Causes and Conditions

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I. CAUSES AND CONDITIONS

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ASKED what a cause is, we may be tempted to say that it is an event which precedes the event of which it is the cause, and is both necessary and sufficient for the latter's occurrence; briefly, that a cause is a necessary and sufficient preceding condition. There are, however, many difficulties in this account. I shall try to show that what we often speak of as a cause is a condition not of this sort, but of a sort related to this. That is to say, this account needs modification, and can be modified, and when it is modified we can explain much more satisfactorily how we can arrive at much of what we ordinarily take to be causal knowledge; the claims implicit within our causal assertions can be related to the forms of the evidence on which we are often relying when we assert a causal connection.

§ 1. SINGULAR CAUSAL STATEMENTS

Suppose that a fire has broken out in a certain house, but has been extinguished before the house has been completely destroyed. Experts investigate the cause of the fire, and they conclude that it was caused by an electrical short-circuit at a certain place. What is the exact force of their statement that this short-circuit caused this fire? Clearly the experts are not saying that the short-circuit was a necessary condition for this house's catching fire at this time; they know perfectly well that a short-circuit somewhere else, or the overturning of a lighted oil stove, or any one of a number of other things might, if it had occurred, have set the house on fire. Equally, they are not saying that the short-circuit was a sufficient condition for this house's catching fire; for if the short-circuit had occurred, but there had been no inflammable material nearby, the fire would not have broken out, and even given both the short-circuit and the inflammable material, the fire would not have occurred if, say, there had been an efficient automatic sprinkler at just the right spot. Far from being a condition both necessary and sufficient for the fire, the short-circuit was, and is known to the experts to have been, neither necessary nor sufficient for it. In what sense, then, is it said to have caused the fire?

At least part of the answer is that there is a set of conditions (of which some are positive and some are negative), including the presence of inflammable material, the absence of a suitably placed sprinkler, and no doubt quite a number of others, which combined with the short-circuit constituted a complex condition that was sufficient for the house's catching fire—sufficient, but not necessary, for the fire could have started in other ways. Also, of *this* complex condition, the short-circuit was an indispensable part: the other parts of this condition, conjoined with one another in the absence of the short-circuit, would not have produced the fire. The short-circuit which is said to have caused the fire is thus an indispensable part of a complex sufficient (but not necessary) condition of the fire. In this case, then, the so-called cause is, and is known to be, an *insufficient* but *necessary* part of a condition which is itself *unnecessary* but *sufficient* for the result. The experts are saying, in effect, that the short-circuit is a condition of this sort, that it occurred, that the other conditions which conjoined with it form a sufficient condition were also present, and that no other sufficient condition of the house's catching fire was present on this occasion. I suggest that when we speak of the cause of some particular event, it is often a condition of this sort that we have in mind. In view of the importance of conditions of this sort in our knowledge of and talk about causation, it will be convenient to have a short name for them: let us call such a condition (from the initial letters of the words italicized above), an INUS condition.[1]

This account of the force of the experts' statement about the cause of the fire may be confirmed by reflecting on the way in which they will have reached this conclusion, and the way in which anyone who disagreed with it would have to

[1] This term was suggested by D. C. Stove who has also given me a great deal of help by criticizing earlier versions of this article.

challenge it. An important part of the investigation will have consisted in tracing the actual course of the fire; the experts will have ascertained that no other condition sufficient for a fire's breaking out and taking this course was present, but that the short-circuit did occur and that conditions were present which in conjunction with it were sufficient for the fire's breaking out and taking the course that it did. Provided that there is some necessary and sufficient condition of the fire—and this is an assumption that we commonly make in such contexts—anyone who wanted to deny the experts' conclusion would have to challenge one or another of these points.

We can give a more formal analysis of the statement that something is an INUS condition. Let 'A' stand for the INUS condition—in our example, the occurrence of a short-circuit at that place—and let 'B' and '$\bar{C}$' (that is, 'not-C', or the absence of C) stand for the other conditions, positive and negative, which were needed along with A to form a sufficient condition of the fire—in our example, B might be the presence of inflammable material, $\bar{C}$ the absence of a suitably placed sprinkler. Then the conjunction '$AB\bar{C}$' represents a sufficient condition of the fire, and one that contains no redundant factors; that is, $AB\bar{C}$ is a minimal sufficient condition for the fire.[2] Similarly, let $D\bar{E}F$, $\bar{G}\bar{H}I$, etc., be all the other minimal sufficient conditions of this result. Now provided that there is some necessary and sufficient condition for this result, the disjunction of all the minimal sufficient conditions for it constitutes a necessary and sufficient condition.[3] That is, the formula "$AB\bar{C}$ or $D\bar{E}F$ or $\bar{G}\bar{H}I$ or . . ." represents a necessary and sufficient condition for the fire, each of its disjuncts, such as '$AB\bar{C}$', represents a minimal sufficient condition, and each conjunct in each minimal sufficient condition, such as 'A', represents an INUS condition. To simplify and generalize this, we can replace the conjunction of terms conjoined with 'A' (here '$B\bar{C}$') by the single term 'X', and the formula representing the disjunction of all the other minimal sufficient conditions—here "$D\bar{E}F$ or $\bar{G}\bar{H}I$ or . . ."—by the single term 'Y'. Then an INUS condition is defined as follows:

> A is an INUS condition of a result P if and only if, for some X and for some Y, (AX or Y) is a necessary and sufficient condition of P, but A is not a sufficient condition of P and X is not a sufficient condition of P.

We can indicate this type of relation more briefly if we take the provisos for granted and replace the existentially quantified variables 'X' and 'Y' by dots. That is, we can say that A is an INUS condition of P when (A . . . or . . .) is a necessary and sufficient condition of P.

(To forestall possible misunderstandings, I would fill out this definition as follows.[4] First, there could be a set of minimal sufficient conditions of P, but no necessary conditions, not even a complex one; in such a case, A might be what Marc-Wogau calls a moment in a minimal sufficient condition, but I shall not call it an INUS condition. I shall speak of an INUS condition only where the disjunction of all the minimal sufficient conditions is also a necessary condition. Secondly, the definition leaves it open that the INUS condition A might be a conjunct in each of the minimal sufficient conditions. If so, A would be itself a necessary condition of the result. I shall still call A an INUS condition in these circumstances: it is not part of the definition of an INUS condition that it should *not* be necessary, although in the standard cases, such as that

[2] The phrase "minimal sufficient condition" is borrowed from Konrad Marc-Wogau, "On Historical Explanation," *Theoria*, vol. 28 (1962), pp. 213–233. This article gives an analysis of singular causal statements, with special reference to their use by historians, which is substantially equivalent to the account I am suggesting. Many further references are made to this article, especially in n. 9 below.

[3] Cf. n. 8 on p. 227 of Marc-Wogau's article, where it is pointed out that in order to infer that the disjunction of all the minimal sufficient conditions will be a necessary condition, "it is necessary to presuppose that an arbitrary event C, if it occurs, must have sufficient reason to occur." This presupposition is equivalent to the presupposition that there is some (possibly complex) condition that is both necessary and sufficient for C.

It is of some interest that some common turns of speech embody this presupposition. To say "Nothing but X will do," or "Either X or Y will do, but nothing else will," is a natural way of saying that X, or the disjunction (X or Y), is a *necessary* condition for whatever result we have in mind. But taken literally these remarks say only that there is no sufficient condition for this result other than X, or other than (X or Y). That is, we use to mean "a necessary condition" phrases whose literal meanings would be "the only sufficient condition," or "the disjunction of all sufficient conditions." Similarly, to say that Z is "all that's needed" is a natural way of saying that Z is a sufficient condition, but taken literally this remark says that Z is the only necessary condition. But, once again, that the only necessary condition will also be a sufficient one follows only if we presuppose that some condition is both necessary and sufficient.

[4] I am indebted to the referees for the suggestion that these points should be clarified.

sketched above, it is not in fact necessary.[5] Thirdly, the requirement that X by itself should not be sufficient for P insures that A is a nonredundant part of the sufficient condition AX; but there is a sense in which it may not be strictly necessary or indispensable even as a part of *this* condition, for it may be replaceable: for example KX might be another minimal sufficient condition of P.[6] Fourthly, it *is* part of the definition that the minimal sufficient condition, AX, of which A is a nonredundant part, is not also a necessary condition, that there is another sufficient condition Y (which may itself be a disjunction of sufficient conditions). Fifthly, and similarly, it *is* part of the definition that A is not by itself sufficient for P. The fourth and fifth of these points amount to this: I shall call A an INUS condition only if there are terms which actually occupy the places occupied by 'X' and 'Y' in the formula for the necessary and sufficient condition. However, there may be cases where there is only one minimal sufficient condition, say AX. Again, there may be cases where A is itself a minimal sufficient condition, the disjunction of all minimal sufficient conditions being (A or Y); again, there may be cases where A itself is the only minimal sufficient condition, and is itself both necessary and sufficient for P. In any of these cases, as well as in cases where A is an INUS condition, I shall say that A is *at least an* INUS *condition*. As we shall see, we often have evidence which supports the conclusion that something is *at least* an INUS condition; we may or may not have other evidence which shows that it is *no more than* an INUS condition.)

I suggest that a statement which asserts a singular causal sequence, of such a form as "A caused P," often makes, implicitly, the following claims:

(i) A is at least an INUS condition of P—that is, there is a necessary and sufficient condition of P which has one of these forms: (AX or Y), (A or Y), AX, A.

(ii) A was present on the occasion in question.

(iii) The factors represented by the 'X', if any, in the formula for the necessary and sufficient condition were present on the occasion in question.

(iv) Every disjunct in 'Y' which does not contain 'A' as a conjunct was absent on the occasion in question. (As a rule, this means that whatever 'Y' represents was absent on this occasion. If 'Y' represents a single conjunction of factors, then it was absent if at least one of its conjuncts was absent; if it represents a disjunction, then it was absent if each of its disjuncts was absent. But we do not wish to exclude the possibility that 'Y' should be, or contain as a disjunct, a conjunction one of whose conjuncts is A, or to require that *this* conjunction should have been absent.[7])

I do not suggest that this is the whole of what is meant by "A caused P" on any occasion, or even that it is a part of what is meant on every occasion: some additional and alternative parts of the meaning of such statements are indicated below.[8] But I am suggesting that this is an important part of the concept of causation; the proof of this suggestion would be that in many cases the falsifying of any one of the above-mentioned claims would rebut the assertion that A caused P.

This account is in fairly close agreement, in substance if not in terminology, with at least two accounts recently offered of the cause of a single event.

Konrad Marc-Wogau sums up his account thus:

> when historians in singular causal statements speak of a cause or the cause of a certain individual event β, then what they are referring to is another individual event α which is a moment in a minimal sufficient and at the same time necessary condition *post factum* β.[9]

[5] Special cases where an INUS condition is also a necessary one are mentioned at the end of § 3.

[6] This point, and the term "nonredundant," are taken from Michael Scriven's review of Nagel's *The Structure of Science*, in *Review of Metaphysics*, 1964. See especially the passage on p. 408 quoted below.

[7] See example of the wicket-keeper discussed below.

[8] See §§ 7, 8.

[9] See pp. 226–227 of the article referred to in n. 2 above. Marc-Wogau's full formulation is as follows:

"Let 'msc' stand for minimal sufficient condition and 'nc' for necessary condition. Then suppose we have a class K of individual events $a_1, a_2, \ldots a_n$. (It seems reasonable to assume that K is finite; however even if K were infinite the reasoning below would not be affected.) My analysis of the singular causal statement: α is the cause of β, where α and β stand for individual events, can be summarily expressed in the following statements:

(1) $(EK)\ (K = \{a_1, a_2, \ldots, a_n\})$;
(2) $(x)\ (x \in K \equiv x \text{ msc } \beta)$;
(3) $(a_1 \vee a_2 \vee \ldots a_n) \text{ nc } \beta$;
(4) $(x)\ ((x \in K\ x \neq a_1) \supset x$ is not fulfilled when α occurs);
(5) α is a moment in a_1.

(3) and (4) say that a_1 is a necessary condition *post factum* for β. If a_1 is a necessary condition *post factum* for β, then every moment in a_1 is a necessary condition *post factum* for β, and therefore also α. As has been mentioned before (note 6) there is assumed to be a temporal sequence between α and β; β is not itself an element in K."

He explained his phrase "necessary condition *post factum*" by saying that he will call an event a_1 a necessary condition *post factum* for x if the disjunction "a_1 or a_2 or a_3 . . . or a_n" represents a necessary condition for x, and of these disjuncts only a_1 was present on the particular occasion when x occurred.

Similarly Michael Scriven has said:

> Causes are *not* necessary, even contingently so, they are not sufficient—but they are, to talk that language, *contingently sufficient*. . . . They are part of *a* set of conditions that does guarantee the outcome, and they are non-redundant in that the rest of *this* set (which does not include all the other conditions present) is not alone sufficient for the outcome. It is not even true that they are relatively necessary, i.e., necessary with regard to that set of conditions rather than the total circumstances of their occurrence, for there may be several possible replacements for them which happen not to be present. There remains a ghost of necessity; a cause is a factor from a set of possible factors the presence of one of which (*any* one) is necessary in order that a set of conditions actually present be sufficient for the effect.[10]

There are only slight differences between these two accounts, or between each of them and that offered above. Scriven seems to speak too strongly when he says that causes are not necessary: it is, indeed, not part of the definition of a cause of this sort that it should be necessary, but, as noted above, a cause, or an INUS condition, may be necessary, either because there is only one minimal sufficient condition or because the cause is a moment in each of the minimal sufficient conditions. On the other hand, Marc-Wogau's account of a minimal sufficient condition seems too strong. He says that a minimal sufficient condition contains "only those moments relevant to the effect" and that a moment is relevant to an effect if "it is a necessary condition for β: β would not have occurred if this moment had not been present." This is less accurate than Scriven's statement that the cause only needs to be nonredundant.[11] Also, Marc-Wogau's requirement, in his account of a necessary condition *post factum*, that only one minimal sufficient condition (the one containing α) should be present on the particular occasion, seems a little too strong. If two or more minimal sufficient conditions (say a_1 and a_2) were present, but α was a moment in each of them, then though neither a_1 nor a_2 was necessary *post factum*, α would be so. I shall use this phrase "necessary *post factum*" to include cases of this sort: that is, α is a necessary condition *post factum* if it is a moment in every minimal sufficient condition that was present. For example, in a cricket team the wicket-keeper is also a good batsman. He is injured during a match, and does not bat in the second innings, and the substitute wicket-keeper drops a vital catch that the original wicket-keeper would have taken. The team loses the match, but it would have won if the wicket-keeper had *both* batted *and* taken that catch. His injury was a moment in two minimal sufficient conditions for the loss of the match; either his not batting, or the catch's not being taken, would on its own have insured the loss of the match. But we can certainly say that his injury caused the loss of the match, and that it was a necessary condition *post factum*.

This account may be summed up, briefly and approximately, by saying that the statement "A caused P" often claims that A was necessary and sufficient for P in the circumstances. This description applies in the standard cases, but we have already noted that a cause is nonredundant rather than necessary even in the circumstances, and we shall see that there are special cases in which it may be neither necessary nor nonredundant.

§ 2. Difficulties and Refinements[12]

Both Scriven and Marc-Wogau are concerned not only with this basic account, but with certain difficulties and with the refinements and complications that are needed to overcome them. Before dealing with these I shall introduce, as a refinement of my own account, the notion of a causal field.[13]

[10] *Op. cit.*, p. 408.

[11] However, in n. 7 on pp. 222–233, Marc-Wogau draws attention to the difficulty of giving an accurate definition of "a moment in a sufficient condition." Further complications are involved in the account given in § 5 below of "clusters" of factors and the progressive localization of a cause. A condition which is minimally sufficient in relation to one degree of analysis of factors may not be so in relation to another degree of analysis.

[12] This section is something of an aside: the main argument is resumed in § 3.

[13] This notion of a causal field was introduced by John Anderson. He used it, e.g., in "The Problem of Causality," first published in the *Australasian Journal of Psychology and Philosophy*, vol. 16 (1938), and reprinted in *Studies in Empirical Philosophy* (Sydney, 1962), pp. 126–136, to overcome certain difficulties and paradoxes in Mill's account of causation. I have also used this notion to deal with problems of legal and moral responsibility, in "Responsibility and Language," *Australasian Journal of Philosophy*, vol. 33 (1955), pp. 143–159.

This notion is most easily explained if we leave, for a time, singular causal statements and consider general ones. The question "What causes influenza?" is incomplete and partially indeterminate. It may mean "What causes influenza in human beings in general?" If so, the (full) cause that is being sought is a difference that will mark off cases in which human beings contract influenza from cases in which they do not; the causal field is then the region that is to be thus divided, *human beings in general*. But the question may mean, "Given that influenza viruses are present, what makes some people contract the disease whereas others do not?" Here the causal field is *human beings in conditions where influenza viruses are present*. In all such cases, the cause is required to differentiate, within a wider region in which the effect sometimes occurs and sometimes does not, the sub-region in which it occurs: this wider region is the causal field. This notion can now be applied to singular causal questions and statements. "What caused this man's skin cancer?"[14] may mean "Why did this man develop skin cancer now when he did not develop it before?" Here the causal field is the career of this man: it is within this that we are seeking a difference between the time when skin cancer developed and times when it did not. But the same question may mean "Why did this man develop skin cancer, whereas other men who were also exposed to radiation did not?" Here the causal field is the class of men thus exposed to radiation. And what is the cause in relation to one field may not be the cause in relation to another. Exposure to a certain dose of radiation may be the cause in relation to the former field: it cannot be the cause in relation to the latter field since it is part of the description of that field, and being present throughout that field it cannot differentiate one sub-region of it from another. In relation to the latter field, the cause may be, in Scriven's terms, "Some as-yet-unidentified constitutional factor."

In our first example of the house which caught fire, the history of this house is the field in relation to which the experts were looking for the cause of the fire: their question was "Why did this house catch fire on this occasion, and not on others?" However, there may still be some indeterminacy in this choice of a causal field. Does this house, considered as the causal field, include all its features, or all its relatively permanent features, or only some of these? If we take all its features, or even all of its relatively permanent ones, as constituting the field, then some of the things that we have treated as conditions—for example the presence of inflammable material near the place where the short-circuit occurred—would have to be regarded as parts of the field, and we could not then take them also as conditions which in relation to this field, as additions to it or intrusions into it, are necessary or sufficient for something else. We must therefore take the house, in so far as it constitutes the causal field, as determined only in a fairly general way, by only some of its relatively permanent features, and we shall then be free to treat its other features as conditions which do not constitute the field, and are not parts of it, but which may occur within it or be added to it. It is in general an arbitrary matter whether a particular feature is regarded as a condition (that is, as a possible causal factor) or as part of the field, but it cannot be treated in both ways at once. If we are to say that something happened to this house because of, or partly because of, a certain feature, we are implying that it would still have been *this* house, the house in relation to which we are seeking the cause of this happening, even if it had not had this particular feature.

I now propose to modify the account given above of the claims often made by singular causal statements. A statement of such a form as "A caused P" is usually elliptical, and is to be expanded into "A caused P in relation to the field F." And then in place of the claim stated in (i) above, we require this:

(ia) A is at least an INUS condition of P in the field F—that is, there is a condition which, given the presence of whatever features characterize F throughout, is necessary and sufficient for P, and which is of one of these forms: (AX or Y), (A or Y), AX, A.

In analyzing our ordinary causal statements, we must admit that the field is often taken for granted or only roughly indicated, rather than specified precisely. Nevertheless, the field in relation to which we are looking for a cause of this effect, or saying that such-and-such is a cause, may be definite enough for us to be able to say

[14] These examples are borrowed from Scriven, *op. cit.*, pp. 409–410. Scriven discusses them with reference to what he calls a "contrast class," the class of cases where the effect did not occur with which the case where it did occur is being contrasted. What I call the causal field is the logical sum of the case (or cases) in which the effect is being said to be caused with what Scriven calls the contrast class.

that certain facts or possibilities are irrelevant to the particular causal problem under consideration, because they would constitute a shift from the intended field to a different one. Thus if we are looking for the cause, or causes, of influenza, meaning its cause(s) in relation to the field *human beings*, we may dismiss, as not directly relevant, evidence which shows that some proposed cause fails to produce influenza in rats. If we are looking for the cause of the fire in *this house*, we may similarly dismiss as irrelevant the fact that a proposed cause would not have produced a fire if the house had been radically different, or had been set in a radically different environment.

This modification enables us to deal with the well-known difficulty that it is impossible, without including in the cause the whole environment, the whole prior state of the universe (and so excluding any likelihood of repetition), to find a genuinely sufficient condition, one which is "by itself, adequate to secure the effect."[15] It may be hard to find even a complex condition which was absolutely sufficient for this fire because we should have to include, as one of the negative conjuncts, such an item as the earth's not being destroyed by a nuclear explosion just after the occurrence of the suggested INUS condition; but it is easy and reasonable to say simply that such an explosion would, in more senses than one, take us outside the field in which we are considering this effect. That is to say, it may be not so difficult to find a condition which is sufficient in relation to the intended field. No doubt this means that causal statements may be vague, in so far as the specification of the field is vague, but this is not a serious obstacle to establishing or using them, either in science or in everyday contexts.[16]

It is a vital feature of the account I am suggesting that we can say that A caused P, in the sense described, without being able to specify exactly the terms represented by 'X' and 'Y' in our formula. In saying that A is at least an INUS condition for P in F, one is *not* saying what other factors, along with A, were both present and nonredundant, and one is *not* saying what other minimal sufficient conditions there may be for P in F. One is not even claiming to be able to say what they are. This is in no way a difficulty: it is a readily recognizable fact about our ordinary causal statements, and one which this account explicitly and correctly reflects.[17] It will be shown (in § 5 below) that this elliptical or indeterminate character of our causal statements is closely connected with some of our characteristic ways of discovering and confirming causal relationships: it is precisely for statements that are thus "gappy" or indeterminate that we can obtain fairly direct evidence from quite modest ranges of observation. On this analysis, causal statements implicitly contain existential quantifications; one can assert an existentially quantified statement without asserting any instantiation of it, and one can also have good reason for asserting an existentially quantified statement without having the information needed to support any precise instantiation of it. I can know that there is someone at the door even if the question "Who is he?" would floor me

Marc-Wogau is concerned especially with cases where "there are two events, each of which independently of the other is a sufficient condition for another event." There are, that is to say, two minimal sufficient conditions, both of which actually occurred. For example, lightning strikes a barn in which straw is stored, and a tramp throws a burning cigarette butt into the straw at the same place and at the same time. Likewise for an historical event there may be more than one "cause," and each of them may, on its own, be

[15] Cf. Bertrand Russell, "On the Notion of Cause," *Mysticism and Logic* (London, 1917), p. 187. Cf. also Scriven's first difficulty, *op. cit.*, p. 409: "First, there are virtually no known sufficient conditions, literally speaking, since human or accidental interference is almost inexhaustibly possible, and hard to exclude by specific qualification without tautology." The introduction of the causal field also automatically covers Scriven's third difficulty and third refinement, that of the contrast class and the relativity of causal statements to contexts.

[16] J. R. Lucas, "Causation," *Analytical Philosophy*, ed. R. J. Butler (Oxford, 1962), pp. 57–59, resolves this kind of difficulty by an informal appeal to what amounts to this notion of a causal field: ". . . these circumstances [cosmic cataclysms, etc.] . . . destroy the whole causal situation in which we had been looking for Z to appear . . . predictions are not expected to come true when quite unforeseen emergencies arise."

[17] This is related to Scriven's second difficulty, *op. cit.*, p. 409: "there still remains the problem of saying what the other factors are which, with the cause, make up the sufficient condition. If they can be stated, causal explanation is then simply a special case of subsumption under a law. If they cannot, the analysis is surely mythological." Scriven correctly replies that "a combination of the thesis of macro-determinism . . . and observation-plus-theory frequently gives us the very best of reasons for saying that a certain factor combines with an unknown sub-set of the conditions present into a sufficient condition for a particular effect." He gives a statistical example of such evidence, but the whole of my account of typical sorts of evidence for causal relationships in §§ 5 and 7 below is an expanded defence of a reply of this sort.

sufficient.[18] Similarly Scriven considers a case where

> . . . conditions (perhaps unusual excitement plus constitutional inadequacies) [are] present at 4.0 P.M. that guarantee a stroke at 4.55 P.M. and consequent death at 5.0 P.M.; but an entirely unrelated heart attack at 4.50 P.M. is still correctly called the cause of death, which, as it happens, does occur at 5.0. P.M.[19]

Before we try to resolve these difficulties let us consider another of Marc-Wogau's problems: Smith and Jones commit a crime, but if they had not done so the head of the criminal organization would have sent other members to perform it in their stead, and so it would have been committed anyway.[20] Now in this case, if 'A' stands for the actions of Smith and Jones, what we have is that AX is one minimal sufficient condition of the result (the crime), but $\bar{A}Z$ is another, and both X and Z are present. A combines with one set of the standing conditions to produce the result by one route: but the absence of A would have combined with another set of the standing conditions to produce the same result by another route. In this case we *can* say that A was a necessary condition *post factum*. This sample satisfies the requirements of Marc-Wogau's analysis, and of mine, of the statement that A caused this result; and this agrees with what we would ordinarily say in such a case. (We might indeed add that there was *also* a deeper cause—the existence of the criminal organization, perhaps—but this does not matter: our formal analyses do not insure that a particular result will have a unique cause, nor does our ordinary causal talk require this.) It is true that in this case we cannot say what will usually serve as an informal substitute for the formal account, that the cause, here A, was necessary (as well as sufficient) in the circumstances; for $\bar{A}$ would have done just as well. We cannot even say that A was nonredundant. But this shows merely that a formal analysis may be superior to its less formal counterparts.

Now in Scriven's example, we might take it that the heart attack prevented the stroke from occurring. If so, then the heart attack *is* a necessary condition *post factum*: it is a moment in the only minimal sufficient condition that was present in full, for the heart attack itself removed some factor that was a necessary part of the minimal sufficient condition which has the excitement as one of its moments. This is strictly parallel to the Smith and Jones case. Again it is odd to say that the heart attack was in any way necessary, since the absence of the heart attack would have done just as well: this absence would have been a moment in that other minimal sufficient condition, one of whose other moments was the excitement. Nevertheless, the heart attack was necessary *post factum*, and the excitement was not. Scriven draws the distinction, quite correctly, in terms of continuity and discontinuity of causal chains: "the heart attack was, and the excitement was not the cause of death because the 'causal chain' between the latter and death was interrupted, while the former's 'went to completion'." But it is worth noting that a break in the causal chain corresponds to a failure to satisfy the logical requirements of a moment in a minimal sufficient condition that is also necessary *post factum*.

Alternatively, if the heart attack did not prevent the stroke, then we have a case parallel to that of the straw in the barn, or of the man who is shot by a firing squad, and two bullets go through his heart simultaneously. In such cases the requirements of my analysis, or of Marc-Wogau's, or of Scriven's, are not met: each proposed cause *is* redundant and not even necessary *post factum*, though the disjunction of them is necessary *post factum* and nonredundant. But this agrees very well with the fact that we *would* ordinarily hesitate to say, of either bullet, that it caused the man's death, or of either the lightning or the cigarette butt that it caused the fire, or of either the excitement or the heart attack that it was the cause of death. As Marc-Wogau says, "in such a situation as this we are unsure also how to use the word 'cause'." Our ordinary concept of cause does not deal clearly with cases of this sort, and we are free to decide whether or not to add to our ordinary use, and to the various more or less formal descriptions of it, rules which allow us to say that where more than one at-least-INUS-condition, and its conjunct conditions, are present, each of them caused the result.[21]

The account thus far developed of singular causal statements has been expressed in terms of

[18] *Op. cit.*, pp. 228–233.

[19] *Op. cit.*, pp. 410–411: this is Scriven's fourth difficulty and refinement.

[20] *Op. cit.*, p. 232: the example is taken from P. Gardiner, *The Nature of Historical Explanation* (Oxford, 1952), p. 101.

[21] Scriven's fifth difficulty and refinement are concerned with the direction of causation. This is considered briefly in § 8 below.

statements about necessity and sufficiency; it is therefore incomplete until we have added an account of necessity and sufficiency themselves. This question is considered in § 4 below. But the present account is independent of any particular analysis of necessity and sufficiency. Whatever analysis of these we finally adopt, we shall use it to complete the account of what it is to be an INUS condition, or to be at least an INUS condition. But in whatever way this account is completed, we can retain the general principle that at least part of what is often done by a singular causal statement is to pick out, as the cause, something that is claimed to be at least an INUS condition.

§ 3. General Causal Statements

Many general causal statements are to be understood in a corresponding way. Suppose, for example, that an economist says that the restriction of credit causes (or produces) unemployment. Again, he will no doubt be speaking with reference to some causal field; this is now not an individual object, but a class, presumably economies of a certain general kind; perhaps their specification will include the feature that each economy of the kind in question contains a large private enterprise sector with free wage-earning employees. The result, unemployment, is something which sometimes occurs and sometimes does not occur within this field, and the same is true of the alleged cause, the restriction of credit. But the economist is not saying that (even in relation to this field) credit restriction is either necessary or sufficient for unemployment, let alone both necessary and sufficient. There may well be other circumstances which must be present along with credit restriction, in an economy of the kind referred to, if unemployment is to result; these other circumstances will no doubt include various negative ones, the absence of various counteracting causal factors which, if they were present, would prevent this result. Also, the economist will probably be quite prepared to admit that in an economy of this kind unemployment could be brought about by other combinations of circumstances in which the restriction of credit plays no part. So once again the claim that he is making is merely that the restriction of credit is, in economies of this kind, a nonredundant part of one sufficient condition for unemployment: that is, an INUS condition. The economist is probably assuming that there is some condition, no doubt a complex one, which is both necessary and sufficient for unemployment in this field. This being assumed, what he is asserting is that, for some X and for some Y, (AX or Y) is a necessary and sufficient condition for P in F, but neither A nor X is sufficient on its own, where 'A' stands for the restriction of credit, 'P' for unemployment, and 'F' for the field, economies of such-and-such a sort. In a developed economic theory the field F may be specified quite exactly, and so may the relevant combinations of factors represented here by 'X' and 'Y'. (Indeed, the theory may go beyond statements in terms of necessity and sufficiency to ones of functional dependence, but this is a complication which I am leaving aside for the present.) In a preliminary or popular statement, on the other hand, the combinations of factors may either be only roughly indicated or be left quite undetermined. At one extreme we have the statement that (AX or Y) is a necessary and sufficient condition, where 'X' and 'Y' are given definite meanings; at the other extreme we have the merely existentially quantified statement that this holds for *some* pair X and Y. Our knowledge in such cases ordinarily falls somewhere between these two extremes. We can use the same convention as before, deliberately allowing it to be ambiguous between these different interpretations, and say that in any of these cases, where A is an INUS condition of P in F, (A ... or ...) is a necessary and sufficient condition of P in F.

A great deal of our ordinary causal knowledge is of this form. We know that the eating of sweets causes dental decay. Here the field is human beings who have some of their own teeth. We do not know, indeed it is not true, that the eating of sweets by any such person is a sufficient condition for dental decay: some people have peculiarly resistant teeth, and there are probably measures which, if taken along with the eating of sweets, would protect the eater's teeth from decay. All we know is that sweet-eating combined with a set of positive and negative factors which we can specify, if at all, only roughly and incompletely, constitutes a minimal sufficient condition for dental decay—but not a necessary one, for there are other combinations of factors, which do not include sweet-eating, which would also make teeth decay, but which we can specify, if at all, only roughly and incompletely. That is, if 'A' now represents sweet-eating, 'P' dental decay, and 'F' the class of human beings with some of their own teeth, we can say that, for some X and Y, (AX or Y) is necessary and sufficient for P in F, and we *may* be able to go beyond this merely existentially quantified statement to at least a partial specification of the *X* and *Y* in question. That is, we can say that (*A* ... or ...) is a necessary and sufficient condition, but that *A* itself is only an INUS condition. And the same holds for many general causal statements of the form "*A* causes (or produces) *P*." It is in this sense that the application of a potential difference to the ends of a copper wire produces an electric current in the wire; that a rise in the temperature of a piece of metal makes it expand; that moisture rusts steel; that exposure to various kinds of radiation causes cancer, and so on.

However, it is true that not all ordinary general causal statements are of this sort. Some of them are implicit statements of functional dependence. Functional dependence is a more complicated relationship of which necessity and sufficiency can be regarded as special cases. (It is briefly discussed in § 7 below.) Here too what we commonly single out as causing some result is only one of a number of factors which jointly affect the result. Again, some causal statements pick out something that is not only an INUS condition, but also a necessary condition. Thus we may say that the yellow fever virus is the cause of yellow fever. (This statement is not, as it might appear to be, tautologous, for the yellow fever virus and the disease itself can be independently specified.) In the field in question—human beings—the injection of this virus is not by itself a sufficient condition for this disease, for persons who have once recovered from yellow fever are thereafter immune to it, and other persons can be immunized against it. The injection of the virus, combined with the absence of immunity (natural or artificial), and perhaps combined with some other factors, constitutes a sufficient condition for the disease. Beside this, the injection of the virus is a necessary condition of the disease. If there is more than one complex sufficient condition for yellow fever, the injection of the virus into the patient's bloodstream (either by a mosquito or in some other way) is a factor included in every such sufficient condition. If '*A*' stands for this factor, the necessary and sufficient condition has the form (*A* ... or *A* ... etc.), where *A* occurs in every disjunct. We sometimes note the difference between this and the standard case by using the phrase "the cause." We may say not merely that this virus *causes* yellow fever, but that it is *the cause* of yellow fever; but we would say only that sweet-eating *causes* dental decay, not that it is *the cause* of dental decay. But about an individual case we could say that sweet-eating was *the cause* of the decay of this person's teeth, meaning (as in § 1 above) that the only sufficient condition present here was the one of which sweet-eating is a nonredundant part. Nevertheless, there will not in general be any one item which has a unique claim to be regarded as *the cause* even of an individual event, and even after the causal field has been determined. Each of the moments in the minimal sufficient condition, or in each minimal sufficient condition, that was present can equally be regarded as the cause. They may be distinguished as predisposing causes, triggering causes, and so on, but it is quite arbitrary to pick out as "main" and "secondary," different moments which are equally nonredundant items in a minimal sufficient condition, or which are moments in two minimal sufficient conditions each of which makes the other redundant.[22]

§ 4. Necessity and Sufficiency

One possible account of general statements of the forms "*S* is a necessary condition of *T*" and "*S* is a sufficient condition of *T*"—where '*S*' and '*T*' are general terms—is that they are equivalent to simple universal propositions. That is, the former is equivalent to "All *T* are *S*" and the latter to "All *S* are *T*." Similarly, "*S* is necessary for *T* in the field *F*" would be equivalent to "All *FT* are *S*," and "*S* is sufficient for *T* in the field *F*" to "All *FS* are *T*." Whether an account of this sort is adequate is, of course, a matter of dispute; but it is not disputed that these statements about necessary and sufficient conditions at least *entail* the corresponding universals. I shall work on the assumption that this account is adequate, that general statements of necessity and sufficiency are equivalent to universals: it will be worth while to see how far this account will take us, how far we are able, in terms of it, to understand how we use, support, and criticize these statements of necessity and sufficiency.

A directly analogous account of the corresponding singular statements is not satisfactory. Thus it will not do to say that "A short-circuit here was a necessary condition of a fire in this house" is equivalent to "All cases of this house's catching fire are cases of a short-circuit occurring here," because the latter is automatically true if this house has caught fire only once and a short-circuit has

[22] Cf. Marc-Wogau's concluding remarks, *op. cit.*, pp. 232–233.

occurred on that occasion, but this is not enough to establish the statement that the short-circuit was a necessary condition of the fire; and there would be an exactly parallel objection to a similar statement about a sufficient condition.

It is much more plausible to relate singular statements about necessity and sufficiency to certain kinds of non-material conditionals. Thus "A short-circuit here was a necessary condition of a fire in this house" is closely related to the counterfactual conditional "If a short-circuit had not occurred here this house would not have caught fire," and "A short-circuit here was a sufficient condition of a fire in this house" is closely related to what Goodman has called the factual conditional, "Since a short-circuit occurred here, this house caught fire."

However, a further account would still have to be given of these non-material conditionals themselves. I have argued elsewhere[23] that they are best considered as condensed or telescoped *arguments*, but that the statements used as premisses in these arguments are no more than simple factual universals. To use the above-quoted counterfactual conditional is, in effect, to run through an incomplete argument: "Suppose that a short-circuit did not occur here, then the house did not catch fire." To use the factual conditional is, in effect, to run through a similar incomplete argument, "A short-circuit occurred here; therefore the house caught fire." In each case the argument might in principle be completed by the insertion of other premisses which, together with the stated premiss, would entail the stated conclusion. Such additional premisses may be said to *sustain* the non-material conditional. It is an important point that someone can use a non-material conditional without completing or being able to complete the argument, without being prepared explicitly to assert premisses that would sustain it, and similarly that we can understand such a conditional without knowing exactly how the argument would or could be completed. But to say that a short-circuit here was a necessary condition of a fire in this house is to say that there is some set of true propositions which would sustain the above-stated counterfactual, and to say that it was a sufficient condition is to say that there is some set of true propositions which would sustain the above-stated factual conditional. If this is conceded, then the relating of singular statements about necessity and sufficiency to non-material conditionals leads back to the view that they refer indirectly to certain simple universal propositions. Thus if we said that a short-circuit here was a necessary condition for a fire in this house, we should be saying that there are true universal propositions from which, together with true statements about the characteristics of this house, and together with the supposition that a short-circuit did not occur here, it would follow that the house did not catch fire. From this we could infer the universal proposition which is the more obvious, but unsatisfactory, candidate for the analysis of this statement of necessity, "All cases of this house's catching fire are cases of a short-circuit occurring here," or, in our symbols, "All *FP* are *A*." We can use this to represent approximately the statement of necessity, on the understanding that it is to be a consequence of some set of wider universal propositions, and is not to be automatically true merely because there is only this one case of an *FP*, of this house's catching fire.[24] A statement that *A* was a sufficient condition may be similarly represented by "All *FA* are *P*." Correspondingly, if all that we want to say is that (*A*... or ...) was necessary and sufficient for *P* in *F*, this will be represented approximately by the pair of universals "All *FP* are (*A*... or ...) and all *F* (*A*... or ...) are *P*," and more accurately by the statement that there is some set of wider universal propositions from which, together with true statements about the features of *F*, this pair of universals follows. This, therefore, is the fuller analysis of the claim that in a particular case *A* is an INUS condition of *P* in *F*, and hence of the singular statement that *A* caused *P*. (The statement that *A* is *at least* an INUS condition includes other alternatives, corresponding to cases where the necessary and sufficient condition is (*A* or ...), *A*..., or *A*.)

Let us go back now to general statements of necessity and sufficiency and take *F* as a class, not as an individual. On the view that I am adopting, at least provisionally, the statement that *Z* is a necessary and sufficient condition for *P* in *F* is

[23] "Counterfactuals and Causal Laws," *Analytical Philosophy*, ed. R. J. Butler (Oxford, 1962), pp. 66–80.

[24] This restriction may be compared with one which Nagel imposes on laws of nature: "the vacuous truth of an unrestricted universal is not sufficient for counting it a law; it counts as a law only if there is a set of other assumed laws from which the universal is logically derivable" (*The Structure of Science* [New York, 1961], p. 60). It might have been better if he had added "or if there is some other way in which it is supported (ultimately) by empirical evidence." Cf. my remarks in "Counterfactuals and Causal Laws," *op. cit.*, pp. 72–74, 78–80.

equivalent to "All FP are Z and all FZ are P." Similarly, if we cannot completely specify a necessary and sufficient condition for P in F, but can only say that the formula "(A... or ...)" represents such a condition, this is equivalent to the pair of incomplete universals, "All FP are (A... or ...) and all F (A... or ...) are P." In saying that our general causal statements often do no more than specify an INUS condition, I am therefore saying that much of our ordinary causal knowledge is knowledge of such pairs of incomplete universals, of what we may call elliptical or *gappy* causal laws.

§ 5. Evidence for Causal Connections

If we assume that the general causal statement that A causes P, or the singular causal statement that A caused P, often makes the claims set out in §§ 1, 2, 3, and 4, including the claim that A is at least an INUS condition of P, then we can give an account of a combination of reasoning and observation which constitutes evidence for these causal statements.

This account is based on what von Wright calls a complex case[25] of the Method of Difference. Like any other method of eliminative induction, this can be formulated in terms of an assumption, an observation, and a conclusion which follows by a deductively valid argument from the assumption and the observation together. To get any positive conclusion by a process of elimination, we must assume that the result (the phenomenon a cause of which we are going to discover) has *some* cause in the sense that there is some condition the occurrence of which is both necessary and sufficient for the occurrence (as a rule, shortly afterwards) of the result. Also, if we are to get anywhere by elimination, we must assume that the range of possibly relevant causal factors, the items that might in some way constitute this necessary and sufficient condition, is restricted in some way. On the other hand, even if we had specified some such set of possibly relevant factors, it would in most cases be quite implausible to assume that the supposed necessary and sufficient condition is identical with just one of these factors on its own, and fortunately we have no need to do so. If we represent each possibly relevant factor as a single term, the natural assumption to make is merely that the supposed necessary and sufficient condition will be represented by a formula which is constructed in some way out of some selection of these single terms, by means of negation, conjunction, and disjunction. However, any formula so constructed is equivalent to some formula in disjunctive normal form—that is, one in which negation, if it occurs, is applied only to single terms, and conjunction, if it occurs, only to single terms and/or negations of single terms. So we can assume without loss of generality that the formula of the supposed necessary and sufficient condition is in disjunctive normal form, that it is at most a disjunction of conjunctions in which each conjunct is a single term or the negation of one, that is, a formula such as "(ABC or GH or J)." Summing this up, the assumption that we require will have this form:

For some Z, Z is a necessary and sufficient condition for the phenomenon P in the field F, that is, all FP are Z and all FZ are P, and Z is a condition represented by some formula in disjunctive normal form all of whose constituents are taken from the range of possibly relevant factors A, B, C, D, E, etc.

Along with this assumption, we need an observation which has the form of the classical difference observation described by Mill. This we can formulate as follows:

There is an instance I_1, in which P occurs, and there is a negative case N_1, in which P does not occur, such that one of the possibly relevant factors (or the negation of one), say A, is present in I_1 and absent from N_1, but each of the other possibly relevant factors is either present in both I_1 and N_1 or absent both from I_1 and from N_1.

We can set out an example of such an observation as follows, using 'a' and 'p' to stand for "absent" and "present."

	P	A	B	C	D	E	
I_1	p	p	p	a	a	p	etc.
N_1	a	a	p	a	a	p	

Given the above-stated assumption, we can reason in the following way about any such observation:

[25] *A Treatise on Induction and Probability* (New York, 1951), pp. 90 ff. The account that I am here giving of the Method of Difference, and that I would give of the eliminative methods of induction in general, differs, however, in several respects from that of von Wright. An article on "Eliminative Methods of Induction," which sets out my account, is to appear in the *Encyclopedia of Philosophy*, edited by Paul Edwards, to be published by the Free Press of Glencoe, Collier-Macmillan.

Since P is absent from N_1, every sufficient condition for P is absent from N_1, and therefore every disjunct in Z is absent from N_1. Every disjunct in Z which does not contain A is therefore also absent from I_1. But since P is present in I_1, and Z is a necessary condition for P, Z is present in I_1. Therefore at least one disjunct in Z is present in I_1. Therefore at least one disjunct in Z contains A.

What this shows is that Z, the supposed necessary and sufficient condition for P in F, is either A itself, or a conjunction containing A, or a disjunction containing as a disjunct either A itself or a conjunction containing A. That is, Z has one of these four forms: A; A...; (A or ...); (A... or ...). We can sum these up by saying that Z has the form (A- - - or - - -), where the dashes indicate that these parts of the formula may or may not be filled in. This represents briefly the statement that A is at least an INUS condition. It follows also that if there are in the (unknown) formula which represents the complete necessary and sufficient condition any disjuncts not containing A, none of them was present as a whole in N_1 (but of course some of their component terms may have been present there), and also that in at least one of the disjuncts that contains A, the terms, if any, conjoined with A stand for factors (or negations of factors) that were present in I_1. This is all that follows from this single observation. But in general other observations will show that the dotted spaces do need to be filled in, and that A alone is neither sufficient nor necessary for P in F. We can then infer that the necessary and sufficient condition actually has the form (A... or ...), and that A itself is only an INUS condition.

This analysis is so far merely formal, and we have still to consider whether such a method can be, or is, actually used, whether an assumption of the sort required can be justified and whether an observation of the sort required can ever be made. Even at this stage, however, it is worth noting that the Method of Difference does not require the utterly unrealistic sort of assumption used in what von Wright calls the simple case—namely, that the supposed necessary and sufficient condition is some single factor on its own—but that the much less restrictive assumption used here will still yield information when it is combined with nothing more than the classical difference observation. It is worth noting also that the information thus obtained, though it falls far short of what von Wright calls absolutely perfect analogy, that is, of a full specification of a necessary and sufficient condition, is information of exactly the form that is implicit in our ordinary causal assertions, both singular and general.[26]

But can observations of the kind required be made? A preliminary answer is that the typical controlled experiment is an attempt to approximate to an observation of this sort. The experimental case corresponds to our I_1, the control case to our N_1, and the experimenter tries to insure that there will be no possibly relevant difference between these two except the one whose effect he is trying to determine, our A. Any differential outcome, present in the experimental case but not in the control case, is what he takes to be this effect, corresponding to our P.

The before-and-after observation is a particularly important variety of this kind. Suppose, for example, that we take a piece of blue litmus paper and dip it in a certain liquid, and it turns red. The situation before it is dipped provides the negative case N_1; the situation after it is dipped provides the instance I_1. As far as we can see, no other possibly relevant feature of the situation has changed, so that I_1 and N_1 are alike with regard to all possibly relevant factors except A, the paper's being dipped in a liquid of this sort, but the result P, the paper's turning red, is present in I_1 but not in N_1. We can take this in either of two ways. First, we may take the field F to be pieces of blue litmus paper, and if we assume that in this field there is some necessary and sufficient condition for P, made up in some way from some selection from the factors we are considering as possibly relevant, we can conclude that (A- - - or - - -) is necessary and sufficient for P in F. Other observations may show that A alone is neither necessary nor sufficient, and hence that the necessary and sufficient condition is (A... or ...). Thus we can establish the gappy causal law, "All FP are (A... or ...) and all F(A... or ...) are P." This amounts to the assertion that in some circumstances being dipped in a liquid of this sort turns blue litmus paper red. Secondly, we can take the field (which we shall here call F_1) to be this particular piece of paper, and what the experiment then establishes

[26] What is established by the present method may be compared with the four claims listed in § 1 above, that A is at least an INUS condition, that A was present on the occasion in question, that the factors represented by 'X'—that is, the other moments in at least one minimal sufficient condition in which A is a moment—were present, and that every disjunct in Y which does not contain A—that is, every minimal sufficient condition which does not contain A—was absent.

is the singular causal statement that on this particular occasion the dipping in this liquid turned this piece of paper red. This is established in accordance with the analysis of singular causal statements completed in § 4. For the experiment, together with the assumption, has established the wider universals indicated by the above-stated gappy causal law. It has shown that for some X and Y all FP are (AX or Y) and all $F(AX$ or $Y)$ are P, and from these, since F_1 is an F (that is, this piece of paper is a piece of blue litmus paper), it follows that for some X and Y all F_1P are (AX or Y) and all $F_1(AX$ or $Y)$ are P. Also, 'X' represents circumstances which were present on this occasion, and 'Y' circumstances which were not present in N_1, the "before" situation. That is to say, the observation, together with the appropriate assumption, entails that there are true propositions which sustain the counterfactual and factual conditionals, "If, in the circumstances, this paper had not been dipped in this liquid it would not have turned red, but since it was dipped it did turn red"; but it does not fully determine what these propositions are, it does not fill in the gaps in the causal laws which sustain these conditionals. The importance of this is that it shows how an observation can reveal not merely a sequence but a causal sequence: what we discover is not merely that the litmus paper was dipped *and then* turned red, but that the dipping *made* it turn red.

It is worth noting that despite the stress traditionally laid, in accounts of the Method of Difference, on the requirement that there should be only *one* point of difference between I_1 and N_1, very little really turns upon this. For suppose that two of our possibly relevant factors, say A and B, were both present in I_1 and both absent from N_1, but that each of the other possibly relevant factors was either present in both or absent from both. Then reasoning parallel to that given above will show that at least one of the disjuncts in Z either contains A or contains B (and may contain both). That is, this observation still serves to show that the cluster of factors (A, B) *contains* something that is at least an INUS condition of P in F, whether this condition turns out in the end to be A alone, or B alone, or the conjunction AB, or the disjunction (A or B). And similar considerations apply if there are more than two points of difference between I_1 and N_1. However many there are, an observation of this form, coupled with our assumption, shows that a cause in our sense (in general an INUS condition) lies somewhere within the cluster of terms, positive or negative, in respect of which I_1 differs from N_1. (Note that it does *not* show that the other terms, those common to I_1 and N_1, are causally irrelevant; our reasoning does not exclude factors as irrelevant, but positively locates some of the relevant factors within the differentiating cluster.)

This fact rebuts the criticism sometimes leveled against the eliminative methods that they presuppose and require a finally satisfactory analysis of causal factors into their simple components, which we never actually achieve. On the contrary, any distinction of factors, however rough, enables us to start using such a method. We can proceed, and there is no doubt that discovery has often proceeded, by what we may call *the progressive localization of a cause*. Using the Method of Difference in a very rough way, we can discover first, say, that the drinking of wine causes intoxication. That is, the cluster of factors which is crudely summed up in the single term "the drinking of wine" contains somewhere within it an INUS condition of intoxication; and we can subsequently go on to distinguish various possibly relevant factors within this cluster, and by further observations of the same sort locate a cause of intoxication more precisely. In a context in which this cluster is either introduced or excluded as a whole, it is correct to say that the introduction of this cluster was nonredundant or necessary *post factum*, and experiments can establish this, even if, in a different context, in which distinct items in the cluster are introduced or excluded separately, it would be correct to say that only one item, the alcohol, was nonredundant or necessary *post factum*, and this could be established by more exact experimentation.

One merit of this formal analysis is that it shows in what sense a method of eliminative induction, such as the Method of Difference, rests upon a deterministic principle or presupposes the uniformity of nature. In fact, each application of this method requires an assumption which in one respect says much less than this, in another a little more. No sweeping general assumption is needed: we need not assume that every event has a cause, but merely that for events of the kind in question, P, in the field in question, F, there is some necessary and sufficient condition. But—and this is where we need something more than determinism or uniformity in general—we must also assume that this condition is constituted in some way by some selection from a restricted range of possibly relevant factors.

It is this further assumption that raises a doubt about the use of this method to make causal discoveries. As for the mere deterministic assumption that the phenomenon in question has some necessary and sufficient condition, we may be content to say that this is one which we simply do make in all inquiries of this kind, and leave its justification to be provided by whatever solution we can eventually find for the general problem of induction. But the choice of a range of possibly relevant factors cannot be brushed aside so easily. Also, the wider a range of possibly relevant factors we admit, the harder it will be to defend the claim that I_1 and N_1 are observed to be alike with respect to all the possibly relevant factors except the one, or the indicated cluster of factors, in which they are observed to differ. Alternatively, the more narrowly the range of possibly relevant factors is restricted, the easier it will be to defend the claim that we have made an observation of the required form, but at the same time the less plausible will our assumption be.

However, this difficulty becomes less formidable if we consider the assumption and the observation together. We want to be able to say that there is no possibly relevant difference, other than the one (or ones) noted, between I_1 and N_1. We need not draw up a complete list of possibly relevant factors before we make the observation. In practice we usually assume that a causally relevant factor will be in the spatial neighborhood of the instance of the field in or to which the effect occurs in I_1, or fails to occur in N_1, and it will either occur shortly before or persist throughout the time at which the effect occurs in I_1, or might have occurred, but did not, in N_1. No doubt in a more advanced application of the Method of Difference within an already-developed body of causal knowledge we can restrict the range of possibly relevant factors much more narrowly and can take deliberate steps to exclude interferences from our experiments; but I am suggesting that even our most elementary and primitive causal knowledge rests upon implicit applications of this method, and the spatio-temporal method of restricting possibly relevant factors is the only one initially available. And perhaps it is all we need. Certainly in terms of it the observer could say, about the litmus paper, for example, "I cannot see any difference, other than the dipping into this liquid, between the situation in which the paper turned red and that in which it did not, that might be relevant to this change."

It may be instructive to compare the Method of Difference as a logical ideal with any actual application of it. If the assumption and the observation were known to be true, then the causal conclusion would be established. Consequently, anything that tells in favor of both the assumption and the observation tells equally in favor of the causal conclusion. No doubt we are never in a position to say that they are known to be true, and therefore that the conclusion is established; but we are often in a position to say that, given the deterministic part of the assumption, we cannot see any respect in which they are not true (since we cannot see any difference that might be relevant between I_1 and N_1), and consequently that we cannot see any escape from the causal conclusion. In this sense at least we can say that an application of this method confirms a causal conclusion: the observer has looked for but failed to find an escape from this conclusion.[27]

In practice we do not rely as much on single observations as this account might suggest. We assure ourselves that it was the dipping in this

[27] An account of how eliminative inductive reasoning supports causal conclusions is given by J. R. Lucas in the article cited in n. 16 above. His account differs from mine in many details, but agrees with it in general outline. Contrast with this the remarks of von Wright, *op. cit.*, p. 135: ". . . in normal scientific practice we have to reckon with plurality rather than singularity, and with complexity rather than simplicity of conditions. This means that the weaker form of the Deterministic Postulate, or the form which may be viewed as a reasonable approximation to what is commonly known as the Law of Universal Causation, is practically useless as a supplementary premiss or 'presupposition' of induction." I hope I have shown that this last remark is misleading.

It has been argued by A. Michotte (*La perception de la causalité* [Louvain, 1946], translated by T. R. and E. Miles as *The Perception of Causality* [London, 1963]) that we have in certain cases an immediate perception or impression of causation. His two basic experimental cases are these. In one, an object *A* approaches another object *B*; on reaching *B*, *A* stops and *B* begins to move off in the same direction; here the observer gets the impression that *A* has "launched" *B*, has set *B* in motion. In the other case, *A* continues to move on reaching *B*, and *B* moves at the same speed and in the same direction; here the observer gets the impression that *A* is carrying *B* with it. In both cases observers typically report that *A* has caused the movement of *B*. Michotte argues that it is an essential feature of observations that give rise to this causal impression that there should be two distinguishable movements, that of the "agent" *A* and that of the "patient" *B*, but also that it is essential that the movement of the patient should in some degree copy or duplicate that of the agent.

This would appear to be a radically different account of the way in which we can detect causation by observing a single sequence, for on Michotte's view our awareness of causation can be direct, perceptual, and non-inferential. It must be conceded that not only spatio-temporal continuity, but also qualitative continuity between cause and effect (*l'ampliation du* liquid that turned the litmus paper red by dipping other pieces of litmus paper and seeing them, too, turn red just after they are dipped. This repetition is effective because it serves as a check on the possibility that some other relevant change might have occurred, unnoticed, just at the moment when the first piece of litmus paper was dipped in the liquid. After a few trials it will be most unlikely that any other relevant change has kept on occurring just as each piece was dipped (or even that there has been a succession of different relevant changes at the right times). Of course, it may be that there is some other relevant change (or set of relevant changes) which keeps on occurring just as each paper is dipped because it is linked with the dipping by what Mill calls "some fact of causation."[28] If so, then this other relevant change may be regarded as part of a cluster of factors which can be grouped together under the title "the dipping of the paper in this liquid," taking this in a broad sense, as possibly including items other than the actual entry of the paper into the liquid. But if this is not so, then it would be a sheer coincidence if this other relevant change kept on occurring just as each piece of paper was dipped, or if there was a succession of relevant changes at the right times. The hypothesis that such coincidences have continued will soon become implausible, even if it cannot be conclusively falsified.[29] It is an important point that it is not the repetition as such that supports the conclusion that the dipping causes the turning red, but the repetition of a sequence which, on each single occasion, is already *prima facie* a causal one. The repetition tends to disconfirm the set of hypotheses each of which explains a single sequence of a dipping followed by a turning red as a mere coincidence, and by contrast it confirms the hypothesis that in each such single sequence the dipping is causally connected with the change of color.

The analysis offered here of the Method of Difference has this curious consequence: in employing this method we are liable to use the word "cause" in different senses at different stages. In the assumption, it is said that the phenomenon P has some "cause," meaning some necessary and sufficient condition; but the "cause" actually found—A in our formal example—may be only an INUS condition. But we do need to assume that *something* is both necessary and sufficient for P in F to be able to conclude that A is at least an INUS condition, that it is a moment in a minimal sufficient condition that was present, and that it was necessary *post factum*.

§ 6. Falsification of Incomplete Statements

A possible objection to this account is that the gappy laws and singular statements used here are so incomplete that they are internally guaranteed against falsification and are therefore not genuine scientific statements at all. However, it is not a satisfactory criterion of a scientific statement that it should be exposed to conclusive falsification: what is important is that to treat a statement as a scientific hypothesis involves handling it in such a way that evidence would be allowed to tell against it. And there are ways in which evidence can be, and is, allowed to tell against a statement which asserts that something is an INUS condition.

Suppose, for example, that by using the I_1 and N_1 set out in § 5 above we have concluded that A is at least an INUS condition of P—taking this both as a singular causal statement about an individual

mouvement), are important ingredients in the primitive concept of causation; they may contribute to the notion of causal "necessity"; and both these continuities can sometimes be directly perceived. But it is equally clear that these continuities are not in general required either as observed or as postulated features of a causal sequence, and that a sequence which has these continuities may fail to be causal. What is perceived in Michotte's examples is neither necessary nor sufficient for causal relationship as we now understand it, though it may have played an important part in the genesis of the causal concept. It is worth noting that these examples also exhibit the features stressed in my account. They present the observer with an apparently simple and isolated causal field, within which there occurs a marked change, B's beginning to move. The approach of A is the only observed possibly relevant difference between the times when B is stationary and when B begins to move. If B's beginning to move has a cause, then A's approach is a suitable candidate, and nothing else that the observer is allowed to see or encouraged to suspect is so. Thus these examples could *also* give rise to an inferential awareness of causation, though it is true that other examples which would do this equally well would fail, and in Michotte's experiments do fail, to produce a direct impression of causation.

[28] E.g., in the Fifth Canon, *A System of Logic*, Book III, Chapter VIII, § 6.

[29] Cf. J. R. Lucas, *op. cit.*, p. 53: "It might be that two quite independent processes were going on, and we were getting constant concomitance for no reason except the chance fact that the two processes happened to keep in step. If this be so, an arbitrary disturbance in one will reveal the independence of the other. If an arbitrary disturbance in the one is followed by a corresponding alteration in the other, it always could be that it was a genuine coincidence. . . . But to argue this persistently is to make the same illicit extension of 'coincidence' as some phenomenalists do of 'illusion'. . . . It is no longer a practical possibility that we are eliminating but a Cartesian doubt."

field F_1 and as an incomplete law about the general field F. Now suppose that closer examination shows that some other factor, previously unnoticed, say K, was present in I_1 and absent from N_1, and that we also discover (or construct experimentally) further cases I_2 and N_2, such that the observational evidence is now of this form:

	P	A	B	C	D	E	...K	...
I_1	p	p	p	a	a	p	...p	...
N_1	a	a	p	a	a	p	...a	...
I_2	p	a	p	a	a	p	...p	...
N_2	a	p	p	a	a	p	...a	...

Here N_2 shows that for any X which does not contain K, AX is not sufficient: so X must contain K. But any X that contains K is present in I_2, and *may* therefore be sufficient for P on its own, without A. This evidence does not conclusively falsify the hypothesis that A is an INUS condition as stated above, but it takes away all the reason that the previous evidence gave us for this conclusion. Observations of this pattern would tell against this conclusion, and would lead us to replace the view that A causes P, and caused P in I_1, with the view that K causes P, and caused P both in I_2 and in I_1, with A not even forming an indispensable part of the sufficient condition which was present in I_1. (A fuller treatment of this kind of additional evidence would require accounts of the Method of Agreement and of the Joint Method, parallel to that of the Method of Difference given in § 5.)

It remains true that some of the claims made by singular causal statements and by causal laws as here analyzed—that is, claims that some factor is at least an INUS condition of the effect—are not conclusively falsifiable. But ordinary causal laws and singular causal statements are not conclusively falsifiable, as direct consideration will show. It is a merit of the account offered here, not a difficulty for it, that it reproduces this feature of ordinary causal knowledge.[30]

§ 7. Functional Dependence and Concomitant Variation

As I mentioned in § 3, causal statements sometimes refer not to relations of necessity and sufficiency, nor to any more complex relations based on these, like that of being an INUS condition, but to relations of functional dependence. That is, the effect and the possible causal factors are things which can vary in magnitude, and the cause of some effect P is that on whose magnitude the magnitude of P functionally depends. But causal statements of this sort can be expanded and analyzed in an account parallel to that which we have given of causal statements of the previous kinds. Again we speak of a field, individual or general, in relation to which a certain functional dependence holds. Also, we can speak of the *total cause*, the complete set of factors on whose magnitude the magnitude of P, given the field F, wholly depends: that is, variations of P in F are completely covered by a formula which is a function of the magnitudes of all of the factors in this "complete set," and of these alone. This total cause is analogous to a necessary and sufficient condition. It can be distinguished from each of the factors that compose it, each of which is causally relevant to the effect, but it is not the whole cause of its variations: each of these *partial causes* is analogous to an INUS condition.

The problem of finding a cause in this new sense would require, for its full solution, the completion of two tasks. We should have both to identify all the factors in this total cause, and also to discover in what way the effect depends upon them—that is, to discover the law of functional dependence of the effect on the total cause, or the partial differential equations relating it to each of the partial causes. The first—but only the first—of these two tasks can be performed by what is really the Method of Concomitant Variation, developed in a style analogous to that in which the Method of Difference was developed in § 5. That is, we assume that there is something on which the magnitude of P in F functionally depends, and that there is a restricted set of possibly relevant factors; then if while all other possibly relevant factors are held constant one factor, say A, varies and P also varies, it follows that A is at least a partial cause, that it is one of the actually relevant factors. It is this relationship that is commonly asserted by statements of such forms as "A affects P" and "On this occasion A affected P." Some of our causal statements, singular or general, have just this force, and all that I am trying to show here is that these statements can be supported by reasoning along the lines of the Method of Concomitant Variation, developed analogously with the development in § 5 of the Method of Difference. Just as we there assumed that there was some necessary and sufficient condition, and by combining this assumption with our observations dis-

[30] This was pointed out by D. C. Stove.

covered something which is at least an INUS condition, so we here assume that there is some total cause and so discover something which is at least a partial cause. However, a complete account of the Method of Concomitant Variation would involve the examination of several other cases besides the one sketched here.[31] For our present purpose, we need note only that there is this functional dependence part of the concept of causation as well as the presence-or-absence part, indeed that the latter can be considered as a special limiting case of the former,[32] but that the two parts are systematically analogous to one another, and that our knowledge of both singular and general causal relationships of these two kinds can be accounted for on corresponding principles.

§ 8. The Direction of Causation

This account of causation is still incomplete, in that nothing has yet been said about the direction of causation, about what distinguishes *A* causing *P* from *P* causing *A*. This is a difficult question, and it is linked with the equally difficult question of the direction of time. I cannot hope to resolve it completely here, but I shall state some of the relevant considerations.[33]

First, it seems that there is a relation which may be called *causal priority*, and that part of what is meant by "*A* caused *P*" is that this relation holds in one direction between *A* and *P*, not the other. Secondly, this relation is not identical with temporal priority; it is conceivable that there should be evidence for a case of backward causation, for *A* being causally prior to *P* whereas *P* was temporally prior to *A*. Most of us believe, and I think with good reason, that backward causation does not occur, so that we can and do normally use temporal order to limit the possibilities about causal order; but the connection between the two is synthetic. Thirdly, it could be objected to the analysis of "necessary" and "sufficient" offered in § 4 above that it omits any reference to causal order, whereas our most common use of "necessary" and "sufficient" in causal contexts includes such a reference. Thus "*A* is (causally) sufficient for *B*" says "If *A*, then *B*, and *A* is causally prior to *B*," but "*B* is (causally) necessary for *A*" is not equivalent to this: it says "If *A*, then *B*, and *B* is causally prior to *A*." However, it is simpler to use "necessary" and "sufficient" in senses which exclude this causal priority, and to introduce the assertion of priority separately into our accounts of "*A* caused *P*" and "*A* causes *P*." Fourthly, although "*A* is (at least) an INUS condition of *P*" is not synonymous with "*P* is (at least) an INUS condition of *A*," this difference of meaning cannot exhaust the relation of causal priority. If it did exhaust it, the direction of causation would be a trivial matter, for, given that there is some necessary and sufficient condition of *A* in the field, it can be proved that if *A* is (at least) an INUS condition of *P*, then *P* is also (at least) an INUS condition of *A*: we can construct a minimal sufficient condition of *A* in which *P* is a moment.[34]

Fifthly, it is often suggested that the direction of causation is linked with controllability. If there is a causal relation between *A* and *B*, and we can control *A* without making use of *B* to do so, and the relation between *A* and *B* still holds, then we decide that *B* is not causally prior to *A* and, in general, that *A* is causally prior to *B*. But this means only that if one case of causal priority is known, we can use it to determine others: our rejection of the possibility that *B* is causally prior to *A* rests on our knowledge that our action is causally prior to *A*, and the question how we know the latter, and even the question of what causal priority is, have still to be answered. Similarly, if one of the causally related kinds of event, say *A*, can be randomized, so that occurrences of *A* are either not caused at all, or are caused by something which enters this causal field *only* in this way, by causing *A*, we can reject both the possibility that *B* is causally prior to *A* and the possibility that some common cause is prior both to *A* and separately to *B*, and we can again conclude that *A* is causally prior to *B*. But this still means only that we can infer causal priority in one place if we first know that it is absent from another place. It is true that our knowledge of the direction of causation in ordinary cases is thus based on what we find to be controllable, and on what we either find to be random or find that we can randomize; but this cannot without circularity be taken as providing a full account either of what we mean

[31] I have given a fuller account of this method in the article cited in n. 25.

[32] Cf. J. R. Lucas, *op. cit.*, p. 65.

[33] As was mentioned in n. 21, Scriven's fifth difficulty and refinement are concerned with this point (*op. cit.*, pp. 411–412), but his answer seems to me inadequate. Lucas touches on it (*op. cit.*, pp. 51–53). The problem of temporal asymmetry is discussed, e.g., by J. J. C. Smart, *Philosophy and Scientific Realism* (London, 1963), pp. 142–148, and by A. Grünbaum in the article cited in n. 36 below.

[34] I am indebted to one of the referees for correcting an inaccurate statement on this point in an earlier version.

by causal priority or of how we know about it.

A suggestion put forward by Popper about the direction of time seems to be relevant here.[35] If a stone is dropped into a pool, the entry of the stone will explain the expanding circular waves. But the reverse process, with contracting circular waves, "would demand a vast number of distant coherent generators of waves the coherence of which, to be explicable, would have to be shown . . . as originating from one centre." That is, if *B* is an occurrence which involves a certain sort of "coherence" between a large number of separated items, whereas *A* is a single event, and *A* and *B* are causally connected, *A* will explain *B* in a way in which *B* will not explain *A* unless some other single event, say *C*, first explains the coherence in *B*. Such examples give us a *direction of explanation*, and it may be that this is the basis, or part of the basis, of the relation I have called causal priority.

§ 9. Conclusions

Even if Mill was wrong in thinking that science consists mainly of causal knowledge, it can hardly be denied that such knowledge is an indispensable element in science, and that it is worth while to investigate the meaning of causal statements and the ways in which we can arrive at causal knowledge. General causal relationships are among the items which a more advanced kind of scientific theory explains, and is confirmed by its success in explaining. Singular causal assertions are involved in almost every report of an experiment: doing such and such *produced* such and such an effect. Materials are commonly identified by their causal properties: to recognize something as a piece of a certain material, therefore, we must establish singular causal assertions about it, that this object affected that other one, or was affected by it, in such and such a way. Causal assertions are embedded in both the results and the procedures of scientific investigation.

The account that I have offered of the force of various kinds of causal statements agrees both with our informal understanding of them and with accounts put forward by other writers: at the same time it is formal enough to show how such statements can be supported by observations and experiments, and thus to throw a new light on philosophical questions about the nature of causation and causal explanation and the status of causal knowledge.

One important point is that, leaving aside the question of the direction of causation, the analysis has been given entirely within the limits of what can still be called a regularity theory of causation, in that the causal laws involved in it are no more than straightforward universal propositions, although their terms may be complex and perhaps incompletely specified. Despite this limitation, I have been able to give an account of the meaning of statements about singular causal sequences, regardless of whether such a sequence is or is not of a kind that frequently recurs: repetition is not essential for causal relation, and regularity does not here disappear into the mere fact that this single sequence has occurred. It has, indeed, often been recognized that the regularity theory could cope with single sequences if, say, a unique sequence could be explained as the resultant of a number of laws each of which was exemplified in many other sequences; but my account shows how a singular causal statement can be interpreted, and how the corresponding sequence can be shown to be causal, even if the corresponding complete laws are not known. It shows how even a unique sequence can be directly recognized as causal.

One consequence of this is that it now becomes possible to reconcile what have appeared to be conflicting views about the nature of historical explanation. We are accustomed to contrast the "covering-law" theory adopted by Hempel, Popper, and others with the views of such critics as Dray and Scriven who have argued that explanations and causal statements in history cannot be thus assimilated to the patterns accepted in the physical sciences.[36] But while my basic analysis of singular causal statements in §§ 1 and 2 agrees closely with Scriven's, I have argued in § 4 that this analysis can be developed in terms of complex

[35] "The Arrow of Time," *Nature*, vol. 177 (1956), p. 538; also vol. 178, p. 382 and vol. 179, p. 1297.

[36] See, for example, C. G. Hempel, "The Function of General Laws in History," *Journal of Philosophy*, vol. 39 (1942), reprinted in *Readings in Philosophical Analysis*, ed. by H. Feigl and W. Sellars (New York, 1949), pp. 459–471; C. G. Hempel and P. Oppenheim, "Studies in the Logic of Explanation," *Philosophy of Science*, vol. 15 (1948), reprinted in *Readings in the Philosophy of Science*, ed. by H. Feigl and M. Brodbeck (New York, 1953), pp. 319–352; K. R. Popper, *Logik der Forschung* (Vienna, 1934), translation *The Logic of Scientific Discovery* (London, 1959), pp. 59–60, also *The Open Society* (London, 1952), vol. II, p. 262; W. Dray, *Laws and Explanation in History* (Oxford, 1957); N. Rescher, "On Prediction and Explanation," *British Journal for the Philosophy of Science*, vol. 9 (1958), pp. 281–290; various papers in *Minnesota Studies in the Philosophy of Science*, vol. III, ed. by H. Feigl and G. Maxwell (Minneapolis, 1962); A. Grünbaum, "Temporally-asymmetric Principles,

and elliptical universal propositions, and this means that wherever we have a singular causal statement we shall still have a covering law, albeit a complex and perhaps elliptical one. Also, I have shown in § 5, and indicated briefly, for the functional dependence variants, in § 7, that the evidence which supports singular causal statements also supports general causal statements or covering laws, though again only complex and elliptical ones. Hempel recognized long ago that historical accounts can be interpreted as giving incomplete "explanation sketches," rather than what he would regard as full explanations, which would require fully-stated covering laws, and that such sketches are also common outside history. But in these terms what I am saying is that explanation sketches and the related elliptical laws are often all that we can discover, that they play a part in all sciences, that they can be supported and even established without being completed, and do not serve merely as preliminaries to or summaries of complete deductive explanations. If we modify the notion of a covering law to admit laws which not only are complex but also are known only in an elliptical form, the covering-law theory can accommodate many of the points that have been made in criticism of it, while preserving the structural similarity of explanation in history and in the physical sciences. In this controversy, one point at issue has been the symmetry of explanation and prediction, and my account may help to resolve this dispute. It shows, in agreement with what Scriven has argued, how the actual occurrence of an event in the observed circumstances—the I_1 of my formal account in § 5—may be a vital part of the evidence which supports an explanation of that event, which shows that it was A that caused P on this occasion. A prediction on the other hand cannot rest on observation of the event predicted. Also, the gappy law which is sufficient for an explanation will not suffice for a prediction (or for a retrodiction): a statement of initial conditions together with a gappy law will not entail the assertion that a specific result will occur, though of course such a law may be, and often is, used to make tentative predictions the failure of which will not necessarily tell against the law. But the recognition of these differences between prediction and explanation does not affect the covering-law theory as modified by the recognition of elliptical laws.

Although what I have given is primarily an account of physical causation, it may be indirectly relevant to the understanding of human action and mental causation. It is sometimes suggested that our ability to recognize a single occurrence as an instance of mental causation is a feature which distinguishes mental causation from physical or "Humean" causation.[37] But this suggestion arises

Parity between Explanation and Prediction, and Mechanism versus Teleology," *Philosophy of Science*, vol. 29 (1962), pp. 146–170.

Dray's criticisms of the covering-law theory include the following: we cannot state the law used in an historical explanation without making it so vague as to be vacuous (*op. cit.*, especially pp. 24–37) or so complex that it covers only a single case and is trivial on that account (p. 39); the historian does not come to the task of explaining an event with a sufficient stock of laws already formulated and empirically validated (pp. 42–43); historians do not need to replace judgment about particular cases with deduction from empirically validated laws (pp. 51–52). It will be clear that my account resolves each of these difficulties. Grünbaum draws an important distinction between (1) an asymmetry between explanation and prediction with regard to the grounds on which we claim to know that the explanandum is true, and (2) an asymmetry with respect to the logical relation between the explanans and the explanandum; he thinks that only the former sort of asymmetry obtains. I suggest that my account of the use of gappy laws will clarify both the sense in which Grünbaum is right (since an explanation and a tentative prediction can use similarly gappy laws which are similarly related to the known initial conditions and the result) and the sense in which, in such a case, we may contrast an entirely satisfactory explanation with a merely tentative prediction. Scriven (in his most recent statement, the review cited in n. 10 above) says that "we often pin down a factor as a cause by excluding other possible causes. Simple—but disastrous for the covering-law theory of explanation, because we can eliminate causes only for something *we know has occurred.* And if the grounds for our explanation of an event *have* to include knowledge of that event's occurrence, they cannot be used (without circularity) to predict the occurrence of that event" (p. 414). That is, the observation of this event in these circumstances may be a vital part of the evidence that justifies the particular causal explanation that we give of this event: it may itself go a long way toward establishing the elliptical law in relation to which we explain it (as I have shown in § 5), whereas a law used for prediction cannot thus rest on the observation of the event predicted. But as my account also shows, this does not introduce an asymmetry of Grünbaum's second sort, and is therefore not disastrous for the covering-law theory.

[37] See, for example, G. E. M. Anscombe, *Intention* (Oxford, 1957), especially p. 16; J. Teichmann, "Mental Cause and Effect," *Mind*, vol. 70 (1961), pp. 36–52. Teichmann speaks (p. 36) of "the difference between them and ordinary (or 'Humian') sequences of cause and effect" and says (p. 37) "it is sometimes in order for the person who blinks to say absolutely dogmatically that the cause is such-and-such, and to say this independently of his knowledge of any previously established correlations," and again "if the noise is a cause it seems to be one which is known to be such in a special way. It seems that while it is necessary for an observer to have knowledge of a previously established correlation between noises and Smith's jumpings, before he can assert that one causes the other, it is not necessary for Smith himself to have such knowledge."

from the use of too simple a regularity account of physical causation. If we first see clearly what we mean by singular causal statements in general, and how we can support such a statement by observation of the single sequence itself, even in a physical case, we shall be better able to contrast with this our awareness of mental causes, and to see whether the latter has any really distinctive features.

This account also throws light on both the form and the status of the "causal principle," the deterministic assumption which is used in any application of the methods of eliminative induction. These methods need not presuppose determinism in general, but only that each specific phenomenon investigated by such a method is deterministic. Moreover, they require not only that the phenomenon should have some cause, but that there should be some restriction of the range of possibly relevant factors (at least to spatio-temporally neighboring ones, as explained in § 5). Now the general causal principle, that every event has some cause, is so general that it is peculiarly difficult either to confirm or to disconfirm, and we might be tempted either to claim for it some *a priori* status, to turn it into a metaphysical absolute presupposition, or to dismiss it as vacuous. But the specific assumption that this phenomenon has some cause based somehow on factors drawn from this range, or even that this phenomenon has some neighboring cause, is much more open to empirical confirmation and disconfirmation: indeed the former can be conclusively falsified by the observation of a positive instance I_1 of P, and a negative case N_1 in which P does not occur, but where each of the factors in the given range is either present in both I_1 and N_1 or absent from both. This account, then, encourages us to regard the assumption as something to be empirically confirmed or disconfirmed. At the same time it shows that there must be some principle of the confirmation of hypotheses other than the eliminative methods themselves, since each such method rests on an empirical assumption.

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