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Max Kistler

Vague and indeterminate causation

SOCIÉTÉ DE PHILOSOPHIE DES SCIENCES (SPS)
École normale supérieure
45, rue d'Ulm
75005 Paris
www.sps-philoscience.org

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Sommaire

Il est parfois indéterminé si deux événements sont causalement liés et il existe des énoncés causaux vagues. Trois sortes d'indétermination causale ou de causalité vague sont analysées. 1. Si les omissions peuvent être des causes, l'effet d'une omission peut être indéterminé. 2. Les énoncés causaux peuvent être vagues de deux manières : l'une provient du caractère vague du prédicat désignant la cause ou l'effet, l'autre du caractère vague de certains types de causalité, tels que la "causalité forte". 3. Un troisième type d'indétermination regroupe des situations de surdétermination indéterministe et de "coupe" indéterministe. Il est plausible qu'il existe des situations du premier type ; en revanche, il est plausible que des situations du second type ne sont possibles que sur le plan conceptuel mais non sur le plan scientifique.

It is sometimes indeterminate whether two events are causally related and causal statements can be vague. Three sorts of causal indeterminacy or vagueness are analyzed. 1. If omission can be causes, it can be indeterminate what the effect of an omission is. 2. Causal statements can be vague in two ways. One arises from the vagueness of the predicate designating the cause or the effect, the other from the vagueness of certain sorts of causation, such as "strong causation". 3. A third type of indeterminacy covers situations of indeterministic overdetermination and indeterministic "trumping". It is plausible that the former actually exist, whereas the latter are only conceptually but not scientifically possible.

Mots clés : causalité, vague, indéterminé, indétermination, omission, surdétermination, causalité coupante.
Keywords: causation, vague, vagueness, indeterminate, indeterminacy, omission, overdetermination, trumping.

1. Two distinctions

1.1 Three types of indeterminacy

Some predicates and concepts are vague (Varzi 2003). "Bald" is a paradigmatic example. Someone with no hair at all or with one hair is definitely bald, someone with 100 000 hairs is definitely not bald, but in many intermediate cases it is indeterminate whether a person is bald or not. Vague predicates can be used to produce paradoxes of the sorites kind[1]. It is controversial whether there are, independently of vague predicates and concepts, also vague properties and objects.

Vagueness is a specific form of indeterminacy. The open future belongs to another, very different sort of indeterminacy. If the future is open, it may be indeterminate, e.g., whether tomorrow I will drink coffee or tea for breakfast. However, this doesn't make the future vague.

There may be indeterminate states of affairs in quantum physics (Calosi & Mariani 2021, Torza 2023). If a particle has been prepared in an eigenstate of observable O_1 and if O_2 is an observable that is non-commuting with O_1, then the outcome of a measurement of O_2 is indeterminate. This doesn't seem to have anything to do with vagueness but it may belong to the same category as the open future because the indeterminacy ends when a measurement of O_2 is carried out.

One difference between these types of indeterminacy relates to sorites paradoxes[2]. Vagueness leads to sorites paradoxes, whereas other forms of indeterminacy do not. One can construct a sorites paradox starting with propositions containing the predicate "bald", but not with propositions bearing on the future or on outcomes of measurements of quantum systems in superposed states.

1.2 Three interpretations of indeterminacy

Indeterminacy can be epistemic, semantic, or metaphysical[3]. According to an *epistemic* conception of vagueness, the truth-

1 *Two examples of such paradoxes will be discussed below.*

2 *"It would not be unreasonable for someone to restrict the term 'vagueness' to sorites-susceptible phenomena." (Williams 2008, p. 767). See also Barnes (2010); Eklund (2011, p. 150).*

3 *"Ontic" indeterminacy is a sub-species of metaphysical indeterminacy (Williams 2008, p. 767-8). Ontic indeterminacy concerns indeterminacy of existence or identity of objects or events. If there are indeterminate causal relations, their indeterminacy may be metaphysical, but not ontic.*

value of a proposition is indeterminate if and only if we cannot know whether it is true, or if, even in epistemically ideal circumstances, neither p nor not-p can be appropriately justified. According to a *semantic* interpretation of vagueness, it may be indeterminate whether or not Peter is bald if he has 100 hairs on his head although there is nothing vague or indeterminate about the number of hairs on his head. The vagueness of the statement and the indeterminacy of its truth value result from the logic, or the rules of use, of the predicate "bald". These rules determine whether it applies to clear-cut cases (0 hair, 100 000 hairs) but they do not determine whether it applies to cases in an intermediate range (whose limits are themselves vague). Some authors (Russell 1923, p. 62, Evans 1978; Lewis 1986, p. 212) deny whereas others (Akiba 2004, Williams 2008, Barnes 2010, Torza 2023) hold that there is a third, *metaphysical* form of vagueness.

With these two distinctions in mind, let us examine three cases of causal indeterminacy.

2. Indeterminacy in cases of omission

A first type of case of causal indeterminacy concerns omissions. Sartorio (2006, p. 374) offers a thought experiment in which Jane is on a battlefield. Jane can save one but only one of four soldiers who are in danger of being killed. (She has only one bullet left.) However, she cannot make up her mind about whom of the four she should save, and eventually saves none. Bernstein judges that Jane causes (and is responsible for[4]) a death, but that "it is indeterminate which death she caused" (Bernstein 2016, p. 438). According to Swanson, "for each soldier, it is indeterminate whether [Jane's inaction is] [...] causally relevant to the fact that that soldier died" (Swanson 2017, p. 610).

Jane's inaction, i.e., her omission to save any of the soldiers, makes a difference. If she hadn't remained inactive, one of the soldiers would have survived. Difference-making is widely taken to be a central feature of causation. "We think of a cause as something that makes a difference, and the difference it makes must be a difference from what would have happened without it. Had it been absent, its effects – some of them, at least, and usually all – would have been absent as well" (Lewis 1973/1986, p. 161).

If difference making is sufficient for causation, we have a case of indeterminacy that is not a case of vagueness. We couldn't build a sorites paradox that makes use of it. It is not of the open future type either, because the indeterminacy remains after the effect has occurred. The indeterminacy is not epistemic. We are supposed to know everything about the circumstances yet it seems indeterminate which one of the four deaths is caused by the Jane's inaction. The indeterminacy is not semantic either because all expressions in the relevant statements are semantically definite. Therefore, the causal indeterminacy regarding what Jane's omission causes must be metaphysical. The concept of causation is such that its conditions of use or application determine that the omission causes one cancellation, yet these conditions do not settle which one it causes.

The reasoning that leads to this conclusion depends on the controversial premise that omissions can be causes. If causation between two events requires a process of transference between them[5] (Fair 1979, Kistler 1998; 2006) then omissions are not causes but non-causal difference makers. Whether one of the soldiers is saved or whether all die non-causally depends on what Jane does or does not, but not all forms of dependence are causal. Some state of affairs A may depend counterfactually or nomically, i.e., by virtue of laws of nature, on another state of affairs B, without B causing A. It is widely acknowledged that this is, e.g., the case when B is part of A[6].

The controversy over whether difference-making is sufficient for causation can be illustrated by omissive prevention. Omissions are situations where some event is (counterfactually or nomically) dependent on the non-occurrence of some action. Preventions are situations where the fact that something does not happen depends on some action. If omissions and preventions are cases of causation, so are omissive preventions. There is an omissive prevention each time I don't do anything and as a consequence, nothing happens. Omissive preventions make a difference. Within a framework that construes causation in terms of difference-making, omissive preventions are cases of causation. They share moral and legal status with other cases of difference-making. Preventing an accident by omitting to cross has moral value. However, in the framework of accounts of causation in terms of processes of transmission, omissive preventions are relations of non-causal dependence.

4 The link between causation and moral and legal responsibility is complex and controversial, but the fact that agent A causes event E is at least often taken to be a crucial factor for whether A is also morally and/or legally responsible for E.

5 Transference accounts share Dowe's (2000) thesis that causation in the actual world rests on conserved quantities such as energy. However, Dowe denies that the concept of transference can be applied to conserved quantities.

6 "Events that are not distinct cannot stand in causal dependence" (Lewis 1986, p. 259).

3. Two types of vague causal relations

The case for causal indeterminacy does not depend on the controversial thesis that omissions can be causes. Some causal statements are semantically indeterminate because they contain vague predicates. Such causal statements can generate sorites paradoxes.

Hoffmann-Kolss (2024, p. 9) describes a scenario where Jimmy has a headache and takes two (identical) pills each of which is in itself sufficient for relieving his headache. In a first version of the scenario, Jimmy takes the second pill immediately after the first and the headache disappears. Intuitively, the second pill has as much causal influence as the first. Suppose the quantity of active substance contained in one pill exceeds the threshold for relief, and all quantities over the threshold are sufficient for relief. Taking both pills leads to the active substance contained in both pills together being absorbed. That total amount exceeds the threshold; the contributions of both pills merge and become part of the cause of the relief[7].

In a second version, Jimmy swallows the second pill four hours after the first pill, at a time when the headache has already been completely relieved by the first pill. In this situation, the second pill does intuitively not have any causal influence on the relief of Jimmy's headache, because at the time he takes it there isn't any headache left to be relieved.

These two situations constitute clear-cut limit cases. In between lies a series of intermediate cases. Given that the disappearance of Jimmy's headache has vague boundaries, there is an intermediate period of time in which it is indeterminate whether the second pill contributes to relieve the headache.

This situation is a case of vagueness that can give rise to a sorites paradox.

(1) If the second pill is taken immediately after the first, the second pill contributes to relieving headache just as much as the first.

(2) For any number t of seconds, if when the second pill is taken t seconds after the first the second pill contributes to relieving headache just as much as the first, then when the second pill is taken t + 1 seconds after the first the second pill also contributes to relieving headache just as much as the first.

(3) If the second pill is taken four hours after the first the second pill contributes to relieving headache just as much as the first.

This is paradoxical because (1) and (2) are intuitively true, (3) follows validly from (1) and (2), but (3) is false because four hours after having taken the first pill, there is no headache left to be relieved.

This shows that it can be indeterminate whether an event c has a causal influence on an event e. However, I do not think that this shows that the causal relation itself can be indeterminate. The case of Jimmy taking the second pill at various later times than the first yields causal statements with indeterminate truth value, but it is not a case of a "vague causal relation". To see why let me compare it with statements containing the predicate "is much taller than", which is vague because "much" is vague. Statements containing the predicate "is much taller than" can have indeterminate truth value even when the relata it is applied to are perfectly sharp, such as heights measured in centimeters.

By contrast, the fact that the statement that the second pill caused the relief of Jimmy's headache is vague, does not have its origin in the vagueness of the relation expressed by the predicate "relieves Jimmy's headache". In the scenario as it is described, this is a sharp all or nothing matter. Take one pill (or take any amount of the active substance above the threshold, which is supposed to be sharp) whenever you have a headache, whatever the strength of the headache, and the headache will completely disappear. The indeterminacy of the truth value of a statement according to which the second pill causally contributes to relieving the headache, exclusively stems from the vagueness of the second term of the relation of relieving: it is vague whether or not at the time at which the second pill is taken, Jimmy still suffers from a headache.

Consider buying a heap of sand. Given that the predicate "is a heap" is vague, the truth value of the statement "I buy this heap of sand" can be indeterminate, because the set of grains of sand maybe a borderline case of a heap, although the relation of buying is perfectly sharp.

Or consider a pill that causes one to lose all one's hair. The dose contained in one pill (the minimum that it is possible to take) is always sufficient for the person absorbing it to lose all her hair. In that case there is nothing vague about the causal influence of the pill on the loss of hair. It is an all or nothing affair. Nevertheless, the statement "taking a pill caused her to become bald" can have indeterminate truth value if the person who takes the pill is borderline for being already bald.

7 Hitchcock speaks of a "probability pool" (Hitchcock 2004, p. 407) which corresponds to the total probability of the effect to which each of two causes contributes. According to a metaphysical interpretation of probabilistic causality (as opposed to an epistemic interpretation), the amount of the conditional probability of the effect E given the cause C determines not only whether (and with which probability) it is probable that C causes E, but determines also directly whether C causes E.

The statement that the second pill relieves Jimmy's headache has the same structure as the two cases just mentioned: buying a borderline case of a heap, and making someone bald who is already a borderline case of bald. In the case of the pill that causes baldness, the vagueness lies in the result: in order for the pill to cause a person to become bald, the person must not yet be bald, and whether that is the case may be indeterminate because baldness is vague. The statement, "taking the pill caused her to become bald" is vague, not because the causal relation comes in degrees and is characterized by a vague transition from not causing to causing, but because it is vague whether someone is already bald when she takes the pill.

Now, consider the situation in which in it is vague whether taking the second pill of pain killer relieves pain. Here the indeterminacy corresponds to the time at which the person takes the second pill. Is this a case in which the vagueness is due to the vague boundaries of one of the terms of the relation "relieving one's pain" or is the vagueness of the proposition due to the vagueness of the relation itself? Hoffmann-Kolss suggests that it is the latter. "There is a crucial difference" (Hoffmann-Kolss, 2024, p. 13), she says, between the indeterminacy in the scenario of the two painkiller pills and scenarios of the sort of the bald-making pill. In the case of the second painkiller pill, the vagueness stems from the temporal structure of the situation: "Since temporal distance is a graded notion, there may be borderline cases that leave the causal structure indeterminate" (Hoffmann-Kolss, 2024, p. 13). Indeed, the vagueness stems from the vague temporal boundary of the headache. However, the relation of relieving is an all or nothing affair, and the vagueness of whether taking the second pill at t relieves the headache stems from the vagueness of whether there still is any headache to be relieved at t.

Let me compare this to a case where it is vague whether there is causal influence although the relata are sharp. Here is a variant of the case of the pill that provokes losing one's hair. Say the dose contained in some pills is so diluted that one pill doesn't normally cause any loss of hair but that there is some threshold (maybe different for each individual) above which taking pills starts to cause loss of hair, and another threshold above which it causes loss of all hair.

The relation of *strongly causing* loss of hair comes in degrees, and its extension has a vague boundary. Taking more or less pills causes stronger or weaker loss of hair, and it is vague how much loss of hair counts as strong. Consider the relation expressed by the predicates "causes loss of much hair" or "strongly causes loss of hair". Propositions containing the relation of strongly causing loss of hair can have indeterminate truth value; and their indeterminacy is due to the vagueness of the relation of "strongly causing". Say taking one pill is below the first threshold, so that taking one pill clearly does not strongly cause one to lose one's hair, and taking ten pills lies above the second threshold, so that taking 10 pills clearly causes one to strongly lose one's hair.

Say taking 5 pills is somewhere between the two thresholds and a borderline case. Taking 5 pills makes someone lose some but not all hair, so that it is neither definitely true nor definitely false to say that "Taking 5 pills strongly caused her to lose her hair". It is possible to construct a sorites paradox for the relation of strongly causing.

(4) Taking one pill does not strongly cause losing one's hair.

(5) For any natural number n, if taking n pills does not strongly cause losing one's hair, then taking n +1 pills does not strongly cause losing one's hair either.

(6) Taking 10 pills does not strongly cause losing one's hair.

This is paradoxical because (4) is true by stipulation, (5) is intuitively true, (6) follows validly from (4) and (5), but (6) is false by stipulation.

The case of hair loss is a toy example, chosen for its link with the paradigmatically vague predicate "is bald". However, strong influence, strong increase, strong enhancement and the like are concepts that are widely used in science, such as medicine (Kurihara and Wada 2004) and biology (Huang et al 2004, Coors et al 2008).

4. Indeterminacy in probabilistic causation

Lastly, let us as examine whether probabilistic causation gives rise to a third type of indeterminate causal statements.

4.1 Indeterministic overdetermination

Here is a scenario described by Humphreys (1989, p. 15).

> "A laboratory mouse is given a diet containing both gyromitrin and diazonium metabolite and contracts a stomach tumor. Neither substance is sufficient to produce tumors at low dosages, but each individually has been shown to increase the incidence of tumors in laboratory mice[8]. Neither substance was necessary in the circumstances to produce the tumor". Humphreys gives an affirmative answer to the ques-

8 *Humphreys (1989, p. 15, note 22) indicates that "sources for this claim are* J. Agri. Food Chem. *31 (1983): 1117; Carcinogens and Mutagens in the Environment, edited by H. F. Stitch (Boca Raton, Fla.: CRC Press, 1984), pp. 99-108".*

tion whether we "should [...] call such carcinogenic factors contributing causes in the production of tumors".

In his words,

> "Presupposing that the statistical associations involved here are representative of the true chances [...], I think that we should judge such factors as causal and for the [...] reason [...] that each factor contributes an increase in probability to the outcome, even though neither factor is sufficient for the effect. In doing so, we follow a widespread epidemiological and biological practice" (Humphreys 1989, p. 15).

According to Humphreys' conception of the link between conditional probability and causation, if 1) each of two factors C_1 and C_2 independently raises the chance of a given type of effect E, 2) there is no interaction between C_1 and C_2, in the sense that the influence that each has on E is independent of the influence the other has on E, this is a sufficient reason to conclude that, in every particular situation where C_1 and C_2 are both present and followed by E, both C_1 and C_2 have causally influenced E. In other words, the very fact that the presence of these factors raises the chance of E is sufficient for each of them to contribute to causing E in every case in which E occurs. Put in more abstract terms, if a factor raises the probability of an effect at the level of populations, i.e., if C is a type level cause of E, then in each case where event c of type C is followed by an event e of type E, the fact that c is C has contributed to cause e which is of type E. This is the case also, when two such factors act in parallel. If c is both C_1 and C_2, and both C_1 and C_2 are type level causes of E, then if c is followed by e which is E, both the fact that c is C_1 and the fact that c is C_2 have contributed to cause e which is of type E.

Woodward (1994) challenges Humphreys' analysis of the situation. He denies there are any good reasons to privilege the hypothesis that both C_1 and C_2 contributed to causing E over the alternative hypothesis that the cancer was "caused by C_1 alone or C_2 alone" (Woodward 1994, p. 366). Each of C_1 and C_2, he argues, is known to be able to cause E by itself, and, in the scenario where C_1 and C_2 are both present, we have no reason to exclude the possibility that one of C_1 and C_2 alone, but not the other, caused E. In other words, the fact that both are present and both individually increase the probability of E is not enough to conclude that both contributed to causing E. This underdetermination between two possibilities (both C_1 and C_2 contributed to causing E and one of them alone caused E) does not stem from an epistemic interpretation of the relevant probabilities. Humphreys explicitly takes them to be objective "real world" chances, and Woodward accepts this interpretation.

Hitchcock (2004) suggests that Humphreys' description underdetermines the situation. The description leaves it open which of two possible types of situations the case of the two carcinogens belongs to. In one type of situation (type A), Humphreys is right that the fact that each of C_1 and C_2 individually raises the probability of E, and the fact that at some particular occasion, instantiations of C_1 and of C_2 were followed by an instantiation of E, is in itself sufficient to conclude that both C_1 and C_2 contributed to causing E. Such situations are correctly modeled by what Hitchcock calls the "probabilistic pool conception of indeterministic causation" (Hitchcock 2004, p. 413). However, in another type of situation (type B), one of C_1 and C_2 alone causes E, whereas the other factor remains causally inert.

Suppose that Humphrey's description of the scenario contains all facts relevant for causation, i.e., suppose there aren't any facts which, although unknown and not mentioned in the description, make it the case that the situation belongs either to type A or to type B. Suppose, in other words, that the situation itself does not provide sufficient reasons for taking as more appropriate to the situation a conception of causation in which probability raising is all there is to causation and a conception in which the fact that C raises the probability of E makes the effect E more probable but is not sufficient for C to contribute causally to E. Humphreys' claim is justified only on the former conception of causation.

Hitchcock (2004, p. 409) sketches a situation that clearly belongs to type A. A source emits photons that are polarized in the vertical direction. The photons then hit a polarizer that is oriented so that horizontally polarized photons are transmitted and vertically polarized photons are absorbed. Photons that are polarized at an angle α with the vertical direction are transmitted with a probability $\sin^2(\alpha)$.

Juan and Jennifer each turn the apparatus by 30 degrees, so that the emitted photons make an angle of 60° with the vertical direction, and the probability of transmission is $\sin^2(60°)=0.75$. In this scenario, both Juan's push (C_1) and Jennifer's push (C_2) enhance the probability of transmission of the photons (E). In this situation, the fact that each of C_1 and C_2 raises the probability of E is enough to conclude that, for a given individual photon that has been transmitted, both C_1 and C_2 have causally contributed to its transmission. In Hitchcock's terms, "the two pushes determine the probability of transmission, and nothing else causal happens – transmission follows by sheer chance" (Hitchcock 2004, p. 413).

In situations of type B, there is a marker of the effect that singles out one of C_1 and C_2 as its cause. In such cases, we know that only one of C_1 and C_2 caused E although both were present. Here is such a situation. On a given day there is a probability of 0.5 for each of X and Y to send me a message, where X's messages are marked as different from Y's mes-

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sages[9]. There is a 0.75 probability that I will get a message from one or the other. In this case, for a given message *m* that I receive, although both X's disposition to send me messages (C_1) and Y's disposition to send me messages (C_2) raised the probability of my receiving a message (E), my reception of *m* was caused by one of C_1 and C_2, to the exclusion of the other. It bears the mark of the sender.

My suggestion is that the scenario of the two carcinogens belong to a third type C of situation. It doesn't belong to type B of situations in which the effect bears a marker that indicates by which factor it has been caused. As the case of the two carcinogens is described, there is no such marker, in the sense that for a given mouse that has been exposed to both gyromitrin (C_1) and diazonium metabolite (C_2) and has developed stomach tumor (E), the tumor is not of a type specific to one or the other carcinogen. In other words, the tumor doesn't bear any mark that would indicate that it was caused either by C_1 or by C_2. But it doesn't belong to type A of situations either, where some theory (such as quantum physics in the scenario with the polarized photons) tells us that, in a situation where both C_1 and C_2 were present, each event e of type E has been caused by both C_1 and C_2.

If this is correct, the case belongs to a third type C. In cases of type C, in each particular situation where both factors C_1 and C_2 are present, where each of C_1 and C_2 individually raises the probability of E, and where an event of type E occurs, it is indeterminate whether C_1 alone or C_2 alone has caused e, or whether e has been caused by both C_1 and C_2.

There may be situations of type C in psychology. In a protocol of classical conditioning (Rescorla & Wagner 1972; Rescorla 1988), a stimulus that is neutral for some animal before conditioning (to take Pavlov's example, the sound of a bell for a dog) is associated with a stimulus (the so-called unconditioned stimulus, US) that provokes a behavioral response. To take Pavlov's example, the smell of food is an unconditioned stimulus for salivation in dogs, in that it naturally provokes a dogs' salivation. If the smell of food is associated during a conditioning protocol with some formerly neutral stimulus, such as the ringing of a bell, the ringing of the bell becomes a "conditioned stimulus" (CS), which provokes, after the end of the conditioning protocol, the same reaction of salivation as the US. In Rescorla's (1988) interpretation, after conditioning the animal reacts to the CS as it would react to US because the CS carries the information that the US is about to occur. It is possible to associate two different stimuli CS_1 and CS_2 with the same US, so that both conditioned stimuli CS_1 and CS_2 provoke the same behavioral response R that was originally provoked by the US (Rescorla and Wagner 1972). The causal relation between each of the conditioned stimuli CS_1 and CS_2 and R is probabilistic: for each of CS_1 and CS_2, R follows CS_i with a certain probability.

Situations where both CS_1 and CS_2 are present and where a conditioned animal reacts by R, may belong to type C of situations. It belongs to type C insofar as it is indeterminate whether R is caused by CS_1, by CS_2, or by both. Whether this is indeed true, depends on the empirical fact that it is not just a matter of ignorance whether R is caused by CS_1, by CS_2 or by both. However, it seems empirically possible that there is no fact of the matter that could provide an empirical ground for giving a determinate answer to the question whether the cause of a dog's reacting by R in a particular situation is CS_1, CS_2, or both CS_1 and CS_2.

Two objections may be raised.

(1) According to the first, there really are no situations of type C. If there is no marker as in situations of type B, the situation belongs to type A. This means that C_1 and C_2 are both causally contributing to E.

(2) According to the second, if there is no marker and if there is no reason to think that both C_1 and C_2 contributed to causing E, then it is inappropriate to ask the question whether C_1 or C_2 caused E or whether both C_1 and C_2 causally contributed to bring about E. If there is no marker then it is inappropriate to judge that one of C_1 and C_2 alone caused E, as in situations of type B. However, the determinate answer (appropriate in situations of type A) that C_1 and C_2 contributed both to bringing about R is appropriate only in situations where some physical theory tells us that the contributions of both causes are merged in a common source of causing E.

In reply to the first objection, there must be some positive reason for taking a situation to be of type A. This is the case in the situation of the polarized photons where quantum theory tells us that the contribution of C_1 and C_2 merge so that in each case where a photon is transmitted, the transmission both C_1 and C_2 have equally contributed to cause its transmission. In the absence of such a theory, there is no reason to accept that the situation belongs to type A. Since it doesn't belong to type B either, there is a third type C of situations in which it is indeterminate whether C_1 or C_2 alone caused E or whether both C_1 and C_2 causally contributed to bring about E.

My reply to the second objection is that the burden of proof lies with those who reject a question to which a coherent answer can be provided. The judgment according to which it is inappropriate to ask whether both CS_1 and CS_2 together caused R in a given episode or whether it was one of CS_1 and CS_2 alone, to the exclusion of the other, seems justified only in the absence of the category of indeterminate causation.

9 *I borrow the idea of using e-mail messages to think about indeterministic overdetermination from Hoffmann-Kolss (2024).*

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If there were no indeterminate causation, or if there were strong reasons for not accepting the existence of situations of type C, so that every situation must necessarily belong either to type B where one or the other of C_1 and C_2 has caused E, or to type A, where both merged to influence E together, it would indeed be justified to reject the possibility to categorize the situation in one of these two types. However, insofar as there are no strong reasons against accepting the possibility of situations of type C, the most plausible verdict in cases like the conditioning on two stimuli CS_1 and CS_2, and maybe also in the case of Humphreys' carcinogens, may be that it is indeterminate whether one of the two factors alone caused E or whether both together brought about the effect.

4.2 Indeterministic trumping[10]

In a thought experiment of Schaffer's (2000), a magical spell, if it is the only spell cast during a given day, determines what happens at midnight, namely that the prince is turned into a frog. Hoffmann-Kolss constructs an indeterministic variant of Schaffer's thought experiment, where, if there are 2 spells cast the same day, "the probability that the first spell determines what happens at midnight is 0.9 and the probability that the second spell, but not the first spell determines what happens at midnight is 0.1" (Hoffmann-Kolss, 2024, p. 20).

During a particular day, first Merlin and then Morgana cast a spell, each raising the probability that the prince turns into a frog at midnight. The prince turns into a frog, and one of the spells was the cause of that transformation. By the construction of the situation, it is, before midnight, metaphysically (and not just epistemically) indeterminate which of the two spells will become effective. However, the indeterminacy disappears at midnight, when one of the spells becomes effective, to the exclusion of the other. "The two spells hang in the air until midnight, and then one of them takes effect, but which one depends on an indeterministic magical process" (Hoffmann-Kolss, 2024, p. 21).

As the case is described, at midnight it becomes determined whether it is one or the other that was effective. The case belongs to the open future category of indeterminacy. From the time when both spells have been cast, and until midnight, it is open which will be effective. However, it is not open, as it was in the case of the polarized photons we considered above, whether one of them will be effective. One of them will be. Moreover, at midnight and later, it remains epistemically indeterminate which spell has caused the transformation; however, it does not remain metaphysically indeterminate which of the spells became effective. It is just that there is in principle no way of finding out which it was.

The possibility to construct this scenario shows that indeterminate trumping is conceivable, or in other words, that it is conceptually possible. However, indeterminate trumping is not a sort of indeterminate causation. It doesn't belong to type C of situations sketched above. Moreover, the fact that indeterminate trumping is conceptually possible doesn't entail that it exists or is scientifically possible in our world, in the sense that it would be compatible with scientific knowledge.

It doesn't seem plausible that indeterminate trumping is scientifically possible. By construction of the situation, it is not the case that both C_1 (Merlin's spell) and C_2 (Morgana's spell) contributed (as in situations of type A) to bringing about E (the prince's turning into a frog) and it is not indeterminate whether it is one of C_1 and C_2 alone or both (as in situations of type C) that caused E. However, there is also no marker (as in situations of type B), in the sense that no property of the effect E indicates whether it was caused by C_1 or by C_2. The indeterministic trumping scenario postulates that one of C_1 and C_2 caused E, just as in type A but that this is the case without any natural ground: there is neither a marker at E that could ground the fact that it was one of C_1 and C_2 to the exclusion of the other that caused E, nor any natural process that might ground the fact that one of C_1 and C_2 to the exclusion of the other caused E.

This reasoning doesn't show that indeterministic trumping doesn't exist in the real world. However, as long as no situation has been described that fits the description without requiring magic, it remains a merely conceptual possibility. Moreover, it doesn't seem compatible with science that the actual world contains situations that share the structure of magical trumping. If there is no marker (the situation does not belong to type B) and if we have no reasons to think that both have contributed together (the situation does not belong to type A), the most plausible judgment seems to be that it is indeterminate whether one of the potential causes or both together brought about the effect (the situation belongs to type C). However, the situation of the two spells is not a case of metaphysical indetermination because it does not remain, after midnight, metaphysically (but only epistemically) indeterminate which of the two spells was effective. If indeterminate trumping were scientifically possible, it would constitute a subcategory of type B where it is epistemically indeterminate but metaphysically determinate which of C_1 and C_2 was the cause of E.

10 The concept of "trumping" has been introduced by Schaffer (2000). If both C_1 and C_2 are alone sufficient for bringing about E, but, if both C_1 and C_2 are present, C_1 alone causes E, whereas C_2 does not contribute to E at all, C_1 is said to trump C_2 or to be a "trumping cause" (Schaffer 2000, p. 177) of E. Schaffer offers the example of two officers giving the same order to the same soldier at the same time. If the soldier obeys, her act is caused by the order of the higher-ranking officer, whose orders "trump" (Schaffer 2000, p. 175) the orders of the lower-ranking officer.

5. Conclusion

There are at least three types of situations that seem to contain indeterminate causation. A first type of indeterminate causation concerns omissions. Statements designating an omission as a cause can be indeterminate. The conclusion that this entails the existence of indeterminate causation depends on the controversial premise that omissions can be causes.

A second type of indeterminate causation corresponds to causal statements whose truth value is indeterminate because they contain vague predicates. Such vagueness can have two sources. Either a vague predicate characterizes the terms of the relation or a vague predicate, such as "strongly causes", characterizes the causal relation itself. The statement that the second pill contributes to relieve Jimmy's headache belongs to the former category. However, only cases of the second type are, strictly speaking, cases of indeterminate causation.

A third type of indeterminacy involves probabilistic causation. In situations where factors of two types C_1 and C_2 are present, each of which independently influences the probability of occurrence of an event of type E, and where an event of type E occurs, it can be indeterminate whether one of C_1 and C_2 alone caused the occurrence of E, or whether both C_1 and C_2 contributed to bring E about. This may be the case when an animal is classically conditioned with two different conditional stimuli CS_1 and CS_2. When both stimuli are present and the animal reacts as conditioned by R, it maybe metaphysically and not just epistemically indeterminate whether one of the stimuli to the exclusion of the other has caused the animal's reaction R or whether R has been caused by both CS_1 and CS_2 together.

"Indeterministic trumping" is a conceptually possible type of indeterminate causation that belongs to the categories of the open future and of epistemically indeterminate causation, but it is not a sort of metaphysically indeterminate causation. Awaiting the description of a situation that is possible in the actual world according to scientific knowledge, it seems cautious to judge that this sort of indeterminate causation is conceptually possible but does not correspond to any situation in the actual world[11].

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CONTACT ET COORDONÉES

Max Kistler
UFR de philosophie
Université Paris 1 Panthéon-Sorbonne
17 rue de la Sorbonne
F-75005 PARIS
mkistler@univ-paris1.fr

SOCIÉTÉ DE PHILOSOPHIE DES SCIENCES (SPS)

École normale supérieure
45, rue d'Ulm
75005 Paris

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