LANGARA COLLEGE

Notes on Causation and Determination

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These notes are intended to provide some useful background ideas on the topic of free will and determinism. In order to make any sense of this problem, I think it's essential to realise that causation and determination are quite different relations.

Some philosophers talk as if determination and causation are the same thing. See, for example, a fairly typical definition of determinism in a philosophy textbook (Gary Kessler, 1998):

> **Determinism** … refers to the idea that all events are caused. For every event there is a set of conditions such that if the conditions were repeated, the event would recur. Simple determinism implies that the universe and what happens in it is lawful, that is, that the law of causality (or law of cause and effect) governs events. Hence, we can assume that any given event is determined (caused) by some set of antecedent events even if we are not fully aware of what those antecedent events are.

This definition seems to take it for granted that, if event A caused event B, then A determined B as well. In other words, *a cause always determines its effects*. In 1971, however, Elizabeth Anscombe gave a famous lecture, *Causality and Determination*, which argued for a sharp distinction between the two relations, and in particular convinced many philosophers that one event can cause another without also determining it.

In this handout I will refer to the view that causes determine their effects as 'CIED', short for *Causation Is Essentially Deterministic*. A key reason to be interested in CIED is that it seems to rule out free will, as is shown in Section 5. If there is a conceptual possibility of indeterministic causation, on the other hand, then this opens a possible path for free will.

1. Causation and Inference

When logic students first learn about conditional statements of the form *if A then B*, they often have the idea that they mean the same as ‘A causes B’. However, a conditional actually expresses an inference from a hypothetical premise, and there is an important difference between causation and inference. Consider, for example, the following two conditionals:

> If Fred ate that rotten fish yesterday, then he is sick today.
>
> If Fred is still in bed, then he is sick today.

The first sentence is inferring the effect of a hypothetical cause, i.e. it predicts that Fred eating rotten fish will make him sick. The second claim, however, isn’t reasoning from cause to effect. Rather, it takes his remaining in bed as *evidence* for his being sick. The speaker seems to assume that a healthy Fred would be up by now.

Causing is a concrete process that happens in the world, whereas inference is a mental process that occurs in the mind of a rational person. There is a big difference between saying:

> (1) The physical event A *produced* the physical event B, and
>
> (2) From *knowing* that A occurred, I can *infer* that B also occurred.

From the ‘Rationality and Truth’ handout, you should remember the distinction between deductive inferences and inductive (probabilistic) inferences. When two propositions A and B are so related that it is valid to deductively infer B from A, then we say that B is a logical consequence of A. The relation of physical necessitation, or determination, is definable in terms of logical consequence, and is thus a relation between propositions.

2. What is Causation?

Following Anscombe, I believe that causation is a relation between concrete objects or events. ‘C caused E’ means that C produced, or generated, E, C brought E about, or made it happen. For example, a meteor striking the ground produces a crater, a woman and man generate a child, a thrown rock causes a window to break, and a burning candle emits light. A cause, we might say, is a *source* of the effect, i.e. where the effect comes from. The effect gets its existence from the cause, so we can also refer to causation as *ontological dependence*.[1]

Note that efficient causation can be either *partial* or *total*. C is a partial cause of E just in case C played some part in bringing E about. For example, a child’s father is only a partial cause of the child, as he did not produce the child by himself. If two people co-author a book, then each is only a partial cause of the book. A total cause is one that brings about its effect all by itself, without any help. Total causes are hard to identify, in the real world, as you almost always find that extra factors were involved.

Sometimes we think that C caused E, even though C and E are far apart in space and time. For example, a decision in the Pentagon may, some hours later, cause a bomb to strike a bridge somewhere in Asia. Or a child may break a window, even though he was never less than fifty feet from it. In these cases we find that the cause and the effect are linked by a continuous *causal process*. A causal process is basically a linear chain of events, each of which is a cause of its immediate successor. In the case of the child breaking the window, for example, the child may have thrown a stone at the window, which provides a continuous causal chain linking the child to the window.

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[1] N.B. ‘ontological’ means pertaining to *existence*. Kant noted that existence isn’t an abstract concept, and so lies outside of the sphere of logic. The difference between states of affairs that exist concretely, and those that are merely possible, is not amenable to logical analysis (despite its importance).

3. Counterfactual dependence

To get a better grip on what causation is, it may be helpful to compare it with counterfactual dependence, which is actually a logical relation.

a. "Causation" by Omission

Suppose Fred is house-sitting for some friends, and has instructions to water the plants. Being rather absent minded, he completely forgets to do this, and some of the plants die. If he had watered them, the plants would have remained healthy. Did Fred *cause* the plants to die, by not watering them?

It seems reasonable to say that Fred did kill the plants, or cause them to die. Yet consider these two points. First, the Queen of Canada didn't water the plants either. So did the Queen also kill the plants? Obviously not, but then how can it be true that Fred killed them? One difference is that, unlike the Queen, Fred was *supposed* to water the plants. He had a moral duty to do so. That may be true, but should causation, as a concrete connection between events, depend on one's moral obligations?

Second, it is quite possible that Fred is not connected to those plants by any causal process. Perhaps they were all in a certain room, that Fred never in fact entered. He *should* have entered that room, to water the plants, but he didn't do so. Given this fact, it seems clear that the plants died of natural causes – their water evaporated, they dried up, and they died. Fred played no part in their history. So, even though we might blame Fred for the death of the plants, he did not (even partially) *cause* the death of the plants.

b. "Causation" by Double Prevention

Suppose Fred is severely injured in a car accident, so that he will soon die, unless he gets immediate medical attention. Fortunately there is an ambulance that is just 10 minutes away, and should get to him in time. But, alas! The ambulance gets a flat tire, that causes a lengthy delay, so that ambulance arrives too late, when Fred is already a goner. Did the flat tire cause Fred to die?

Again, I think we might well say this, but (in the sense of efficient causation) there is no cause-effect relation here. The flat tire is not connected to Fred by any causal process.

In both of these cases, there is an inferential, or logical, relation between the two events, that is called *counterfactual dependence*. Event B counterfactually depends on A just in case:

(i) A and B both occurred in fact, and
(ii) If A had not occurred, then B would not have occurred either.

Note that, when we say "If A had not occurred, then …", we are *predicting* (inferring) the effect of a hypothetical state of affairs, in which A does not occur, but everything else stays the same (as far as possible). This assumption, that other things remain the same, as far as possible, is called a *ceterus paribus* ("other things being equal") assumption. You can see this at work in the flat tire example. We take our knowledge of the actual situation, but then alter it by imagining that the tire had not gone flat. Then, if nothing else also changes (e.g. we don't add that the ambulance driver suddenly has a seizure) then we infer Fred's survival.

Counterfactual dependence is thus fundamentally a logical or inferential relation, even though it involves causation indirectly – it involves predicting the effects of a hypothetical cause.

c. Probabilistic "causation"

As shown by David Lewis (1986), in an indeterministic system the relation of counterfactual dependence becomes probabilistic. One cannot predict the effects of a hypothetical cause with *certainty*, if determinism is false, but one can still predict the *likely* effects. For example, one can say that if these ten fair coins were all flipped, then *probably* at least one would land heads. (One can even calculate the probability of this, if one is so inclined.)

If the world is indeterministic, then the relation of counterfactual dependence can be generalised to one of *probabilistic* counterfactual dependence, as follows. B depends probabilistically on A if and only if:

(i) A and B both occurred in fact, and
(ii) If A had not occurred, then B would have been less probable.

In other words, the occurrence of A *raised the chance* of B. In the case of Fred 'killing' the plants, for example, we can suppose that plants behave somewhat randomly—the unwatered plants were not certain to die, but had a small chance of surviving, and that even getting the proper amount of water would not quite have ensured their survival. If failing to water the plants increased their chance of death by a large amount, however, e.g. from 0.02 to 0.95, then this probabilistic counterfactual dependence (chance-raising) relation isn't much different from the 'full' counterfactual dependence that exists under determinism.

Many philosophers reacted to Anscombe's paper by concluding that causation and probabilistic dependence are the very same relation. This idea does seem to agree with Anscombe on her central claim that causation can occur without determination, as event A can raise the chance of B without raising it all the way up to 1. However, this apparent agreement is a mirage, since *chance-raising is a logical relation*, and so is quite different from causation as she understood it, as ontological dependence—which is also the sense of causation that's used in discussions of free will. (See Section 5 below.) Also note that, since counterfactual relations are a matter of reasoning from causes to (likely) effects, these relations presuppose an underlying causal structure. Probabilistic 'causation' therefore has no relevance to CIED, i.e. to whether or causation in the sense of ontological dependence is essentially deterministic.

4. What is Determination?

In defining determination, it will help to first consider predictable systems, i.e. systems where we can say, with high confidence, what they will do in the future. The motions of the planets in the solar system, for example, can be predicted with great accuracy by someone who knows Newton's laws, is able to do the calculations, and knows the state of the system at one time. For example, using careful measurements of the current positions and velocities of the planets, and a computer to crunch the numbers, we can learn exactly when and where all the solar eclipses will happen over the next few hundred years. In a similar way, the present state also enables us to calculate the past history of the solar system. We can infer past eclipses.

Laplace (1814) gave definition of determinism essentially says that a deterministic system is a predictable system, but for technical reasons 'predictable' here cannot mean predictable *by humans*. These reasons are:

1. The calculations are too difficult.
2. We can't get enough knowledge about the initial state.

These reasons might look like lazy excuses, but in fact it can be shown that any computer capable of predicting the universe's behaviour would have to be bigger than the universe! Also, the "butterfly effect" that applies to most systems means that any inaccuracy in our knowledge of the initial state will lead, sooner or later, to huge errors in our predictions. Laplace's response was to define a deterministic system as one that is predictable for a *sufficient* intellect, with *maximal* knowledge of the initial state. Thus Laplace imagined a superhuman intelligence ("Laplace's demon"), who has no cognitive limitations. If the demon knows the present state with perfect accuracy, and has complete knowledge of the laws of physics, then "… for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes".

Today, Laplace's definition of determinism as idealised predictability is generally seen as missing the essence of determinism. Whether or not any super-intelligences exist, or are inclined to calculate the future, pre-determined events are those that are *necessitated* by their total causes. But what does 'necessitated' mean here?

Necessity is actually a tricky concept, as it comes in a few different flavours, including logical, epistemic, physical, and metaphysical necessity. Determinism is a matter of *physical* (or 'nomic') necessity, which is a kind of necessity that depends on the laws of physics. (If the laws of physics were to change, then a different future would be the one determined to occur.)

Assuming that the laws of physics can be expressed as a proposition L, a standard definition of physical necessity is as follows:

Definition *A determines B* means that B is a logical consequence of A together with the laws of physics, i.e. $(A \,\&\, L) \Rightarrow B$.

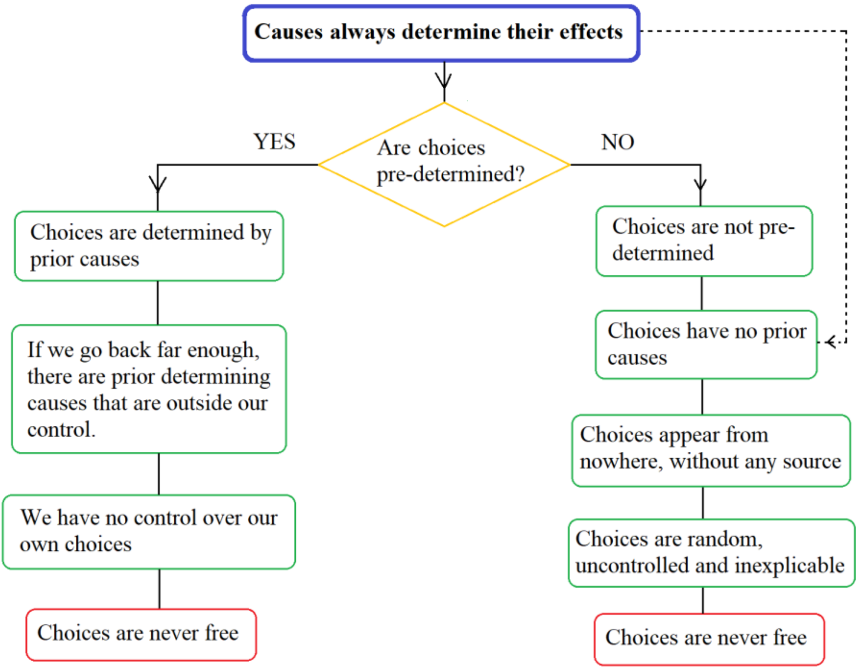
A useful way to think about a deterministic system is in terms of the *physically possible histories* of the system – the histories that obey all the laws of physics. Each possible history can be pictured as a railway track, that a train can pass along. The parts of the track represent the different states that the system passes through as it changes over time.

The set of tracks in the image below are like the set of possible histories for an *in*deterministic (non-deterministic) system. If the train starts on one of the tracks at the top of the image, and follows a possible path, then there are many different places it can end up – since the tracks fork here and there.

In the second image, by contrast, the tracks remain separate, and never fork. This is like the possible histories of a deterministic system. No matter where the train starts, there is only one possible path it can take from that initial point. (Its path is also predictable, if we know where it starts and what the possible histories are.)

5. The Dilemma of Determinism

Many have used an argument called the 'dilemma of determinism' to argue that free will is impossible. The structure of this argument is shown in the diagram below.



The argument begins (often implicitly) with the assumption outlined in blue, that causation is essentially deterministic (CIED). Then we face the question of whether determinism is true or false, as applied to human choices. The two options are described as "horns" of the dilemma (pointy objects that you can get impaled on) as both chains of reasoning end with the painful conclusion that free will is an illusion.

This argument has a long history, and is still used today. Richard Taylor (1963), for example, summarises the reasoning in the left horn as follows:

> If determinism is true … all those inner states which cause my body to behave in what ever ways it behaves must arise from circumstances that existed before I was born; for the chain of causes and effects is infinite, and none could have been the least different, given those that preceded.

Ishtiyaque Haji (1998, p. vii) describes the left horn rather poetically as follows:

> [how can we have free will] if determinism is true and all our thoughts, decisions, choices, and actions are simply droplets in a river of deterministic events that began its flow long, long before we were ever born? The specter of determinism, as it were, devours agents, for if determinism is true, then arguably we never initiate or control our actions; there is no driver in the driver's seat; we are simply one transitional link in an extended deterministic chain originating long before our time.

The reasoning for the right horn is harder to pin down. The following summary by Galen Strawson (1986, p. 25) is typical:

> "And surely we can no more be free if determinism is false and it is, ultimately, either wholly or partly a matter of chance or random outcome that we and our actions are as they are?"

We must ask: What is meant by 'a matter of chance' and 'random' here? In the discussion of probabilistic causation above I used 'chance' in the standard sense of objective probability, or degree of determination. In science a 'random' event is usually one that has an objective chance that isn't 0 or 1, so that it isn't pre-determined to occur, or not to occur. If this is what he means by 'random' then Strawson is giving no argument at all, but just making the statement that indeterministic actions cannot be free. Other authors, however, make it clear that terms like 'random', 'accidental' and 'a matter of chance' in this context mean *uncaused*. E.g. Mark Balaguer (2004):

> "Any event that's undetermined is uncaused and, hence, accidental. That is, it *just happens*; i.e., happens randomly."

It is clear that *an uncaused event cannot be a free act*, for an uncaused event has no source for its existence – it simply appears from nowhere. A free act must be caused by the person whose act it is. It must arise from their character, their understanding of the world, their goals, and so on.[2]

This inference from actions being undetermined to being uncaused is the key step in the right horn, and (as shown by the dotted line in my diagram) requires the initial assumption CIED. This key inference is the weak point in the dilemma of determinism, according to the 'libertarian' view of free will.

6. *Do* Causes Always Determine their Effects?

We have already pointed to some differences between causation and determination that seem to show that these relations are not the *same thing*. For example, causation is a relation between concrete events, whereby one event brings about another, while determination is an abstract relation between propositions. It seems perfectly reasonable to ask the following: "I grant you that A produced B, all by itself, but from full knowledge of A, and the physical laws, can one infer with certainty that B occurred?"

Here are four additional arguments to support the view that causing an event is different from determining it.

a. The present state (B, say) of the solar system determines its past state (A) five years ago. But the present state didn't *cause* the past state! (A caused B, but B didn't cause A.) Since B can determine A without B causing A, the relations are distinct.

b. Harry Frankfurt discussed many cases of determination without causation. For example, suppose Fred is in a room with two exit

[2] Note also that the sense of 'cause' here is Anscombe's notion of ontological dependence. The statement makes no sense if we mean probabilistic 'causation'.

doors, and wants to leave. He picks one of the doors (call it D1), opens it, and walks out. Fred thinks that he could have opened D2 instead, but what he doesn't know is that I secretly locked D2, the other door, after he entered the room. If he had tried to open D2 he would have failed, and would have been forced to use D1 instead. What we should notice here is that my action L of locking D2 *determined* that Fred would leave though D1. But L played no part in bringing it about that Fred left through D1. (There is no causal process connecting the two events.) Thus, L determined the event, but didn't (even partially) *cause* it.

c. Merely possible, *non-actual events* can determine other non-actual events. E.g. if I had shot an arrow (which I didn't) from a certain place and with a certain velocity, then it would have followed a particular path through the air to a certain point on the ground below, a predictable number of seconds later. Thus, non-actual events determine other non-actual events. Yet non-actual events are mere abstract possibilities, and cannot cause anything. Only events *that occur* can be causes. Causation, unlike determination, is inseparable from concrete existence.

d. Logical consequence is a matter of degree, so determination is a matter of degree, whereas causation is two-valued (all-or-nothing). One event A might be very likely to cause B, or have some slight chance of causing B, in which case A determines *to some degree*. But despite such partial determination, if B doesn't occur in fact then A didn't cause B *at all*. A two-valued relation cannot be identical to one that takes continuous values between 0 and 1.

These arguments make it clear that causation and determination are two very different relations. They do not refute CIED (causation is essentially deterministic) but I would say that the burden of proof now rests on those who assert CIED. If two relations are conceptually distinct, as causation and determinism are, then any alleged connection between the two needs a supporting argument – which is entirely lacking at present. Also, the following arguments can be given against CIED.

e. The QM Argument.

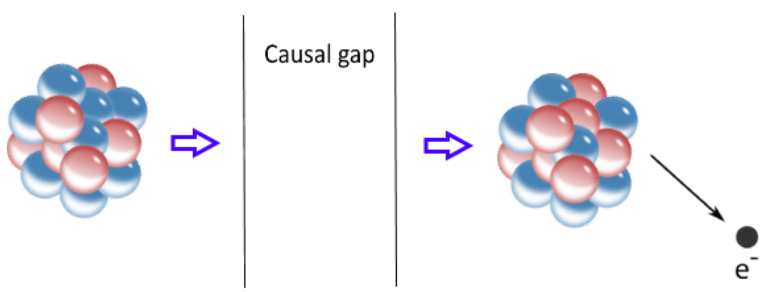
> Physics used to give some support to CIED, in the pre-quantum era when all of our fundamental laws in physics were deterministic. Today, however, quantum mechanics (QM) is our best theory of atomic and sub-atomic physics, and it is an indeterministic theory. For many experiments the theory doesn't allow us to predict exactly what will happen, but provides only probabilities of outcomes. For example, some radioactive nuclei are unstable, so that each nucleus has a certain probability of decaying in a given time interval. Thus, the event of a particular nucleus decaying, at a certain time, is not pre-determined. Yet the decay is still *caused* by the unstable nature of the nucleus. Some nuclei (e.g. Carbon-12) are stable, whereas others (e.g. Carbon-14) are unstable. Clearly the decay, when it occurs, is caused by the nature of the nucleus.

The QM argument is pretty simple, but there are two possible objections to it. First, while it is true that quantum mechanics as it *presently* stands provides only probabilities of outcomes, this may be only a temporary condition. There are already proposed alternatives to quantum mechanics that are deterministic, such as Bohm's theory that adds 'hidden variables' to the existing formalism, and Everett's branching universe theory. The second objection is that the argument just asserts, and does not prove, that nuclear decays are caused by the nucleus itself. A critic could reply that, if nuclear decays really are random, then they are necessarily uncaused as well.

The first objection, that the randomness of QM is only apparent, is not as reasonable as it might appear. For, while it is still possible that the quantum world is ultimately deterministic, very few physicists accept this due to the technical difficulties involved. The standard view is that quantum probabilities are real, and not just due to our ignorance of the exact state. (I will not delve into the technicalities here, however.) It should also be noted that physicists regard the view that there are irreducible objective probabilities as *coherent* at least, and the mere conceptual possibility of indeterministic causation is enough to render the dilemma of determinism invalid.

The second objection proposed that, even if the probabilities of QM are objective, this shows merely that non-determined events exist. Why should we regard those events as caused? The objector can make an alternative suggestion that the unstable nature of the nucleus doesn't cause the decay *itself*, but merely creates a tendency, or propensity, for it to decay at a random (uncaused) time. The actual decay of a Carbon-14 atom, when it occurs, simply appears 'by chance' on this view, which means that it wasn't caused. (There is, in other words, a causal gap between the nucleus and the decay.)

Is this alternative view of random events (as being uncaused) coherent, however? To answer this question, let us do our best to formulate it precisely, taking beta decay as an example. (Beta decay is where a neutron turns into a proton, and an electron is ejected from the nucleus.) The theory that the decay is uncaused is illustrated by the diagram below.



One question is what the blue arrows mean in this diagram. Do they represent cause and effect? That would be paradoxical, since between the arrows is a causal gap! So let's say that they just show the temporal sequence.

The problem with this picture is that the decay occurs with a certain *probability*. This probability is objectively real, as it can be measured experimentally by looking at the rate of decay for a sample of the isotope in question, containing many trillions of atoms. This probability is a feature of physical reality, so where does it reside?

In the diagram, the beta decay appears after the causal gap, so it looks as if the objective probability must be a property of the gap. But this is nonsense, as the gap isn't an entity at all, but the absence of an entity – so it cannot have any properties.

The probability of decay is a property of some *thing*, and it must be a feature of the pre-decay nucleus. We know that adding neutrons to a nucleus changes its degree of stability, either lengthening or reducing its half life, and we have an understanding of why this is, in terms of quantum tunnelling. Clearly, there is no causal gap, so if the probabilities of QM are irreducible, then indeterministic causation exists and so CIED is false.

The QM argument is the main reason to reject CIED, but here is one more argument for good measure.

f. As noted in Argument d above, determination is a matter of degree, whereas our concept of causation seems to be all or nothing. This fact also creates problems for the view that causation is essentially deterministic. On this view, an event with probability 1 must be caused, but an event that occurs by chance, with probability ½ say, cannot be caused. What about an event with probability 0.99, however? Or 0.99999? (Etc.) Such events are technically indeterministic, and hence uncaused according to CIED. But this seems rather ridiculous, that an arbitrarily small difference in probability should make such an enormous difference in causation. Yet if an event with probability 0.99999 needs a cause, then what is the probability below which an event must be uncaused? Any such value seems arbitrary.

7. Is the universe fully rational?

The arguments in the previous section make it very difficult to maintain CIED, but indeterministic causation remains a complete mystery—we don't yet have a clear conceptual understanding of how an event can be caused without being determined. Doesn't this indicate that the concept is incoherent? In this section we will try to make sense of this.

The expectation that causal processes in the natural world will be fully comprehensible is sometimes called the Principle of Sufficient Reason, which Leibniz (1714, #7) expressed as follows:

> "for any true proposition P, it is possible for someone who understands things well enough to give a sufficient reason why it the case that P rather than not-P."

Saying *why* something happened generally requires saying what *caused* it, but this isn't enough to count as a full explanation. To understand the reason for high and low tides, for example, it isn't enough just to know that they're caused (mostly) by the moon's gravity. Being told this doesn't give me any understanding of why the moon's contribution to the tides is much greater than the sun's, despite the fact that the sun's pull on the earth is 177 times greater than the moon's. Or why a high tide occurs not just when the moon is overhead, as you would expect, but also about 12 hours later, when the moon is under our feet. To explain some event E requires not just providing the cause C, but also *deducing E from C*. The logical deduction of E, from C, gives us rational insight into why C produces E. In the cases of the tides, doing the math (using Newton's laws) shows us that the tides actually arise from *variations* in the moon's gravitational field over the earth's surface, and the moon's proximity to the earth entails that it creates a more variable field than the sun does. Doing those calculations allows us to understand the *reason* for the tides.

In other words, in a fully rational universe, where the Principle of Sufficient Reason holds, causal processes correspond to logical inferences. For every concrete sequence of events, each event produced by its predecessor, there is also an abstract sequence of propositions, each a logical consequence of its predecessor, together with the laws of physics.

If the Principle of Sufficient Reason were true, making the universe fully rational in this sense, then one might wonder: Why does the concrete universe should go to all the bother of existing? In this ultra-rationalist picture, the concrete universe of events looks like a redundant duplicate of the pre-existing abstract universe of propositions. So perhaps the universe isn't *fully* rational?

The impressive expansion of scientific knowledge over the past few centuries shows beyond doubt that the universe is indeed highly rational. Our abstract understanding of nature now stretches from ATP synthesis in living cells to nuclear fusion within stars. But such discoveries don't prove that the universe is *completely* rational, any more than finding a lot of white swans proves that all swans are white. Let's make a guess then that the universe isn't completely rational, and see what follows from it.

Note that we are *not* supposing here that the universe is *irrational*, in the sense of containing logical impossibilities (e.g. married bachelors, square circles, or rooms that contain 2 men, 2 women, and exactly 3 people.) The idea instead is that the universe isn't fully comprehensible, even in principle, so that even Laplace's demon cannot calculate the effect of every cause. Perhaps, for example, there is something about concreteness, or real existence, that is somehow more than an abstract idea, so that nothing abstract can fully represent it. What follows from this picture?

Suppose Laplace's demon is trying to predict the effect of a particular cause, but (as assumed above) the cause isn't fully comprehensible, so that the demon has an incomplete understanding of it. We may then say that the cause contains 'inscrutable' properties that are missing from the demon's understanding. In that case, if the inscrutable properties are involved in the production of the effect, it's likely that Laplace's demon won't be able to predict what the effect will be. However, the demon has partial information about the cause, and this might warrant an uncertain or probabilistic prediction about the effect. Thus, each possible effect might have a degree of determination, or objective probability, given the cause. In other words, some causal processes are likely to be indeterministic in a world that is not fully rational.

If this account is correct, then the belief that indeterministic causation involves causal gaps results from a "fallacy of reification". This fallacy is committed when we mistake a map for the territory, or our understanding of a concrete process for the process itself. Alfred North Whitehead (1925) describes this as the "error of mistaking the abstract for the concrete". He writes:

> "The enormous success of the scientific abstractions has foisted onto philosophy the task of accepting them as the most concrete rendering of fact … Thereby, modern philosophy has been ruined."

If an event isn't determined by its causes, then by definition there is a *logical* gap between our understanding of the cause, and our understanding of the effect. The latter does not follow from the former. Then a person who mistakes the abstraction for reality itself will think they see a *causal* gap. This is analogous to seeing a crease in a map and thinking it's an actual mountain.

8. Conclusion

Generations of philosophers have regarded causation as some kind of logical relation—such as determination, counterfactual dependence, or probabilistic dependence. Here I have presented Anscombe's view, however, that causation is a relation between concrete things rather than abstract propositions. This view only makes sense if one regards all abstract representations of the concrete world (such as those used by physicists) as essentially incomplete. In that case, the ‘gaps’ involved in non-deterministic processes exist only in the representations, not in reality.

The possibility of indeterministic causation is significant for a number of reasons, but mostly because it is essential for free will. If causation is essentially deterministic (CIED) then the dilemma of determinism is sound, and free will is impossible. Of course, not every indeterministic causal process has free will—radioactive nuclei don’t have free will, for example. Indeterministic causation is *necessary* for free will, not sufficient, so that free will requires other factors to be present.

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