EXPLANATION AND CAUSATION

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Abstract

This thesis deals with the nature of theoretical explanation and causation. In chapter one, I examine Wesley Salmon's S-R basis of scientific explanation, through which prior events or conditions are sought out that are statistically correlated to explanandum. However, it seems that Salmon's account fails to *explain* events. Salmon attempts to provide a causal account of the statistical relevance relations. This is done by providing a novel account of causality.

In chapter two I discuss Salmon's treatment of causality. Salmon's treatment comprises four components. First, he takes "processes" rather than "events" as the basic entities of the universe. Second, he argues that through causal processes causal influence is propagated, and such propagation by causal processes is the "necessary connection" between cause and effect. Third, Salmon distinguishes three sorts of causal forks that are explained in terms of causal processes and certain statistical relations. Fourth, he maintains that it is causal interaction which produces causal marks of processes that are capable of being transmitted. Events are occasions where causal processes intersect, interact, and undergo changes. Thus in our attempt to explain, what we seek are causal processes connecting the event-to-be-explained and the events that constitute the S-R basis. If no such connecting processes is found, we may try to find common causes leading to both the event-to-be-explained and the statistically relevant events contained in the S-R basis. For Salmon, only knowledge of the causal processes, or common causes, counts as explanatory knowledge.

This, however, does not settle the question of justification. What right do we have to impute causal relations to events and processes in the universe? Salmon

makes appeal to the pragmatic efficacy of science. But science itself cannot prove the reality of causal processes or relations; rather these are among the basic presuppositions of the scientific enterprise. The justification of causality, if any is possible, must rest on different grounds.

Thus in chapter three, I introduce Rescher's metaphysical realism in an attempt to offer a possible justificatory strategy. For Rescher, the objective causal order of the universe is a metaphysically necessary presupposition. This much can readily be reconciled with the principle of "fallibilism" in science by making reference to, most prominently, the interaction between mind and nature. This approach dissolves the question of whether or not science ever has to reach, or will ever reach, the "real" truth by asserting that scientific truth is, while objective, always conditioned. The "conditionedness" of scientific truth does not, however, detract from the universality of scientific truth or mind-independent reality of causal relations.

I will address two specific problems concerning the objectivity and universality of causal explanation: (1) the seemingly pragmatic aspect of causal explanation; and (2) whether intentional actions can be understood and explained causally. I believe these problems do not pose any difficulties for causal explanation, and I believe that the validity of causal explanation can be established.

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Introduction

The primary concern of my essay is the nature of theoretical explanation--namely, what sort of knowledge is explanatory knowledge, and on what basis can we say it constitutes or contributes to our understanding of the world? The scope of theoretical explanation, as I view it, extends beyond what we mean by "scientific explanation" in physical sciences. It can, however, be equated with "scientific explanation" spoken of in common context--that is, explanation which takes the form of formal argument, and which is regarded as true of the world and providing knowledge, as opposed to unfounded beliefs or speculations. Therefore, all social sciences invariably fall into this category. The theories presented by Freud and Marx, for example, are theoretical explanations as well, though their truth may be controversial.

Since the middle of this century, the dominant view in this respect has been the "covering law model" as espoused by Hempel. The central tenet of this view is that, essentially, explanations are arguments--i.e., the explanation of an event-to-be-explained is alway an inference from a law and a set of initial conditions. There is another view, however, which takes theoretical explanation as essentially causal. It makes appeal to the supposedly causal structure of the world and asserts that only effect relation (SECSW, pp.137-38). Nevertheless, there has also been extensive controversy over the nature of both the relata and the relation.[2] In short, the concept of causality has been philosophically so suspect that most contemporary philosophers of science have shunned it in their accounts of the nature of scientific explanation.

Salmon, however, conceives causality afresh. First of all, he treats "processes" rather than "events" as the basic entities of the universe, among which he distinguishes causal processes from pseudo-processes by the ability to transmit a mark. Secondly, he argues that it is through those causal processes that causal influence is propagated or transmitted, and such propagations by causal processes are the "necessary connections" Hume could not find between causes and effects. Thirdly, Salmon distinguishes three sorts of causal forks--interactive forks, conjunctive forks, and perfect forks--each of which is explained in terms of causal processes plus certain statistical relations. Finally, he maintains that it is causal interaction--which is to be analysed in terms of interactive forks--that produces causal marks or characteristics of processes which are capable of being transmitted, and events, in Salmon's presentation, become none other than interactions of processes.

Armed with this novel account of causality, Salmon argues that all theoretical explanations whatever are causal in character. This causal conception of explanation also implies that causality is, in Hume's term, "in the objects". Given a statistical

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[2]See *The Cement of the Universe* (Mackie, 1974) for an excellent historical and systematic survey of various approaches to causation.

relevance correlation between events of type A and events of type B, there must be *either* a direct causal connection--which consists in causal processes--*or* an indirect causal connection, in which case a common cause links A and B via intermediate causal processes.[3] Only knowledge of such underlying causal mechanisms, in Salmon's view, constitutes genuine explanatory knowledge. Accordingly, genuine scientific explanation is not a deductive argument as Hempel thought; it is an exhibition of how events fit into the causal structure of the world.

There is one problem that Salmon does not address explicitly, that of the justification of his account of causality. Salmon claims that he has discovered the "necessary connections" that Hume searched for in vain, yet Hume's sceptical question about the "necessary connections" remains largely intact: How can causality be "in the objects"? It appears to me that Salmon's account of causality is at most an account of the structure of causal explanation--an exhibition of the structure of our notion of causality when we employ it for the purpose of explanation. But that is a far cry from a proof of the reality of Hume's "necessary connections". It seems that Salmon invokes--though not overtly--the pragmatic success of science as the justification of his account of causality--i.e., if scientific explanations are

[3]See SECSW, pp. 261-62. I consider that Salmon's construal of causality leads to an "either...or..." scenario, which is imperative for our inquiry and must be regarded as true of the world.

pragmatically successful, then the causality they attribute must be real. But in my opinion this argument is inadequate.

I propose, instead, to employ Rescher's "metaphysical realism" to shed light on the problem of the justification of causality. I believe that only when our notion of causality--whose structure I think is correctly revealed by Salmon--is looked upon in the light of Rescher's metaphysical realism can the ontological status of causality, on which science and all our empirical inquiries pivot, be secured, and causal explanations acquire universal validity.

After introducing ideas from Salmon and Rescher, I will address two specific problems concerning the objectivity and universality of causal explanation: 1) the seemingly pragmatic aspect of causal explanation, and 2) whether intentional actions can be understood and explained causally. If these two problems pose no difficulties for causal explanation, as I believe they do not, then we are in a position to claim not only that theoretical explanations--and virtually all attempts to understand and explain how our world goes on--are causal in character, but also that our understanding of the world is ultimately an understanding of its causal structure.

Chapter One: An Outline of Salmon's Approach

What is involved in scientific explanation, over and above mere description of the phenomena? For Salmon, this question poses a deep and perplexing problem for philosophy. He believes that apart from experimental confirmation, something more is demanded of a scientific theory. This "something" is characterized by Salmon, along with others, as an answer to "why" as opposed to "what" questions. In response to "why" questions, philosophers of the twentieth century have usually maintained that, with the aid of suitable initial conditions, an event is explained by subsuming it under one or more regularities or laws of nature. The explanans (initial conditions and laws) and the explanandum (the event to be explained) taken together constitute the explanation.

However, this view of the issue is too general. In fact, three conceptions of this covering-law model have been developed--namely, the epistemic conception, the modal conception and the ontic conception (SECSW, pp. 15-20). The epistemic conception maintains that we *deduce* the explanandum from the explanans.[4] The key to this sort of explanation, as Salmon characterizes it, is "nomic expectability"

[4]In chap. 4, SECSW, Salmon discusses three versions of the epistemic conception--the inferential version, the information-theoretical version, and the erotetic version--among which the inferential version enjoys the status of the "received view". Due to its enormous influence , for the present purpose I will simply refer to the inferential version as representing the epistemic conception of scientific explanation.

(SECSW, p. 84). The event, which was initially quite unexpected in the absence of knowledge of the initial conditions, is made expectable on the basis of the knowledge of the lawful connections it possesses with those conditions. On this view, therefore, a relation of logical necessity holds between the explanandum and the explanans. According to the modal conception of explanation it is nomological (which is as well physical) necessity that holds between antecedent conditions and explanandum-event. Still another conception of explanation holds that to explain an event is to "fit the explanandum-event into a discernible pattern", which amounts to saying that an event is explained if it is exhibited as "occupying its (nomologically necessary) place in the discernible patterns of the world" (SECSW, pp. 17-18).

It seems that these three conceptions are more or less equivalent, perhaps with somewhat distinct emphases. However, as Salmon argues, a striking divergence appears when they are considered in the indeterministic framework where explanations involve statistical or probabilistic laws. Whether nature is deterministic or indeterministic is still an open question; nevertheless, even in "rigorous" physical science there is a strong tendency in the twentieth century to assume that there are some basic laws of nature that are irreducibly statistical. This indicates that probability relations may constitute a fundamental feature of the physical world. A tenable philosophical theory of scientific explanation has to be viable, Salmon maintains, in both deterministic and indeterministic contexts. In Salmon's presentation, the ontic conception implemented by a theory of causality is the only viable candidate for a theory of scientific explanation.[5]

According to Salmon, an explanation must achieve two distinct goals: First, the event-to-be-explained is subsumed under an appropriate set of statistical relevance relations. This approach resembles the "received" view, which treats "statistical-inductive" explanation as a variation on deductive-nomological explanation and maintains that some events can be explained by subsumption under statistical laws in much the same way that others are explained by appeal to universal laws. However, Salmon also argues that subsumption of this type qualifies as a "statistical analysis" rather than "statistical explanation", and supplies a basis or beginning for scientific understanding rather than complete explanation. For Salmon, the statistical relevance relations invoked at the first level must themselves be "explained in terms of causal relations", and it is our knowledge of causal relations, connecting the event-to-be-explained with statistically relevant events, and covered by irreducibly statistical laws, that comprises the true foundation of scientific explanation and provides genuine answers to "why" questions.[6]

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[5]Salmon has a detailed refutation of inferential and infomation-theoretical versions of the epistemic conception as well as the modal conception of scientific explanation in an indeterministic context; see SECSW, chap. 4, which is summarized at the end of chap. 9. In chap. 8 (especially p. 238), furthermore, he rejects the erotetic version for the reason that an agnostic attitude regarding unobserable entities is virtually unacceptable to the practice of science. My thesis, nonetheless, will focus mainly on his own argument.

[6]A clarification of terminology is necessary here. To the extent that universality can be viewed as a special species of probability, that is, its probability value is 1, I speak of statistical

The Statistical Relevance Basis

If explanations are deductive arguments, as Hempel has argued with his deductive-nomological (D-N) model, we naturally suppose inductive or statistical explanations are inductive arguments. That is, the explanandum, presumably, is to get strong inductive support from the explanans. However, it has long been known that there are deep disanalogies between inductive and deductive logic. Most crucial among them is that, according to Hempel, "the deductive principle that permits the addition of an arbitrary term to the antecedent of an entailment does not carry over at all into inductive logic."[7] That is, in contrast to the case of deductive logic, where whatever C stands for, A.C entails B if A entails B, in inductive logic there is no constraint upon P(B|A.C) no matter how high P(B|A) is. To cope with this problem, Hempel proposed the requirement of maximal specificity, which says that we must know no way to divide the class, to which the individual case is referred for explanatory purposes, into subclasses in which the probability of the event-to-be-explained differs from its probability in the whole class. Even so, the inductive-statistical or I-S variety of the D-N model is not satisfactory for explanations where statistical laws are invoked. On this model the event is explained by virtue of the high

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relations as covering universal relations. In this sense, irreducibly statistical laws include irreducibly universal laws.

[7]SECSW, p. 28. Also see Hempel, "Deductive-Nomological vs Statistical Explanation", in *Minnesota Studies in the Philosophy of Science*, vol. 3 (Minneapolis, 1962), ed. H. Feigl and Grover Maxwell.

probability the explanans lends it. This high probability requirement, as a parallel to the deductive entailment relation in D-N model, leads to two difficulties. One of them, as spelled out by Salmon, is that even though "Hempel's requirement of maximal specificity guarantees that *all* known relevant facts must be included in an adequate scientific explanation", there is "no requirement to insure that *only* relevant facts will be included". However, we normally expect an explanation includes only relevant facts--the fact that Lincoln was assassinated never enters the explanation of the fall of Roman empire. The other difficulty is that "high probability does not constitute a necessary condition for legitimate statistical explanations". The high probability for me to eat poisonous mushrooms without developing an illness does not explain the fact I was actually poisoned by poinonous mushrooms, which was a realization of a low probability. Salmon concludes that the high probability that the explanans lends to the explanandum is "neither necessary nor sufficient for correct statistical explanations" (SECSW, pp. 31-32).

Rather than the high probability requirement of the Hempelian I-S account, Salmon appeals to "statistical relevance" as the key explanatory relationship. In Salmon's terminology, a factor C is statistically relevant to the occurrence of B under circumstances A if and only if $P(B|A.C) \neq P(B|A)$. In other words, a satisfactory statistical explanation, on Salmon's view, involves a comparison between the prior probability of the occurrence-to-be-explained and one or more posterior probabilities. If the posterior probability of B under the circumstance A.C is not equal to the prior probability of B under the circumstances A, then factor C is statistically relevant to the occurrence B under circumstances A, and may (but also may not) possess explanatory import. By contrast, Hempel's high-probability requirement demands only that the posterior probability be sufficiently large without making reference to any prior probability. The difference can be illustrated by a concrete example given by Salmon. Let C stand for the taking of vitamin C. What is in question is why a person with a cold (A) who takes vitamin C recovers within a fortnight, which is represented by B. We are interested, of course, in the posterior probability P(B|A.C), which is the probability of the recovery of a person who takes vitamin C. Let's suppose this probability is sufficiently high. Thus a Hempelian explanation would be that, because it is highly probable that any person who suffers from a cold and takes vitamin C recovers within a fortnight, and because this man is a person with a cold and taking vitamin C, it is very probable that he recovers within a fortnight. However, Salmon maintains that a prior probability must be considered for a statistical explanation. In this case, it is represented by the probability that a person with a cold recovers with a fortnight, P(B|A). If it turns out that P(B|A) = P(B|A.C), then the taking of vitamin C plays no role in the explanation of the recovery and is not statistically relevant.

Let us examine a concrete example in light of Salmon's formal elaboration of the S-R basis. But first, let us consider the steps involved in the S-R basis:[8]

1. We select an appropriate initial reference class A with respect to which the prior probabilities $P(B_i|A)$ of the B_i are to be taken, where $1 \leq i \leq m$, and where B_is are a set of exclusive and exhaustive attributes functioning to partition the sample space to which the explanandum belongs;

2. We furnish an explanans-partition by invoking a set of statistically relevant factors (properties), $\{D_1, \ldots, D_k, \ldots D_m, E_1, \ldots, E_h, \ldots, E_n, \ldots N_1, \ldots, N_g, \ldots, N_q, \ldots\}$, and by partitioning A into a set of mutually exclusive exclusive and exhaustive cells $\{A.C_{11\ldots1\ldots}, A.C_{kh\ldots g\ldots}, \ldots\}$, where $C_{kh\ldots g\ldots} = D_k \wedge E_h \wedge \ldots \wedge N_g \wedge \ldots$, $(1 \leq k \leq m,\ 1 \leq h \leq n,\ 1 \leq g \leq q)$;

3. We ascertain two sets of probabilities:

prior probabilities $P(B_i|A) = p_i$, for all i $(1 \leq i \leq m)$, and

posterior probabilities $P(B_i|A.C_{kh\ldots g\ldots}) = p_{ikh\ldots g\ldots}$, for all i, k, h, ..., g...;

4. We require each of the cells $A.C_{kh\ldots g.}$ to be homogeneous with respect to the explanandum-partition $\{B_i\}$-- that is, none of the cells in the partition can be further subdivided in any manner relevant to the occurrence of any B_i--so that we can ensure that *every* relevant factor has been employed in effecting the partition;[9]

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[8]For Salmon's formal formulation of the S-R basis, see SECSW, pp. 36-7. My reformulation makes a bit of a departure, especially with respect to his notation, which is somehow confusing.

[9]To say that a reference class is objectively homegeneous with respect to a given attribute is to say that there is no way, in principle, of effecting a relevant partition. Objective homogeneity is not relativized to our knowledge situation--that is, it does not depend on the mode of existence

5. We require the explanans-partition be a maximal homegeneous partition, that is, for $s \neq t$ we require that $p_{ikh...gs...} \neq p_{ikh...gt}...$, so that we *only* employ relevant factors to partition A;

6. We need to ascertain the relative size of the cells in our explanans-partition in terms of the marginal probabilities, $P(C_{kh...g...}|A) = q_{kh...g...}$, so that we can determine the probability that a member of A with just *one* factor will have one of the attributes of the explanandum-partition.

7. We determine which cell $A.C_{kh...g...}$ contains the individual x whose possession of the attirbute B_i was to be explained.

This version of formulation, I believe, better represents Salmon's S-R basis. Now, following Salmon, let us suppose we want to know why Albert has committed a delinquent act--say, stealing a car, a major crime. We may *choose* to take this question as asking: Why does Albert, as an American teenager, commit a major crime?[10] By this interpretation of the question we select an initial reference class--American teenagers-- in respect to which we impose an explanandum-partition in terms of an exclusive and exhaustive set of attributes--for example, B_1 = no criminal convictions, B_2 = conviction for minor infractions only, and B_3 =conviction for a

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of intelligent beings. This requirement is of critical importance to Salmon's S-I basis, and Salmon has a detailed argument for objective homogeneity (see SECSW pp. 48-83). For my present purpose I will take his argument for granted.

[10]We will soon find that how a question is taken to be, or the exact manner in which a question is asked, may give rise to completely different explanations.

major offence. We are told by our sociological theories, or probably just by common sense, that certain factors are relevant to a delinquent act--sex, religious background, marital status of parents, type of residential community, socioeconomical status, and so on. We then use these factors to partition the initial reference class A (American teenagers) into a set of mutually exclusive and exhaustive cells, such as males from Protestant background with parents divorced, living in a surburn area, belonging to the middle class, and so forth. The relevant factors furnish the explanans-partition. We then need to ascertain the prior probabilities $P(B_i|A) = p_i$, where $1 \leq i \leq 3$. We also need to ascertain and assign the various degrees of delinquent behavior to each of the cells--that is, the posterior probabilities associated with various cells $P(B_i|A.C_{kh..g..})$ $= p_{ikh..g..}$, which represent the statistical outcome of the interplay of the various factors contributing to or counteracting the act of delinquency. The comparison between the prior probabilities and the posterior probabilities, then, comprises a basis for the explanation for Albert's delinquency behavior.

If we want to know how much each factor--his sex, or social status, or the like, designated by D_k, or E_h, or N_g--or a combination of some of them contribute to or counteract one of the attributes of the explanandum-partition, which can be indicated by $P(B_i|A.D_k)$, or $P(B_i|A.E_h)$, or $P(B_i|A.N_g)$, or $P(B_i|A.D_k.E_h)$, we may invoke the marginal probabilities $P(C_{kh.g..}|A)$.[11] We might find that his sex and socioeconomic

[11]This computation can be done with the aid of rudimentary knowledge in probability theory. See SECSW, p. 40, footnote 11, though Salmon's notation system is different from mine.

status function to contribute to his delinquency--that is, they bear positive statistical relevance to his delinquent behavior, while his religious background and the marital status of his parents counteract his delinquency, or are negatively relevant to this offence. Such knowledge, on Salmon's view, enhances the S-R basis for the explanation for Albert's delinquency act at the statistical relevance level.

In addition, it is worth noting that, since statistical laws imply that the same circumstances that produce E in some cases may give rise to non-E in others, the information we obtain from the comparison between prior probabilities of the explanandum and its posterior probabilities may furnish the explanation of "why the event E occurred" as well as "why the event non-E occurred" --i.e., "why the event E did not occur". Of course, this explanation holds only if we admit that statistical laws are objective and independent of our mind.

Certain problems arise, however. First, given objective homogeneity, as Salmon claims, how can we ensure that our partition includes every relevant factor and only relevant factors? Salmon concedes that in a concrete situation we, of course, have to admit the limit of our knowledge and must acknowledge that there may be factors we have not considered or have misconsidered in partitioning the explanans and the explanandum. Nevertheless, Salmon claims that his philosophical

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Meanwhile, I would also suggest such a procedure is not indispensable for the determination of the probabilities $P(B_i|A.D_k)$ and the like, for we can ascertain these probabilities directly in the population as we do with $P(B_i|A.C_{kh...g...})$.

analysis is "designed to capture the notion of a fully satisfactory explanation." Thus the S-R basis, with all its strong requirements, is justified in the sense that it describes an ideal that can be achieved only in principle.

The second problem concerns the kind of explanandum-partition we impose on the initial reference class and, correlatively, our selection of such a class with respect to which to take the prior and posterior probabilities. Is this selection of the initial reference class arbitrary? Not necessarily. As I noted before, a clarification of the question and therefore of what type of answer is sought may provide enough information to demarcate a sample space for the explanandum-partition, and therefore help us to determine the appropriate reference class. In the preceding example, we understand the question as "why did Albert, as an American teenager, commit a delinquent act?" If we ask instead "why did Albert, as a member of his gang, steal a car?" or "why did Albert steal a car rather than a camera or a diamond?", the answers necessarily differ. For the former question, the answer may be that Albert was the most adept at car-stealing in his gang; for the latter, a car dealer had promised to buy a stolen car for $500. Therefore, we can say that the multiplicity of the answers to the seemingly "same" question is elicited not by the nature of explanation per se, but by the ambiguity of the question posed. It can be ruled out, in principle, by the clarification of the question. There might be cases, nevertheless, where exact questions are posed and the answers still differ. This problem will be dealt with in chapter three.

A third problem is that, as Salmon is aware, "mere statistical correlations explain nothing" (SECSW, p.43). A rapidly falling barometric reading is a sign of an imminent storm, and statistically it is highly correlated with the onset of storms. However, none of us makes the falling barometric reading a satisfactory explanation of the occurrence of a storm. To deal with problems of this sort, Salmon proposes that a factor C, which is relevant to the occurrence of B in the presence of A, may be "screened off" in the presence of some additional factor D. To illustrate this "screening-off relation", let A stand for some particular days at a particular place. Usually it is the case that the probability of a storm occurring (B) is quite different from the probability of a storm if there has been a recent sharp drop in the barometric reading (C). However, if we take into account the further fact that there is an actual drop in the atmosphere (D) in the region, Salmon argues, then we will see that whether or not the drop is registered on the barometer has no hearing upon the storm B. That is, D screens off C from B:

$$P(B|A.C.D) = P(B|A.D)$$

Meanwhile, C does not screen off D from B, that is,

$$P(B|A.C.D) \neq P(B|A.C)$$

The reason for this difference is that "barometers sometimes malfunction". Furthermore, he claims is that "it is the atmosphere pressure, not the reading on the barometer per se, that is directly relevant to the occurrence of the storm" (SECSW, p. 44). The screening-off relationship thus characterized supplements the statistical relevance relationships, and together they constitute, Salmon once believed, a full-scaled scientific explanation.[12],

However, I shall suggest reasons to be dissatisfied with this screening-off relationship argument. For usually the barometer functions normally, that is,

$$P(B|A.C.D) = P(B|A.C).$$

We may thus consider the appeal to the malfunction of the barometer ad hoc. But more important, if we do not know in advance--suppose we did not have the relevant scientific knowledge--that it is the atmospheric pressure rather than the reading on the barometer that is directly relevant to the occurrence of the storm, then we would have no idea whether we can identify a screening-off relation between the barometric reading and the drop of atmospheric pressure. Thus the screening-off relation argument does not necessarily work without the aid of relevant scientific knowledge. The nature of scientific knowledge, nevertheless, is the very issue here that calls for elaboration.

This problem might have prompted Salmon to introduce causality as an explanation of the statistical correlation. The statistical correlation occurs, as we will see, because there is a causal relation between the event-to-be-explained and the explanatory facts. The S-R approach thus provides a set of facts that are statistically relevant to the event-to-be-explained. This set of facts provides a basis for the causal

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[12]This view can be found in Salmon's book, *Statistical Explanation and Statistical Relevance* (Pittsburgh, 1971).

relations between the event-to-be-explained and the explanatory facts. It is our knowledge of those causal relations that constitutes the genuine scientific explanation.

To conclude, let us contrast Hempel's I-S model of scientific explanation and Salmon's S-R basis model. For the I-S model, an explanation is an argument that renders the explanandum highly probable given the explanans; for the S-R basis model, a set of events statistically relevant to the explanandum provides an explanatory basis that leads to further investigation of causal relations linking explanans with explanandum. The degree of probability of the explanandum given the explanans does not by itself count as an explanation. The S-R basis model of statistical explanation consists in a probability distribution over a "homogeneous partition" of an initial reference class. The epistemic value of such an explanation is measured by the information provided by the probability distribution over the explanandum-partition relative to the explanans-partition. It is true that both approaches pivot on the notion of subsumption. However, for the I-S model, the subsumption is exhibited in terms of inductive argument. In contrast, the S-R basis model takes the relation of subsumption to hold between (generally nonlinguistic) facts. The event-to-be explained is conceived of as an instance of a statistically regular pattern of occurrence in the objective world. It is this physical subsumptive relation, rather than the inferential relations of deductive or inductive logic, that is exhibited by good scientific explanations. A merit of this ontic conception of scientific explanation is that in taking subsumptive relations as objective rather than linguistic or logical, it opens the way for investigating what lies beneath those physical regularities--i.e., the causal mechanisms of the world, as Salmon would argue. A detailed knowledge of the causal mechanisms underlying such regularities may not be required for successful prediction--mere descriptive knowledge may well suffice for this purpose; however, such knowledge is indispensable for genuine scientific understanding. To give satisfactory answers to "why" questions, we must, Salmon suggests, explore the causal structure of the world.

Chapter Two: Salmon's Account of Causality

A perennial difficulty with regard to causation is about the precise nature of the causal "connections"or "relations". In a celebrated passage, Hume claimed that "beyond ... three circumstances of continuity, priority, and constant conjunction" he could "find nothing in [the] cause". [13] Hume brilliantly analysed the seemingly psychological origins of our notion of causal "necessary connection", arguing that such a connection is not found in events and is not objective. Rather, causal relation is read into the conjunctions of events , and is a habit of mind. Since Hume there has been considerable controversy regarding the nature of the relation between cause and effect. Traditionally the relation has been analysed in terms of sufficient condition or necessary condition, or sometimes a combination of the two. Typical of this approach is J. L. Mackie's account in terms of INUS conditions--i.e., "insufficient but non-redundant parts of unncecessary but sufficient conditions",[14] which since the time of its proposal has almost enjoyed the status of the standard view.

Let us examine Mackie's INUS conditions in somewhat more detail. According to Mackie, a cause of an event is neither a necessary nor a sufficient condition of that event, although it is a condition of a sort closely related to necessary

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[13]Hume, "An Abstract of A Treatise of Human Nature", An Inquiry Concerning Human Understanding, ed. C. W. Hendel (New York, 1955), p. 187.

[14]J. L. Mackie, *The Cement of the Universe* (Oxford, 1974), p. 62.

and sufficient conditions. For example, a short circuit may be said to be the cause of a fire in a house. But it is neither necessary nor sufficient for that fire, since the fire might have been caused by careless smoking in bed. Also, in the absence of flammable material near the short circuit, the fire would not have occurred. So the short circuit is the cause of the fire in the house only in the sense that is an indispensable part of a complex sufficient (but not necessary) condition of the fire. There could be numerous sets of such conditions which, taken individually, are all sufficient to cause a fire, but none of them is necessary. Therefore, eventually, the notion of INUS condition has to be explained in terms of necessary and sufficient conditions which, according to Mackie, have to be analysed in terms of counterfactual conditionals. Counterfactuals, Mackie further maintains, have to be explained on the ground of deterministic regularities and laws.[15] But there are laws that are irreducibly statistical. A complex of conditions may be highly likely to cause a fire, but without necessarily doing so. Consequently, in some cases there may be no strictly necessary or sufficient causal conditions, not if that implies rigidly deterministic laws.

This point is also made forcefully by Salmon. In fact, Salmon has two criticisms of the necessary-and-sufficient condition view of causality. First, he

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[15]For Mackie's argument in this respect, see his "Counterfactuals and Causal Laws", in *Analytical Philosophy: First Series*, ed. by R. J. Rutler, reprinted in *Philosophical Problems of Causation*, ed. by Tom L. Beauchamp (California and Belmont, 1966).

believes that there are clear cases of cause-effect relations that defy an analysis of this kind. For example, suppose someone throws a baseball which hits and breaks a window. Salmon suggests that it seems plausible to suppose that windowpanes of the same size, shape and thickness shatter in 95% of all instances in which they are struck by baseballs of the same size travelling at the same velocity. Therefore, all other conditions being the same, a window's being struck by a baseball does not constitute a sufficient condition for breaking. Nonetheless, "the fact that breakage does not occur in every case does not constitute an adequate ground for denying that the impact of *this* baseball caused *this* window to break" (SECSW, p. 188). Furthermore, it is obvious that being struck by a baseball is not a necessary cause for the window to break. Second, Salmon claims that it is unnecessary to burden our common-sense concept of causality with the dubious metaphysical thesis of determinism. In this respect he aligns himself with Suppes, who remarks:

> It is easy to manufacture a large number of additional examples of ordinary causal language, which express causal relationships that are evidently probabilistic in character. One of the main reasons for this probabilistic character is the open-textured nature of analysis of events as expressed in ordinary language. The completeness and closure conditions so naturally a part of classical physics are not at all a part of ordinary talk. Thus in describing a causal relation in ordinary circumstances, we do not explicitly state the boundary conditions or the limitations on the interaction between the events in question and other events that are not mentioned.[16]

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[16]Patrick Suppes, *A Probabilistic Theory of Causality* (Amsterdam, 1970), p.8; also cited in SECSW, pp.189-190.

The idea is that even if determinism turned out to be false, ordinary causal talk would not dissolve into nonsense. Thus the necessary-and-sufficient condition approach to causality is untenable. As an alternative, Salmon maintains, probabilistic notions should play a central role in the analysis of causality, which also encompasses a sufficient cause as a limiting case.

In the standard probability approach to causality, statistical relevance relations play a fundamental role. Although their explanatory significance is indirect, they nevertheless constitute evidence for causal relations. In the probabilistic causality theories such as those proposed by Reichenablch and Suppes, the relation of positive statistical relevance plays the fundamental role. What lies at the heart of their program is the idea that causes must, in some way, make their effects more likely. The major difficulty confronting such an account is, as Salmon points out, "the problem of negative relevance". This problem is a common one we are all very familiar with. Consider Salmon's example. Suppose two and only two candidates are running for a public office, and both of them advocate a major bridge reconstruction project. Assume that candidate A has a 2/5 chance of winning, while candidate B has a chance of 3/5. Furthermore, if A is elected, the chance of an appropriation for the reconstruction is 1/10, whereas if B is elected, the probability is ½. Thus the prior probability of the bridge reconstruction is 0.34. Suppose, however, that A is elected, and that his effort to have the bridge reconstructed is successful. The posterior probability is reduced to 1/10. Nevertheless, the election of A is still a part of the causal chain that leads to the reconstruction of the bridge.[17] In other words, a cause may actually make an effect less likely.

If positive relevance is not the essential ingredient in a theory of probabilistic causality, what is the fundamental notion? For Salmon, the answer lies in "the transmission of probabilistic causal influence" (SECSW, p.202). Although Salmon argues that purely probabilistic approaches to causation are exposed to serious objections like the one we have just seen, he is nevertheless sympathetic to the idea that the concept of probability enters into the analysis of the concept of causation in a fundamental way. He suggests that the appropriate response to the difficulties in question is not to abandon the attempt to relate causation to probability, but to supplement probabilistic concepts with other ones--in particular, with the concept of a causal process.

Two concepts lie at the heart of Salmon's account of causation: propagation and production. Although the two concepts are intimately related to one another, there is an important distinction between them: causal production involves changes, while causal propagation involves the spatio-temporally continuous transmission of a causal influence from one region to another. Consider first Salmon's idea of causal propagation. Such propagation is achieved by means of a causal process that spans from one space-time region to another. Salmon takes processes rather than events

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[17]For a detailed examination of the problem of negative relevance, see SECSW pp.192--202.

as basic entities. What are processes? Although Salmon does not offer a rigorous definition, in his presentation the main difference between events and processes is that "events are relatively localized in space and time, while processes have much greater temporal duration, in many cases, much greater spatial extent" (SECSW, 139). In space-time diagrams events are represented by points, whereas processes are represented by lines. For example, the colliding of a baseball with a window would count as an event, while the baseball, travelling from the bat to the window, constitutes a process. Taken to the extreme, a material object at rest also qualifies as a process. Throughout processes there is constancy of quality and structure, whereas an event involves a sudden change of either structure or quality or both.

Salmon argues that causal processes can be distinguished from pseudo-processes in terms of the ability to transmit a mark. The ability to transmit a mark, on Salmon's account, is to be understood in terms of the ability of a process to maintain its own uniformity. While a given process, whether it be causal or not, has a certain degree of uniformity in terms of quality or structure, a causal process is capable of transmitting its quality or structure, whereas a pseudo-process is not. Whether a process is able to transmit its uniformity, in turn, is judged by whether it can transmit certain modifications in its quality and structure. If a process is capable of transmitting its quality and structure, then it is self-determined and is a causal process. In contrast, the pseudo-processes are not self-determined; their uniformity or regularity is parasitic upon causal regularities exterior to themselves. To illustrate this point, we may consider a concrete example given by Salmon.

Suppose a car is travelling along a road on a sunny day. The moving car constitutes a causal process, whereas its shadow, moving at the same speed, is a pseudo-process. If the car collides with a stone wall, it will subsequently carry with it the marks of that collision--the dents and scratches. However, if only its shadow collides with the wall, the shadow will be deformed momentarily, but will resume its normal shape as soon as it has passed the wall. The point of this example is simply that the shadow, as a process that has structure and quality but cannot maintain its uniformity, is a pseudo-process, parasitic upon a real causal process which is capable of transmitting its uniformity and any modification of that uniformity. Generally speaking, a causal process is one that "transmits energy as well as information and causal influence"; the fundamental criterion for distinguishing causal processes from pseudo-processes is "the capability of such processes of transmitting marks" (SECSW, p. 146).

We may, however, feel some misgivings about the uncritical use of such concepts as "capability" and "mark". What counts as the ability of a process to "transmit" a "mark"?

What do we mean when we speak of transmission? Salmon's answer is simple and straightforward: The transmission of a mark from point A in a causal process to point B in the same process is the fact that it appears at each point between A and B without further interactions. He further explicates this MT (mark transmission) thesis in terms of counterfactuals:

> Let P be a process that, in the absence of interactions with other processes, would remain uniform with respect to a characteristic Q, which it would manifest consistently over an interval that includes both of the space-time points A and B ($A \neq B$). Then, a mark (consisting of a modification of Q into Q'), which has been introduced into process P by means of a single local interaction at point A, is transmitted to point B if P manifests the modification Q' at B and at all stages of the process between A and B without additional interventions (SECSW, p.148).

A related principle is that of structure transmission (ST): If a process is capable of transmitting changes in structure due to marking interactions, then that process can be said to transmit its own structure (SECSW, p. 154).

The main reason for Salmon to devote his attention to causal processes is apparently to show that these processes transmit causal influence, which, in his own terms, is the propagation of causal influence. He writes: "A process that transmits its own structure is capable of propagating a causal influence from one space-time locale to another" (SECSW, p.155). This propagation of causal influence by means of causal processes constitutes, on Salmon's view, the connection between cause and effect which Hume sought but was unable to find.

The import of this discussion of causal propagation is that *by providing a causal process between the cause and the effect we can legitimately make sense of a cause-effect relation.* The cause-effect relation, therefore, can be analysed in terms of three components--one event that constitutes the cause, another event that constitutes the effect, and a causal process that connects the two events. (Furthermore, as we shall see, both cause-event and effect-event can be construed in terms of the intersection of two or more causal processes.) It is the spatio-temporally continuous causal processes, rather than a chain of discrete events, that constitute not only "the cement of the universe"--that is, causal connections among events--but also "the bricks of the universe", as I shall call them. For our universe also teems with entities that relatively maintain their structural and qualitative stability in space and time and qualify as causal processes.

In approaching the second basic causal concept, production, Salmon distinguishes three type of causal forks--interactive forks, conjunctive forks, and perfect forks--each of which is concerned with situations in which a common cause gives rise to two or more effects that are somehow correlated with one another, and each of which is explained in terms of causal processes plus certain statistical relations. The point of departure for his discussion is Reichenbach's "principle of the common cause", which states that "when apparent coincidences occur that are too improbable to be attributed to chance, they can be explained by reference to a common causal antecedent" (SECSW, p. 158).

Let us consider conjunctive forks first. According to Reichenbach, a conjunctive fork is defined in terms of the following conditions:[18]

$$P(A.B|C) = P(A|C) \times P(B|C) \qquad (1)$$

$$P(A.B|\overline{C}) = P(A|\overline{C}) \times P(B|\overline{C}) \qquad (2)$$

$$P(A|C) > P(A|\overline{C}) \qquad (3)$$

$$P(B|C) > P(B|\overline{C}) \qquad (4)$$

They entail: $$P(A.B) > P(A) \times P(B) \qquad (5)$$

Compare that with: $$P(A.B) = P(A) \times P(B) \qquad (6)$$

What this means, for example, is that, given two effects, A and B, that occur together more frequently than they would if they were statistically independent of one another, there must be some prior event C--which is a cause of A and is also a cause of B--that explains the lack of independence between A and B. (3) and (4) simply assert that C is a positive cause of A and B. (6) exposes the fact that if two events are totally independent of one another, the probability that they occur together would be equal to the product of the probabilities of their separate occurrences. The relation between the conditional probabilities in (1) and (2) states that, *given either the presence or the*

[18] See Reichenbach, *The Direction of Time* (Berkeley and Los Angeles, 1956), sec.19; also cited in SECSW, pp.159-161.

absence of a prior event C, A and B occur independently. For, according to the multiplication theorem,

$$P(A.B|C) = P(A|C) \times P(B|A.C)$$

If $P(A|C) \neq 0$, equation (1) entails

$$P(B|C) = P(B|A.C).$$

This is to say, C screens off A from B, or *given C,* A is statistically irrelevant to B. A similar computation can show that the non-existence of C renders A statistically irrelevant to B. However, because of (5), which is derived from (1)-(4), the two effects A and B cannot be unconditionally independent. This lack of unconditional statistical independence is due to the existence of the common cause C. For example, suppose two students happened to hand in the same term paper. Such an occurrence, we believe, is too improbable to be a coincidence. If we rule out the possibility that one term paper was copied directly from the other--indeed, we may reasonably believe that no student ever deliberately copies his classmate's term paper and submits it in the same class, then we may suspect there must be some common source of these two papers. Careful investigation may then reveal that it was the existence of a file of term papers, to which both students have access, that gave rise to the two identical papers.

An appropriate statistical relation among events A, B and C may only be suggestive of the existence of a conjunctive causal fork--how can we tell whether C is a *genuine* common cause of A and B? Salmon's account of causal processes provides the answer. To qualify as a genuine common cause of A and B, C must be spatio-temporarily connected to A and B by suitable causal processes. In the case of the two plagiarists, the causal processes were their viewing and copying of the same term paper in the file, and these two processes were relatively independent of each other.

There is another common cause situation, Salmon tells us, that cannot be appropriately characterized in terms of conjunctive forks. Whereas in the case of conjunctive forks separate and distinct causal processes arise out of common background conditions and do not intersect each other, there are cases in which causal processes do intersect each other and produce effects on each other. Salmon calls such cases "interactive forks". Two colliding balls, for example, constitute the simplest type of interactive fork. There are, however, cases where two processes intersect but do not interact. This will happen at the intersection of two "pseudo-processes"--for instance, the intersecting of the shadows on the ground of two airplanes--as well as between that of two causal processes--for example, light rays normally pass through one another without effect. Therefore, we may consider that the intersection of processes is a necessary but not sufficient condition of the production of lasting change in them.

What Salmon calls a "causal interaction" occurs when two processes intersect and produce persisting modifications to both of them. Let C stand for the event consisting of the intersection of the two processes, and let A stand for a modification in one, and B for a modification in the other. Then the following inequality holds:

$$P(A.B|C) > P(A|C) \times P(B|C)$$

Compare it with the case of conjunctive forks, in which

$$P(A.B|C) = P\ (A|C) \times P(B|C)$$

The significance is that the modifications of the two processes are *correlated* with each other in virtue of the *interaction between the two processes that produces the change.*

Recall Salmon's characterization of causal processes. Causal processes are distinguished from pseudo-processes in terms of mark transmission: A mark is a modification of a process, and if the modification persists, the mark is transmitted. Salmon claims that a modification in a process occurs only when it intersects with other processes, and if the modification persists beyond the point of intersection, then the intersection constitutes a causal interaction and produces a mark that is transmitted. Here is his principle for causal interaction (CI):

> Let P_1 and P_2 be two processes that intersect with one another at the space-time point S, which belongs to the histories of both. Let Q be a characteristic that process P_1 would exhibit throughout an interval (which includes subintervals on both sides of S in the history of P_1) if the intersection with P_2 did not occur; let R be a characteristic R that process P_2 would exhibit throughout an interval (which includes subintervals on both sides of S in the history of P_2) if the intersection with P_1 did not occur. Then, the intersection of P and P at S constitutes a causal interaction if and only if:
> (1) P_1 exhibits the characteristic Q before S, but it exhibits a modified characteristic Q' throughout an interval immediately following S; and
> (2) P_2 exhibits the characteristic R before S, but it exhibits a modified characteristic R' throughout an interval immediately

following S.

He adds that the modifications that Q and R undergo are normally correlated in accordance with laws which are statistical in character. Such causal interactions are termed as x-type by Salmon, and he believes his principle incorporates the basic features of such causal interactions.[19]

Interactive forks characterize direct physical interactions, whereas conjunctive forks characterize relatively independent processes arising under special background condition. Furthermore, conjunctive forks are always open to the future and never to the past. That is, since the statistical relations found in conjunctive forks are said to explain otherwise improbable coincidences, it follows that such coincidence "are expected to be explained only in terms of common causes, never common effects". This is not a mere prejudice against teleological explanations; Salmon asserts that "a world in which teleological causation operates is not logically impossible, but our world does not seem, as a matter of fact, to be of such a kind."[20] Such temporal asymmetry is not, however, to be found in interactive forks. In fact, Salmon

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[19]Salmon also mentions the existence of two other types of causal interaction -- the y-type and λ-type -- according to the shape of their space-time diagrams. See pp. 181-82. The y-type interaction consists of a single process that bifuracates into two processes--for example, an amoeba that divides to form two daughter amoebas. The λ-type involves two processes that come together and fuse into a single ongoing one--for example, a hydrogen atom absorbs a photon and then exists for a time in an excited state. Salmon uses the x-type interaction to define interactive forks in order to exploit the idea of mutual modification.

[20]See SECSW, pp. 163-66, where Salmon offers several examples to illustrate this temporal asymmetry principle..

maintains that "causal interactions and causal processes do not, in and of themselves, provide a basis for temporal asymmetry" (SECSW, pp. 175-76).

There is still another type of fork. Salmon stipulates that for both conjunctive forks and interactive forks, P(A|C) and P(B|C) always falls between zero and one. Now, he considers the statistical relation

$$P(A.B|C) = P(A|C) \times P(B|C) = 1.$$

On his view, such a relation represents a limiting case of either a conjunctive or an interactive fork, and he calls such cases "perfect forks". The reason perfect forks are to be distinguished from the other two types is that "when the probabilities take on the limiting values, it is impossible to tell from the statistical relations alone whether the fork should be considered interactive or conjunctive". Only on separate grounds--that is, only by detecting the temporal asymmetry of the perfect fork--can we tell whether the fork in question is a limiting case of a conjunctive or of an interactive one.

The Causal Structure of the World

On Salmon's view, the foregoing characterization of causal processes and various causal forks provides a basis for understanding several important aspects of causality. We have seen that, first of all, causal processes are the means by which structure and order are transmitted from one space-time region to other times and places. Thus they can be viewed as the connections among causally related happenings in various parts of space-time. Secondly, causal interactions, explicated in terms of interactive forks, produce the structure and modifications of structures that we find in the patterns exhibited by the world. Thirdly, conjunctive common causes, characterized as conjunctive forks, play a vital role in the production of structures and orders that are relatively independent, but the co-occurrence of which is utterly improbable in the absence of a common causal background. Finally, there are causal laws that govern causal processes and interactions. Note, however, that the existence of laws does not imply a deterministic structure for the world, for (1) laws themselves may be statistical in character, which means that (2) intersections and interactions of *some* causal processes--which produce certain modifications transmitted by processes rather than *alternative* ones--are indeterministic and, in some cases, may even be random.[21]

Salmon's account appears promising as a way of dealing with various puzzles surrounding our notion of causation. First, what is the mechanism, if any, that underlies causation? Salmon would reply that the basic causal mechanism is "a causal process that carries with it probability distributions for various types of interactions" (SECSW, p. 203), which in many cases (but not all) could be construed as

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[21]This characterization of causality is based on Salmon's analysis but also significantly different, especially with respect to the roles of common causes and causal laws in the production of structure and order. For his explicit treatment of this issue, see SECSW pp. 179-81. However, I believe that my formulation is faithful to the Salmonian spirit, and that Salmon would agree with my modification, although I am not going to argue for my revision at length here.

"propensities". Secondly, what constitutes the connections between causes and effects? Evidently the answer Salmon supplies is that causal processes fill the bill. Thirdly, if asked to characterize the relationship between causes and effects in terms of necessary or sufficient conditions, Salmon would say that causes are neither sufficient nor necessary for effects; rather, causes, as the interactions of numerous processes, are related to effects in virtue of the fact that marks they produce are transmitted by the processes to effects, where they participate in further interactions. And all those processes and interactions are governed by laws which are often statistical in character. Fourthly, must causes precede their effects, or may they be simultaneous with them? The answer Salmon's account furnishes is that in typical cause-effect situations where a causal process joins two distinct interactions, then the cause must precede the effect, for causal propagation over a finite time interval is an essential feature of cases of this type. However, if a causal interaction is in question, where an intersection of some processes produces lasting changes in each of them, then the cause is simultaneous with the effect, since in this case each process intersects the other at the same time. Finally, do statements about causal relations pertain to individual events, or do they hold only with respect to classes of events? In this respect Salmon, I believe, would suggest that causal relations have both particular and general aspects. For, on the one hand, a causal process is an individual entity which transmits causal influence, and which sustains a causal connection between an individual cause and an individual effect. The relation between any particular cause and effect can be stated in singular terms. On the other hand, when we invoke statistical relations to construe common causes, we are implicitly referring to statistical generalizations. This amounts to saying that, to the extent that statistical laws are involved in the processes and interactions, we can assert the existence of the general *kinds* of things (events) with law-like causal relations between them, although such laws may not be known and our assertion of such laws need not enter our singular causal analysis in most cases.

Salmon on Causal Explanation

Salmon's account of causality is meant to provide insight into the issues of explanation and understanding. In his terminology, the causal relations among events fall into two categories: those with direct causal relevance, and those with indirect causal relevance. The former applies to the case in which two events are connected with each other by a causal process; the latter pertains to cases where two events are the result of a common cause, whether by an interactive fork or a conjunctive fork. To carry explanatory power, statistical relevance relations have to be explained in terms of relations of direct or indirect causal relevance--direct causal relevance involves the existence of spatio-temporally continuous causal processes, and indirect causal relevance requires a common cause in addition to the connecting causal processes. It is these processes that constitute the mechanism by which causal influence is propagated in our universe. An explanation must be considered manifestly unsatisfactory, on Salmon's view, if either the common cause or the continuous connecting causal processes are lacking.

An implication of the principles of common cause and spatiotemporally connecting causal processes is that our belief in the existence of the common cause and the continuous connecting causal processes comprises the basis for a fundamental dual play in scientific investigation and understanding. We *infer* the existence of a process to provide spatiotemporally connecting causal connections to statistically correlated events, or, where a directly connecting process is lacking, we *infer* the existence of a common cause giving rise to the two statistically correlated events. Very often, such processes or common causes are subsequently discovered, and we employ them to *explain* the coincidence of the events at issue. Founded on the belief in action-by-contact and common causes, the dual play of inference and explanation has met with great success in the history of science, as Salmon has demonstrated with abundant examples.

What is to be noted here is that, as is easily seen, to the extent that the characterization of the common cause always involves a spatio-temporally continuous connecting process, our search for a common cause involves the search for connecting processes between the common cause and its independent effects. In fact, the search for the common cause of two statistically correlated events is successful only by virtue of the discovery of the processes that connect those two events with the other event, which is then termed the "common cause". Nevertheless, to the extent that such connecting processes are in most cases evident, once the common cause has been found, we hardly need any explicit mention of those connecting processes--not because they are lacking, but because they are already implicit in our mention of the effects and their common cause.

There are cases in which we may not be able to find the connecting causal process or the common cause. Following Salmon, let us suppose a crystal-ball gazer who is able to predict with high reliability the outcome of horse races at the local track. We would be confident in the existence of either a causal process or, more likely, a common cause, like the case of the falling barometer reading. We might hunt in vain for such a process or a common cause; we might not discover how the information is transmitted or who fixes the race. However, the failure in our search would not cast doubt on our belief that such processes or common causes exist; we maintain our confidence in their existence, which, in turn, is founded on our firm belief in causality (SECSW, p. 211).

Indeed, we have gone much further in imputing the principles of spatio-temporal continuity and common cause to our world. Salmon's examination of the history of science reveals forcefully that the principle of the common cause, in which the causal process is also involved, played a key role in the scientific investigation that convinced scientists of the existence of atoms and molecules during the early part of the century.[22] Except for the domain of quantum mechanics, in which science is not yet ready to claim a fair understanding, Salmon believes scientific experience has provided strong support for the appeal to unobservable common causes and causal processes when observable entities do not furnish the required causal connection. He further contends that it is "the common cause argument for the existence of molecules and atoms" that "legitimizes the appeal to unobservables for the purpose of providing causal explanations of observable phenomena--especially explanations of empirical regularities" (SECSW, p. 228).

Salmon believes such a causal argument has a strong bearing on the dispute over physicalism and phenomenalism. Although he does not intend to mount a full-fledged argument against phenomenalism or the agnostic attitude regarding the unobservable, he nevertheless observes:

> If the account of causal processes, causal interactions, and causal forks offered ... is anywhere near correct, then causal mechanisms frequently involve unobservable entities. ... For the ontic approach, any causal mechanism that is invoked for explanatory purposes must be taken to be real. If we are not prepared to assert its existence, we cannot attribute explanatory force either to that mechanism or to any theory that involves it. (SECSW, p. 238)

It is with respect to the existence of unobservable causal processes and, correlatively, the justification of our notion of causality that I consider Salmon's account somehow unsatisfactory. Let us make clear his line of reasoning. On the one

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[22]For Salmon's detailed examination in this respect, see SECSW, pp.213-238.

hand, a careful investigation enables him to claim that our notion of causality, as characterized by the search for spatio-temporally continuous causes or common causes, plays a critical role in scientific inquiry; science cannot dispense with the notion of causality. It follows that the success of science lends strong support to the legitimacy of our notion of causality. On the other hand, he claims that if his characterization of causality is correct, then the practice of postulating the existence of unobservable causes must be considered justified. In other words, it is our belief in causality that justifies the "real" existence of unobservable causes. However, our belief in causality draws its justification, according to his previous argument, from the success of science. Thus it follows that the "real" existence of unobservable causes is justified by the success of science, which amounts to saying that the pragmatic efficiency of the postulation of unobservable causes in science licences our notion of causality on the one hand, and warrants the "real" existence of unobservable causes on the other hand. On this account, then, the practical efficacy of science is the whole story of the justification of the scientific enterprise, and the validity of the postulation of causality need not enter into the justification of unobservable entities.

However, this account might not work well. Although Salmon does not tell us what he means exactly by taking the unobservable as "real", I suspect his view is of a robust physicalistic type that uncompromisingly asserts the existence of the unobservable in exactly the way our *current* scientific theory conceives of it. If I am not mistaken, I wonder precisely what kind of response Salmon, or any other physicalist, would give when confronted with not only the fallibilism of science but, moreover, the prospect of ongoing but nonconvergent scientific revolutions and the historical and often revolutionary changes in scientific conceptions with regard to the unobservable. I agree that it is beyond doubt that causal reasoning plays a critical role in all scientific inquiries, as Salmon would claim. And clearly, the postulation of unobservable causes always has some pragmatic value. But this consideration does not mean that later science may not always find earlier science fallacious in some respects, especially with regard to the unobservable. Taking this into account, I believe the pragmatic value of the postulation of unobservable causal processes can hardly be considered an adequate justification for an ontic conception of causality or the physical reality of unobservable causal processes. The justification, if there is any, must lie somewhere else.

Nonetheless, I have no intention to object to Salmon's ontic view of scientific explanation on the whole; on the contrary, I regard the ontic conception as the only viable view concerning the nature of scientific explanation not only in the domain of physical science, but in science in general, including biology and social science. But I do believe that a viable ontic view--concerned with causal mechanisms and unobservable entities that produce the facts-to-be-explained -- has to account for the fallibilism of science. This issue inevitably leads us to the dispute surrounding instrumentalism and realism. Few, if any, contemporary philosophers still cling to instrumentalism. Thus what concerns us here is how to reconcile an ontic view of scientific explanation with the fallibilism of science in an overall perspective of realism of some sort. Yet any realism that can accommodate fallibilism must, as we shall see, grant substantial concessions to anti-realism as the price of being compatible with the fallibilism and tendency to revolution in science.

Chapter Three: Metaphysical Realism and the Justification of Causality

The sort of scientific realism I have in mind is clearly spelled out by Nicholas Rescher in his book, *Scientific Realism: A Critical Reappraisal.*[23] Rescher treats the unending and nonconvergent character of scientific progress seriously, although in his view "the phenomena we detect will depend not only on nature's doings alone, but on the physical and conceptual instruments we use in probing nature" (SR, p. 18). It is from our interaction with the nature that we extract knowledge of the constituents and regularities of nature. He also thinks that "significant scientific progress is genuinely revolutionary in involving a fundamental change of mind about how things happen in the world"; it is generally not a matter of "adding further facts", but of *change*--of "changing the framework itself" (SR, p. 24). And this fact blocks the expectation of convergence.

Indeed, the fact that a non-convergent science draws its truth from our interrogation of nature inevitably conditionalizes or relativizes science. An interaction is always a two-sided process to which each party makes a contribution and, moreover, the character of these contributions cannot be clearly distinguished and separated. Accordingly, Rescher argues in a Kantian vein that our science is conditioned and delimited by the modes of our sensory involvement in the world to

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[23]Nicholas Rescher: *Scientific Realism: A Critical Reappraisal,* D. Reidel Publishing Company, 1987. Henceforth SR.

an extent we cannot ascertain with precision; the scientific truth that we discover about the world is *our* truth, "not so much in the sense that we 'make it up', but rather in the sense that it reflects our human mode of emplacement within nature" (SR, p. 94). This entails not only that current science is not capable of revealing the "real" truth of things-in-themselves, but that such a task is beyond the reach of future science as well.

If we grant the anthropomorphic character of science, how can we possibly justify the claim that science is objective and reflects, by and large, the real? How is the impressively effective coordination of thought and reality, which is manifested in our common sense, but most significantly provided by the mathematicizing of natural science, to be explained? How can one account for the enormous success of science with regard to prediction and control? To answer these questions, Rescher introduces considerations from the theory of biological evolution.

In Rescher's view, a two-sided explanation-- "one in which both mind and nature must play a duly collaborative role"-- is needed to account for the cognitive accessibility of nature (SR, p. 97). This, clearly, accords with his principle that science is a product of the interaction between nature and mind. "In human knowledge there is agreement between mental operations and extra-mental reality through a mutual accommodation engendering a process of give-and-take interaction, in the course of which our conceptions are coordinated with the ways of extra-mental reality through the operation of evolutionary processes" (SR, p. 98). "Our" side of the this bilateral story, in Rescher's explication, is straightforward. Homo sapiens is an "integral part" of nature, and the experience *we* have is inevitably an experience of *nature* as well. Mathematics is destined to be "congenial" to nature because it is part of our experience in the world, and therefore must be deemed a product of nature -- "it fits nature because it reflects the way we are emplaced within nature as integral constituents thereof" (SR, p. 102). Mathematics is not, however, supposed to conduce to human survival or reproductive fitness and is not a practical resource on a par with food or shelter; the bearing of evolution on mathematics is more indirect than that.

> Mathematics is the natural product and expression of certain capabilities (of synthetic representation) and certain interests (the impetus to understanding) which themselves are survival-conducive. It is not mathematics that is of evolutionary instrumentality but the cognitive resources and interest that provide the building blocks by whose means we erect its structure. (SR, p.103)

Thus, for Rescher, the question "why do our conceptual methods and mechanisms fit the real world with which we interact intellectually?" is to be answered in the same way as the question "why do our bodily processes and mechanisms fit the world with which we interact physically?" Both questions, he believes, are to be resolved in essentially evolutionary terms. "If we did not possess these", Rescher writes, "we just would not be here as inquiring creatures emplaced in nature thanks to evolutionary processes" (SR, p. 103).

We are just one side of the story of the success of science. To complete the story, he believes, we must turn to nature's contribution. Rescher argues that a world in which intelligence emerges has to be pervaded by regularities of organism-nature interaction, which means that nature must be stable, regular, and sufficiently structured for there to be "appropriate" responses on the part of intelligence to natural events. In other words, to permit the evolution of inquiring beings, nature must present an environment that affords sufficiently stable patterns to make coherent "experiences" possible. The existence of such learnable and stable "structures" or "patterns" in nature means that there must be some useful role for mathematics, which, after all, is "the abstract and systematic theory of structure-in-general" (SR, p.105). This line of deliberation leads, Rescher believes, to the conclusion that a world in which intelligence has evolved must be one amenable to mathematical understanding.

Evolution, however, is not an argument for the "real" truth of science. On the contrary, he contends that evolution is " an indicator of our capacity to err and 'get away with it'" (SR, p.108). The implication of the role of evolution in the success of science is that nature is an "error-tolerant" system. If a belief-guided creature lived in an environment that exacts a great penalty for "getting it wrong", it would have been eliminated long ago. It follows that if the world is to be home to intelligent beings that develop in it through evolution, it must be sufficiently benign, or "error-forgiving" in Rescher's term. An error-tolerant system, moreover, must generously reward the cognitive enterprise of its creatures--that is, by and large, the "science" the intelligence devises must pay off in terms of application or predictive success, even though, once again, that success is not an argument for the realistic "truth" of science. Such success does, Rescher thinks, imply *some* alignment between our science and the world's actual structure; but this alignment, he maintains, is just enough to yield "the particular success at issue" in an error-tolerant system and cannot be explained in terms of science's "getting to the real truth".

But how can we possibly posit, in the first place, the actual existence of things that science strives to understand, though inevitably without perfection, if the success of science is not able to provide an unequivocal foundation of objectivity? Why posit some actual, intrinsic structure for the world in itself? To put this question differently, what basis is there for scientific realism once we have granted Rescher's argument to this point? Rescher's realism has two components, ontological and epistemic. The former maintains that there is a mind-independent, objective, physical world; the latter claims that we can *to some extent* secure adequate information about it. Clearly, the latter claim presupposes the former one. But how can the first contention be justified? Rescher's metaphysical realism is a regulative presupposition which, he thinks, that makes science possible in the first place:

> How could we ever learn by inference from observations that our observations are *objectively* valid, that our mental experience is itself largely the *causal* product of the machinations of a mind-independent matrix, that all those phenomenal appearances are *causally* rooted in a physical reality? All this is clearly something we do not learn from

> inquiry. For what is at issue is, after all, a precondition for empirical inquiry--a presupposition for the usability of observational data as sources of objective information. (SR, pp. 126-27, italics mine)

This thesis echoes the Kantian doctrine that objective experience is possible only if the existence of an objective world is already presupposed from the outset. Only with this realistic postulate can we proceed *evidentially* with the exploration of the physical world that we share in common, and subscribe to the principles of inductive systematization, common cause, explanatory economy, and so on. The realistic presumption of the mind-independent existence of the causal world must be considered an existential precondition by which we live. The truth of Hume's incisive remark can now be fully appreciated: "All reasoning concerning matters of fact seem to be founded on the relation of *cause and effect*. By means of that relation alone we can go beyond the evidence of our memory and senses".[24]

Once we are willing to credit our observational data with objectivity and thus with evidential bearing, we can make use of them to inform ourselves of the nature of reality, for we have already presupposed and acknowledged that subjective phenomena are signs of objective realities and that particular cases are exemplifications of general causal relations. *A mind-independent and causal world in which objects function in accordance with causal laws and regular patterns has to be predictable and controllable to a great extent.* The very objectivity of the world

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[24]Hume, *Enquires* (Oxford, 1975), ed. L. A. Selby-Bigge, p. 26.

and our experience in it implies that science, although exhibiting remarkable efficacy with respect to prediction and control, is inevitably incomplete and fallible. Such incompleteness and fallibility do not, however, hamper the predictive success of science, which, again, confirms Rescher's earlier point that nature is "error-tolerant".

With regard to causality and the unobservable, therefore, what we can learn from Rescher's book is this. Our belief in causality and in unobservable entities serving in our theories as causes is based fundamentally not on science, but on metaphysics--on our metaphysical presumption that there is a causal, lawful, mind-independent world to which we, as conditioned and limited creatures, have some--but in no way complete--access. Science does not--and cannot--teach us that the observable order is explicable in terms of underlying causes, or that the observed phenomena are signs of really existing structures or causal processes. None of this is the result, but rather the presupposition of science. What then does science tell us? The answer is straightforward: it *descriptively* teaches us the structure and order of the objective world--including the unobservable--in term of causes and effects, laws and patterns, and therefore enhances our understanding of the world and promotes our ability to cope with it.

To be sure, a metaphysical realism of this sort, in particular with respect to causality and unobservable causes, is still highly pragmatic in character. That may be why traditional idealistic themes--that values and purposes play a pivotal role in our understanding of the nature of things, and that the knower plays an active role in the constitution of what is known--return to Rescher's realism. Although the causal structure and order of the world envisioned by current science need not, and could not, be *fully* descriptive of reality as it is, we are obliged to accept that there must be a mind-independent and causal world--even without any descriptive knowledge of it. This obligation is not thrust upon us by the content of science itself, however, *but by the metaphysical, existential, pragmatic, and, in a sense, idealistic presuppositions of the scientific enterprise.*

In Rescher's realism, therefore, scientific knowledge, including the unobservable causes, must be largely descriptive of an objective and lawful world that we posit metaphysically. But at the same time science has no right to pronounce any "final word" about such a world, even though it is founded on the notion of objectivity and causality of the world in general. It is justifiable, I believe, to claim the infallibility of the notion of objectivity and causality of the world while still accommodating the fallibilism of science.

I totally agree with Rescher that knowledge is a product of an interaction between nature and our mind which, although it has access to nature, is bound to be conditioned, limited, and subject to ongoing change. There is a correspondence of some sort between knowledge and nature. But this correspondence draws its character from our interaction with nature, rather than from nature *itself.* The character of our knowledge depends as much on our mind as on nature's structure and order, and therefore we cannot claim its perfect correspondence with nature, even though we may contend for its ongoing "resemblance". The imperfection of correspondence is, in other words, the imperfection of our knowledge. But all in all, there must be correspondence of some sort between knowledge and nature, even it is doomed to be imperfect, insofar as this knowledge facilitates our living in the world.

To return to Salmon's concept of causation, he does not need to argue at length for the actual existence of causality and unobservable causes: we have been assuming their *general* existence all along, not as a result of science, but as its metaphysical presupposition. Insofar as Salmon draws most support for his argument from the actual practice of science, he is articulating a common-sense belief in causality that is embodied in our practice of inquiry into the world--but no more. A clear explication of a notion, however, is not a justification of the notion. Moreover, pragmatic efficacy of the notion of causality does not constitute--as Salmon seemingly hints--an adequate justification for our belief in causality or unobservable causes. The justification of this belief rests, rather, on the fact that it is an indispensable metaphysical presupposition.

The central thrust of Salmon's account of causality is, as we have seen, the illustration of the causal structure of the world where causal processes, as the basic entities of the universe, transmit causal influence as well as energy and information. These processes intersect, interact, and produce events. Events are interactions of causal processes in which certain properties or characteristics of the causal processes involved undergo modifications. In other words, events are occasions where *changes* in the properties or characteristics of the related *processes* occur by virtue of their interaction. What leads to a change of an established process, is termed the "cause" of a change. And, apparently, insofar as we view processes as the basic entities of the universe, what leads to a change of an established process must be the intervention and interaction of other established processes. As to why interaction leads to change in properties of processes, we can only posit that those processes possess causal influence that operates in accordance with laws, even laws that may be indeterministic in character. Insofar as processes possess causal influence and energy, and insofar as events consist in changes in the processes involved, *events cannot come from nowhere and must have origins, which are what we term causes, the interaction of which is lawful and brings about events*. To this extent, our notion of causality is a shortened way of referring to the origin and nature of events and, within the indispensable framework of the metaphysical realism, is true of reality.

Moreover, I'd suggest that the notion of causality thus construed, together with the notion of objectivity, are the two most fundamental notions that give us the world and enable us to live in it. The *ordinary* concepts of space and time might not hold on the quantum mechanical level, as Salmon, along with scientists, surmise. The concepts of objectivity and causality--that things are independent of our mind and that they must not come from nowhere--still hold, however, as we probe the microphysical world, even implicitly, and even with altered structures in light of the ongoing inquiry of science. Once again, we appreciate Hume's remark, that "by means of [causal] relation alone we can go beyond the evidence of our memory and senses".[25]

Before concluding, I want to discuss two related questions concerning causal explanation. First, how should we understand the pragmatic quality of causal explanation? Secondly, can the explanation of action by reasons be counted a species of causal explanation?

Is Causal Explanation Purely Pragmatic?

There has been a tendency in philosophy to assimilate, or even to reduce, the category of the causal relation to that of explanation. Consider a passage from Norwood Hanson:

> There are as many causes of x as there are explanations of x. Consider how the cause of death might have been set out by a physician as "multiple haemorrhage," by the barrister as "negligence on the part of the driver," by a carriage-builder as "a defect in the brake block construction," by a civic planner as "the presence of tall shrubbery at that turning." [26]

Hanson claims that "theories" are the whole story about causation. "Causes certainly are connected with effects," he says, "but this is because our theories connect them, not because the world is held together by cosmic glue".[27] It is his view

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[25]Ibid.

[26]Norwood Hanson, *Patterns of Discovery* (Cambridge, 1961), p.54; reprinted in *Philosophical Problems of Causation*, ed. Tom L. Beauchamp, pp.207-08, Henceforth PPC.

[27]Ibid, p.64; reprinted in PPC, p.215.

that theories have been so deeply imbedded in our language that our language functions to guarantee inferences from cause-terms to effect-terms. Such an attempt to reduce causation to *pure* semantical--or "logical"--relations is, I believe, untenable. A full fledged argument against it would entail an examination of the nature of logic, particulars and universals, and the acquisition of our language, which is beyond the present essay. However, based on the ideas from two authors, I do want to make some observations.

To the extent that different people hold different theories, Hanson's claim naturally gives rise to the view that which causal relations hold may be contextually and pragmatically *determined.* This is a notion Salmon explicitly rejects. He argues that pragmatic and contextual factors indeed influence considerably what kind of explanations are sought, or in other words, precisely which "why" questions are formulated. However, Salmon also maintains that once such questions are formulated, the answers are objective and nonpragmatic. With regard to the passage cited above, Salmon observes that the explanation the medical examiner seeks is significantly different from the other three cases. For him, the reference class is human beings, and the event in question is death. The explanandum-partition may contain two cells: dying and surviving. The factor of multiple haemorrhage furnishes an explanans-partition--people with multiple hemorrahage and people without--and is statistically (and causally) relevant to death. The medical examiner, presumably, is not interested in why the accident occurred. For the barrister, the automotive engineer, and the civic planner, however, the reference class would perhaps be the class of trajectories of carriages through curves, turns, and intersections. For the barrister, the explanandum-partition may be: no accident, accident without significant property damage or personal injury, accident involving personal injury or property damage. His concern is whether, *given the defective brakes and tall shrubbery at the corner*, a negligent act on the part of the driver is also relevant to the accident. The comparison between the two different conditional probabilities may provide information about whether the negligence was causally relevant to the event. Similarly, the automotive engineer and the civil planner are concerned with whether, given other factors, the factor of their interest---the defect of brake-block construction and the presence of tall shrubbery, respectively--is causally relevant to the accident. The point is that, being concerned with the same "why" question, all these three experts may actually look for the *same* set of statistically or causally relevant factors, but that "the fact that one person is more interested than another in one particular relevant factor does not mean that they are seeking or finding different explanations of the same fact" (SECSW, p. 130).

Besides, it should be noted that the statistical relevance of the three factors--multiple haemorrhage, the presence of tall shrubbery at the corner and the defect in the brake-block construction--can easily be translated into causal relevance, since the spatio-temporal processes capable of transmitting causal influence can easily be found. The driver's negligence, however, poses an opposite case, in which the absence of alertness on the part of the driver is termed the cause of an accident. In this case we may wonder what is the causal process involved. This problem, in my view, does not raise real trouble for our account of causal relevance. For we can consider the counterfactual condition that the driver was alert and the accident probably did not happen. Then we might identify the counterfactual alertness on the part of the driver as the cause of the counterfactual safe passage of the carriage through the corner and, obviously, the actual causal process could be then found. The absence of a cause, which in this case is the alertness on the part of the driver, might lead to an absence of an effect--the safe passage of the carriage in this case. Or in other words, without a relevant condition, the class of the rest of the conditions may well produce an effect other than the one we expect with the presence of the relevant condition. The reason we are inclined to recognize the driver's negligence as the cause of the accident rather than his possible alertness as the cause of the possible safe passage is probably because we consider the accident is a deviation from a normal course of events, and in general we are more interested in abnormal events than normal events.

Here we encounter the problem of distinguishing causes from conditions. Mill argued that the cause of any phenomenon is "the sum total of the conditions positive and negative taken together; the whole of the contingencies of every description, which, being realized, the consequent invariably follows".[28] Despite the deterministic tone that was inevitable at that time, Mill's view accords with Salmon's account of causation. Clearly, if an effect is the result of an interaction of several causal processes with an exchange or modification of energy, information, and causal influence, then strictly speaking, we have to recognize all the participating causal processes as the real cause of the effect. Nevertheless, this is not the way of our ordinary causal talk, which is prone to recognize among a set of conditions one or a few as "the" cause.

Numerous authors have made an effort to clarify this issue, among whom Gorvitz has offered, in my view, a nice exposition of our common-sense notion of "cause".[29] He suggests that we tend to identify as causes those conditions which constitute the "differentiating factor" in a particular situation. Roughly speaking, a differentiating factor C, as a cause we recognize for the event E, is a condition that is *selectively* distinguishable from a mere condition of E by contrasting the situation S of the effect's occurrence with some other similar type of situation in which C and E do not occur.[30] Gorovitz's account of "differentiating factors" corresponds to Salmon's view of "statistically relevant factors" by which the initial reference class

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[28]J. S. Mill, *A System of Logic* (Cambridge, 1970), p. 214.

[29]See, for example, H. L. A Hart and A. M. Honore, *Causation in Law* (Oxford, 1958), pp. 25-41; S. Gorovitz, "Causal Judgements and Causal Explanations", in the *Journal of Philosophy* (Dec. 2, 1965); both are reprinted in PPC.

[30]Gorovitz has a formal formulation of "differentiating factors"; see PPC, p.240.

is partitioned into mutually exclusive and exhaustive cells. Salmon's account, however, has the virtue of more precision with regard to how "statistically relevant factors" differentiate the outcome events. By comparing the conditional probabilities induced by those factors, we can have a clear idea of whether or not the factor at issue serves to differentiate the outcome event. Thus we have a solid ground to ascertain whether a factor, or a condition, that interests us is causally relevant to the effect and, accordingly, make our cause claim.

Let us return to the seemingly pragmatic quality of causality. Admittedly, based on different interests and background knowledge, in ordinary cause talk we recognize different causes for the same effect. But this does not mean that the divergent causes different people tend to identify are purely pragmatic and subjective--*whether those factors, or conditions, are statistically and causally relevant to the effect-event is an objective fact and has nothing to do with our interest or knowledge.* As conditioned beings, we are inevitably prone to identify *a section* of all the objective causes according to our own interest and background knowledge, and are fully justified in doing so. In our inquiry into the "cause", the approach we follow is inextricably pragmatic, but *what we are after* is in no way pragmatic or subjective. The limit of our causal inquiry and the confusion in our ordinary causal talk extend no warrant to the idea that our notion of causality is an artificial or merely pragmatic instrument. In other words, pragmatic interest may well influence--even dominate--

what kind of explanatory information we seek, but this fact grants no licence to the judgement that such explanatory information is itself pragmatic or subjective.

Reasons and Causes

Causal explanation in one particular domain deserves special attention--that of reasons and actions. We commonly assume that reasons are the cause of our action. We say "I did this *because* I wanted to do so". When we begin to philosophize, however, the situation becomes complicated. In fact, some philosophers believe that actions do not have causes at all. Their main argument is that actions are internally or logically related to the intentions embodied in them, whereas causes must be separate from their effects and contingently or extrinsically related to them, or extrinsic to them. For instance, A. I. Meldon writes:

> citing the motive was giving a further characterization of the action; it was indeed providing a better understanding of what the driver was doing. But no Humean cause could possibly do this; any alleged cause, in this sense, of the action of raising the arm ... would merely explain how the action of raising the arm came to be. From the driver's statement that he raised his arm in order to inform others of what he was about to do, it follows *logically* that he was signalling or at least attempting to signal.[31]

This passage is meant to suggest that because the relation between reason and action is logical or inferential, a statement of the reasons for actions cannot be a statement

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[31]A. I. Melden, *Free Action* (London, 1961), pp. 88-89; italics mine.

of the causes of the action. Donald Davidson argues the opposite case, that our reasons typically are the cause of action. On his account, the agent's reason is a conjunction of a "pro-attitude" and a belief. Pro-attitudes may be "desires, wants, urges, prompts, and a great variety of moral views, aesthetic principles, economic prejudices, social conventions, and public and private goals and values."[32] The agent has a pro-attitude towards actions of a certain kind, and he believes that the action he intends to perform is indeed of that kind. Taken together, Davidson asserts, the agent's pro-attitude and the associated belief are the "primary reason" why he performed the action, and this reason is also the cause of the action.

Nevertheless, Davidson's account of causality adheres to a sufficiency/necessity model, which again makes appeal to deterministic laws. Davidson thinks that one event can causally explains another only when both can be described in ways which instantiate some deterministic causal laws.[33] In the context of reasons and actions, this view of causality amounts to saying that if reasons cause actions, then there must be deterministic causal laws which reasons and actions instantiate. As we have seen in our discussion of Salmon's book, any account of causality in terms of necessary and sufficient conditions, with its metaphysical thesis of determinism, renders our common concept of causality untenable. This is also true

[32]Davidson, "Actions, Reasons, and Causes", in *Essays on Actions and Events* (Oxford, 1980), p. 4.

[33]See Davidson, "Mental Events", ibid, pp. 207-225.

with the common sense notion of reasons as causes of actions. And it for this reason that I consider Davidson's account of reasons as causes of action unsatisfactory.

I believe Salmon's scheme of causal processes provides a better approach to the relation between reasons and causes. Recall that in this scheme events can be viewed as interactions of causal processes that bring about *changes* in properties or characteristics they carry. The transmission and interaction of these properties and characteristics -- in Salmon's terminology, causal marks or influences -- are governed by laws, but very likely indeterministic in character. Two events are causally related, according to Hume, by virtue of their constant conjunction. Constant conjunction is construed by Salmon in terms of a statistical relation between the two events. For a statistical relation to be a causal relation, spatio-temporally continuous causal processes must link the two events. Ultimately, it is causal processes that cause events, which are none other than the intersection and interaction of such processes characterized by changes in their properties. But in our common causal talk, we speak of one event causing another in the sense that the causal marks or influence of the prior event are transmitted and contribute to the occurrence of a later event in which those marks exhibit themselves or undergo changes. So long as we understand that causes and effects are just interactions of causal processes and must be linked by them, this common-sense talk still makes sense and is warranted. Finally, bear in mind that the direction of causality is always toward the future. For the statistical relations that are found in causal relations explain the otherwise improbable coincidences--the contingent conjunction of two *distinct and separate* events. It follows that such coincidences are explained only in terms of causes, never effects.

How can we apply Salmon's scheme of the causal network to the causation of action? The problem is how to recognize and locate those processes where interactions give rise to actions. But let us make clear what actions are. Actions can be done inadvertently, but in most cases actions are done intentionally, that is, performed for a reason. It is such intentional actions that interest us here. Intentional actions, to make them more specific, are people's doing things-- their behaviours through which they control their environment and express their beliefs, feelings, desires, and so on. Actions first of all involve our bodily changes, speech included, which can themselves be considered events. For the sake of simplicity, therefore, I shall restrict my attention to bodily changes as representing actions at the most basic level. Thus it is through bodily changes that actions are done, that is, intended information or influence transmitted.

Suppose a turn is coming up, and the driver raises his hand to signal. Let's start in the middle of the physiophysical process. A message is produced in the central nervous system, and information travels in the form of bio-electric pulses through to the motion nerve endings, where they activate neuro-transmitters in the muscles. Neuro-transmitters, in turn, activate interactions of molecules which release chemicals and energy necessary to move the muscles in the intended direction. Thus generally speaking, the event of the driver's moving his hand is an interaction of two processes: one is muscles in their normal or stable state, another is the whole process the information travelling from the central nervous system to the muscles. In other words, it is the two processes that are the direct cause of the driver's raising his hand. But we usually consider--to employ Gorovitz's "differentiating factor analysis"--the information-transmitting process as something relatively rare and functioning to intervene with and differentiate the state of muscles from its normal course, and we are warranted to refer to this factor--the information-transmitting process--as "the" cause of the event of the driver's raising his hand, so long as we remember the simplifications this way of speaking involves.

Few would seriously doubt that this whole process is a physical one and therefore is governed by laws, some of which may be indeterministic in character. To the extent that causality is construed in terms of the transmission and interaction of causal influence (information, or energy, or properties), we may speak of the whole process -- the driver's seeing a turn coming up, his having a reason to signal, and raising his hand -- as causal in character.

Some additional remarks might be appropriate here. It appears to me that the essential spirit of Salmon's account of causality is that events cannot come from nowhere, that they must be linked by processes, and that they themselves *are* the interactions of processes. On this account, then, causation is essentially the transmission of, and the interaction among, causal influences carried by processes. When we speak of an earlier event causing a later event, we actually mean that the causal influences (information, energy, or properties) produced or exhibited in the earlier event are, via some spatio-temporally continuous processes, transmitted to the later event, in which they undergo modifications or initiate other processes. Thus our common sense causal talk can be regarded as a rough and loose delineation of the structure of our world in terms of causally interacting processes.

It seems appropriate to consider the driver's reason to raise his hand as a mental event, for apparently his intention to signal is a fleeting mental occurrence rather than an enduring attitude or habit. This mental event is spatially and temporally distinct from the bodily event of raising his hand. The mental event, insofar as it is an event, must be an interaction among some neurophysiological processes in the brain. The information conveyed by the mental event, or the causal influence of some process in the brain after being modified by some other processes in the central nervous system, is "to raise his hand to signal". The driver might not raise his hand even after this mental event has occurred. But in that case we can be fairly sure that there must be other mental processes present which intersect with and change the process. Therefore, it appears there is no major difficulty in construing the intention, a mental event, as the cause of the bodily event of raising his hand.

Conclusion

The aim of my thesis is to elucidate the causal nature of explanation. What we seek are causal processes connecting the event-to-be-explained and the events or conditions that constitute the S-R basis. Or if no such connecting processes is found, we may attempt to find common causes leading to both the event-to-be-explained and the statistically relevant events contained in our S-R basis. Only knowledge of the causal processes or common causes counts as explanatory knowledge.

That is the form of causal explanation as Salmon sees it. But setting out that much does not settle the question of justification. With what right do we impute causal relations to events and processes in the universe? Salmon appeals to the pragmatic efficacy of science, from which, actually, he ascertain the structure of our notion of causal relations. But science itself cannot prove the reality of causal processes or relations, which are instead among the basic *presuppositions* of the scientific enterprise. If scientific explanations, especially those involving unobservable entities, are to be true of the world, we have to justify our fundamental notion of causality on independent grounds.

Rescher's metaphysical realism, as we have seen, serves this purpose. For Rescher, the objective causal order of the universe is a metaphysically necessary presupposition. Yet this much metaphysical realism can readily be reconciled with the fallibilism of science by making reference to the functional complexity of the world and, more essentially, the interaction between mind and nature. This approach dissolves the question whether science has ever reached, or will ever reach, the "real truth" by asserting that scientific truth is alway conditioned and limited, though it is still objective. Nevertheless, the conditionedness or locality of scientific truth does not detract from the universality of scientific truth or the mind-independent reality of causal relations.

It is my contention that causal explanation is possible only by virtue of objective causal relations as construed above, that causation is indeed "the cosmic glue" or "the cement of the universe" that holds events together. Causal explanation as I have explained it is not limited to the sciences, but applies wherever we try to understand why things happen as they do, including people's actions.

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