The Pragmatic Character of Explanation[1]

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Some of those, including the present writer, who criticize standard models of explanation, such as Hempel's D-N model or Salmon's S-R model, do so on the grounds that explanation is a "pragmatic" or "contextual" concept--an idea which the standard models seem to reject. Yet the sense in which explanation is, or is not, pragmatic is not always made clear by the critics or champions of the models. Indeed, some critics and some champions may even mean different things by "pragmatic" or "contextual". In this paper I want to try to clarify a sense in which explanations might reasonably be considered pragmatic, discuss a couple of theories that are or are not pragmatic in this sense, argue the advantages of a pragmatic account, and briefly note some consequences of this for those seeking models of explanation.

1. Hempel's Characterization of "Pragmatic"

Hempel certainly acknowledges that there is a pragmatic aspect of explanation. He writes:

> Very broadly speaking, to explain something to a person is to make it plain and intelligible to him, to make him understand it. Thus construed, the word "explanation" and its cognates are pragmatic terms: their use requires reference to the persons involved in the process of explaining. In a pragmatic context we might say, for example, that a given account A explains fact X to person P_1. We will then have to bear in mind that the same account may well not constitute an explanation of X for another person P_2, who might not even regard X as requiring an explanation, or who might find the account A unintelligible, or unilluminating, or irrelevant to what puzzles him about X.
>
> Explanation in this pragmatic sense is thus a relative notion: something can be signficantly said to constitute an explanation in this sense only for this or that individual. (1965, p. 425)

PSA 1984, Volume 2, pp. 275-292

Now although Hempel recognizes a pragmatic use, or sense, or concept, of explanation, he sees his own task as one of

> . . .constructing a nonpragmatic concept of scientific explanation--a concept which is abstracted, as it were, from the pragmatic one, and which does not require relativization with respect to questioning individuals. . . . (1965, p. 426).

I take Hempel to be saying something like this. There are sentences, such as ones of the form

(1) Account A explains fact X to person P,

which make essential reference to some person or type of person who is explaining or being explained to. Such sentences are examples of a pragmatic use or concept of explanation. By contrast, there are other sentences, such as ones of the form

(2) Account A explains fact X,

which make no reference to any (type of) explainer or audience. These sentences are examples of a nonpragmatic use or concept of explanation. Hempel's D-N and I-S models are meant to provide truth-conditions for certain sentences of this type.

Let me use the term "explanation-sentence" to refer to any sentence containing the terms "explains" or "explanation". I shall say that the terms for persons replacing S and P in sentences with forms such as the following are terms for explainers or audiences:

S explains fact X to P
The explanation of X given by S to P is _____
S gave account A to P as an explanation of _____

S and P may be terms for particular explainers and audiences or for types. For example, we might have "Achinstein explained his theory to philosophers at the 1984 PSA meetings" for a particular explainer and audience, and "the contemporary physicist explains the structure of matter by invoking quarks" for a type of explainer.

Now I shall broaden what I take to be Hempel's characterization by saying that an explanation-sentence is "pragmatic" if (a) it contains terms for a (particular or type of) explainer or audience, or if (b) its truth-conditions contain such terms or others defined using such terms. Clause (b) will take into account a view which says that although some explanation-sentences are not explicitly pragmatic they are implicitly so. For example, one might hold the view that an explanation-sentence of the form "Account A explains fact X" is true iff some (type of) explainer S explains (or could explain) fact X to an audience (of type) Y by citing A. On this conception, the explanation-sentence in question would be pragmatic.

Whether this characterization of "pragmatic" captures what Hempel has in mind I will take up later. For the present let us

accept it as a sufficient condition.

Hempel's claim can now be put like this. Admittedly, there are pragmatic explanation-sentences, e.g., ones of the form

Account A explains fact X to person P
Explainer S explains X to person P by giving account A.

But there are also non-pragmatic explanation-sentences. Most important for our purposes (Hempel will claim) an explanation-sentence of the following form is non-pragmatic:

(2) Account A explains fact X.

I shall say that someone holds a pragmatic theory of explanation with respect to explanation-sentences of a given form if he maintains that explanation-sentences of that form are pragmatic. Someone holds a non-pragmatic theory with respect to explanation-sentences of a given form if he maintains that explanation-sentences of that form are not pragmatic. Hempel holds a pragmatic theory with respect to sentences of form (1) but not of form (2).

I want to raise some questions about non-pragmatic theories of sentences of form (2) and others like it. But before doing so let me turn to someone who claims to be an arch-pragmatist, viz., Bas van Fraassen.

2. Van Fraassen's Pragmatism

In the chapter entitled "The Pragmatics of Explanation" in his book The Scientific Image van Fraassen seems to be arguing in direct opposition to Hempel's non-pragmatic theory of explanation-sentences of form

(2) Account A explains fact X.

Van Fraassen writes:

> The description of some account as an explanation of a given fact or event is incomplete. It can only be an explanation with respect to a certain relevance relation and a certain contrast-class. These are contextual factors, in that they are determined neither by the totality of accepted scientific theories, nor by the event or fact for which an explanation is requested. (p. 130)

I shall briefly characterize van Fraassen's position by using as an example some of my home town lore. By the dawn's early light Francis Scott Key is able to see the flag atop Fort McHenry. And he asks:

Q: Why is our flag still there?

This interrogative, van Fraassen will say, can be used to pose different questions depending on the contrast intended. For example, Key might be asking:

> Why is our flag (rather than some other flag) still there?
> Why is our flag still there (rather than somewhere else)?
> Why is our flag (rather than something else) still there?

And so forth. The contrast class includes what is presupposed by the question (our flag being there) together with the alternatives (there being some other flag there, our flag being somewhere else, etc.) More generally, van Fraassen claims, in the case of any why-question there is a contrast-class that is usually implicit in the context:

> In general, the contrast is not explicitly described because, in context, it is clear to all discussants what the intended alternatives are. (p. 128)

For Key the context will tell us that the likely contrast is between our flag being there and the British flag being there.

Now let's turn to the second contextual concept van Fraassen mentions, the relevance relation. Francis Scott Key's interrogative

> Q: Why is our flag still there?

might be construed (in van Fraassen's terms) as a request for the "events leading up to its being still there". If so, we might answer by appeal to the battle raging throughout the night and the failure of the British to capture Fort McHenry. However, there is another possible (though perhaps less likely) interpretation of this interrogative, viz., as a request for the function or purpose of our flag's being there. What we need to know, says van Fraassen, is what "relevance relation" is being requested--"events leading up to", "function", or something else. And this, as in the case of the contrast class, is to be determined by looking to the context. "Looking to the context" in our example means invoking the intentions, beliefs, and puzzlements of Francis Scott Key. And this is pragmatic.

Now let's apply this to explanation-sentences of the Hempelian type (2). For our example consider:

> (3) The hypothesis that the British failed to capture Fort McHenry during the night's battle explains the fact that our flag is still there.

Recall van Fraassen's words:

> The description of some account as an explanation of a given fact or event is incomplete. It can only be an explanation with respect to a certain relevance relation and a certain contrast-class.

And the latter are contextual, requiring reference to some particular person. Well, if (3) is incomplete, let us complete it by specifying some relevance relation and contrast-class. We can do so, van Fraassen tells us, by understanding the question being raised as having three components: the topic (in this case "our flag is still

there"), the contrast class (in this case let's say: "our flag is still there", "the British flag is there"), and the relevance relation (in this case let's say: "events leading up to"). Although van Fraassen does not do it quite this way we might now reformulate (3) above by writing:

> (4) The hypothesis that the British failed to capture Fort McHenry during the night's battle explains (by citing "events leading up to") why our flag is still there (rather than the British flag being there).

We now have an explanation-sentence which provides the sort of information van Fraassen wants. Is it pragmatic?

It is not explicitly pragmatic, since it contains no terms for an explainer or audience. Is it implicitly so? Do its truth-conditions contain terms for an explainer or audience or others defined by reference to these? Van Fraassen points out, correctly I think, that to determine what relevance relation and contrast-class are being requested appeal is made to the context. We look to the explainer, Francis Scott Key, and what intentions and beliefs he had. But this is not sufficient to show that the truth-conditions for (4) must contain terms for an explainer or audience.

Indeed, Hempel--presumably van Fraassen's arch-foe--could agree that in order to determine what question someone wants to answer, or what event someone wants to explain, essential reference to the intentions and beliefs of the questioner will need to be made. This is no damaging admission for the non-pragmatist, Hempel will say. The important issue is whether once the question being asked has been identified, it can be determined whether the explanation explains without invoking any term for an explainer or audience. So far van Fraassen has offered no reason why this cannot be done. All he has said is that (3) is incomplete. By analogy, Hempel might say, the following sentence is incomplete:

> The hypothesis that the British failed to capture Fort McHenry during the night's battle explains _____.

Suppose we find this incomplete sentence in a history book. To complete it appeal is made, let us say, to the historian's likely intentions and beliefs, and/or perhaps to those of Francis Scott Key. That won't make the resulting completed sentence "pragmatic" in what I have so far taken to be Hempel's sense. Suppose we complete the sentence by identifying the explanandum as

why our flag (rather than the British) is still there.

Just because we have appealed to pragmatic considerations in identifying the explanandum, Hempel will ask, how does that show that the truth-conditions for the completed explanation-sentence must contain terms for an explainer or audience? Indeed, Hempel will urge us to accept his own truth-conditions for the completed sentence--say those of the D-N or I-S model--which contain no terms for an explainer or audience.

What about van Fraassen's truth-conditions? I find his intentions a bit cloudy at this point. He seems to present two sets of conditions, one set (perhaps) for the concept of a (merely, or minimally) correct explanation, and another for the concept of a good explanation. To give the first set of conditions we have a question Q determined by the topic P, the contrast class X, and the relevance relation R. And we have an answer of the form

P in contrast to X because A.

Van Fraassen asks: what is claimed in this answer (p. 143)? He gives four conditions. First, that P is true. Second, that the other members of the contrast class are not true. Third, that A is true. And fourth, that A does bear the relevance relation R to P and X--e.g., that the answer A does give the events "leading up to" the event in P. I'm not sure if this is supposed to be a set of sufficient conditions, or only necessary ones, or, indeed, if it is supposed to be a set of conditions for the truth of sentences of the above form (the latter is suggested by van Fraassen's question "What is claimed in this answer?")[2] In any case, these conditions, let it be noted, contain no terms for an explainer or audience. Nor does their application to sentences of the form "P in contrast to X because A" require any reference to explainers or audiences once the question Q is given. Nor do the definitions of van Fraassen's technical terms in these conditions ("topic", "contrast class", and "relevance relation") appear to require the concept of an explainer or audience.

What about van Fraassen's second set of conditions for (as he puts it) "evaluating" answers. Again, we have a question Q determined by the topic P, the contrast class X, and the relevance relation R. How good is the answer

P in contrast to X because A?

Van Fraassen proposes three things that must be determined (pp. 146-147):

1. We must determine whether proposition A is "acceptable" or "likely to be true".

2. We must determine whether A shifts the probability toward P more than toward other members of the contrast class X.

3. We must compare "because A" with other possible answers to the explanatory question in three respects:
   a. Is A more probable than other answers given the background information K?
   b. Does A shift the probability toward P more than other answers do?
   c. Does some other answer probabilistically "screen off" A from P? (Is there an answer A' such that $p(P/A'\&A) = p(P/A')$?)

This evaluation of explanations introduces two important new factors: a set of background beliefs K relative to which probabilities are to be determined, and a set of answers to the

question Q with which the answer A is being compared. Both factors might be deemed pragmatic or contextual. To determine what background beliefs should be used, and what alternative answers proposition A should be compared with, reference will be made to intentions and beliefs of the explainer or perhaps of the evaluator of the explanation. (Indeed, van Fraassen insists that only part of the background information K is to be used in the evaluation, and that which this is "must be a further contextual factor" (p. 147).)

I don't propose here to assess van Fraassen's conditions. (For criticisms see my 1983, Chapter 4.) I will simply note what I believe the non-pragmatist's response is likely to be. Just as van Fraassen earlier accused the non-pragmatists of focusing on an incomplete explanation-sentence, so the non-pragmatists will retort "tu quoque" to van Fraassen. All van Fraassen is arguing, the non-pragmatist will say, is that sentences of the following form are incomplete:

"P in contrast to X because A" is a good explanation of q.

The (more) complete form of such explanation-sentences is

(5) "P, in contrast to X, because A" is a good explanation of q relative to alternatives $A_1, \ldots, A_n$, and relative to background information K (or relative to such and such a subset of K).

Now that we have completed the explanation-sentence by relativization to a specific set of alternative hypotheses and to background information we are in a position to use the three conditions van Fraassen presents. These conditions invoke no terms for an explainer or audience. Nor will their application to sentences of form (5) require any such terms. Indeed Hempel himself insists on relativizing inductive-statistical (I-S) explanations to a set of background beliefs K, which, of course, can be different from one explanatory context to the next. This doesn't suffice to make Hempel believe that he is analyzing a pragmatic concept of explanation when he offers his inductive-statistical model.

I conclude that van Fraassen ought not to view his position as a pragmatic one--at least with reference to complete explanation-sentences such as those of forms (4) and (5). To be sure, to obtain such complete sentences to begin with reference may have to be made to explainers. With this Hempel could agree. But once the sentences are complete no reference to any (particular or type of) explainer or audience needs to be made to understand what they mean, or to determine whether or not they are true.

3. The Ordered Pair Theory

Let me turn from van Fraassen's theory to one that I elaborate in my recent book The Nature of Explanation. Here I don't plan to present the theory in detail but only to say enough about it to show that it is pragmatic and to argue the advantages of a pragmatic account.

As did Sylvain Bromberger in a seminal essay in 1965, I begin with the concept of an explaining act. The explanation-sentences of concern to me are ones of the form

(6) S explains q by uttering u,

where q is the indirect form of a question Q. Simplifying my view, such sentences are true iff S utters u with the intention of rendering q understandable by producing the knowledge that u expresses a correct answer to the question Q. To develop this one needs to talk about the concept of understanding. I do so in the book, but the discussion is complex, and I will not attempt to summarize it here. In any case there is no need to do so, for explanation-sentences of the form "S explains q by uttering u" are clearly pragmatic in the Hempelian sense. Such sentences make essential reference to an explainer.

The second stage in my theory consists in an attempt to provide a definition of an explanation itself--i.e., the product of an act of explaining or at least of a potential act of explaining. For certain reasons which we need not explore here I say that an explanation of q can be construed as an ordered pair whose first member is a proposition or set of propositions that constitutes an answer to Q, and whose second member is a type of explaining act, viz., explaining q. So, e.g., if Newton explains why the tides occur by saying that they occur because of the gravitational pull of the moon, then his explanation--whether good or bad, right or wrong--can be construed as the ordered pair

(7) (The tides occur because of the gravitational pull of the moon; explaining why the tides occur).

The second member of this pair invokes the concept of a type of explaining act, to which the account briefly summarized above is applicable. The first member of the pair is a proposition that constitutes an answer to the question cited in the second member. Unlike usual accounts, an explanation need not be restricted to why-questions. There can be an explanation of what event is now occurring in the bubble chamber, of what significance the American election has for Europe, and so forth. The view I develop attempts to characterize in a general way the kinds of questions (which I call content-questions) that can appear in explanations, and also to characterize in a general way what constitutes an answer to a content-question. The present manner of viewing explanations allows us easily to distinguish explanations from other products, whose second members will not be types of explaining acts, but something else. Furthermore, although this account defines explanation by reference to the concept of an explaining act, for something to <u>be</u> an explanation it is not required that it be the product of some particular exlaining act. The ordered pair above would be an explanation, on my account, even if neither Newton nor anyone else expressed the proposition that is its first member (i.e., even if no one ever explained why the tides occur by uttering any sentence expressing that proposition).

The latter point is important for the issue of the pragmatic

character of explanation, so let me take it just a bit further. Let's consider explanation-sentences of the form

E is an explanation of q,

where there is no implication regarding E's goodness or correctness. On the ordered pair theory, the following is a set of truth-conditions for sentences of this form:

(i) Q is (what I call) a content-question;
(ii) E is an ordered pair whose first member is (what I call) a complete content-giving proposition with respect to Q and whose second member is the act-type explaining q.

Do these truth-conditions contain terms for an explainer or audience or any terms defined by reference to these? They do not do so explicitly. Nor do the definitions of "content-question" and "complete content-giving proposition". This leaves the act-type "explaining q", which I take to be definable as a type of act whose instances are acts in which explainers explain q. (a is a type of act "explaining q" iff (S)(S performs an act of type a $\equiv$ ($\exists$u)(S explains q by uttering u).) If so then a term for an explainer is invoked in defining one of the concepts in the truth-conditions. And by our previous criterion of "pragmatic", this suffices to make sentences of the form "E is an explanation of q" pragmatic.

Yet there is something different about this case and the ones Hempel may have in mind. For although a term for an explainer is invoked, the truth-value of sentences of the form "E is an explanation of q" will not vary with who, if anyone, is giving or receiving the explanation E mentioned in the explanation-sentence. Earlier I characterized an explanation-sentence as pragmatic if it contains terms for a (particular or type of) explainer or audience or if its truth-conditions contain such terms or others defined using such terms. We might now introduce a second condition, and say that the truth-value of explanation-sentences of that form can vary with a change in the person giving or receiving the explanation mentioned or referred to in the explanation sentence. If both of these conditions are satisfied, let us say that the explanation-sentence is strongly pragmatic. If only the first is satisfied, the explanation-sentence is weakly pragmatic. By this criterion, sentences of the form

S explains q by uttering u

are strongly pragmatic. (Such sentences contain a term for an explainer, and their truth-value can vary with a change in explainer.) On the ordered pair theory, sentences of the form

E is an explanation of q

are only weakly pragmatic. Truth-conditions for sentences of this form (according to the ordered pair theory) invoke a term for a type of explainer, one who explains q; but the truth-value of sentences of this form does not vary with any change in who is giving E as an explanation of q, or to whom. On the ordered pair theory the concept

of an explanation is defined by reference to the concept of an act in which an explainer explains something (thus making "E is an explanation of q" weakly pragmatic). But whether some particular sentence of the form "E is an explanation of q" is true will not depend upon who, if anyone, gives the explanation (thus preventing such sentences from being strongly pragmatic). By contrast, according to Hempel's models of explanation, sentences of the form "E is an explanation of q" are neither strongly nor weakly pragmatic.[3]

I am inclined to think that when Hempel uses the term "pragmatic" he has in mind "strongly pragmatic", and that he would not object too strenuously to a "weakly pragmatic" concept of explanation, since the latter can be "objective". But this is speculation on my part.

Let me turn to another, perhaps more important, concept for which the ordered pair theory offers an account, viz., that of a "good explanation". Are sentences of the form "E is a good explanation of q" pragmatic in either sense?

Different evaluations of explanations are possible depending on what ends are to be achieved. The ends might be purely universal ones, e.g., the achievement of truth, empirical adequacy, simplicity, unification, etc. Or they might be more contextual. The end I am particularly concerned with is one that, by the definition given in the first part of the theory, an explainer has when he performs an act of explaining q, viz., rendering q understandable (in some appropriate way) by producing the knowledge of the answer one gives that it is a correct answer to Q. An evaluation with this end in view will take into account both universal and contextual criteria. Very roughly, E will be a good explanation for an explainer to give in explaining q to an audience if E is capable of rendering q understandable in an appropriate way to that audience by producing the knowledge of the answer to Q that it supplies that it is correct; or if it is reasonable for the explainer to believe that this obtains. The appropriateness of the understanding will depend on what the audience already knows and is interested in finding out. It will also depend on what it would be valuable for the audience to know--which, especially in the sciences, can bring in universal criteria. (For details see Achinstein 1983, pp. 107-117.)

In the case of such evaluations, which I call "illocutionary", sentences of the form "E is a good explanation of q" will be construed as elliptical for "E is a good explanation for an explainer to give in explaining q to an audience". Explanation-sentences of the latter form are strongly pragmatic. They contain terms for an explainer and audience, and the truth-value of sentences of this form can vary with a change in explainer or audience.

Now I am not claiming that illocutionary evaluations are the only possible ones. I do insist that they are important, that they are frequently given, and that using them, by contrast to non-illocutionary, non-pragmatic evaluations, will enable us to see why certain scientific explanations are generally judged better than others. Let me illustrate this by invoking a simple example, Rutherford's 1911 explanation of the results of scattering

experiments involving alpha particles.

In experiments published in 1909 Geiger and Marsden showed that when alpha particles are directed at a thin metal foil most of them go through the foil with small angles of deflection, but some are scattered through an angle of more than 90°, thus emerging on the side of incidence. In order to explain these surprising results Ernest Rutherford proposed a new theory of the structure of the atom. He assumed that an atom contains a positive charge that is not evenly distributed but is concentrated in a nucleus whose volume is small compared to that of the atom. He also assumed that the positively charged nucleus is surrounded by a compensating charge of moving electrons. Finally, he assumed that each scattering was the result of a single encounter between an alpha particle and a foil atom. Since most alpha particles penetrate the foil without being appreciably scattered, the foil atoms are mostly empty of matter. An alpha particle that is scattered at a wide angle is not scattered by a much less massive electron, but by a positive charge concentrated in the nucleus. From these assumptions, together with classical principles including conservation of energy and momentum, Rutherford derived a formula which gives the number of alpha particles falling on unit area deflected through an angle θ as a function of several other quantities. From this formula it is possible to calculate the number of alpha particles scattered at wide angles such as 150° or 135°.

Is Rutherford's explanation of the scattering results a good one? If we evaluate it in a non-illocutionary way using only criteria that are non-pragmatic, it would, I suppose, get a mixed review. True it derives the wide scattering angles in a precise way from lawlike, quantitative assumptions; it appeals to micro-entities; and it offers a cause of the scattering--all of which physicists and philosophers of science tend to regard with favor. But, as later developments in physics show, it is only a crude approximation to what actually occurs in the foil atoms. And it introduces a conception of the atom as involving moving electrons that is incompatible with classical electrodynamics. (Moving electrons should radiate energy and collapse into the nucleus, which clearly they do not.) Furthermore, if we use only non-pragmatic criteria in our evaluation, we will have a difficult time seeing why Rutherford's explanation is better than certain others we might construct that are clearly inferior.

Consider, e.g., the following quantitative hypothesis that Geiger and Marsden could have constructed from their experiments without appeal to Rutherford's theory. (I'll call it the G-M hypothesis.)

> The G-M hypothesis: When alpha particles are directed at thin metal foils the atoms comprising the foils cause the alpha particles to be scattered at various angles in accordance with the formula

$$N = Qnt(Ze)^2E^2 /4r^2(MV^2)^2\sin^4 \theta/2$$

(N is the number of alpha particles deflected at angle θ, Q is the total number of alpha particles incident on the foil, n the number of atoms per unit volume in the foil, t the thickness of the foil, Z the atomic number of the metal of the foil, e the elementary unit of charge, E the charge of the alpha particle, r the distance from the foil to the detection screen, and M and V the mass and velocity of the incident alpha particle.)

From the G-M hypothesis, together with information about a particular experimental set-up indicating the number of alpha particles, the thickness and the atomic number of the foil material, and so forth, the number of alpha particles scattered at various angles, including large ones, can be described in a precise way, using lawlike, quantitative assumptions. Moreover, this explanation is unifying in the sense that it permits the derivation of several different results obtained in the experiments of Gieger and Marsdon. (For example, it permits a derivation of the fact that the number of alpha particles scattered through a given angle is directly proportional to the thickness of the scattering foil, and that the number is inversely proportional to the square of the energy of the alpha particles.) The explanation is causal in the sense that the G-M hypothesis contains a description of something that causes the scattering, viz., the presence of the atoms in the metal foil. And in so doing it appeals to micro-entities. Yet I think it would be regarded as vastly inferior to Rutherford's explanation. But objective, non-pragmatic values such as derivability from quantitative laws, unification, causation, and micro-entities will not by themselves tell us why Rutherford's explanation is a good one by contrast with the G-M hypothesis. Rutherford's explanation is good, or is as good as it is, not simply because it answers a causal question about the scattering in a quantitative way at a unifying micro-level, but because it does so at the subatomic level of matter in a way that physicists at the time were interested in understanding the scattering.

By 1911, the time of Rutherford's paper, the atomic theory of matter was widely accepted in physics, as was the idea that the atom itself is not atomic but has an internal structure. The latter idea emerged from the discovery of radioactivity and the electron, and the results of scattering of beta particles by atoms. It was also thought reasonable to suppose that alpha particle scattering was produced by events at the subatomic level. The question was how to work this out quantitatively using some theory about the structure of the atom. About five years before Rutherford's paper, J.J. Thomson had proposed the "plum pudding" model of the atom according to which the positive electricity in the atom is uniformly distributed throughout the atom and the electrons are held stationary in equilibrium positions by the positive charges surrounding them and the repulsion of other electrons. However, it was impossible to derive the wide scattering angles of alpha particles from the Thomson model.

One of the reasons Rutherford's explanation is highly regarded is that it does derive these angles from a model of the internal structure of the atom--which physicists at the time were seeking.

And I think that the major reason the G-M explanation would not be so highly regarded--despite the fact that it derives the wide scattering angles from quantitative hypotheses--is that it does not give an explanation by appeal to subatomic structure. (It simply says that the scattering is produced by atoms, and it provides an empirical formula for the scattering.) But to assess Rutherford's explanation in the manner suggested is to offer an illocutionary evaluation. In the present case we are considering whether Rutherford's explanation (by contrast say to G-M) is a good one for Rutherford to have given. To determine this we need to look at the situation of Rutherford and other physicists in 1911. What did they know, and what did they seek to know? Doing this means treating the explanation-sentence "Rutherford's explanation of the alpha scattering is a good one" as strongly pragmatic. We need not, of course, treat it this way only with reference to Rutherford as explainer or a 1911 audience. The explanation-sentence might have a different truth-value if construed as elliptical for one making reference to a contemporary explainer and audience.

Now let me offer a conjecture. Suppose, following in the footsteps of Hempel and Salmon, you formulate a set of objective, non-pragmatic criteria that you think all scientific explanations must satisfy to be evaluated highly. These criteria will be universal in the sense that they are not to vary from one explanation to the next, but are to be ones applicable to all scientific explanations. They are also universal in the sense that they are not to incorporate specific empirical assumptions or presuppositions that might be made by scientists in one field or context but not another. So they might include the use of laws, causal factors, and quantitative hypotheses, the satisfaction of some criterion of unification or simplicity, and so forth. My conjecture is that whatever set of objective, non-pragmatic, universal criteria you propose you will be able to find or construct counterexamples to it, both as a set of necessary conditions and as a set of sufficient conditions. You will be able to find explanations that you will want to evaluate highly, despite the fact that they violate one or more of your favorite criteria. (Although this is not something I have illustrated here, you will evaluate them highly because they satisfy pragmatic criteria that are appropriate to use in the context of evaluation.) And you will be able to find, or at least construct, explanations (as I tried to do with the G-M explanation) that satisfy your criteria yet would not be highly regarded. You can emphasize criteria such as the introduction of laws, causal factors, and unification. But unless you say something more specific about the kinds of laws and causal factors to be used, or what is to be unified, you won't find your criteria sufficient to exclude examples you want excluded. But this "something more", as I tried to illustrate in the Rutherford case, will involve fairly specific empirical assumptions that may be made by certain scientists at certain times but not by others at other times: You want to derive the scattering angles not just from any laws that will do the job, or from any causes no matter how described, but (e.g.) from ones that invoke events occurring within the atom. You desire an explanation that provides unification, but not just any sort of unification. (One that unifies only various results obtained in scattering experiments, as does the G-M hypothesis, may not be of sufficient

interest to you.) To determine what this "something more" is requires pragmatic assumptions about the explanatory context.

Now let me consider one major objection the non-pragmatist may offer. It is the one mentioned earlier that he might make against van Fraassen. Even if you accept the importance of illocutionary evaluations, the non-pragmatist may say, all this shows is that sentences of the form "E is a good explanation of q" are incomplete. In the case of illocutionary evaluations the view I have espoused completes such sentences by writing "E is a good explanation for an explainer to give in explaining q to an audience"--which makes them strongly pragmatic. But there may be ways to complete such sentences that yield the same evaluations but that are not pragmatic.

Let me use the term "instructions" to refer to a set of rules or guidelines an explainer may be following when he explains q to an audience, or that an audience may want followed when q is explained to it. Instructions impose conditions on the answer to the explanatory question. They may incorporate very specific empirical conditions assumed by the explainer or audience. (For example, "Describe the structure of the atom in such a way that the interaction between alpha particles and either positively or negatively charged constituents of the atom produces the scattering.") They may also incorporate some very general conditions. ("Derive the scattering angles from quantitative laws.") Suppose that by appeal to a particular explanatory context--by appeal to the knowledge, beliefs, desires, and values of the explainer and audience--we determine that some set of instructions I is an appropriate one for that explainer to follow in explaining q to that audience. (The instructions themselves will not include reference to any explainer or audience.) We can now take the (allegedly) incomplete sentence "E is a good explanation of q" and complete it by relativizing it to the instructions I (and perhaps also to some set of beliefs K of explainer and/or audience):

(8) E is a good explanation of q relative to instructions I (and K).

We then supply truth-conditions for sentences of this form which are "objective" and are not relativized to explainer or audience. Here is one possibility:

(9) A sentence of form (8) is true iff
(a) E satisfies instructions I, and E provides a correct answer to question Q; or
(b) Given K, it is probable that (a) obtains.

I don't wish to defend these conditions but only to use them as an example. By our earlier definition, sentences of the form (8) should be neither strongly nor weakly pragmatic. Such sentences contain no terms for an explainer or audience; their truth-conditions (9) do not contain such terms; and their truth-values will not vary with a change in who is explaining or to whom (as long as instructions I are kept the same). So, the non-pragmatist will admit, just as you need to appeal to the context to determine what question Q is being

raised, and what beliefs K can be assumed, so you need to appeal to the context to determine what instructions I are to be followed. But once all these things are determined, then the issue of whether E is a good explanation of q relative to I and K is settleable in an objective, non-pragmatic way (by determining, e.g., whether (a) or (b) of (9) is satisfied).

This reply, I suggest, trivializes the non-pragmatist's position with regard to the evaluation of explanations. The aim of non-pragmatists such as Hempel and Salmon is to provide non-pragmatic criteria of evaluation--criteria whose applicability does not depend on, or vary with, who is explaining or to whom. What I have called "instructions" are rules that incorporate criteria to be used in evaluating explanations. And the non-pragmatist is now agreeing with me that the applicability or appropriateness of some set of instructions will depend upon, and vary with, explainer and audience. But this is too much of an admission. When it comes to evaluating explanations I take the non-pragmatist to be seeking a set of instructions whose appropriateness is not affected by context.

Let me put this in another way. The non-pragmatist should not transform a sentence of the form "E is a good explanation of q" into "E is a good explanation of q relative to instructions I", but into "E is a good explanation of q relative to appropriate instructions I". Or better, he should say that sentences of the form "E is a good explanation of q" are true only if there is some set of appropriate instructions that E satisfies. In either case the instructions are to be appropriate ones. And if, as above, the non-pragmatist admits that appropriateness always depends, in part, on context, he is in agreement with the pragmatist. If the very definition of "appropriateness" with regard to instructions requires reference to an explainer and audience (see The Nature of Explanation, pp. 112ff), and if the truth-conditions for "E is a good explanation of q" require the satisfaction of appropriate instructions, then "E is a good explanation of q" is strongly pragmatic.

In sum, the situation here is different from that of van Fraassen, who appeals to the context to determine only the question being raised, a set of alternative hypotheses, and the background information. By contrast, the instructions he formulates for evaluating explanations are not pragmatic. Their applicability does not depend on, or vary with, explainer or audience.

4. Implications

Let me comment briefly on the implications of a pragmatic theory of explanation for two recently contested issues in the philosophy of science.

a. Realism--anti-realism. Of course, a good deal depends on how you define "realism" and "anti-realism". According to van Fraassen's formulation, the realist aims to give "a literally true story of what the world is like", while the anti-realist aims to give "theories that are empirically adequate" (pp. 9, 12), i.e., theories that yield truths about "observables".

The first point I want to make is that, contrary to what might be thought, a pragmatic theory of explanation does not commit one to anti-realism. Consider a theory of the sort I offer for pragmatic explanation-sentences of the form

> E is a good explanation for an explainer to give in explaining q to an audience.

The theory proposes several truth-conditions for sentences of this form, but the important one for the present issue is that E provides a correct answer to question Q or that it is reasonable for the explainer to believe it does. The fact that E provides a correct answer to Q is not by itself sufficient to make E a good explanation of q; further contextual conditions need to be satisfied. But these contextual conditions in no way prevent a realist construal of "correct answer to Q" as one that, among other things, provides a "literally true story". The contextual conditions do not require that we construe a "correct answer" to be one that simply "saves the phenomena". By reference to the context of Rutherford's 1911 explanation, we can determine the need to provide an explanation of the scattering that appeals to the inner structure of the atom. We may evaluate Rutherford's explanation highly, in part because it satisfies such contextually determined instructions. But this need to appeal to context does not mean that we must construe Rutherford's explanation non-realistically.

Indeed, so far as I can see, even van Fraassen's own evaluative theory--which earlier I argued is not pragmatic--does not require an anti-realist position of the sort he himself urges. We are supposed to evaluate the goodness of the explanation "P in contrast with X because A" by determining whether proposition A is "acceptable" or "likely to be true", and by determining certain probabilistic relationships between A, the contrast class X, and the other answers being considered. None of this would seem to require anti-realism. And the fact that the contrast class and alternative answers are determined contextually in no way precludes a realistic construal of answer A.

Conversely, pragmatism with regard to explanation does not commit one to realism. A "correct answer to questions Q" might be construed anti-realistically as one that "saves the phenomena". Or, perhaps better, one might drop the condition that the explanation provides a correct answer to Q in favor of the condition that the explanation provides an answer to Q that saves the phenomena. This modification is in no way precluded by the need to appeal to contextual facts about an explainer or audience. (There are other more compelling reasons to resist anti-realism having to do with the concept of understanding that I will not explore here. My point is only that the need to invoke explainers and audience is not a compelling reason.)

b. Relativism vs. Absolutism. Pragmatism with regard to explanation, particularly strong pragmatism, is a form of relativism. The truth-value of a strongly pragmatic explanation-sentence will vary with explainer and/or audience. But this relativism does not necessarily commit one to particularly virulent forms such as

subjectivism or (Feyerabendian) anarchism. For example, it will not be the case that an explanation will be a good one for an explainer to give an audience if it simply satisfies any criteria set by the explainer or audience. For one thing, the explanation must satisfy some truth or confirmation requirement. For another, there may be certain criteria the satisfaction of which by the explanation is valuable for the explainer or audience, despite their own beliefs about these criteria. The form of relativism I would support could agree that the introduction of laws, causes, unification, and so forth, are general methodological criteria valued in science. They are "prima facie" virtues. But in giving assessments of explanations of the sort I have been describing--in giving illocutionary evaluations--they cannot be treated as necessary or sufficient conditions. They are relevant, but they must be combined in appropriate ways with pragmatic information.

Notes

[1]I am indebted to the National Science Foundation for support.

[2]In conversation van Fraassen suggests that the answer "P in contrast to X because A" should be understood as relativized to some particular set of assumptions B made in the context. If so his conditions might be construed as truth-conditions for sentences of the form "P in contrast to X because A, given B."

[3]The two conditions are independent. We have already seen an example satisfying the first but not the second. Here is something satisfying the second but not the first: "The fact that I was delayed in traffic is the correct explanation of why I am late." This sentence contains no terms for an explainer or audience (in the sense indicated earlier: it contains nothing of the form "S explains q to P" or "the explanation of q given by S to P is ---".) Yet its truth-value will vary with a change in the person giving the explanation mentioned. By the definitions above, this explanation-sentence is neither strongly nor weakly pragmatic. (To transform it into a strongly pragmatic explanation-sentence satisfying both conditions we could write: "The fact that he was delayed in traffic is the correct explanation given by Danny Dawdle of why he is late.")

References

Achinstein, Peter. (1983). The Nature of Explanation. New York: Oxford University Press.

Bromberger, Sylvain. (1965). "An Approach to Explanation." In Analytic Philosophy. 2nd Ser. Edited by R.J. Butler. Oxford: Basil Blackwell. Pages 72-105.

Geiger, H. and Marsden, E. (1909). "On a diffuse reflection of the α-particles." Proceedings of the Royal Society (A) 82: 495-500.

Hempel, Carl G. (1965). Aspects of Scientific Explanation and Other Essays in the Philosophy of Science. New York: Basic Books.

Rutherford, E. (1911). "The scattering of α and β particles by matter and the structure of the atom." Philosophical Magazine 21: 669-688.

Thomson, J.J. (1904). "On the structure of the atom - an investigation of the stability and periods of oscillation of a number of corpuscles arranged at equal intervals around the circumference of a circle; with application of the results to the theory of atomic structure." Philosophical Magazine 7: 237-265.

van Fraassen, Bas. (1980). The Scientific Image. Oxford: Clarendon Press.