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Chapter 10

Causation, Laws and Dispositions

Andreas Hüttemann

In this paper I will take a look at what I believe to be the best argument for dispositions. According to this argument we need dispositions in order to understand certain features of scientific practice (pp. 207-9). I will point out that these dispositions have to be continuously manifestable (pp. 209-11). Furthermore I will argue that dispositions are not the causes of their manifestations (pp. 211-13). Nevertheless, dispositions and causation are closely connected. What it is to be a cause can best be understood in terms of counterfactuals that are based on dispositions (pp. 213-9).

Why Do We Need Dispositions?

According to Galileo, in a vacuum all bodies fall with the same speed. Here is how Salviati, Galileo's spokesman, argued for this claim:

> We have already seen that the difference of speed between bodies of different specific gravities is most marked in those media which are the most resistant: thus, in a medium of quicksilver, gold not merely sinks more rapidly than lead but it is the only substance that will descend at all; all other metals and stones rise to the surface and float. On the other hand the variation of speed in air between balls of gold, lead, copper, porphyry, and other heavy materials is so slight that in a fall of 100 cubits a ball of gold would surely not outstrip one of copper by as much as four fingers. Having observed this I came to the conclusion that in a medium totally devoid of resistance all bodies would fall with the same speed.[1]

There are at least two noteworthy features in Salviati's argument.[2] Firstly, the law according to which all bodies fall with the same speed concerns a situation that is not realized. Secondly, there appears to be some kind of continuity between the actual and the counterfactual. Salviati is able to provide evidence for what would happen if the vacuum were realized. The historian of ideas Amos Funkenstein has

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[1] Galileo Galilei, trans. H. Crew and A. de Salvio, *Dialogues Concerning Two New Sciences* (New York, 1954), pp. 71-72.

[2] For an analysis of this passage see A. Bartels: 'The Idea which we call Power. Naturgesetze und Dispositionen', *Philosophia Naturalis*, 37 (2000): 255-268.

emphasized that this commensurability of the actual and the counterfactual was a new and characteristic feature of early modern physics.[3]

Let me turn to the issue of non-realization first. The law in question concerns the behaviour of a system under very special circumstances. It pertains to bodies falling in a vacuum. The question is not so much whether this situation ever gets realized. The point is rather that for the law to be established as well as for its being explanatorily useful, it does not seem to be necessary that it ever will.

This situation is typical of many laws. The law that hydrogen atoms behave according to Schrödinger's equation with the Coulomb-potential is valid in case there are no magnetic or electric fields. Newton's law of gravitation describes the behaviour of heavy bodies as long as there are no charges and no electro-magnetic fields. Crystals have a certain specific heat, given there are no disturbing factors such as impurities. Both for the testing of these laws, and for their being explanatorily useful, it is not necessary that the relevant conditions ever obtain.

The behaviour that laws of nature attribute to physical or other systems is in general not manifest under all conditions. It is manifest under certain conditions only. As long as these conditions are not realized, laws of nature are counterfactual claims. In physics these ascriptions typically concern systems in isolation, i.e. in the absence of disturbing factors. Another way of putting the same point is the observation that laws are often *ceteris paribus* laws. *If all else is equal, i.e.* if the relevant conditions are realized, the regular behaviour in question will be observed. So laws of nature describe how physical systems would behave if the systems were isolated, or if other ideal conditions were to obtain.

It is sometimes argued that laws of nature cannot be *ceteris paribus* laws, because if they were, they would be immune to empirical testing. It would always be possible to claim that the relevant conditions are not realized if an attempt to verify the law in question fails. This objection assumes that laws can only be tested by, and can only be explanatorily relevant for the regularities that are implied by the laws, i.e. it is assumed that laws can only be tested or explanatorily useful if the manifestation conditions are realized.

I take it that it is simply a fact about the science we have that, firstly, its laws describe ideal situations and, secondly, these laws can nevertheless be tested in, and are explanatorily relevant to less-than-ideal situations. The challenge is to explain how this is possible.

Cartwright's idea is that the introduction of what she calls 'capacities' rationalizes our scientific practice:

> When [...] disturbances are absent the factor manifests its power explicitly in its behaviour. When nothing else is going on, you can see what tendencies a factor has by looking at what it does. This tells you something about what will happen in very different, mixed

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[3] A. Funkenstein, *Theology and the Scientific Imagination* (Princeton, 1986), pp. 152-179.

> circumstances – but only if you assume that the factor has a fixed capacity that it carries with it from situation to situation.[4]

Something carries over from the ideal to the less-than-ideal. It is present and manifest under ideal circumstances. It is present but fails to be manifest in less-than-ideal circumstances.

Properties of systems which become manifest provided certain conditions are given are dispositional properties, as opposed to categorical or occurrent properties which are manifest under all circumstances. Solubility and fragility are dispositional properties. The systems in question have these properties under all circumstances, but the property becomes manifest only when certain manifestation or enabling conditions are given.

Thus, if we want to understand why *ceteris paribus* laws can be tested in, and are explanatorily relevant for non-ideal situations, we have to assume that something carries over. The systems in question have dispositional properties. This is Cartwright's argument for dispositions (or capacities). Put differently: If one thinks that laws of nature are explanatorily relevant only for those situations in which the regularities implied by the laws actually obtain, the use scientists make of these laws cannot be explained. It is only if what the law says somehow carries over from the ideal to the less-than-ideal that sense can be made of the scientific practice as illustrated by Salviati. The assumption of dispositions is the best explanation of certain features of our scientific practice.[5]

In what follows I will take a closer look at this argument. I am particularly interested in what we have to assume about these dispositions so that they can do the work they are supposed to do.

Continuously Manifestable Dispositions

The first thing to note is that not all dispositions will do the work the carrying-over-argument supposes them to do. Dispositions ought to explain how laws that describe the behaviour of systems under ideal circumstances can be tested in, and be explanatorily relevant for less-than-ideal situations. However, if a disposition fails to be partially manifest in less-than-ideal situations, then it is of no help. If the disposition's manifestation is an all or nothing affair, it will be impossible to attain empirical evidence for what will happen under ideal circumstances on the basis of the mere presence of the disposition. Thus, if the disposition is what I call a discontinuously manifestable disposition (DMD) then, even if it is true that it carries over from the ideal to the less-than-ideal, it will explain neither how we can test the ideal in non-ideal situations, nor the explanatory relevance of the ideal for the less-

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[4] N. Cartwright, *Nature's Capacities and their Measurement* (Oxford, 1989), p. 191.

[5] Elsewhere I have argued in more detail that theories of laws which do not assume dispositions cannot explain our explanatory practice. See A. Hüttemann: 'Laws and Dispositions', *Philosophy of Science*, 65 (1998): 121-135.

than-ideal. The reason is that DMDs are empirically inaccessible as long as the ideal circumstances are not realized. Fragility is an example of a DMD. A thing is either broken or it is not; fragility cannot be partially manifest.

Not all dispositions are *dis*continuously manifest. Continuously manifest dispositions (CMDs) allow for partial manifestations. If the partial manifestations are continuously ordered they permit an extrapolation. Here is an example which illustrates how one might get evidence for dispositions even though they are not completely manifest.

Lithium fluoride is a crystal. Its specific heat can be expressed as follows:

$$c_V = (12/5)\pi^4 n k_B \, (T/\theta_{\mathrm{D}}{}^{\mathrm{L}})^3$$

where c_V is the specific heat, if the volume is kept constant, n is the phonon-density, k_B the Boltzmann constant, T the temperature and $_{\mathrm{D}}$ the Debye-temperature – its value for Lithium fluoride being $\theta_{\mathrm{D}}{}^{\mathrm{L}} = 730$ K.

The law attributes a behaviour to the crystal in case there are no impurities that would work as disturbing factors. Even if this is a disposition that will never be completely manifest, we might nevertheless get empirical evidence for the disposition's being present. We may proceed as follows: First collect a few samples of impure lithium fluoride crystals. With the help of spectroscopic investigations and other means we will be able to find out the amount of impurities in the samples. We can therefore order them according to the degree that the manifestation condition for the disposition is realized. The fewer the impurities, the more the relevant condition is realized. If we measure the specific heat of all of these samples, we are able to extrapolate to the behaviour of the pure system as the limiting case. What is essential is that the disposition is partially manifest in the non-ideal situation, and that the transition from the less-than-ideal to the ideal is continuous so as to allow for extrapolation.

The falling objects in a vacuum as discussed by Salviati provide another example of a CMD. The thinner the medium, that is, the closer we approach the ideal condition – the more the behaviour in question becomes manifest. Given such a continuity we can accumulate evidence for what would happen if the ideal circumstances were realized even if they actually never are. The partial manifestations of the disposition allow for an extrapolation to the ideal situation under the assumption of a continuity between partial and complete manifestation. If the disposition is supposed to explain how the testing of the behaviour of a system under ideal conditions is possible in less-than-ideal situations, we have to assume that it is a CMD rather than a DMD.

CMDs as opposed to DMDs not only allow for extrapolation when it comes to testing. It is only if the disposition in question is a CMD rather than a DMD that the counterfactual or ideal situation is of any explanatory interest for the actual or less-than-ideal situations.

The fact that an object is fragile (DMD) does not tell us anything about the behaviour of an object as long as the manifestation conditions for fragility aren't realized, even though the disposition carries over from the ideal to the less-than-ideal situation. In contrast, what we know about the behaviour of falling bodies in a vacuum does help us, e.g. to explain and to predict the behaviour of falling bodies in a medium.

Possessing a disposition implies that something carries over from the ideal to the non-ideal. What is constant across the various conditions is the dispositional property. However, it is only in the case of CMDs, i.e. dispositions that are partially manifest in non-ideal situations, that this fact can be exploited in prediction, explanation etc. In the case of DMDs, such as fragility, the carrying over has no implication for prediction or explanation of the behaviour of the system in less-than-ideal situations.

Galileo's law of free-falling bodies describes the behaviour of objects in a vacuum. His argument assumes these objects to have CMDs. On the basis of such a CMD we can explain or predict the behaviour of falling bodies in a medium, given that we are able to calculate how the disturbing factor, the medium, affects the falling body.

Let me close this section by some remarks on the notion of 'continuity'. It is not meant to imply that the manifestation of a disposition is a process that takes some time. If there is such a process, then what I am interested in is manifestation as the product of this process. A CMD is manifest given ideal conditions and it is partially manifest (as opposed to DMDs) in non-ideal situations such that there is some kind of continuity between the ideal and the non-ideal.

What kind of continuity is there between the ideal and the non-ideal? In the case Salviati describes, continuity is simply assumed. It is assumed that nothing spectacular is going to happen if the vacuum condition is reached. If we have a complete description of the medium (or other disturbing factors), continuity is not just a mere assumption. In that case we can consider the medium plus the falling body as a compound system, and give a complete account of its behaviour. There are laws of composition that tell us how the medium affects the velocity of the falling body. These laws of composition will also tell us what is going to happen if the medium is replaced by a thinner medium. So if we have a complete description of all the relevant factors, it is the laws of composition on the basis of which we can give a quantitative account of the continuity between the non-ideal and the ideal situation.

What Is Explained by the Assumption of CMDs?

CMDs have to be assumed in order to rationalize our testing and explanatory procedures. Their assumption is the best explanation of the success of certain features of our scientific practice.

In the philosophy of science, dispositions do not have the best reputation. They are often associated with occult qualities of pre-seventeenth-century natural philosophy.

With respect to the explanation of regular behaviour of physical objects a three-step development from the scholastics to the twentieth-century seems to have occurred, and the introduction of dispositions seems to be a fall-back to pre-cartesian times.

Roughly speaking the picture is somewhat as follows: Before the seventeenth-century the manifest behaviour of physical systems was explained with recourse to the essences or natures of the systems in question. These essences or natures had certain capacities or dispositions to bring something about. The dispositions were conceived of as causes, and the explanations in terms of dispositions as causal explanations of the manifest behaviour of physical systems. In the seventeenth-century this conception was abandoned. Physical systems were no longer thought to have dispositions or capacities that were postulated to explain the observed behaviour. It was rather laws of nature that philosophers appealed to. These laws in turn were explained in terms of God's activity, or in terms of the activity of created spiritual or mental substances (plastic natures, monads). Today the behaviour of physical systems is still explained in terms of laws of nature but these are no longer thought to be grounded in something else. Ultimately it is a brute fact that certain systems behave according to certain laws. The laws themselves need no explanation in terms of God's activity or in terms of the capacities and dispositions of the scholastics.

The introduction of CMDs appears to be a fall-back to pre-Cartesian times. It looks as though CMDs give a *causal explanation* of why physical systems manifest a certain behaviour.[6] But the lesson of Molière's well-known little dialogue on the *virtus dormitiva* seems quite plausible. Molière ridicules these kinds of explanations, because they are trivial. To call the cause of the act of falling asleep the *virtus dormitiva* is not an informative answer.

The important point is that CMDs as introduced by the carrying-over argument are not of the same kind as the *virtus dormitiva*. The explanandum of a CMD is not the manifestation of the disposition of a physical system. CMDs (as opposed to causal capacities) are *not* introduced as causes of their manifestations.[7] What CMDs explain are features of scientific practice. This is why we had to assume that physical systems have dispositions. They explain why we are allowed to extrapolate from less-than-ideal, to ideal circumstances. They explain why the ideal circumstances are explanatorily relevant for less-than-ideal situations. They explain why in experimentation we are interested in placing physical systems in certain surroundings, rather than others. We assume that they possess dispositions that become manifest under these, and not under other experimental conditions.

The disposition that lithium crystals have the specific heat

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[6] Some of Cartwright's remarks suggest this view. See N. Cartwright: *The Dappled World* (Cambridge, 1999), p. 28 and p. 66 where she describes natures and capacities as trying to bring about an effect.

[7] In fact, it is often the case that some of these dispositions never get perfectly manifested. In these cases the alleged explanandum does not even exist (because the disposition is not completely manifest).

$$c_V = (12/5)\pi^4 nk_B\,(T/\theta_D{}^L)^3$$

does not explain *why* lithium has this specific heat rather than another. Dispositions are not meant to give causal explanations of this specific heat. Why the specific heat is the way it is *remains a brute fact* (unless it can be micro-explained). Rather, what the CMD explains is why this specific heat can be measured even though it is not (completely) manifest. It explains why we are interested in measuring the behaviour of crystals which are as pure as possible. It explains why the law in question can be used to explain the behaviour of impure lithium crystals.

Furthermore, CMDs help to understand causation as I will elaborate in the second part of the chapter.

Causation

The carrying-over argument requires physical systems to possess dispositions. Bodies have the disposition to fall with a certain speed in a vacuum. According to this dispositional interpretation of laws of nature, these laws tell us what would happen if ideal circumstances were realized. In what follows I will argue that counterfactuals relating to what physical systems would do, if certain (ideal) circumstances were realized, provide the basis for claims about causal dependence. Thus, the introduction of dispositions does not only rationalize our scientific practice, it also allows for an analysis of causation.

Lewis's Account and its Difficulties

Laws of nature or theories ascribe dispositions to physical systems, they describe how these systems would behave if they were isolated. Causation comes into play when we describe the behaviour of systems that are disturbed and thus fail to be isolated.

The observation that a cause is something that makes a difference – and a disturbance is such a difference – has been the motivation for counterfactual analyses of causation. If the cause had not occurred neither had the effect. I will use David Lewis's account as my own starting point.[8]

According to Lewis an event *c* is a cause of an event *e* if *c* is part of a causal chain that leads up to *e*. A causal chain is a sequence of events *c*, *d*, *e* etc. such that *d* depends causally on *c*, *e* depends causally on *d*, etc. Finally, causal dependence is spelt out in terms of counterfactual dependence.

Lewis defines counterfactual dependence among *events* as the counterfactual dependence between the corresponding *propositions O(c)* and *O(e)*, which state that

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[8] See D. Lewis, 'Causation', *Journal of Philosophy*, 70 (1973): 556-567, reprinted in his *Philosophical Papers* (Oxford, 1986), vol. 2, pp. 159-172, p. 167.

c and *e* occur respectively. For *e* to depend causally on *c* it has to be true that firstly, if *c* had occurred *e* had occurred, and secondly, if *c* had not occurred *e* would not have occurred either.

1. $O(c) \Box\!\!\rightarrow O(e)$
2. $\sim O(c) \Box\!\!\rightarrow \sim O(e)$ (the Ludovician counterfactuals)

Any two events for which these two counterfactuals are true depend on one another causally.

The following example is an illustration: Billiard balls A and B roll towards each other, they shortly interact at time t_I and move apart from each other in a different direction and with a different velocity at time t_2. We take it that A causes B's behaviour to change, and similarly, that B causes A's behaviour to change.

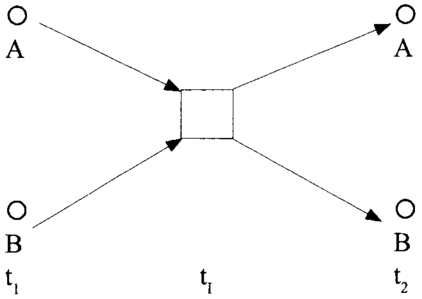
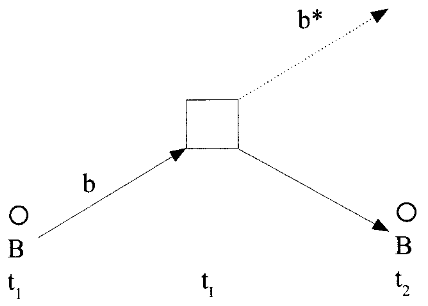


Fig. 1

How does Lewis's account work in this case? Let us focus on A causing B's behaviour to change. Two conditions have to be met for causal dependence to obtain. Firstly, if A had collided with B, B would have been deflected, and secondly, if A had not collided with B, B would not have been deflected. (see figure 2).



b: B's actual path
b*: the path B would have taken if A had not interfered at time t_I

Fig. 2

According to Lewis, the truth-conditions of the relevant counterfactuals are defined in terms of possible worlds.

A□→C is true (at a world *w*) iff either (1) there are no possible A-worlds (in which case A□→C is *vacuous*), or (2) *some* A-world where C holds, is closer (to *w*) than is *any* A-world where C does not hold.[9]

Closeness is spelt out in terms of similarity, and similarity in turn depends to a large extent on shared laws of nature. At any event, the central idea is that we have to consider possible worlds in which A is true and possible worlds in which C is true. A possible world is a way things could be, 'at its most inclusive'.

The counterfactual A□→C is true if among the A-worlds the one most similar to our actual world turns out to be a C-world as well. In the case of the collision of two billiard balls A and B, A's collision with B caused B's deflection. The first counterfactual we need to consider is the claim that if A had collided with B, B would have been deflected. The world closest to our actual world in which the antecedent is true is the actual world itself. The consequent is true in the actual world as well. Thus the first of the Ludovician counterfactuals is true. According to the second counterfactual, if the collision had not occurred, B would not have been deflected. According to Lewis for the second counterfactual we have to consider possible worlds in which no collision occurs. The second counterfactual is true (in our world), says Lewis, if the following holds: The worlds in which B is deflected (even though no collision has occurred) are less similar to our actual world than at least one world in which B is not deflected (and no collision has occurred).

Lewis's account has to face some well-known difficulties. First, there are counterexamples of cases in which the relevant counterfactuals hold but that do not pick out causal relations, such as 'If my sister had not given birth at t, I would not have become an uncle at t.' The birth of the child determined my becoming an uncle, but

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[9] See D. Lewis, 'Causation', p. 164.

my becoming an uncle is not a *causal effect* of the birth.[10] Thus Lewis's account is too broad.

A second problem has been posed by Philip Kitcher. It concerns Lewis's account of the counterfactuals' truth conditions, i.e. its semantics. Lewis relies on possible worlds. The problem that arises concerns our epistemological access to possible worlds. How do we ever get to know, on this account, that a causal relation actually holds?

> [T]he best semantic accounts make reference to possible worlds, our best epistemological views make knowledge (and justification) dependent on the presence of natural processes that reliably regulate belief, and it is (to say the least) unobvious how any natural process could reliably regulate our beliefs about possible worlds.[11]

Causation Based on CMDs

I now want to suggest a way for counterfactual analyses to circumvent these difficulties. In particular, I want to make plausible why we have epistemic access to what makes counterfactuals true. The essential point is that the counterfactuals that go into an analysis of causation hold in virtue of dispositions of physical systems. Let me explain.

The first point is that causes and effects are actual. When we consider whether event c is a cause of event e, we presuppose that c and e are actual or that $O(c)$ and $O(e)$ are true. The truth of $O(c)$ and $O(e)$ collectively entails the truth of the counterfactual 1. But there is no need to state the counterfactual in the first place. For causal dependence among actual events the Ludovician counterfactuals can be replaced by the following two conditions.[12]

1*. $O(c)$
$O(e)$
2. $\sim O(c) \square\!\!\rightarrow \sim O(e)$ (as before)

So we are left with one counterfactual claim. This claim is meant to capture the intuition that if the cause had not occurred, the effect would not have occurred either.

What I maintain is that whether or not 2 is true is entirely a matter of laws of nature, considered as claims about ideal circumstances. I will introduce my proposal by way of discussing the billiard ball example.

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[10] For a discussion of these counter-examples see J. Kim, 'Causes and Counterfactuals', *Journal of Philosophy*, 70 (1973): 570-572, reprinted in E. Sosa and M. Tooley (eds), *Causation* (Oxford, 1993), pp. 205-207.

[11] P. Kitcher, 'Explanatory Unification and the Causal Structure of the World', in P. Kitcher and W. Salmon (eds), *Minnesota Studies in the Philosophy of Science*, vol. 13 (Minneapolis, 1989), *Scientific Explanation*, pp. 410-505, p. 473.

[12] See D. Lewis, 'Causation', p. 167.

So, as before, let us assume that billiard balls A and B roll towards each other, that they shortly interact at time t_1 and move apart from each other in a different direction and with a different velocity at time t_2. With the exception of a short period of interaction both A and B can be considered to be closed or isolated systems before and after the interaction took place.

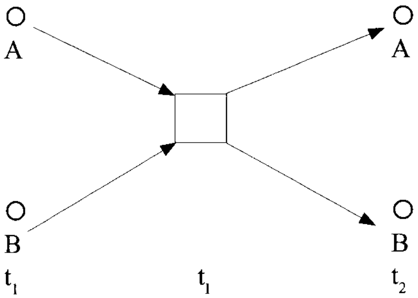
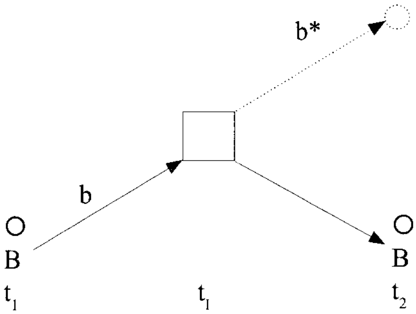


Fig. 1

Why do we hold that A is a cause of B's change in behaviour? If A had not collided with B, B would have taken path b* rather than path b – as it actually has (see figure 2).



b: B's actual path
b*: the path B would have taken if A had not interfered at time t_1

Fig. 2

The fact that B is disturbed by A makes the difference that is relevant for causation. The central idea of my proposal is simple. As I have elaborated on pp. 207-9, laws of nature describe how systems would behave if they were isolated, i.e. they attribute dispositions to physical systems. Laws of nature usually describe counterfactual situations and should therefore be read as saying, for instance, 'If the hydrogen atom were isolated it would behave according to the Schrödinger equation with a Coulomb potential.' According to my proposal, it is exactly these kinds of counterfactuals that make true condition 2. Causal dependence is spelt out in terms of counterfactuals that are based on dispositions. Laws of nature tell us how a system would behave in ideal circumstances.[13]

We want to say that A's collision with B caused B to be deflected. The essential conditions are therefore 1* and 2. 1* is fulfilled because the collision has occurred and B has been deflected. 2 turns out to be true because there is a law that tells us that B would have continued along path b* if it had continued to be isolated. If B were isolated it would behave according to the Hamilton equations with the Hamilton-function $H=p^2/2m$. Less pretentiously, it is Newton's first law that tells us how B will continue in the absence of a collision. The counterfactual 2 is true because there are laws (of succession) about what would happen in the absence of the cause-event. These laws describe the temporal evolution of physical systems under ideal circumstances, i.e. they describe ideal processes.

This analysis seems to be adequate in general. 1* simply registers that the cause-event and the effect-event have occurred. 2 is made true by a law that states how a system that goes into the effect-event would have behaved if it had remained isolated. A consequence of this proposal is that we do not need possible world semantics for assessing the truth-values of 1* and 2. The truth of the counterfactual 2 can be established as discussed by Salviati. What we extrapolate to in such a situation is certainly not a possible world that is similar to ours. The counterfactual situation envisaged is a falling body in a vacuum – that's all there is. One may call this a possible world – or a possible mini-world –, however, these worlds are not the kinds of worlds Lewis deems relevant for our analysis. The worlds he considers to be relevant have to be similar to our actual world, and therefore have to include all kinds of things such as the milky way, earthquakes in Turkey, the complete history of the Roman Empire and other facts, all of which seem to be completely irrelevant for whether or not billiard ball A causes billiard ball B to be deflected.

To summarize: According to my proposal, causation is a relation among events such that an event *c* is a cause of an event *e* if *c* is part of a causal chain that leads up to *e*. A causal chain is a sequence of events *c*, *d*, *e* etc. such that *d* depends causally on *c*, *e* depends causally on *d*, etc. (as in Lewis). Two (actual) events c and e causally depend on one another if the following conditions hold:

1*. $O(c)$
$O(e)$
2. $\sim O(c) \;\Box\!\!\rightarrow\; \sim O(e)$

Counterfactual 2 is true in virtue of laws of nature, which describe the temporal evolution of systems under ideal circumstances.

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[13] For an analysis in a similar spirit see D. Dieks, *Studies in the Foundations of Physics*, PhD thesis (Utrecht, 1981), chap. III, Dieks describes systems such as the billiard balls as semi-closed systems.

Let me finally discuss the advantages of this proposal. Firstly, it excludes some of the counter-examples against Lewis's account such as those depending on linguistic conventions. According to the proposal, condition 2 has to be true in virtue of laws of nature. Thus, counterfactuals that are due conventions have to be excluded.

Secondly, if one accepts the account of laws in terms of testable dispositions (pp. 209-11), Kitcher's problem of the epistemic access is resolved. Causal claims rely essentially on laws of nature. Laws of nature describe dispositions of systems. These dispositions can be measured as exemplified in the case of the specific heat of the lithium crystal and the case discussed by Salviati. They are therefore epistemically accessible. Dispositions allow counterfactuals to be true in virtue of facts in this world only.

Thus, assuming that physical systems possess dispositions not only explains various features of scientific practice, it also provides an account of causation.