, in the third section, criteria of correctness for a philosophical theory of causation. In the fourth section, I review some important counterexamples to the traditional accounts mentioned in the second section, and suggest, in the fifth, that these counterexamples can be seen as grounded on two kinds of intuitions. The sixth section presents results of the linguistic analysis of common sense causal statements. In the seventh section, I offer an analysis of causality in agreement with the criteria elaborated in the third section: Relations of causal responsibility make true causal statements of one type identified in the sixth section, and underlie the intuitions such statements express. Such relations contain as a part another, simpler relation: the causal relation between events, which makes true statements of the other sort identified in the sixth section. The eighth section answers two important objections, one against the thesis that facts can be causes, the other against the thesis that events can be causes[1].

[1] In (2002), (2006a), and (2011), I present a more detailed overview of the most important contemporary analyses of causation than I can give here in section 2. These earlier presentations also contain additional counterexamples against these theories. Much of the material presented in section 6 has appeared in my (1999) and (2006). (2006) and (2006a) offer a similar sorting of intuitions in two kinds as section 5 below, as well as a proposal, similar to the one I put forward in section 7, to account for these intuitions in a unified framework using the notion of a truthmaker. I had already addressed the challenge raised by negative states of affairs in (2001), (2006), and (2006a). However, the present paper improves the overall coherence of the unified theory of causation I offer by giving more weight to the methodological considerations presented in section 3, and to the notion of a truth-maker. This allows me in particular to improve the answer I had given in those earlier works to the challenge raised by negative states of affairs.

2. Some important proposals for analysing causation

The debate on the nature of causation is almost as old as philosophy itself. In the Aristotelian paradigm, which was prevalent up to the 17th century, providing a scientific explanation of some natural phenomenon was the same thing as finding its cause. In modern philosophy, causal explanation has been assimilated to explanation in terms of laws of nature. The doctrine of logical empiricism that has dominated a large part of philosophy of science in the 20th century, has spelled out this idea in the "deductive-nomological" (DN) conception of causation and explanation. Although it has been subject to much criticism since the 1960s, it remains one of the major approaches to the analysis of causation. According to the DN approach, one event *a* is the cause of another event *b*, if and only if there is a law of nature (or a set of such laws), such that a description of the effect-event can be logically deduced from a description of the cause-event, together with a statement of the relevant laws. The so-called initial conditions, which figure – together with one or more laws of nature - in the premises of such an argument, describe the cause, whereas the conclusion of the argument describes its effect. The DN approach is intended to be both an analysis of causation and of scientific explanation, making it a conceptual truth that all scientific explanations are causal explanations. It accounts for deterministic as well as for indeterministic causal processes. This distinction corresponds to the difference between deterministic and indeterministic laws: According to the nature of the laws figuring in the premises of a DN explanation, the causal relation is deterministic or indeterministic. However, as we will see, it is now widely agreed that not all scientific explanations are causal. Thus, even if the DN account provides an adequate analysis of explanation, it is no adequate analysis of causation.

A major alternative to the DN account is the probabilistic approach, which is built on the observation that causes typically raise the probability of their effects. That high emission rates of carbon dioxide cause global warming, implies that, all other factors being supposed constant, high emission rates make strong global warming more probable. It may seem just as plausible to reason in the opposite direction, from higher probability to the existence of a causal relation. The adequacy of the probabilistic approach depends among other things on how the terms of the causal relation are construed. Being based on conditional probabilities between factors, or types of events, it has first been elaborated as a theory of causal relations between factors or types of

events, although some authors have then extended it to cover also causal relations between particular events[2].

In David Hume's analysis of causation, causal judgments are based on the experience of regularities. This idea can be seen as one variant of the nomological approach, insofar as laws themselves are often considered, in the empiricist tradition, as nothing more than a subset of regularities (or statements of such regularities). But Hume also mentions an idea that David Lewis (1986) has recently developed to become another of the main alternatives to the DN approach. According to the counterfactual approach, causal relations are analysed in terms of *counterfactual dependence*. Event *c* causes event *e* if and only if there is a chain of intermediate events c, c_1, c_2, …, e, so that each event in the chain depends counterfactually on its predecessor. If c_i and c_{i+1} are events that have occurred, event c_{i+1} counterfactually depends on event c_i if and only if it is the case that if c_i had not occurred, c_{i+1} would not have occurred. To say that the emission of CO_2 by human activity causes global warming is equivalent to saying that if there had been no (or less) CO_2 emission due to human activity, there would have been no (or less) global warming[3].

One variant of the counterfactual approach has recently gained particularly widespread interest and adhesion. As the probabilistic approach, it is tuned to analyze causal relations among types of events, rather than particular events. According to the interventionist approach[4], a variable *A* representing one type of event is a cause of a variable *B* representing another type of event if and only if an agent could in principle (abstracting away from practical limitations) modify the value of *B* by manipulating the value of *A*, while other variables influencing *B* are held constant. Von Wright (1971) has shown that the fact that manipulability is our main *epistemic* criterion for obtaining *knowledge* of causal relations, is insufficient for establishing that manipulability is the *ontological* ground of causation. However, Woodward (2003) and others have recently reformulated interventionism as a metaphysical theory of causation[5]. Woodward uses mathematical models and methods that have been elaborated in statistics and artificial intelligence to define different causal notions, such as direct cause or contributing cause,

[2] See Eells (1991).
[3] Dowty (1979) has made Lewis' counterfactual analysis of causation influential in linguistics.
[4] It is also often called "manipulationist" approach.
[5] Arguably, Woodward's theory pursues the aim of providing "the metaphysical basis of causal explanation" (Strevens 2007, p. 244) although Woodwards himself denies that his (2003) "is a metaphysical treatise" (Woodward

relatively to a set of variables. Recent versions of interventionism escape the charge of restricting the domain of applicability of the notion of causation to the range of influence of human action, by defining an intervention on a variable in purely probabilistic terms.

Finally[6], it has been proposed to analyse causation in terms of some material process stretching from the cause to the effect event. Processes of different kinds have been suggested as grounding causation; for some, it is the propagation of energy[7], for others, an amount of a conserved quantity[8], for still others, a process capable of transmitting a mark, i.e. of transmitting information[9].

3. Criteria of adequacy and two types of philosophical theories of causation

Faced with such a plethora of approaches, it seems well advised to step back and ask for the criteria of adequacy of a philosophical account of causation. What exactly are we after when we try to analyse causation: Is it some objective structure of reality, or part of our conceptual system, or the meaning of causal expressions in language? Different standards of adequacy are appropriate depending on the type of enquiry we are engaged in.

The most fundamental criterion of adequacy, accepted by all philosophical accounts, is overall coherence. A theory that allows for contradictions, or licences incoherent judgments, is unacceptable. Another crucial criterion of adequacy for philosophical theories of causation is agreement with common-sense intuition[10]. Indeed, the main strategy for criticizing a

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2008, p. 194), claiming that it aims at analysing scientific methodology, rather then the structure of reality revealed by science. Cf. also Strevens (2008).

[6] The list is not exhaustive. To mention another recent proposal, Glennan has suggested analyzing causation in terms of the notion of mechanism: "Events are causally related when there is a mechanism that connects them" (Glennan, 1996, p. 49). However, such an analysis cannot succeed because causation is among the irreducible conceptual instruments of mechanistic analysis. As I have shown elsewhere (Kistler 2009) mechanist causation rests in the last instance on the causation of fundamental physical processes. Another important approach to the semantics of causal language and more generally to the cognitive representation of causation uses the concept of force to analyze the causal structure of processes with the help of "force-dynamic patterns" (Talmy 1988, p. 54). See Wolff, this volume, Copley&Harley, this volume. Mumford and Anjum (2011a; 2011b) have used a similar framework, in which forces and other "powers" are represented by vectors, to construct a metaphysical theory of causation.

[7] Fair (1979). Hall (2004) and Wolff, this volume, call the concept analysed by theories of this category the "production" concept of causation.

[8] Dowe (2000), Kistler (2006).

[9] Salmon (1984).

[10] Intuitions are also the focus of psychological research on causal judgments. Gopnik and Schulz (2007) explore, e.g., to what extent children's and adults' causal intuitions match the results of the interventionist theory of causation. Causal intuitions are also experimentally explored by Knobe and Fraser's (2008) application of "experimental philosophy" to causation. See Egré, this volume.

philosophical account is to come up with a counterexample. A counterexample against an analysis A of causation is a causal statement S (or the situation described by S) such that S is intuitively true but A predicts S to be false, or S is intuitively false but A predicts S to be true.

Besides such direct or first order intuitions about which causal statements are true, there are also intuitions of a more abstract kind. Such "second order" intuitions express general intuitive constraints on causality. One is the asymmetry between cause and effect: Given two particular events *c* and *e*, it is inacceptable that *c* is the (or a) cause of *e*, and that at the same time and for the same events *c* and *e*, *e* is the (or a) cause of *c*. This implies the intuition that no particular event causes itself.

Agreement with intuition would be the only criterion if the only aim of philosophical theorizing were conceptual analysis. Uncovering the conceptual structure expressed in ordinary language is, I take it, among the aims of ordinary language semantics and cognitive psychology. However, philosophical theories aim, at least sometimes, at the structure of reality. To discover it, philosophical analyses usually take common sense intuitions into account, but insofar as the conceptual structure of common sense is only a defeasible indicator of the structure of reality, philosophers will sometimes criticize common sense intuitions[11]. The aim of knowing the structure of reality is not hopeless insofar as science provides us with an access to reality that is in part independent of common sense. Here is one reason for which a philosophical theory cannot rest content with the criterion of agreement with common sense intuition. If there are mutually incompatible intuitions, a theory cannot both aim at representing reality and at being faithful to all intuitions. Reality cannot be inconsistent even though intuitions can. Another, though weaker, reason to think that philosophy must sometimes go beyond intuitions, is that none of the philosophical accounts of causation proposed so far agrees with all intuitions. In other words, there are counterexamples to all of them[12].

Some (but not all) authors also consider it to be essential for a satisfactory analysis of causation to be compatible with contemporary science. If the theory of special relativity tells us that two points in space-time are at a "space-like" distance, which means that the distance

[11] In Strawson's (1959) terms, "descriptive metaphysics" aims at uncovering and analyzing the conceptual structure underlying common sense judgments, whereas "revisionary metaphysics" also intends to criticize and improve it.
[12] Some counterexamples will be considered below, in section 3. In section 4 below, I will put forward an account that is compatible with most intuitions as well as with science. However, it is revisionary in contradicting some intuitions, e.g. those that take omissions to be causes.

between them cannot be bridged by any physical process, not even if it has the speed of light, no account of causation is acceptable that judges them to be causally related.

However, it may turn out to be impossible to satisfy agreement with all intuitions and with science, while preserving coherence. Here is an example of a conflict among intuitions, in this case between direct intuitions and the requirement of the asymmetry of causation. Ice cubes cool drinks. Let us call *c* a particular melting of an ice cube in a particular glass of water, and *e*, a subsequent drop in the temperature of water in that glass. Intuitively, *c* causes *e*. The melting of the ice cube causes the cooling of the water. But now consider what happens from the point of view of the water. The event *e*, the cooling of the water, can also be described as the event of the water's giving off some heat. For some material object to cool down just is the object's losing part of its heat. But now we can see that it is precisely the heat lost by the water that is transferred to the ice cube and that it is precisely the transference of this quantity that melts the ice. Therefore, we find, in violation of the principle of the asymmetry of causation, that both *c* causes *e* and *e* causes *c*.

Here is a simple conflict between intuition and science. The propagation of the peak of a wave propagating on the surface of a lake appears to be a causal process but it is not, as can be seen from the fact that the speed of the peak of a wave can exceed the speed of light, something no causal process can do[13].

In sum, philosophical research on causation is conducted on the background of three different criteria of adequacy: 1) overall coherence of the set of causal statements judged true by the theory, 2) agreement with intuitions and 3) agreement with contemporary science. It turns out to be impossible to meet all these criteria, which makes it necessary to rank them by their relative importance. Different rankings yield different types of philosophical analyses of causation.

For a philosophical theory, coherence is not negotiable[14]. Ranking agreement with common sense over agreement with science, or disregarding agreement with science altogether, is justified if the main task of philosophy is taken to be conceptual analysis. The task of science is to find out about the structure of reality, whereas philosophy should limit itself to uncovering and

[13] The peak of a wave travels with so-called "phase velocity". In certain circumstances, "the phase velocity *does* exceed c [i.e. the speed of light; M.K.], but that does not mean that it is in conflict with the theory of relativity." Crawford (1968, p. 170).

[14] The analysis of linguistic practices or intuitive judgments will often show that such judgments are incoherent. Such incoherence raises no problem for semantics or cognitive psychology: A theory of representations can be correct even if the representations are mutually inconsistent.

analyzing the structure of our conceptual system[15]. The problem is that there is no guarantee that our intuitive conceptual system does not yield incoherent causal judgments. If two intuitively true causal judgments contradict either each other or some general principle such as the asymmetry of causation, as is the case with our two judgments on the melting ice cube, coherence must be restored by rejecting one or several intuitively true causal judgments. One of the judgments on the ice cube - that it cools the water and that the water heats it - must be false although both are intuitively correct. However, there seems to be no way of deciding which intuition to keep and which to abandon. As intuitions, they seem equally compelling.

This problem can be solved by requiring agreement with science, and ranking it over agreement with common sense. In case of conflict between intuitions, science decides which to keep and which to abandon. Such a choice of criteria of adequacy characterizes a different conception of the task of a philosophical account of causation, according to which causation is an objective part of the structure of reality. More precisely, causation is a natural kind of relation (or process)[16], in the sense in which gold, water, cats, or humans can be conceived of as natural kinds of substances or individuals.

The concept of a natural kind is traditionally defined by distinguishing it from kinds of artefacts (such as screwdriver) or common sense kinds (such as grass): Kinds of artefacts and common sense kinds have a *nominal essence*, in other words some set of defining features, but the objects belonging to such kinds do not share any common intrinsic property. They have no *real essence*[17]. The kind "screwdriver" can be defined in functional terms (an object that can be used to screw or unscrew screws), but what makes a screwdriver a screwdriver is no feature of the screwdriver itself. Its being a screwdriver depends on its being used as such by an agent. If I use one half of a pair of scissors as a screwdriver, it thereby becomes a screwdriver, at least on that occasion.

Contrary to artefacts, natural kinds have a real essence. The real essence of gold is the property of being (mostly) composed of atoms with atomic number 79. This is an objective feature possessed by all and only samples of gold. If we consider causation as a natural kind concept, agreement with science will be ranked higher than agreement with common sense

[15] This conception of philosophy has been forcefully defended by Jackson (1998).

[16] I owe this idea to E.J. Lowe (personal communication).

[17] The concept of a real essence has been introduced in the 17th century by Locke. It is the modern descendant of the Aristotelian notion of secondary substance, and of the medieval notion of substantial form.

intuition. We have seen that conceptual analysis theories have no principled reason to reject one or the other of two incompatible causal judgments. Agreement with science may at least sometimes provide an objective ground for choosing. From the point of view of the physical process of heat transfer linking the melting of the ice cube and the cooling of the water, the water heats the ice cube, not the other way round.

Accepting agreement with contemporary scientific knowledge as a criterion of adequacy can also be a source of conflicts. Sometimes, conflicts between intuition and science are resolved by integrating scientific knowledge into common sense. Thus, at some point after the seventeenth century it has become part of common sense that the earth moves and revolves around the sun. However, not all such conflicts have been resolved in this way. I have mentioned above that the propagation of the peak of a wave is not a causal process. However, it is intuitively obvious that waves, such as tsunamis, can cause a lot of destruction. From a scientific point of view, the conflict is due to the fact that common sense does not distinguish the propagation of a wave packet (which is a causal process) and the propagation of a particular phase of a wave, such as its peak (which is not a causal process). In a theory of causation that takes it to be a natural kind, some common sense causal judgments are rejected even though they are not in conflict with other common sense judgments, but because they are incompatible with science.

The fact that scientific knowledge gets absorbed, sometimes after having overcome some resistance, into common sense, has consequences for the philosophical analysis of causation. If the task of philosophical analysis is pure conceptual analysis, causation itself changes each time some relevant piece of scientific knowledge gets integrated into common sense. But if the task of a philosophical theory of causation is taken to be the elaboration of a natural kind concept, causation is independent of how much science common sense has absorbed. We learn more and more about causation, just as we learn more about gold, but this progress of our knowledge does not result in any change in causation itself.

Recourse to science is the only non arbitrary way of resolving conflicts among intuitive judgments. The fact that scientific judgments are rationally justified makes it also rational to give priority to scientific judgments in cases of conflict between science and intuition. My aim in what follows will therefore be to construct an account of causation as a natural kind of relation.

4. Counterexamples to traditional philosophical accounts of causation

Bearing in mind what we just have found out about the task of a philosophical account of causation, let us look at some counterexamples to the analyses of causation mentioned above[18].

According to the DN analysis, the causal relation is equivalent to the relation between premises and conclusion of a scientific explanation, which is analyzed in its turn as a DN argument. Many explanations are counterexamples against the DN analysis of causation. One can construct a DN argument that deduces the height of a tower from the length of the shadow it casts[19]; and one can construct a DN argument in which a storm is explained by the falling of the barometer preceding it. Nevertheless, the length of the shadow is not among the causes of the height of the tower, and the falling of the barometer is not among the causes of the storm.

According to the fundamental hypothesis of probabilistic analyses, A is a cause of B if and only if (1) the occurrence of A raises the probability of the occurrence of B, such that $P(B|A) > P(B|\neg A)$, and (2) this inequality is not due to a common cause[20] of A and B: there is no C, such that $P(B|A\&C) = P(B|\neg A\&C)$. However, probabilistic analyses are ill tuned to account for causality between particular events. Conditions (1) and (2) are not *sufficient* for a token event a (of type A) to be a cause of a token event b (of type B). Although smoking raises the probability of getting lung cancer, John's smoking may well not cause his getting cancer. Even if John smokes and gets lung cancer, the cause of his disease may be his inhalation of asbestos dust, not his smoking. Here is a situation[21] showing that it is not *necessary* for particular event a (of type A) to cause particular event b (of type B), that A raises the probability of B at the type level. Being myself very bad at shooting, I find myself in company of a good hunter who hands me his rifle at the sight of a deer. The situation is such that he shoots if (and only if) I don't. Then my firing the rifle may kill the deer although it *lowers* the probability of the deer's getting killed.

At the level of types, the main problem for probabilistic analyses is the dependence of conditional probabilities on the choice of variables. Say one finds that, in a given set, the conditional probability of factor B given factor A is higher than the probability of B in the absence of A: $P(B|A) > P(B|\neg A)$. If the set in which these probabilities are measured is not homogeneous with respect to other variables that influence B, there is no guarantee that the

[18] For more comprehensive presentations of the contemporary debate on causation, see Kistler (2002), Kistler (2011), and Schaffer (2003).
[19] This example is from Bromberger (1966).
[20] Such a common cause is often called a "screening factor".

inequality is due to a causal influence of A on B. Consider the following scenario, loosely based on a famous discrimination suit brought against the University of California, Berkeley[22]. The University is accused of discriminating against women, on the basis of the observation that the probability to be admitted (B) is higher for male applicants (A) than for female ($\neg$A): P(B|A) > P(B|$\neg$A). It turns out that this inequality reverses once the set of candidates is partitioned according to the departments they apply to. Both history (C) and geography ($\neg$C) in fact favour women over men, so that: P(B|A & C) < P(B|$\neg$A & C) and P(B|A & $\neg$C) < P(B|$\neg$A & $\neg$C). The explanation of this reversal, which is an instance of "Simpson's paradox"[23], is that women apply more often than men in history where the probability of success is much lower than in geography. Cartwright (1983) shows that this difficulty can be overcome by taking into account *all* factors that might possibly influence the candidates' admission. However, it is controversial whether it makes sense to make use of conditional probabilities taken over populations that are homogeneous with respect to all factors that influence the effect factor[24].

The counterfactual account has been criticised among other reasons, because some effects do not seem to depend counterfactually on their causes, for example because the cause is accompanied by a back-up factor. Assume your stomach contains enzymes A and B, which can both decompose protein C, and A is more reactive, in the sense that B steps in if and only if A is absent. Then, take a situation in which A has caused decomposition of C. Given the presence of the back-up cause B, it is not true that the decomposition of C is counterfactually dependent on the presence of A: it would have occurred even in the absence of A, because it would then have been caused by B. Situations of this type are often referred to with the expression "redundant causation" or "pre-emption"[25]. In our case, A causes C, B is a redundant cause of C, and B's causing C is said to be "pre-empted" by A's causing C. This shows that counterfactual dependence is not *necessary* for causation. Another problem is raised by the fact that an event *b* may counterfactually depend on some event *a* that is not among its causes, for example because *a*

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[21] Cf. Edgington (1997, p. 420).
[22] Cf. Cartwright (1983, p. 37).
[23] Cf. Malinas and Bigelow (2009).
[24] Cartwright (1983, p. 38) and Hardcastle (1991) defend this solution, whereas Dupre and Cartwright (1988) argue against it. The requirement of using probabilities taken over homogenous sets raises two problems: the first is that it requires that one already knows which factors influence the effect variable, threatening the account with circularity. The second is that it undermines the very reason to use probabilities as a means to analyze causality: intermediate probabilities between 0 and 1 reflect the fact that one cannot practically take into account all factors influencing the effect variable (Kistler 2002).
[25] Cf. Wolff, this volume, and Thomason, this volume.

and *b* are effects of a common cause. This shows that counterfactual dependence is not *sufficient* for causation either.

According to transference accounts, which are an important subclass of process theories of causation[26], event *a* is a cause of event *b* if and only if something, such as a particular amount of energy, is transferred between events *a* and *b*. The main problem for such approaches is that we judge causal many relations such as omission, prevention, interruption or disconnection, in which nothing flows from cause to effect: if I cause a shortage in gas by shutting down the pipeline, there seems to be no transmission whatsoever between cause and effect.

5. Two kinds of intuition about causation

The intuitions behind the counterexamples to the accounts mentioned seem to fall in two categories. Most counterexamples to the DN, probabilistic and counterfactual accounts rely on the intuition that transference of energy (or of some other conserved quantity) is necessary or sufficient for causation. The judgment that the falling of the barometer is not among the causes of the storm following it is grounded on the fact that nothing flows or is transmitted from the falling of the barometer to the storm; the causal processes transferring energy to both of these events originate from a third event, the drop of atmospheric pressure, which causes both the falling of the barometer and the storm. The judgment according to which I, and not the expert hunter, am the cause of the deer's getting shot, is grounded on the fact that there is a process of transmission, corresponding to the trajectory of the bullet, linking my shooting to the death of the deer, but no such process between the hunter and the death of the deer, although the deer's death does not counterfactually depend on my shooting and my shooting lowers the probability of its death. An analysis of causation in terms of transference can account for both intuitions.

On the other hand, counterexamples to the transference account rely on the intuition that nomic dependency is sufficient for causation. The judgment according to which shutting down the pipeline causes a shortage in gas, seems to be justified by a lawful dependence between supply of gas and transport of the gas through the pipeline. The interruption statement is made true by the same dependence: failure of supply determines absence of gas, just as supply determines presence of gas. Therefore, the intuition that a failure of supply through the pipeline

[26] Cf. Wolff, this volume.

causes the shortage of gas can be accounted for by theories that reduce causation to nomic dependency (DN analysis) or to relations closely related to nomic dependency, such as counterfactual dependency, probability raising and manipulability[27]. These intuitions are grounded on what Hall (2004) calls the "dependence" concept of causation[28].

We seem to face a dilemma: either nomic dependency is necessary and sufficient for causation or transference is necessary and sufficient. The former hypothesis seems to be refuted by intuitive causal judgments about situations where a common cause has two effects, between which there is nomic dependence but no causation, or in which the cause of a given event is accompanied by a back-up cause. The latter hypothesis seems to be refuted by intuitive causal judgments in which a negative event is the cause, as in omission, or the effect, as in prevention or disconnection. Some philosophers have taken this predicament as a reason to embrace eliminativism[29], scepticism[30], or pluralism[31]. The eliminativist judges that no coherent analysis of the concept of causation is possible, and concludes that it must therefore be eliminated from a scientifically and philosophically informed world-view. The sceptic argues that the central role of our concept of causation in our thinking makes it uneliminable but that it is impossible to understand or coherently analyse it, because all possible conceptual analyses of causation have been explored and found wanting. Pluralists argue that the failure to find a satisfying account of causation is due to the erroneous supposition that there is only one such concept; once it is assumed that there are different types of causation, different and satisfying analyses can be found for each of them.

However, we should not give up so easily the search for a unified account of causation. Here is my strategy for constructing an account of causation that is compatible with science and, as far as possible, with intuition. In section 6, I will review the syntactic and semantic analysis of common sense causal statements in order to find a hypothesis about the structure of common sense intuitions. Section 7 then suggests which natural kinds of relations, in the sense explained above, provide the best fit with both scientific knowledge and intuitions having that structure.

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[27] In section 5 below, we shall return to negative causes and effects.
[28] See also Wolff, this volume.
[29] The classic statement of eliminativism with respect to causation is in Russell (1912).
[30] See Schaffer (2006).
[31] Hall (2004), Reiss (2009), Psillos (2009). Against pluralists, Wolff, this volume, argues that a unified account of causation can be built in the framework of force dynamics.

6. Two kinds of causal statements

In this section, I will review results of the linguistic and philosophical analysis of ordinary causal statements, in order to uncover the structure of the intuitions described above, and in particular to discover the nature of the relata of causation[32]. Here are five statements about a situation in which something about the fact that Mary sings surprises me, or causes my surprise.

(1) Her performing the song surprised me.

(2) That she performed the song surprised me.

(3) The fact that she performed the song surprised me.

(4) The performing of the song surprised me.

(5) The performance of the song surprised me.

With respect to their meaning, the expressions referring to the cause in these expressions fall into two categories. The expressions (1a), (2a), and (3a) designating the cause respectively in (1), (2) and (3), are *factive*, whereas the expressions (4a) and (5a) designating the cause in (4) and (5) are "*eventive*", in a sense to be explained below.

The following expressions are factive insofar as they make reference to facts or factive entities:

(1a) her performing the song.

(2a) that she performed the song.

(3a) the fact that she performed the song.

We shall say more in a moment about the facts or factive entities these expressions refer to. The following expressions are on the contrary eventive insofar as they make reference to events:

(4a) the performing of the song.

(5a) the performance of the song.

Let me say some words about the syntactic structure of these factive and eventive expressions designating causes. Here is a hypothesis about the syntactic structure of expressions

[32] What follows is based on Kistler (1999) and (2006). The linguistic analyses are due to Vendler (1967a; 1967b) and Zucchi (1993).

of type G ("verbal gerund", such as (1a)), type P ("perfect gerund", such as (4a)), and type D ("derived nominal", such as (5a))[33]:

(G) [NP [NP Her] [VP performing the song]][34]

(P) [NP [Det The] [N' [N performing] [PP of the song]]]

(D) [NP [Det The] [N' [N performance] [PP of the song]]]

This analysis supports the following hypothesis:

(H1) Nominal phrases (NP) of type G contain a verbal phrase (VP);

NPs of type P and D do not contain any VP.

H1 can be justified by the fact that it can explain a number of grammatical differences between G, P and D:

Expressions of types D and P, but not expressions of type G, can take an article (definite or indefinite).

(6) The performing of the song (Zucchi, p. 38)

(7) * the performing the song (Zucchi, p. 51)

Expressions P and D, but not G, can be modified by an adjective.

(8) "The beautiful singing of the song we heard (Vendler 1967a, p. 707),

(9) * "His beautiful performing the song" (Zucchi, p. 53)

Expressions of type G, but not those of types P and D, can be modified by adverbs.

(10) her beautifully performing the song

(11) * her beautifully performing of the song

G, but not P, can be negated.

(12) her not performing the song

(13) *her not performing of the song

(H1) explains these facts because VPs can be modified by adverbs and can be negated, whereas typical NPs take an article and can be modified by an adjective[35].

[33] The distinction is due to Vendler (1967a; 1967b) and has been elaborated by Bennett (1988) and Zucchi (1993).
[34] Zucchi (1993), p. 48, attributes this analysis to Chomsky (1981).
[35] "[…] the noun phrases typically associated with the 'fact'-group turn out to be imperfectly nominalized sentences, whereas those appropriate to the 'event'-group are exclusively perfectly nominalized sentences. The difference

These syntactic differences are linked to semantic differences that are crucial for our purposes. Here is a hypothesis about the semantic difference concerning their reference, between expressions of type G and expressions of type P and D.

(H2) Expressions of type G designate facts; expressions of types P and D designate events.

Let us look at the meaning that expressions of types G, P and D take in the context of causal statements, with the help of the statements about Mary's song and the surprise it causes. Imagine that Mary uses to perform the song at home but that she is afraid of doing it before a large audience. Now I learn that she performed the song on the stage of the Paris Opera.

In this situation, statements (1), (2) and (3) are *false*. (1), (2) and (3) are all false, for they say that it is *the fact that* she performed the song that caused my surprise. However, it is not the fact that she performed the song, but the *particular circumstances under which* she did it, that are responsible for my surprise. On the other hand, statements (4) and (5) are *true* in that situation, for there is *something about* her performance that causes my surprise. It is true that, as (5) says, Mary's performance, as a particular event, caused my surprise. The crucial difference is that events are particulars, and thus have properties that are not named in the expressions that refer to them, whereas the structure of a fact corresponds to the structure of the proposition expressing it: The proposition "Mary sings" refers to the fact that Mary sings, which is composed by an object and a property. This suggests that expressions of types G, P and D keep their usual meaning, even when they are embedded in causal contexts: G-expressions designate facts, P- and D-expressions designate events.

(H3) Gerundive nominalizations of type G and P and derived event nouns of type D have their usual meaning within causal contexts.

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between these two kinds of nominal is the following. In the imperfect nominal the verb keeps some of its verb-like features: it retains the verb-object intact; tenses, modals and adverbs may be present; and the whole structure is subject to negation. The verb in the perfect nominal sheds these verb-like features and behaves like a noun: it may take relative clauses, adjectives, articles, and prepositions." (Vendler 1967a, p. 707)

Causal statements can contain expressions of both types. This suggests that the causal predicate can also take two different meanings, corresponding to the expressions designating the cause and the effect. There are two types of causal statements, expressing two aspects of the concept of causation[36]. I will call "causation" the relation expressed by eventive causal statements, in which the argument places of the causal verb are filled by expressions (of type P or D) designating events. I will call "causal responsibility" the relation expressed by factive causal statements, in which the argument places of the causal verb are filled by factive expressions, in other words, expressions (of type G) designating facts.

(H4) There are causal statements of two types, one expressing causation between events, the other causal responsibility of one fact for another fact.

In order to uncover the conceptual structure of the relations of causation and causal responsibility and the articulation of the two, one strategy is to examine the inferences that can validly be drawn from causal statements of one type to causal statements of the other type. What we find is that factual causal statements always[37] entail eventive causal statements. In the simplest type of a factive causal statement, the cause is the fact F_1 that event *c* has property G; the effect is the fact F_2 that the event *e* has the property H. The form of an elementary factive causal statement is C_R (Gc, He): The fact that *c* is G is causally responsible (abridged by "C_R") for the fact that *e* is H. From factive causal statements of that form, one can infer an eventive causal statement: *c* causes *e*.

Take proposition (2): That she performed the song surprised me. According to our analysis, the cause is a fact (that *c* is F) and consists of the possession of a property F by an event *c*. F is the property of performing the song. True, (2) attributes this property to an object (in fact a person, Mary), rather than to an event. However, causes are situated in time, and it is only a certain temporal part of Mary whose possession of F is the cause of my surprise. (2) says that the cause of my surprise is the fact that she, at a certain time (event c), has the property F of performing the song.

[36] Hall (2004) argues that there are two concepts of causation. However, it is more correct to speak of two aspects because, as I will argue, one is part of the other.
[37] In section 8 below, we will consider apparent counterexamples to this claim.

Proposition (2) entails proposition (4): The performing of the song surprised me. If the fact that she performed it surprised me, then something about the event of the performance surprised me, and therefore, the event (*c*) surprised me.

However, the opposite is not true. (4) may be true because some unusual aspect of the performance has caused my surprise, while the mere fact that she performs it would not have been surprising. In other words, (4), or for that matter (5), do not entail any of (1), (2), or (3). In fact, eventive causal statements never entail factual statements. An eventive causal statement according to which event *c* causes event *e* – symbolized by C(*c*,*e*) - never contains information about what it is about the cause *c*, in other words about which fact it is concerning event *c*, that is causally responsible for some fact about *e*.

7. Causal relations and causal responsibility

We can explain the possibility of inferring eventive statements from factive causal statements, and the impossibility of making inferences in the reverse direction, by making a simple hypothesis about *what makes those statements true,* in other words, about their *truthmakers*. I suggest that what makes the eventive statement C(*c*, *e*) true is *part of* what makes the factive statement C_R(Gc, He) true. The factive statement C_R(Gc, He) has the meaning of a *conjunction* that contains C(*c*, *e*) as one conjunct.

Let me say a few words at this point on the notion of a truthmaker of a statement or proposition[38]. According to the traditional correspondence theory of truth, a proposition *p* is true if and only if there is some fact *f* that has the same structure as *p,* so that for each constituent of *p*, there is a corresponding constituent of *f.* The proposition that Desdemona loves Cassio is true if and only if there is a fact consisting of Desdemona, Cassio, and the relation of the former loving the latter[39]. The notion of truthmaker is grounded on the fundamental idea that if a statement is true, or is a "truth", this is due to some fact. "The idea of a truthmaker for a particular truth […] is just some existent, some portion of reality, in virtue of which that truth is true." (Armstrong 2004, p. 5) The concept of a truthmaker preserves the central idea of the correspondence theory of truth, but denies that there is always a one-to-one correspondence between true propositions

[38] Cf. Armstrong (2004).
[39] Cf. Russell (1912a), and Engel (2002).

(truths) and facts by virtue of which they are true. For many kinds of true propositions, there does not seem to exist any fact that shares its structure and has corresponding components. In particular, there do not seem to be facts corresponding to negative propositions. The proposition that Theaetetus is not flying is true although there is no fact constituted by Theaetetus and the negative property of not-flying. If we take properties to be what David Lewis calls "sparse" properties[40], there are no negative properties that would mirror negated predicates[41]. There are also many cases where one fact makes true many different propositions. If fact *f* makes true proposition *p*, then, for any arbitrary proposition *q*, *f* makes also true $p \vee q$. Moreover, most, if not all, propositions are made true by many facts. If *f* makes true *p*, then, for any arbitrary fact *g*, $f \wedge g$ makes also true *p*. Each individual human being is a truth-maker for the truth that there are human beings (Armstrong 2004, p. 21), and the world as a whole (the conjunction of all facts[42]) is a truth-maker for every truth (Armstrong 2004, p. 18). In what follows, the expression "truth-maker for *p*" will be short-hand for "minimal truth-maker for *p*", which is such that "you cannot subtract anything from [it] and the remainder still be a truthmaker for *p*" (Armstrong 2004, p. 19). I will use the concept of truthmaking as a means to achieve the second step of the strategy announced above: find natural kinds of relation that fit as well as possible both with scientific knowledge and with the intuitions uncovered by the analysis of common sense causal statements.

Here is my suggestion. The truthmaker of a factive causal statement of the form C_R(Gc, He), saying that the fact that *c* is G is causally responsible for the fact that *e* is H, is equivalent to the conjunction: $C(c,e) \wedge Gc \wedge He \wedge L(G,H)$, where the latter conjunct represents a law of nature linking property G to property H. On this analysis, the truth of C_R(Gc, He) entails the existence of a causal relation between the events *c* and *e* (first conjunct), the possession of property G by the cause event (second conjunct), the possession of property H by the effect event (third conjunct) and the existence of a relation of nomological dependence (i.e. a law of nature) between the

[40]The distinction between "sparse" or "natural" properties and "abundant" properties has been introduced by Armstrong and Lewis. The sparse properties are those "perfectly natural" (Lewis 1986a, p. 61) properties that "carve [nature] at the joints" (Lewis 1986a, p. 60). We may rely on science to find out what they are. Cf. Armstrong (1979, p. 8). By contrast, "abundant" properties correspond to the semantic value of arbitrary meaningful predicates. My desk has the abundant property of being "wooden or pink" simply because it is wooden, and therefore wooden or pink. Sharing a natural property, but not sharing an abundant property, makes objects qualitatively similar.

[41] Armstrong (2004, p. 58) argues that the truthmaker of a negative statement such as "Theaetetus is not flying" is the conjunction of all first-order states of affairs (or facts) corresponding to the ("positive") properties of Theaetetus, together with the higher-order state of affairs that these are all states of affairs involving Theaetetus.

[42] Cf. Armstrong 1997, chap. 8.8.

properties G and H (fourth conjunct). The first conjunct is the truthmaker of an eventive causal statement[43].

Our analysis of the relation between eventive causal statements and laws looks almost exactly like the converse of an analysis suggested by Davidson. "Very often", he says, "our justification for accepting a singular causal statement is that we have reason to believe an appropriate causal law exists, though we do not know what it is" (Davidson 1967, p. 160). This suggests the following analysis: C(c,e) only if there are G, H and a law L(G,H) such that C_R(Gc,He). One might then try to turn this necessary condition into the following necessary and sufficient condition by adding the existence of a relation of transference between *c* and *e*[44]:

(E) C(c,e) if and only if there is a relation of transference between *c* and *e* and there are G, H and a law L(G,H), such that C_R(Gc, He).

Indeed, C(c,e) is made true by a relation of transmission of conserved quantities between *c* and *e*. This guarantees that there is a conserved quantity F=G instantiated by *c* and *e* and a conservation law linking these instances. However, their apparent similarity hides an important difference between the analysis of C_R(Gc, He) and (E). The former shows that factive causal statements contain explicit information about which property G of the cause is responsible for a given property H of the effect, whereas the latter shows that the truth of an eventive statement only guarantees the *existence* of properties G, H and a law linking them, without containing explicit information about what they are.

The two sorts of truthmakers, for factive and eventive causal statements, satisfy both requirements we have set out in beginning of the paper (section 2). They are promising candidates for being "natural kinds of relations", which means that they 1) are in general in agreement with intuitions and 2) can be the object of scientific investigation.

The truthmaker of eventive causal statements is a transmission relation between events. Such statements express the intuition that causation is grounded on some mechanical process of transference. The exact nature of the transference relation, and in particular of what is transferred, is discovered progressively by scientific inquiry: It was first suggested that what is transferred is energy, force, or information, but the most plausible hypothesis now seems to be that it is an amount of some conserved quantity[45].

[43] We return to the nature of this truthmaker in a moment.
[44] This alternative analysis has been suggested to me by Isabelle Drouet.
[45] Energy is a conserved quantity, whereas force and information are not. See Kistler (1998, p. 21, note 20).

However, such eventive causal statements are rather exceptional. The reason is that the information they provide is sufficiently informative only in exceptional circumstances. As a reply to most requests for causal explanation, an explanation of a given effect is accepted as satisfactory only if it goes beyond the mere indication of the identity of the cause event. In general, one wants to know in addition *what it is about* the cause event that is responsible for a certain *aspect* of the effect event. Eventive statements cannot provide such information, but factive statements can[46]. The latter express, over and above the transference aspect, the aspect of nomological dependence between the relevant properties of cause and effect. The truthmaker of factive causal statements, the relation of causal responsibility, contains the truthmaker of eventive statements as a part. The other part of it is the relation of nomic dependence: It satisfies our requirements because 1) science can enquire whether there are laws of nature underlying a given dependency between types of events, and which these laws are, and 2) lawful dependence accounts for the intuitions that motivate the alternative approaches to the transference account, DN, counterfactual, probability raising and interventionism.

How can this analysis justify common sense causal judgments such as our proposition (2): That she performed the song surprised me? First, (2) can only be true if there is some process of transmission originating from an event including Mary on the scene and myself immediately afterwards. The first part of the process is the propagation of light from Mary to the retina of my eyes; the second is the process of transmission of nervous signals from my retinas to my cortex. At the level of properties, the propagation of light from the scene to the retina, the transduction of the incoming light into a nervous signal, and the transmission of the signal through the cortex all obey laws. We are certainly far from understanding which incoming signals will lead, in a given background of representations, to surprise. However, according to our hypothesis, the claim that the fact that Mary performed is causally responsible for the fact that I am surprised can only be true if there are such laws[47].

8. The challenge of negative causes and effects

[46] This is compatible with the result of Bennett's analysis of the difference between causal statements of these two kinds. "Event-causation statements … are not very informative, because they existentially quantify over a class of fact-causation statements… The language of fact causation is more sensitive and flexible than the other. This fits it for use in reporting causal connections in fine-grained and unmisleading ways of which the language of event causation is quite incapable." (Bennett 1988, p. 139).

For lack of space, I cannot provide here a full defence of the account of causation suggested above. In this last section, I will just address two major objections. According to the first, there is no causation between facts; according to the second, there is no causation between events.

According to Davidson (1967), causation is exclusively a relation between events. Genuine causal statements express a relation between events; the statements we have called "factive causal statements" are not causal statements in the strict sense, i.e. they do not make reference to causal relations. Rather, they are "rudimentary causal explanations", and "explanations typically relate statements, not events" (Davidson 1967, p. 161). True, a factive statement of the form $C_R(Gc, He)$ contains more information, and is thus more explanatory, than the corresponding eventive statement $C(c, e)$. After all, the latter only tells us *that c* causes *e*, but not *why*. The factive statement indicates which property of the cause is responsible for a given property of the effect. However, the fact that causal explanations typically contain additional information about the causal relata, over and above their mere identity as events, is not sufficient to establish that such explanations do not make reference to causal relations at all. Here are two arguments for the claim that they do.

First, there are situations in which it is explanatory to merely indicate the event *c* that is the cause of a given event *e*. If you already know that the fire broke out because a short-circuit overheated the wire, you may be looking for the crucial additional bit of information of when and where that short-circuit occurred. You might already know that the explanation is either that a short circuit in the kitchen caused the fire $C_R(Gc_1, He)$ or that a short-circuit in the bathroom caused the fire $C_R(Gc_2, He)$. The mere indication of whether the short circuit occurred at event c_1 (containing an appropriate part of the kitchen at the appropriate time) or event c_2 (containing an appropriate part of the bathroom at the appropriate time) fills this informational gap. Here, I take events to be what fills a given space-time region[48]. This shows that, contrary to what Davidson suggests, giving information on the causes of an event can be a way of explaining it.

Second, the fact that factive causal statements always entail eventive causal statements, shows that factive causal statements bear on causal relations. Our analysis explains the possibility

[47] The relevant laws are partly "laws in situ" (Cummins 2000, p. 121), which hold only for specific systems in specific circumstances.
[48] Quine (1985), Kistler (2006).

of such an entailment by the fact that the truthmaker of a factive statement contains the truthmaker of an eventive causal statement. The latter, the causal relation between events C(c,e), is part of the former, the causal responsibility of a fact Fc concerning the cause, for a fact He concerning the effect.

Let us now turn to a second objection to our account, which has been very influential in convincing many philosophers that causation is not a relation between events[49], and does not require any transference. Some factive causal statements do not seem to make reference to any cause event. Thus, it can be argued that, if there are true factive causal statements whose terms do not directly bear on cause and effect events, causation does not require any relation such as transference between events.

Let us have a closer look at how Mellor (1987) argues that causes and effects are facts, not events. Here is his example of a causal statement with negative expressions for both cause and effect:

(6) "Don […] did not die because he did not fall." (Mellor 1987, p. 207)

Mellor's argument has the form of a reductio of Davidson's (1967) thesis that causes and effects are events. If Davidson's analysis were correct, he says, the cause and effect expressions in (6) would make reference to events, i.e. particulars[50]. Take the effect event. It would have to be the event of Don's not dying. But now Mellor argues that there is no such event as Don's non-dying because it would be a negative particular; and there are no negative particulars[51]. His strategy consists in showing that if there were negative events, they would have contradictory properties. If Don's non-dying was an event, it would follow from Davidson's (1966) analysis that this event is both quick and slow. The reason is that "Don does not die" entails both "Don does not die quickly" and "Don does not die slowly". Now, if one applies Davidson's analysis to this case, the adverbs "quickly" and "slowly" qualifying Don's not dying, express, in the context of a causal statement, properties of the alleged event of Don's not dying. Thus, if there was such

[49] Horgan (1978), Mellor (1987). Vendler (1967a) argues that causes are facts whereas effects are events. According to his analysis, causal relations are hybrid in having terms belonging to different ontological categories. His arguments are based on linguistic evidence from causal statements in which a factual expression occupies the cause position and an eventive expression occupies the effect position.

[50] In metaphysics, entities that have properties are called "particulars", as opposed to those properties themselves.

[51] Mellor's argument takes its inspiration from Ramsey's (1925) analogous argument that there are no negative objects.

an event as Don's not dying, Davidson's analysis would entail that "Don's non-death will have to be both instant and slow; but it cannot be both, so it does not exist." (Mellor 1987, p. 208)[52]

Statements such as (6), in which negative expressions designate cause or effect or both raise a serious challenge to our analysis. Such negative expressions do not in general contain information on the events or properties involved in the relation of causal responsibility making true the causal statement. To answer the challenge, let us distinguish two kinds of such statements. In statements of the first kind, the expressions making reference to cause and effect contain explicit information on events causally related by transmission, but do not mention the properties taking part in the relation of causal responsibility. In the second kind of statement, the expressions making reference to cause and effect do not even contain explicit information on the underlying events. Let us consider them in turn.

(6) belongs to the first kind. Both the cause and the effect expression make reference to Don. Insofar as (6) can interpreted as a factive causal statement, our analysis predicts that its meaning can be analysed as: The fact that Don does not fall is causally responsible for the fact that Don does not die. No particular times are specified; however, for a given time at which the statement is true, we can take the cause event to be a "temporal part" (or "time-slice") of Don, and the effect event to be another, later temporal part of Don. Thus, the truthmaker of (6) is:

Is causally responsible for (Not fall (Don at t), Not die (Don at $t+dt$)).

The times t and $t+dt$ are not part of the content of (6); they are fixed by the context of utterance. (6) may be true for many instants t, through a whole stretch of time.

Here is my reply to Mellor's challenge: The fact that (6) does not contain any explicit information about the properties involved in the relation of causal responsibility, does not show that such properties do not exist. If (6) is true, there is a relation of causal responsibility that makes it true. What makes (6) appear problematic is the fact that its truthmaker does not mirror the structure of its linguistic expression. However, this is characteristic of all negative truths. Just

[52] Mellor's argument may seem invalid by an unfortunate choice of adjectives. "Quick" and "slow", as well as "tall" and "short" belong to the class of so-called attributive adjectives; contrary to predicative adjectives, such attributive adjectives are not in general equivalent to a predicate. A man can truthfully said to be both tall and short: He may be tall for a French adult man in 2012 but short for a professional basketball player. Similarly, the event of crossing the channel may be both slow and fast (Davidson 1966, p. 106/7): It may be slow with respect to channel crossings in general but fast with respect to channel crossings by swimming. On this point, cf. Egré, this volume. It is not valid to conclude from the premises that x is quick and that x is slow that x satisfies contrary predicates. If "quick" and "slow" do not express predicates, there need be no contradiction; therefore, these premises do not entail that x does not exist. However, Mellor's argument becomes valid as soon as one substitutes predicative adjectives for the attributive ones he actually uses.

like other negative statements, negative causal statements contain only partial or indirect information about their truthmakers. This does not show that they have no truthmakers. Recall that no eventive causal statement provides information about the properties involved in causal responsibility. Mellor himself suggests which properties may be part of the truthmaker of (6): for the cause, Don's hanging on at the time *t* of the cause, and for the effect, Don's surviving at time *t*+*dt*. (7) is a plausible hypothesis about the truthmaker of (6):

(7) Is causally responsible for (Hangs on (Don at *t*), Lives (Don at *t*+*dt*)).

In sum, the fact that statement (6) does not tell us which properties were responsible for the fact that Don survived at a certain time does not entail that there are no such properties, and it does not refute the thesis that causal responsibility is a relation between facts consisting in the possession of properties by events, or by objects at a time. Here is an example of a scientific causal statement in which a negative expression occupies the cause position.

(8) The fact that the repressor is not fixed on the operator is causally responsible for the fact that the protein is synthesized.

The context is the so-called "operon theory of gene expression", developed by Jacob and Monod in 1961. It puts forward a mechanism that explains why genes are expressed in proteins only in certain situations[53]. The production of a given protein by the mechanism of gene expression can be stopped when a so-called repressor protein gets fixed on a portion of DNA called the operator. Gene expression is then triggered by an "inductor" molecule that attaches to the repressor and detaches it from the operator, thereby making the way free for the process of gene expression.

Naming the cause by a negative expression, (8) is silent about the properties involved in triggering the transcription of the gene. As with all negative statements, one cannot read its truthmaker off from its linguistic structure. However, (8) has a truthmaker. Although not explicitly mentioned by (8), there is a "positive" property of the event implying the operator at

[53] Schaffner (1993, chap. 3) analyses the structure of the explanation provided by the operon theory of the regulation mechanism of protein expression. See also Morange (1998).

the relevant moment before the beginning of transcription, which plays a role in causal responsibility: It is the conformation[54] C of the operator molecule when it is not fixed to the repressor. Thus, the truthmaker of (8) may be

The fact that the operator has conformation C is causally responsible for the fact that the protein is synthesized.

To sum up, we have seen that negative causal statements of the first kind share the characteristics of other statements containing negative expressions: They provide only partial information about their truthmaker.

Let us now turn to the second category of causal statements in which one of the cause and effect expressions is negative: In statements of this type, the cause or effect expression (or both) contains explicit information neither about the cause event in the transmission sense nor about causally responsible facts about the events involved. Here is an example:

(9) The father's not holding back the child made her have an accident.

There has been considerable debate about such omission statements. According to some authors, they are causal statements and provide counterexamples to theories according to which causation requires transmission between events[55]. Others have argued that they are not strictly speaking causal[56], because a statement such as (9) does not directly express a causal relation. Indeed, (9) does not provide any information about the actual cause (of the accident); however, such statements may be useful because they carry relevant *counterfactual* information. (9) provides two pieces of information: 1. some not explicitly specified event caused the child's accident, and 2. if the father had held the child back that event would not have happened, and thus would not have caused the accident[57]. Here is a scientific example of the same kind[58].

(10) A mouse's lacking the fosB gene causes her offspring to die.

[54] Conformation is "any one of the infinite number of possible spatial arrangements of atoms in a molecule that result from rotation of its constituent groups of atoms about single bonds." (*Encyclopedia Britannica*, http://www.britannica.com/EBchecked/topic/132081/conformation).
[55] Schaffer (2000) and Wolff, this volume.
[56] Thomson (2003).
[57] Accounts of omissions along these lines can be found in Dowe (2000), chap. 6, Dowe (2001), Armstrong (2004), p. 64, Kistler (2006a).
[58] See Morange (1998).

The context is the genetic technique called "knock out", which allows producing strains of laboratory animals that lack a certain gene. It has been observed that transgenic mice that lack the fosB gene neglect their offspring. Like (9), (10) does not provide any information at all about the "positive" causes of the death of the mouse's offspring. However, it provides another piece of relevant information: the second part of the truthmaker of (10) is the truthmaker of the counterfactual statement that if the mouse had possessed gene fosB, it would have taken care of its offspring. Like (9), (10) provides information about counterfactual causal processes[59]. Such a negative causal statement presents the real situation as exceptional with respect to a normal situation[60] where the expression of the fosB gene leads to normal maternal care. The causal process leading to the effect (the child's accident or the offspring's death) is in some sense abnormal. The father's behaviour is abnormal with respect to moral obligation, the mouse's behaviour is abnormal both in a statistical sense and in the sense of adaptation or fitness.

9. Conclusion

The contemporary philosophical debate on causation has split in several independent research traditions, and many philosophers have abandoned the ambition of constructing a unified theory that yields the correct result in all cases. One reason for the failure to reach a consensus on

[59] It may seem puzzling that I suggest analyzing the meaning of omission sentences like (9) or statements attributing a causal role to an absence like (10) in terms of counterfactuals, after having argued above against counterfactual analysis of causation. However, there is no contradiction. What I have argued against above is the thesis that the concept of causation itself has a counterfactual meaning and can be analysed in terms of counterfactuals. Against this, I have argued that causation can be analysed in terms of transference and nomological dependence. This is perfectly compatible with the existence of statements which express counterfactual information about causal processes. What would be incompatible with my account would be the claim that these processes are themselves somehow equivalent to counterfactual dependence relations.

[60] According to several authors, the meaning of all (or least of typical) causal statements contains an implicit reference to the normal course of events. According to Mackie (1974), causes are identified relative to a background or "causal field". This idea has recently been taken up by Hitchcock (1996a; 1996b) and Menzies (2004; 2007). Copley and Harley, this volume, suggest that a cognitive system judging the forces structuring a given situation take the "normal field" of background forces into consideration although this normal field is not part of the meaning of causal expressions. Similarly, Thomason, this volume, argues that what is considered to be "normal" is implicit in the meaning of causal expressions: Causal processes are intuitively represented as having "inertial trajectories" (Thomason, this volume, p. 15), determining their evolution in the absence of external interference. By contrast, the reference to normal conditions in my analysis of sentences (9) and (10) is not meant to imply that such a reference is part of the concept of causation or of the meaning of all or most causal expressions. What I suggest is that normal conditions are part of the meaning of omission statements and other statements in which negative expressions occupy the role of the cause or the effect.

the analysis of causation is that there are two ways in which one may conceive of the aim of a philosophical theory of causation. Either the aim is to produce, by pure conceptual analysis, a systematic account of common sense intuitions, which may have to be corrected at some points to achieve coherence. Or the task is to find out what causation is in the real world. On the former conception, scientific knowledge is irrelevant; on the latter, agreement with science is not only a fundamental criterion of adequacy but ranks higher than agreement with intuition. I have argued for adopting the latter view.

We have seen that intuitions themselves fall in two categories: Some of them assimilate causation to nomic dependence, i.e. dependence according to laws of nature; others assimilate causation to a mechanical link between cause and effect. Furthermore, there are two types of causal statements, which can be distinguished according to linguistic criteria. Eventive causal statements express a relation between two events, which are referred to by nouns or perfect gerunds; factive causal statements express a relation of causal responsibility between two facts, which are referred to by imperfect gerunds or other expressions of a propositional type.

I have suggested an analysis of the causal relation that is in agreement with science, while at the same time respecting as far as possible the structure of common sense intuitions, which we have extracted from the analysis of causal statements and of the inference relations between them. I have suggested that an eventive causal statement is made true by a relation of transference between two events. This relation between events is part, but only part, of what makes true factive causal statements: The fact that *c*'s being F is causally responsible for *e*'s being H is made true by a complex relation consisting of 1) a transmission relation between the events *c* and *e* and 2) a relation of nomic dependency between their properties F and H. I have defended this two-fold analysis against arguments denying either facts or events the status of relata of causation. In particular, causal statements in which the expression referring to the cause or the effect has a negative form are often used to refute either the thesis that causation relates events or the thesis that causation between events requires transference. We have found that some of these statements are causal only in a derivative sense: they do not directly bear on a causal relation but provide counterfactual information about "normal" causal processes, where normality may be understood in terms of statistical average, biological fitness or morality[61].

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