Towards A New Non-Ontic Conception of Scientific Explanation

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

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2023

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Abstract

This dissertation is about what is called a conception of scientific explanation. A conception of scientific explanation concerns some ontological questions about scientific explanation. Two related but distinct questions have been investigated: (1) What type of entity is an explanans? (2) In virtue of what, is a thing of that type explanatory?

There are two competing conceptions of scientific explanation. One is the ontic conception and the other is the non-ontic conception. A conception is *ontic* if it says that (a) a type of thing that explains is primarily a thing in the world that is responsible for a target of explanation (*ontic explanation*) and (b) a type of entity explains if and only if it is either ontic explanation or accurately represents the relevant ontic explanation (*ontic determination*). A conception is *non-ontic* if it denies either (a) or (b) or both in one way or the other.

A conception of scientific explanation is distinguished from a model or an account of scientific explanation. One way to understand the relationship between a conception and a model of explanation is to use the type-token distinction. While a conception asks about what type of entity explains an explanandum and what type of relation an explanatory relation is, a model asks about which token of a certain type of entity explains an explanandum and which token of a certain type of relation an explanatory relation is. Think about the ontic conception. The ontic conception says that the type of entity that explains

is a certain thing consisting of the world. There can be various models of explanation that fit with this ontic picture, while they still differ concerning specifics. For example, among the various kinds of things comprising the world, a causal model says that it is a cause that explains, while a nomological model says that it is a law of nature that explains. For explanatory relations, the ontic conception says that an explanatory relation is a mind-independent relation. Again, there can be various models of explanation that belong to the ontic conception of explanatory relations and yet differ in terms of which specific mind-independent relation is seen as explanatory. For example, a causal model says that it is a causal relation that is explanatory among various kinds of mind-independent relations, while a nomological model says that it is a nomic relation. Putting this way, what distinguishes a conception and a model of scientific explanation is the level of generality of the questions each asks about. While a conception asks about some broad ontological questions about explanations, a model asks about more specific ontological questions.

It will be useful to make the working hypothesis behind the debate over conceptions clear, which this thesis is also based on. The working hypothesis is that there is one correct conception of scientific explanation. In the case of models of scientific explanation, there may be several different models that are correct. Those who think that not all explanations are causal but there are also some non-causal explanations believe in the pluralism of models of scientific explanation. I also think the said pluralism is true. But I think that there is only one correct conception of scientific explanation, or so I assume in this dissertation. Accordingly, what is at issue is which conception is correct, either ontic or non-ontic.

While the ontic conception is a pretty fixed view, there can be various kinds of non-ontic conceptions, depending on which part of the ontic conception one disagrees with and in what way. So, if one thinks that a non-ontic conception is the correct conception of scientific explanation, the next task is to spell out what kind of non-ontic conception is the correct view. And this is exactly what this thesis is about. This thesis aims to propose and defend a new non-ontic conception, namely an epistemic conception of scientific explanation.

The three chapters are designed to proceed toward the said aim. In Chapter 1, I challenge claim (a) of the ontic conception, i.e., the existence of an ontic explanation. I examine the existing reasons to believe in ontic explanations and argue against them. The conclusion of this chapter is tentative, for all it shows is that no good reason has yet been proposed to support our commitment to an ontic explanation. Still, the conclusion is strong enough to lend support to the non-ontic conception denying ontic explanations in that it is better not to posit something if not necessary for the ontological parsimony.

In Chapter 2, I deal with claim (b) of the ontic conception, i.e., the ontic determination. To this end, I examine Angela Potochnik's non-ontic view, according to which whether something is explanatory is determined not only by what the relevant part of the world is like but also by some cognitive factor of those seeking an explanation. I agree with Potochnik in that some cognitive factor must play a role in determining whether something is explanatory. But I disagree with Potochnik in terms of the cognitive factor she identifies, namely research interests. So, in this chapter, I argue against the cognitive factor she identifies. Then, I propose and defend an alternative cognitive factor for explanation and

conclude the chapter with the following view of mine: Whether something is explanatory is determined not only by what the relevant part of the world is like but also by whether it can be represented in a cognitively manageable way.

In Chapter 3, I then deal with claim (b) of the ontic conception from a different angle. In this chapter, I question whether a representation must be true to be explanatory (*the truth requirement for genuine explanations*). I provide an epistemological argument against the truth requirement and defend my argument from some possible worries. Then, I provide and defend an alternative view, according to which a representation is explanatory only if it is true for all we know (*the epistemically constrained truth requirement for genuine explanations*). I then clarify what I mean by this alternative condition, how a proposition that is true for all we know plays the explanatory roles in practice with which I define the explanatory genuineness, and what my proposal implies about scientific explanation.

Acknowledgments

This dissertation would not have come into existence without the tremendous support, patience, and feedback from my advisor and committee members. It was truly my honor and pleasure to work with my advisor for the past six years. Without him, I would have not been able to enjoy studying philosophy for those years and complete my dissertation. Words cannot express my gratitude for all the philosophical insights and understanding he provided me. It was also a great honor and pleasure to work with my committee members. Without them, my thoughts could have not possibly been as developed as they are. Once again, I deeply appreciate my professors for showing me the roads I could not see on my own and the directions I have not thought about before. I enjoyed all those philosophical journeys I have had with them more than anything.

I am also very grateful to my colleagues for their feedback and friendship. I especially would like to thank the members of the Society for Philosophy of Science. Without them, this journey would have been far more challenging than it was.

Lastly, I would like to thank my parents. There were not a few moments that I struggled and was deeply frustrated during the whole journey. I would never have finished this journey without their faith and support for me. Especially, I would like to thank my father who has always been my biggest supporter in me living the life I want. I deeply appreciate all his sacrifices and support.

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CHAPTER 1. LIVING WITHOUT ONTIC EXPLANATIONS

Concerning what type of thing does the job of explaining, some philosophers have argued that it is primarily the thing in the world that the occurrence of a target of explanation depends on. Those things in the world are called ontic explanations and the view that commits to ontic explanations is called the ontic conception of explanation. In defense of the ontic conception, Carl Craver provides a semantic reason based on the meanings of the term "to explain" and a theoretical reason based on how explanatory representations are evaluated in scientific practice. In this paper, I will examine these reasons and refute them. I will conclude that in understanding the nature of scientific explanation, positing ontic explanations is not necessary to the point that it may be even better to not posit them.

1. Introduction

An explanatory relation consists of two relata, which are explanans and explanandum. One of the tasks of the metaphysics of scientific explanation is to clarify what type of entity the relata are in the case of scientific explanation. There seems to have been a fairly widespread agreement on what type of entity an explanandum is. An explanandum is some phenomenon that we observe obtains in the world, whether it be an event, a state, a fact, etc., and whether it be some specific part or aspect of a phenomenon specified by a

particular why-question and a contrast class. Arguably, one of the key aims of science is to explain why the world is the way it is. In this light, it seems nearly uncontentious that what we want to explain and understand by way of explanation is what is happening in the world.[1]

Concerning what type of entity explanans is, however, there have been disagreements among philosophers. Some people think that what explains is a thing in the world that the occurrence of a target of explanation depends on, such as causes, mechanisms, laws of nature, etc. They are called *ontic explanations*, and a view is called an *ontic conception* if it commits to ontic explanations. According to this view, say, a cause of a target of explanation is literally speaking an explanation of the target. Others disagree with the ontic conception and think that only certain representations are explanations. The conception these people hold is *non-ontic* in the sense that it denies ontic explanations.[2]

Note that what makes a conception ontic is the commitment to ontic explanations. This leaves it open that the ontic view may also allow representations to be explanatory. And

[1] Bokulich (2018) may be an exception in this respect. Although there is also a subtlety in her view in that sometimes she says what is ultimately explained is the things in the world, she makes it clear the thing that explanans directly explains is a certain representation of a thing in the world, i.e., a representation that represents a thing in the world using a particular theoretical and methodological tools.

[2] Those who flatly deny ontic explanations are Bechtel and Abrahamsen (2005), Bechtel and Wright (2007), Bokulich (2016, 2018), van Eck and Wright (2018), and Wright (2012). Those who indirectly deny or at least question ontic explanations by arguing that explanations must satisfy both the epistemic constraint and the ontic constraint are Glennan (2017), Illari (2013), Sheredos (2016), van Eck (2015).

that is indeed the line the proponents of the ontic conception typically take.[3] Since what the ontic conception says is that a certain thing in the world is an explanation, not that it is the only type of entity that does the explaining, the point of disagreement between the ontic and the non-ontic conceptions is whether representations are the only type of entity that explains or there is also an ontic explanation.

The defenders of the ontic conception make it clear that things in the world are themselves explanations. Following Coffa, Salmon writes, "….one can say that explanations exist in the world. The explanation of some fact is whatever produced it or brought it about".[4] Craver writes, "Conceived ontically, however, the term explanation refers to an objective portion of the causal structure of the world, to the set of factors that produce, underlie, or are otherwise responsible for a phenomenon. Ontic explanations are not texts; they are full-bodied things".[5] Strevens is also one of the advocates of ontic explanations. He writes, "Philosophers sometimes talk as if an explanation were something out in the world, a set of facts to be discovered, and sometimes as if it were a communicative act…. I follow the lead of most philosophers of explanation, and of most proponents of the causal approach in particular, in giving the first, ontological sense of explanation precedence. What explains a given phenomenon is a set of causal facts. It is an aim of science to discover these sets of facts, these explanations".[6] In comparison to the

[3] See Salmon (1989), Craver (2014), Craver and Kaplan (2011), and Strevens (2008).

[4] Salmon (1989), p. 86.

[5] Craver (2014), p. 50.

[6] Strevens (2008), p. 6.

explicit commitment to ontic explanations, however, the reason why we should commit ourselves to ontic explanations had not been clearly stated. At least it had been the case until Craver (2014) provided two reasons to support ontic explanations, one of which is a semantic reason that concerns the meanings of the term "to explain" and the other is a theoretical reason that concerns the two goals of the theory of explanation. In this respect, Craver's work has particular significance in the debate over ontic explanations and is thus worth examining.

Several people have reacted to Craver's defense of ontic explanations. Wright (2012) argues against Craver in the sense that the semantic reason Craver provides rests on a misunderstanding of our language. Bokulich (2016, 2018) also argues against Craver based on that he cannot talk about explanation consistently as long as he maintains the ontic sense of explanation. van Eck and Wright (2018) criticize the commitment to ontic explanations in that it draws a substantial metaphysical claim based on our ordinary language use, while the inference itself needs justification. All of these criticisms, however, only engage in the semantic reason and leave the other reason intact, which I think is more important in understanding scientific explanations. So, in this paper, I aim to contribute to the debate not just by adding a new concern to the semantic reason that ultimately supports why we had better turn our attention to the theoretical reason (section 3), but also by arguing against the theoretical reason (section 4). Let me first explain Craver's two reasons and how they are claimed to support our commitment to ontic explanations in the following section.

2. Craver's defense of ontic explanations

In advancing his defense for ontic explanations, Craver first examines our ways of speaking using the term "to explain". He identifies the four different modes of talking about explanation, whose difference is based on what comes at the subject place of the verb "to explain". The four modes are (i) *the ontic mode* in which what explains is asserted to be a thing in the world (e.g., "The moon's gravitational pulls explain the tides"), (ii) *the communicative mode* in which what explains is asserted to be a person who explains something (e.g., "Estelle explains the tides"), (iii) *the textual mode* in which what explains is asserted to be a representation (e.g., "A model explains the tides"), and (iv) *the cognitive mode* in which what explains is asserted to be a mental representation (e.g., "Estelle's mental representation of the moon's gravitational pulls explains the tides").

Craver argues that each of the four modes corresponds to the four different and distinct ways of thinking about explanation based on that combining two or more different modes as a single subject of the verb "explain" makes the whole sentence meaningless (e.g., "Estelle and the moon's gravitational pulls explain the tides"). In addition, Craver points out that there is a further difference in the four ways of thinking about explanation. Unlike the other modes that involve certain kinds of representations or in Craver's terms, "depend in some way on the existence of intentional agents who produce, interpret, manipulate, and communicate explanatory texts", the ontic mode neither involves representations nor depends on the existence of intentional, representing agents.[7] This difference is more apparent when we look at some sentences as follows:

[7] Craver (2014), p. 35.

A. Our world contains undiscovered phenomena that have explanations.

B. There are known phenomena that we cannot currently explain (in the sense of communicate, textual, or cognitive mode) but that nonetheless have explanations.

C. A goal of science is to discover the explanations for diverse phenomena.

D. Some phenomena in our world are so complex that we will never understand them or model them, but they have explanations, nonetheless.[8]

These sentences talk about explanations whose existence and genuineness do not depend on the existence of intentional agents. Craver has it that these sentences are all natural things to say. Therefore, the ontic way of speaking and thinking about explanation is genuine and distinct from other ways of thinking about explanation, or so he argues.

Based on the differences enumerated so far, the three kinds of explanations that are claimed to be referred to by the communicative, textual, and cognitive senses of the term "to explain" are classified as explanatory representations, while the one that is claimed to be referred to by the ontic sense of the term as the ontic explanation. Craver then argues that there is an asymmetric relation between ontic explanations and explanatory representations, namely that explanatory representations are evaluated by ontic explanations but not vice versa.

[8] Ibid., p. 36.

The reason why ontic explanations are not evaluated by explanatory representations is straightforward. As part of the world, it is not the proper object of evaluation in the first place. Things that exist in the world are just what they are, neither being good nor bad. Craver makes this point clear by saying as follows:

> "Ontic explanations…. are not true or false. They are not more or less abstract. They are not more or less complete. They consist in all and only the relevant features of the mechanism in question. There is no question of ontic explanations being "right" or "wrong," or "good" or "bad." They just are" (2014, 40).

An explanatory representation, on the contrary, is the proper object of evaluation. Craver supports this idea by examining why not all models used in science are explanatorily adequate. Some models are explanatorily inadequate in the sense that they are not explanatorily genuine. The models that describe how a target of explanation might possibly have occurred or those that merely describe the target under study or correlations involved in the target are such examples. Other models are explanatorily inadequate in the sense that they are not explanatorily good. For instance, the models that describe the relevant part of the world only partially or describe not just the relevant parts but also some irrelevant parts of the world count as explanatorily bad. To summarize, the models evaluated as explanatorily inadequate in the sense of not being explanatory at all are evaluated thus and so because they do not accurately describe the part of the world responsible for the occurrence of a target of explanation. In the case of the models that are evaluated as

explanatorily inadequate in the sense of being a bad explanation, they are evaluated thus and so because they do not describe all and only the relevant parts of the world responsible for the occurrence of the targets of explanation.

Based on how models seem to be evaluated in practice, Craver suggests the following two criteria for explanatory representations: (i) A representation is explanatorily genuine when and only when it accurately represents the relevant part of the world responsible for the occurrence of a target of explanation (*explanatory demarcation*); (ii) a representation is explanatorily good when only when it accurately represents all and only the relevant part of the world responsible for the occurrence of a target of explanation (*explanatory normativity*). If these criteria are correct, then it seems to follow that ontic explanations serve as the norm for explanatory representations. This is because an ontic explanation is claimed to be the very part of the world that is responsible for the occurrence of a target of explanation. The genuineness and goodness of explanatory representations are thus evaluated based on whether it accurately represents all and only the relevant ontic explanation.

Craver summarizes his points as follows: "If the philosophical topic of explanation is to provide criteria of adequacy for scientific explanations, then the ontic conception is indispensable".[9] And for the reason why ontic conception is indispensable, he writes, "One cannot achieve these goals without undertaking commitments about the kinds of ontic structures that plausibly count as explanatory. Representations convey explanatory information about a phenomenon when and only when they describe the ontic explanations

[9] Craver (2014), pp. 36-7.

for those phenomena".[10] This line of reasoning Craver provides for ontic explanations is a form of an indispensability argument, which can be put as follows:

(1) We ought to have ontological commitment to the entities that are indispensable for making sense of explanatory demarcation and explanatory normativity.
(2) By serving as the norm for the criteria of adequate explanations, ontic explanations are indispensable in making sense of explanatory demarcation and explanatory normativity.
(3) Therefore, we ought to have ontological commitment to ontic explanations.

Since this argument has to do with the two goals the theory of scientific explanation tries to achieve, let me call this argument a theoretical reason for ontic explanations. In comparison, I will call the reason Craver provides based on the meanings of the term "to explain" a semantic reason for ontic explanations. In the following sections, I will examine and put into question these reasons one by one. Let me start with the semantic reason.

3. On the semantic reason for ontic explanations

Craver makes the two semantic claims for ontic explanations. One concerns the *meaningfulness* of the ontic sense of the term "explain": Using the term in the ontic way - e.g., "The moon's gravitational pulls explain the tides" - is a legitimate way of speaking about explanation. The other concerns the *distinctiveness* of the ontic sense from the other

[10] Ibid., pp. 27-8.

representation-involving senses of explanation: The ontic sense does not depend on the existence of intentional agents, unlike the other senses of explanation. Based on the meaningfulness and the distinctiveness claims, Craver argues that there is indeed an ontic way of thinking about explanation, which is not only genuine but cannot also be assimilated with the other non-ontic ways of thinking about explanation.

Let me first examine the two reasons Craver offers for the distinctiveness claim. One reason is that combining two or more different senses of the term "to explain" and using them as a single subject of the predicate yields a meaningless sentence. For example, the following sentence is meaningless according to Craver: (a) "Estelle and the moon's gravitational pulls explain the tides". There is certainly something awkward about asserting this sentence in the sense that we would not normally say this way. That said, it is not clear whether the sentence is meaningless, even though the judgment may differ depending on which theory of meaning one thinks is right.

The sentence in question can be seen as an abbreviation of the following sentence: (b) "Estelle explains the tides and the moon's gravitational pulls explain the tides". (b) is neither awkward nor meaningless. If (b) is meaningful and it can be rewritten into (a) while maintaining its meaning and truth condition, then (a) would be also meaningful. Alternatively, perhaps (a) means something like the following, in which "to explain" cannot be distributed to each of the conjuncts of its subject: (c) Estelle and the moon's gravitational pulls together explain the tides". Still, it is not clear to me whether (c) is meaningless, not just an unnatural thing to say. Suppose Estelle explains the tides to someone, invoking the moon's gravitational pulls. In this case, there is a sense in which it

is both Estelle and the moon's gravitational pulls that do the explanatory job. Not only that, but they seem to play an important and irreplaceable role in explaining. We need both Estelle and the moon's gravitational pulls to explain the tides to someone; Estelle cannot explain the tides to someone without invoking the moon's gravitational pulls, while the moon's gravitational pulls cannot explain the tides to someone unless Estelle invokes it and delivers that information to someone. And this kind of situation may be the truth condition of (c). To summarize, (a) is equivalent either with (b) or with (c). And both (b) and (c) do not seem to be ungrammatical nor lack truth conditions. If so, it is not clear in what sense (a) is meaningless.

What Craver provides as another evidence for the distinctiveness claim is the sentences that would make sense only if there is an ontic sense of speaking about explanation distinctive from the non-ontic senses, i.e., the senses that depend on the existence of representing agents. Such sentences were:

A. Our world contains undiscovered phenomena that have explanations.
B. There are known phenomena that we cannot currently explain (in the sense of communicate, textual, or cognitive mode) but that nonetheless have explanations.
C. A goal of science is to discover the explanations for diverse phenomena.
D. Some phenomena in our world are so complex that we will never understand them or model them, but they have explanations, nonetheless.

Craver argues that the sentences like these are natural things to say, which then serve as evidence that there is a distinctively ontic way of thinking about explanation. I also think that these sentences may play the said evidential role at least to some extent if they were indeed the natural things to say. The problem, however, is that it is not altogether clear whether they really are. Whether the sentences are natural things to say depends on what one believes is true about explanations. If one thinks that explanations can exist independently of someone's being aware of it, discovering it, or understanding it, then the sentences (A)-(D) would be read naturally to that person. However, the same sentences would not be read naturally to those who think otherwise about explanations. In this regard, whether the sentences are the natural things to say rests on a view of explanations. And that is the real problem of the second reason Craver provides. The sentences are supposed to support the ontic conception committing to ontic explanations that exist independently of any intentional agent. And yet, the sentences do not seem to be the natural things to say to everyone, except to those who already explicitly or implicitly hold the ontic conception. Since the sentences make sense only when one thinks the ontic conception is true, arguing for the distinctiveness of the ontic way of thinking about explanations on the basis of the sentences like (A)-(D) is question-begging.

That the distinctiveness of the ontic sense is questionable, however, does not thereby imply that there is no ontic sense of explanation. All that implies is that there may be no distinctively ontic way of speaking and thinking about explanation. Perhaps, the ontic sense of explanation is tightly connected to the non-ontic sense of explanation or may even be

reduced to the non-ontic sense.[11] Still, so long as the ontic sense of explanation is a meaningful way of speaking and thinking about explanation, that may still be able to serve as a reason to support ontic explanations. However, the problem is that the meaningfulness claim also does not stand on firm ground.

One problem that the meaningfulness claim has is not about the claim itself but what Craver seems to infer from the claim. From the fact that people do sometimes use the term "to explain" in the ontic sense, Craver draws that the term refers to a thing that is itself explanatory. As van Eck and Wright (2018) point out, however, the inference that infers a metaphysical claim directly from a semantic fact needs a justification. Perhaps the inference may not be always bad and sometimes even favorable for a semantic reason. For the meaning of our term "apples", it may be the most natural and straightforward to think that there are apples in the world that the said term refers to. Still, the inference does not seem to be the one we can do all the times without some further justification. For there can be a discrepancy between how we talk and what there really is. For instance, we use the term "table" meaningfully and yet there may actually be no table in the world but only particles arranged table-wise. In this case, our term refers to something in the world, but the thing referred to is not a thing that is itself a table. Similarly, our term "to explain" may refer to something in the world, but the thing referred to may or may not be a thing that is

[11] For example, Wright (2012) argues that the ontic sense of explanation is in fact derivative from the non-ontic sense of explanation. Wright has is that the default sense of expressions such as "to explain" or "explanation" is communicative. Explanations are what are given and taken between people. In this light, the ontic way of talking is rather a way of speaking using metaphors of personification.

itself an explanation. In the end, it can be one thing that we may call a thing in the world as an explanation, and yet it can still be another whether that thing thus has a property of being explanatory.

The foregoing worry about the inference has been raised by others in one way or the other. Quine has it that it is one thing how we use terms in our language and another whether we should commit ourselves to the existence of certain entities that seem to be denoted by the terms, which is why we need a different criterion for ontological commitment.[12] Others such as natural language metaphysicians argue that we cannot simply draw a metaphysical claim that *X* exists by interpreting a sentence with the term "*X*" in a literal way. The best thing we can say with relevant semantic data is that we are talking *as if* something exists, which does not entail that the thing does exist as they are.[13] What all these concerns share in common is this: Even though how we talk may truly be suggestive about what there is, one still cannot simply draw an ontological claim about what there is from how we talk. And because we cannot simply make such an inference, we need a further reason that can support the inference if we ever make the inference. And Craver does seem to provide such a reason, i.e., the reason why we should commit ourselves to ontic explanations for the theory of explanation. This is one reason why we rather need to pay attention to the theoretical reason he provides. Since language alone is not enough to support the existence of ontic explanations, we need a reason to believe why we should commit ourselves to ontic explanations as our language seems to suggest to us.

[12] See Quine (1948).

[13] See Bach (1986).

The other problem of the meaningfulness claim is about the claim itself. There is an ontic sense of explanation in English and perhaps some other similar languages. However, not all languages have the ontic sense of the term "to explain". For instance, it does not make sense if one says "The moon's gravitational pulls explain the tides" in Korean. In Korean, using the predicate "to explain" in the ontic way is ungrammatical since the predicate does not have the ontic use. Only a person or a representation a person makes can be a subject of the predicate. So, the meaningfulness claim is simply false if it claims that the term "to explain" has the ontic sense in an unrestricted way. Strictly speaking, the ontic sense of the term is legitimate only in some languages.

What does the foregoing fact about different languages tell us? If one wants to maintain the tight relationship between language and ontology, one should conclude from the difference in languages that people using different languages with different uses of certain terms have different ontologies. It sounds too extreme to me to think what exists is relative to how people talk, but it may be a possible view. Still, this does not seem to be the road the debate over ontic explanations would wish to take. When we ask what type of entity an explanation is, what we are interested in is not that different things may be explanations to different people in different linguistic practices. What we are after is rather the fact about explanations which is true not just in some linguistic contexts but in scientific practice in general.

This foregoing idea can also be put in the following way. A conception of scientific explanation concerns what scientific explanation is by asking what type of entity the relata of scientific explanation are. And this inquiry is pursued to better understand the nature of

scientific explanation and explanatory practice in science. In other words, we are seeking a notion of scientific explanation that can reveal and clarify what type of entity, qua explanation, science aims to seek and provide us with and thus what scientists are doing when explaining. And here explanation is not understood as something different in each different linguistic context. Whichever language one may use, what scientists do and should do to explain does not seem to vary in line with the languages they use. There may be some differences, of course, namely how they use the term "explanation" in their own languages. For instance, an English-speaking scientist may call the moon's gravitational pulls an explanation, while a Korean-speaking scientist would not. Still, there seems to be no difference in terms of what scientists should do to explain the tides and which model or theory they accept as a legitimate explanation of the tides. Through a conception of scientific explanation, I take it that what we philosophers want to understand is this kind of explanatory practice in science that is not relative to what language one uses. We philosophers want to know whether we should commit ourselves to ontic explanations to better capture the explanatory practice: The explanatory practice that is simply not about what scientists may call as an explanation, but about what kind of entity scientists provide as an explanation and what makes such an explanation genuinely explanatory or explanatorily good. And this is another reason why we need to turn our attention to the theoretical reason Craver provides. For he argues that we should commit ourselves to ontic explanations to make sense of when and only when an explanatory representation scientists formulate is genuinely explanatory or explanatorily good. And supporting the existence of ontic explanations by means of language only will not be successful because what

languages tell us can be contradictory. Also, languages can be unhelpful in the sense that it diverts our attention to the different ways the term "explanation" is used in different languages from what is common about explanations in scientific practice, which the debate over ontic explanation is genuinely about and for.

The objective of this section was to make it clear what problems the semantic reason has and to motivate why we should examine and focus on the theoretical reason rather than the semantic one. Now let me move on to the theoretical reason in the following section.

4. On the theoretical reason for ontic explanations

The theoretical reason for ontic explanations Craver provides is this. Scientists search for explanations for the phenomena they study and formulate explanatory representations, such as models, diagrams, graphs, etc., to explain the phenomena. Accordingly, some representations are explanatory. However, not all representations are genuinely explanatory or explanatorily good. Based on how explanatory representations seem to be evaluated in practice, Craver suggests the following criteria of adequate explanations: (i) A representation is explanatorily genuine when and only when it accurately represents the relevant ontic structure that plausibly counts as explanatory, i.e., ontic explanation, by being responsible for the occurrence of a target of explanation; (ii) A representation is explanatorily good when only when it accurately represents all and only the relevant ontic structure that plausibly counts as explanatory, i.e., ontic explanation, by being responsible for the occurrence of a target of explanation. Craver then argues that an ontic explanation is indispensable because it makes an essential contribution to the criteria as the norm. And

since ontic explanations are indispensable, we therefore ought to commit ourselves to ontic explanations, or so Craver concludes.

Let me repeat the indispensability argument Craver puts forward:

(1) We ought to have ontological commitment to the entities that are indispensable for making sense of explanatory demarcation and explanatory normativity.
(2) By serving as the norm for the criteria of adequate explanations, ontic explanations are indispensable in making sense of explanatory demarcation and explanatory normativity.
(3) Therefore, we ought to have ontological commitment to ontic explanation.

This argument can be challenged in two ways. One is to question premise 1 claiming the legitimacy of an ontological commitment to ontic explanations based on its indispensability for explanatory demarcation and explanatory normativity. The other is to deny premise 2 claiming the indispensability of ontic explanations. I will not question premise 1 but will assume it in this paper. My focus is premise 2. I will argue that ontic explanations are dispensable in making sense of explanatory demarcation and explanatory normativity.

Suppose that the criteria Craver provides are correct for the sake of argument.[14] The problem is that even granted that representing the relevant ontic structure in the right way

[14] Some people challenge the accuracy condition in the criteria of adequate explanations by arguing that at least sometimes representations explain by representing things inaccurately. See Batterman and Rice (2014) and Bokulich (2016). I also challenge the criteria concerning its accuracy

is required for explanatory demarcation and normativity, it does not necessarily follow that the ontic structure should itself be an explanation. Nothing in the criteria is lost or changed by not seeing the ontic structure as itself being explanatory. The evaluation the criteria would provide will remain the same, even though the relevant ontic structure is not explanatory. A representation will still be evaluated as genuinely explanatory as long as it represents the relevant ontic structure accurately, and it will be evaluated as not being genuinely explanatory if it fails to represent the relevant ontic structure accurately. There is also nothing being added by positing ontic explanations. Whether or not we posit ontic explanations, what a representation must do to be explanatorily genuine and good will still remain the same, i.e., representing the relevant ontic structure in the right way.

One may think that the ontic structure must be itself explanatory because representing any ontic structure would not make a representation explanatorily adequate. Not all ontic structures make a representation explanatory if represented, while there are certain ontic structures that can make a representation explanatory if represented. If so, there must be a difference between these ontic structures. And since the difference has to do with explanations, perhaps the difference may be such that some ontic structures are explanatory while others are not. Accordingly, a representation is explanatory if and only if it represents an explanatory ontic structure, not just any ontic structure.

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condition for a different reason in my last chapter. Others question the specificity and completeness conditions in the criterion for good explanations, the part where "all and only" relevant ontic explanations have to be represented is highlighted. See Levy and Bechtel (2013) for this approach.

But note that the criteria do not say that any ontic structure can be represented for explanatory purposes. They say that only those ontic structures that the occurrence of the targets of explanation depends on must be represented. So, the criteria already provide the distinction between the ontic structures that must be represented to explain a target and those that are not to be represented to explain a target. That the criteria are already specific enough in this respect also shows why those ontic structures that need to be represented for explaining do not have to be themselves explanatory. Suppose that the occurrence of a target of explanation depends on a cause. Then, the cause would be the relevant ontic structure that needs to be represented to explain the target, according to the criteria of adequate explanations. Other causes or other types of ontic structures would not be the relevant ontic structures to be represented. And this is not simply because they are excluded by the criteria, but because those ontic structures are not responsible for the occurrence of the target of explanation in the first place. Likewise, the reason why the cause that the target of explanation depends on has to be represented to explain the target is that it is the cause responsible for the occurrence of the target in the first place, not that the cause is explanatory. If this is correct, an ontic structure that needs to be represented just needs to be the relevant ontic structure a target of explanation depends on. It does not have to be explanatory as well. Considering the ontic structure as explanatory is either redundant in that it adds nothing to the criteria of adequate explanations or potentially misleading in that the ontic structure's being an explanation is not the reason why it needs to be represented, strictly speaking.

All that is required for the criteria of adequate explanations to hold is then that the relevant ontic structure should be the object of representation. The criteria do not depend on whether the ontic structure is itself an explanation. But then an ontic structure does not have to be explanatory to serve as the norm for the criteria. And since ontic structures do not need to be explanatory to serve as the norm, their being explanatory is dispensable in making sense of explanatory demarcation and normativity. Therefore, we do not have to commit ourselves to ontic explanations.

So far, I have argued that considering the ontic structures as themselves explanations are not necessary, even though the criteria of adequate explanations Craver provides are correct. This means that even though some proponents of the non-ontic conception that denies ontic explanations may agree with Craver that the criteria are correct, the situation is more favorable to them. If the ontic structures do not have to count as explanatory, then why should we believe in ontic explanations? At this point, however, one may wonder whether there is any real point of disagreement between the ontic conception and the non-ontic conception if both agree with the criteria of adequate explanations. As long as both conceptions coincide with the criteria, one may think that they do not actually disagree about anything substantial about the criteria, except whether they would like to call the ontic structures explanations. It may be just that the proponents of the ontic conception would like to call the ontic structures explanations and the proponents of the non-ontic conception would not, while they both think that the ontic structures are the things to be represented for a representation to be explanatory. Putting this way, the disagreement between the ontic conception and the non-ontic conception may look like a verbal dispute

in that "a dispute between two parties is verbal when the two parties agree on the relevant facts about a domain of concern and just disagree about the language used to describe that domain".[15]

I think there is something that may make the dispute look like a verbal dispute and yet the dispute is not in fact merely verbal. If both conceptions agree with the criteria of adequate explanations, there will indeed be no disagreement on the facts about a domain of concern, where the domain of concern is about when and only when a representation is an adequate explanation. But there is another domain of concern both parties do disagree not just merely verbally. Such a domain of concern is about what type of entity explanation is, which is what a conception of scientific explanation exactly addresses. Thus, even though both conceptions may also disagree about whether the ontic structures should be called explanations, what they really disagree about concerning conceptions is whether the ontic structures *are* themselves explanations. In this regard, there is a genuine metaphysical issue between the two conceptions that is distinct from how the ontic structures are called. The issue, again, concerns whether a type of entity is an explanation and in what sense. And in the dispute over ontic explanations, both conceptions precisely ask this metaphysical question concerning ontic structures: For the criteria of adequate explanations, which metaphysical picture, either in which the ontic structures are themselves explanations or in which the structures are not themselves explanations, should we subscribe ourselves to and why?

[15] Chalmers (2011), p. 515.

Since the dispute over ontic explanations is not merely verbal but a genuine metaphysical dispute, we do need a reason to commit ourselves to ontic explanations if we should. And the reason must be something substantial, not merely how we use our language, due to the worries I raised in section 3. If there is no substantial reason to think that the ontic structures plausibly count as explanatory even though they do not have to be for the criteria of adequate explanations, then ontic explanations are better to be dispensed with for a metaphysical reason, i.e., for the ontological parsimony. Is there then such a substantial reason that is not merely based on how we speak? Although such a reason is missing in the current literature, we can perhaps push ourselves further, on behalf of the proponents of the ontic conception and in connection to the theoretical reason, in thinking about why the ontic structures responsible for explananda should plausibly count as explanations themselves.

I argued that the criteria do not make it necessary for the relevant ontic structures to be explanatory. This is because all that is required for a representation to be explanatory is to represent the relevant ontic structure, regardless of whether the ontic structure is itself an explanation. But what if the criteria actually require more, namely that for a representation to be explanatory, it must represent something that is itself explanatory? The thought is that what is to be represented can make a representation explanatory only when it is itself explanatory. If this is true, then it will support ontic explanations indirectly in that there will be ontic explanations as long as there are explanatory representations. A representation is explanatory only when what it represents is itself an explanation. And some representations are indeed explanatory and what they represent are the relevant ontic

structures. Then, it follows that the relevant ontic structures are themselves explanations. The question is then whether it is true that a representation is explanatory only when what it represents is itself an explanation and what would be a reason to believe this claim.

Two reasons can be considered that would support the claim - the claim that *a representation is explanatory only when what it represents is itself explanatory*- if they are true. Given that the claim concerns the identity of a representation and the property it has, one such reason is a representational one: For a representation to be a representation of a kind *X*, it must represent something that is of the same kind *X.* The other is a metaphysical reason: A representation can have a property of *X* by virtue of representing something that has a property of *X*. Let me examine these reasons one by one. I will show how they would support the claim and ontic explanations if they were true and yet why they are not in fact true or at least not obviously true.

Let me start with the representational reason. What a representation represents certainly determines what kind of representation it is at least partly but crucially. For instance, a representation of a tree, no matter how it represents a tree, is a representation of a tree and not a representation of a flower because of the kind of thing it represents. Likewise, one may think that if a representation is an explanatory representation, that is because it is a representation of an explanation. And perhaps for this reason, one may hold that a representation is explanatory only when it accurately describes an ontic explanation.

However, even though it is true that what kind of representation a representation is depends on what it represents, it is a stronger claim that what is representing and what is represented thus have to be the same kind of thing. And it is a false claim. For it is not the

case that a representation is of a kind *X* only when it represents something that is the same kind *X*. A thing that represents and a thing that is represented do not have to be the same kind of things and are not usually the same kind of things. A representation of *X* is just *about X*, not *is* an *X*. A representation of a tree neither is nor should be the same kind of thing as a tree for it to be a representation of a tree. What a representation should meet in order to be a representation of a certain kind is instead convey the right kind of information about the thing to be represented.

What about the metaphysical reason? Perhaps one may think that we should believe in ontic explanations because it is not just by which explanatory representations are evaluated but by which explanatory representations come to have the property of being explanatory. If whether a representation has a property *X* depends on whether the thing it represents has the property, then a representation will be explanatory only when it represents what is explanatory. In this picture, ontic explanations serve as the source or ground of the explanatory property a representation can have. Accordingly, it is the ontic structure that has the explanatory property in the first place and a representation comes to have the property by accurately describing the ontic structure.

It seems true that whether a representation has a certain property depends on what property the thing it represents has. A map has a property that can help people figure out how to get to B from A. And a map's having this property depends on the spatial property the region the map represents has. If there is a way to get to B from A, then the map that represents the region would have the property of being helpful to people in finding a way from A to B. And if there is no way to get to B from A, then the map that represents the

region would not have the said property. That being said, the claim that (a) whether a representation has a property *X* depends on whether the thing it represents has the same property is different from the claim that (b) whether a representation has a certain property depends on what property the thing it represents has. (a) is what we need for ontic explanations, while it is a stronger claim than (b). Moreover, (a) is at least not necessarily true even though (b) is true. In the map example, for instance, whether the map's having the dispositional property depends on a spatial property the region it represents has. But the two properties the map and the region have respectively are different. Moreover, the region does not seem to have the dispositional property, although the spatial property of the region determines whether the map would have the dispositional property. Likewise, it seems true that the explanatory property of a representation may depend on the property of the thing that it represents. If an event has the property of causing the occurrence of a target of explanation, a representation that represents the event will have the property of being explanatory. And if an event does not have the property of causing the occurrence of a target of explanation, then a representation that represents the event will not have the explanatory property. Still, it does not follow from this that the event must also have the explanatory property because it determines whether a representation has the explanatory property. Perhaps, the explanatory property of a representation may supervene on a physical property of a cause the representation represents. But the properties in the supervenience relation do not have to be the same kind of properties to be in such a relation.

So, where are we now concerning the debate over ontic explanations? That there is no good reason to posit ontic explanations at least until now lends support to the non-ontic

conception that denies ontic explanations. To be clear, the fact that we do not have to posit ontic explanations to make sense of explanatory demarcation and normativity thereby neither proves nor entails that ontic explanations do not exist. Perhaps there may be a reason other than explanatory demarcation and normativity that shows why we should believe in ontic explanations. But the burden of proof is surely on the proponents of the ontic conceptions. It is those proponents who argue that there are ontic explanations, so they must provide a good reason to commit ourselves to ontic explanations. Since we do not have such a reason at least currently, the conclusion that follows is that the ontic conception is left unjustified. Or putting it on a positive note, since we had better not commit ourselves to the existence of an entity unless necessary, we had better live without ontic explanations at least for now.

5. Concluding remarks

There is no doubt that the philosophical dispute about scientific explanation has exclusively focused on what in the world has to do with explanations. One prominent example of such a debate is whether all explanations are causal, i.e., whether only causal relations are relevant to explaining or whether there are other kinds of relations that are also explanatorily relevant. The ontic conception of scientific explanation, however, goes one step further from this kind of dispute; it says not just that a thing in the world responsible for the occurrence of a target of explanation is explanatorily relevant but that a thing in the world is itself an explanation. In this paper, I question whether making this further step is legitimate by questioning why we should believe in ontic explanations. Craver provides

the reasons for ontic explanations, so I examined the reasons. One of the reasons Craver provides is a semantic one, according to which the term "to explain" has the ontic sense that is not only meaningful but also distinct from the other senses of the term. I argued against both the distinctiveness claim and the meaningfulness claim. Then, based on the criticisms I raised against the semantic reason, I motivated why we should turn our attention to the theoretical reason Craver provides, which has been neglected in the debate. According to the theoretical reason, we should commit ourselves to ontic explanations because ontic explanations are indispensable as the norm for the criteria of adequate explanations. I first argued that positing ontic explanations is not necessary for this purpose. All that is needed for a representation to be explanatorily adequate according to the criteria is that it needs to accurately represent the relevant ontic structure. The relevant ontic structure does not have to be itself an explanation. After clarifying that the dispute between the ontic and the non-ontic conceptions is not merely verbal, I then examined some possible substantial reasons to count the relevant ontic structures as themselves explanatory and argued against them. I concluded that without a good substantial reason for ontic explanations, we had better live without ontic explanations at least for now for the sake of ontological parsimony.

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CHAPTER 2. TOWARDS A COGNITIVE APPROACH TO SCIENTIFIC EXPLANATION

Two questions have been asked concerning the relata of and the nature of explanatory relations. Suppose one of the relata, which is explanandum, is some phenomenon in the world. People have debated over what type of entity is then the other relatum, explanans. Suppose what can be an explanans is a thing in the world on which a phenomenon to be explained depends, say, a cause of the phenomenon. The next question is then how it is determined whether the cause explains the phenomenon to be explained. This paper focuses on this latter question and aims to sketch a novel account of explanatory relations. To this end, I will first examine Potochnik's communicative approach to scientific explanation, according to which whether a cause is explanatory is partially determined by what those seeking an explanation are interested to know. I agree with Potochnik in that some cognitive factor must play a determining role in explanations provided that explanations must generate understanding. However, I disagree that a research interest is such a cognitive factor. After showing why a research interest is not the right kind of cognitive factor by raising a series of objections, I will provide and motivate an alternative view, according to which the right kind of cognitive factor is whether a cause can be represented in a cognitively manageable way.

1. Introduction

Conceptions of scientific explanation are the views dealing with the questions on the broad ontological categories of explanation. It is useful to distinguish two related questions: (1) What type of entity is an explanans?[1] Is it a thing in the world or some kind of representation? (2) In virtue of what, is a thing of that type explanatory? Is whether something is explanatory determined mind-independently, mind-dependently, or in some other way?

Concerning what type of entity is explanatory, a conception is ontic if it says that it is a thing in the world that the occurrence of a target of explanation depends on. Those things are, for example, causes, mechanisms, laws of nature, etc., and called ontic explanations. The ontic conception can also allow other types of entities, such as representations, to be explanatory and the proponents of the ontic conception typically do so.[2] In this regard,

[1] This question concerns explanans only. Most of the debates regarding what type of thing an explanation has indeed been about explanans, presumably because of some agreement or assumption that the things to be explained are some phenomena we observe in the world. Notwithstanding, Bokulich (2018) deals with what type of thing an explanandum is and presents a view that not just explanans but also explanandum is a representation of a phenomenon in the world, not the phenomenon itself.

[2] This seems to be the most apparent in the chief defenders of the ontic conception, Wesley Salmon and Carl Craver. Salmon (1989) says that explanation can also be something that consists of sentences or propositions, following Coffa who distinguishes the two ways of speaking of explanation, (a) explanans-facts and explanandum-fact and (b) explanans-statement and explanandum-statement. Craver (2014) also accepts that some explanations are representations based on that we sometimes use the verb "to explain" in the way that a certain representation explains something. When Craver and Kaplan (2011) discuss what makes a model genuinely explanatory or explanatorily better than some other model, their discussion is based on the idea

what makes the ontic conception distinctive from a non-ontic conception is its commitment to ontic explanation. A conception is then non-ontic if it denies ontic explanations and says that all explanations are representations.[3]

Concerning how it is determined whether a thing of a type is explanatory, a conception is ontic if it says whether something is explanatory is wholly determined by what in the world a target of explanation depends on.[4] Suppose that a cause is a type of thing that can be explanatory. According to the ontic conception, a cause just needs to be the cause that is responsible for the occurrence of a target of explanation. Nothing else needs to be met for a cause to be an ontic explanation. Suppose that a representation is a type of thing that can be explanatory. In the ontic picture, such a representation just has to accurately represent the relevant ontic explanation to be explanatory. Overall, the ontic conception considers explanatory relations as mind-independent in the sense that whether something explains something is nothing but the matter of what the relevant part of the world is like. A conception concerning how it is determined whether something is explanatory is then non-ontic if it says either (a) whether, say, a cause or a representation is explanatory is not

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that a model, a kind of representation, can also be explanatory.

[3] For those who argue that things in the world are not themselves explanations but only representations are, see Bechtel and Abrahamsen (2005), Bechtel and Wright (2007), Wright (2012), and Bokulich (2016, 2018). van Eck and Wright raises an objection against the notion of ontic explanation in their 2018 paper.

[4] The defenders of this ontic claim are Salmon (1989), Craver (2014), Lewis (1986), Strevens (2008), Povich (2018).

entirely determined by what the world is like, or (b) at least in some cases, a representation explains even though it does not accurately represent the relevant part of the world.[5]

Angela Potochnik (2015, 2016, 2017) agrees with the ontic conception with respect to its answer to question (1) about conceptions of explanation. She thinks that there are such things as ontic explanations and thus causes, for example, are themselves explanations. However, she disagrees with the answer the ontic conception provides for question (2). She argues that whether a thing in the world is an ontic explanation is not entirely determined by what the relevant part of the world is like, but also partly determined by whether it meets some cognitive needs of those seeking explanations. In Potochnik's picture, explanatory relations are then neither fully mind-independent nor fully mind-dependent. Rather they are a kind of response-dependent relation: A dependence relation in the world can be explanatory and yet it is the bearer of the explanatory property only when it is in the right kind of relationship with those seeking an explanation.

In this paper, I will examine and argue against Potochnik's view in the hope of finding a better response-dependent view of explanatory relations. I will first explain her view in section 2 and argue against it in section 3. Then in section 4, I will sketch what an

[5] Illari (2013), Glennan (2017) Sheredos (2016) and van Eck (2015) can be classified into those who think that whether something is explanatory is not entirely determined by what the world is like. They argue that an explanation should meet both the ontic constraint and the epistemic constraint. Sheredos and van Eck make a further point, namely that the epistemic constraint is more fundamental than the ontic one. For those who argue whether something is explanatory is not determined by whether it accurately represents the relevant part of the world at least in some cases, see Batterman and Rice (2014), Bokulich (2016, 2018), and Kostic and Khalifa (2021).

alternative non-ontic view about explanatory relations should be like based on the lessons I draw from section 3.

2. Potochnik's communicative approach to scientific explanation

Potochnik thinks that there can be many different kinds of dependence relations that can be explanatory, such as causal, constitutive, nomic, etc. However, the gist of Potochnik's view about how it is determined whether something is explanatory is better captured when one focuses on one type of dependence relation. This simplification does not hurt because her view does not rest on the plurality of the types of explanatory dependence relations. Rather, Potochnik's view rests on the plurality of one type of dependence relation for a target of explanation. Let me explain what that plurality is, focusing on causal dependence relations, and how the plurality leads Potochnik to hold her version of the response-dependence view about explanatory relations.

Suppose that a researcher seeks an explanation of why a target phenomenon occurs. She further characterizes the phenomenon with a particular why-question and a contrast class together which reflect what the researcher is interested to know. Once a target of explanation is specified in the foregoing way, one may think that the only thing left for the researcher to do to identify the explanation is just look at the world and see what the cause of the target is. However, the causal reality is more complex than this, according to Potochnik. She has it that there are potentially many different types of causes for one and the same target of explanation specified by a why-question and a contrast class. This is the kind of plurality she has in mind. For instance, for why vampire bats share food selectively

rather than not sharing, there are not just one but potentially many different types of causes that may be responsible for the target, such as the selective food-sharing behavior evolved over time due to its conduciveness to greater fitness, or a certain gene variation leading to the predominance of the sharing bats over non-sharing bats, or a learned trait propagated by sharing bats and contributing to their predominance.[6]

Because of the foregoing causal plurality, Potochnik thinks that which type of cause out of many explains a target of explanation is not yet decided, even though the target and its various types of causal facts are fixed. The world is too complex for a human researcher with a limited cognitive capacity to study all at once. So, researchers need to decide which type of causes they will focus on and cite in the explanations they formulate.[7] Presumably, such a decision is made based on what a researcher is interested to know, which ends up leading to whether a cause's being an ontic explanation depends on a researcher's interest. She says:

[6] See Potochnik (2016), section 2 for the example.

[7] This idea is the most explicit in the following passage: "Ontic approaches to explanation focus on what out in the world is responsible for the phenomenon to be explained, what we might generically call dependence relations. And yet potentially many dependence relations bear responsibility for any given event. This is especially obvious for causal accounts of explanation, since causal dependencies stretch indefinitely far through time, and at any given point in time there may be several causal dependencies at play…. Accordingly, for any explanation formulated in science, one must decide which of potentially many dependence relations to represent" (2016: 724).

> The trait-propagation explanation and the reciprocal altruism explanation represent different dependence relations, each responsible for the same phenomenon. They target the same explanandum and contrast class: why vampire bats share food selectively (rather than not sharing). But explanation-seekers interests can vary in a way that makes one, but not the other, a successful explanation. The reciprocal altruism explanation succeeds when researchers wonder about the role of natural selection in bringing about the trait in question. The trait-propagation explanation succeeds when researchers wonder about the role of genetic and other forms of transmission in bringing about the trait in question…. For researchers with one of these questions, the explanation that answers the other question is a nonexplanation.[8]

Due to the plurality of types of causes, research interests vary. This leads researchers to look for different types of causes for their inquiries, even though they are all interested in understanding the same target of explanation. As a consequence, Potochnik thinks that a type of cause is explanatory to a researcher whose research interest is about that type, while the same cause is a nonexplanation to other researchers with different research interests. Whether a type of a cause is explanatory then depends on what a researcher is interested to know and thus which research project she is committed to. Potochnik concludes "…any explanation is relative to the background research agenda, that is, to what sort of causal regularities are of interest. Thus, there is always a third factor influencing explanations,

[8] Potochnik (2016), pp. 726-727.

beyond the explanandum and the causal facts: the research program in which the explanation is sought".[9]

Here comes Potochnik's respondent-dependent view about explanatory relations. Explanatory relations are not fully mind-independent in that for a type of cause to be explanatory, it is not enough for it to be a cause responsible for the occurrence of a target of explanation. A cause also has to be in the right kind of relation with the researchers seeking an explanation. And a cause is in the right kind of relation with the researchers only when it is the cause they are interested to know. Therefore, for a type of cause to be explanatory, it must be what a researcher is interested to know. Since to whom an explanation is communicated and what her research interest is play a crucial role in determining whether something is explanatory, as when "to explain" is used in the communicative sense (e.g., "S explains X to S'), the view is called the *communicative approach to scientific explanation*.

At this point, one may wonder why a research interest plays the foregoing determining role in explanations. Something may or may not be the answer one is looking for. But why is something (not) an explanation in what sense, if it is (not) what a researcher is interested to know and thus the answer she is (not) looking for? What does a research interest have to do with whether something is a genuine explanation in the first place? These questions arise because presumably, that one is interested to know about something does not thereby, at least necessarily, determine what that thing is. The fact that I am interested to know about physics does not thereby define what physics is. So, unless there is something about

[9] Potochnik (2015), p. 1175.

an explanation that is not just closely related to but based on what those seeking an explanation are interested to know, there seems to be a gap between research interests and explanatoriness. And with this gap left open, Potochnik's view about explanatory relations is left unjustified.

Note that the gap cannot be closed simply by claiming that an explanation is nothing but an answer to a why-question - strictly speaking, the answer one is looking for - like the pragmatic accounts of explanation say.[10] This is because what is being questioned here is why the explanation is nothing but an answer to a why-question in what sense if it ever is. Potochnik also seems to be aware of this when she makes clear what she tries to show. She says,

> My task in this section is not to advocate for any particular account of explanation. Instead, I consider the prior question of what an account of explanation should accomplish. Strevens (2008b) and Craver (2014) both explicitly defend the view that the task for an account of explanation is to indicate what facts out in the world explain any given event. Craver says, "The philosophical dispute about explanation, from this ontic perspective, is about which kinds of ontic structure properly count as explanatory and which do not" (29). In contrast, my emphasis on how human cognitive needs shape scientific understanding leads instead to a focus on explanations

[10] The proponents of the pragmatic account of scientific explanation focusing on an act of explaining and arguing that explanation is an answer to a why-question or something along the line, see Achinstein (1983), Bromberger (1966), van Fraassen (1980).

> as particular acts of communication. On this alternative approach, an account of explanation should indicate what representation counts as a satisfactory answer to any given request for explanation.[11]

Differently put, what is at issue is why whether something is explanatory cannot be determined purely by what the world is like but also by what those seeking an explanation are interested to know, as Potochnik argues, so that why we should subscribe ourselves to something like the pragmatic accounts of explanation.

So, does Potochnik provide something that can close the gap between research interests and the property of being explanatory? In fact, it is hinted in the above quote when she says about human cognitive needs and scientific understanding and also in other parts of her writings.

Potochnik thinks that whether something is explanatory depends on whether it generates understanding. Arguably, as the means of achieving scientific understanding, "Scientific explanations must be comprehendible by humans – they must generate human understanding".[12] The next question is then when understanding is generated. Something

[11] Potochnik (2017), p. 123

[12] The quote is from Potochnik (2017), p. 127. Also, Potochnik says that explanation is *the* means of achieving scientific understanding, but this claim is debatable even to those who think that generating understanding is what an explanation does. For instance, Peter Lipton (2009) argues that scientific understanding also can be achieved by means other than scientific explanation. The issue, of whether an explanation is the mean for understanding, will not be discussed in this paper. And to be clear, all Potochnik actually needs for her argument is the claim that generating understanding is a necessary condition for something to be an explanation, not that generating

must be represented to someone for an understanding to be forged and apparently not just anything can be represented to this end. Concerning this, Potochnik says the following: "…. the connection between explanation and understanding.... demonstrates the centrality of human cognitive requirements to the production of understanding and thus to scientific explanation. Not only must explanations connect to the world in the proper way, but they must also connect to their human audience—the producers and consumers of explanations—in the proper way". [13] What needs to be represented for the proper connection to the world to obtain is, say, a cause that is responsible for the phenomenon. And what needs to be represented for the proper connection to an explanation's audience to be secured and thus for an understanding to be generated is a cause that meets her cognitive needs, namely what she is interested to know. This is the reason why "[t]he two different causal patterns generate understanding in the context of different research programs"[14], and thus a type of cause is enlightening only in the context where the cited type of cause is of interest, while the same type of cause is not outside of the context.[15]

To sum up, since explanations must afford understanding and "[d]etermining which factors to cite to generate human understanding requires consideration of what exactly

understanding is a sufficient condition for something to be an explanation.

[13] Potochnik (2017), p. 123.

[14] Ibid., p. 151.

[15] Potochnik explicitly uses the notion of enlightenment in the following passage: "…. the game theory explanation is *enlightening* to those who wonder about whether and how natural selection led to this variation in color, while the phenotypic plasticity explanation is *enlightening* to those who wonder about whether and how the environment mediates genetic influence to produce this variation in color. In each case, the other explanation is entirely beside the point" (2015: 1174-5).

explanation-seekers want to understand", determining which factors to cite to explain also requires the same consideration.[16] Therefore, whether something is explanatory to a researcher is partly but ineliminably determined by what her research interest is, or so Potochnik thinks.

Now that the gap between research interests and explanatoriness is closed, let me put Potochnik's view in the following argument:

1. There are potentially many different types of causes for a target of explanation specified by a particular why-question and a contrast class.
2. Researchers are interested in the different types of causes for the target of explanation.
3. A type of cause is an explanation to a researcher *R* only when the type of cause (when represented) brings about understanding to *R*.
4. A type of cause (when represented) brings about understanding to *R* only when the type of cause is what *R* is interested to know.
5. A type of cause is an explanation to *R* only when the type of cause is what *R* is interested to know. (From 3 and 4)
6. Therefore, different types of causes are explanations to different researchers with different research interests. (From 2 and 5)

[16] Potochnik (2016), pp. 730-731.

Potochnik's argument crucially relies on the three premises: P1 on the plurality of causes, P3 on the relation between understanding and explanations, and P4 on a view about understanding. Although all these premises are controversial and thus need justification, I will focus on P4 in this paper. In particular, I will not put P3 into question but assume it in this paper.[17] This means that the focus of this paper is restricted as follows: Provided that explanations must generate understanding, and some cognitive factor must be taken into consideration for an understanding to be generated and thus to render something to be explanatory, what cognitive factor should it be? Is it a research interest as Potochnik contends or something else? In what follows, I will argue that Potochnik identifies the wrong factor.

3. Against Potochnik's communicative approach to explanation

One may wonder, in the first place, whether something like P4 is generally true in the everyday life. They may think that something will generate understanding in someone's mind even though that person is not interested to know about that thing. Even though students may not be interested in what they learn in class, it seems that they can still achieve an understanding of the things they are being taught at least to some extent. It even seems to be the case that sometimes people were not initially interested to know about something, say, a scientific theory, and then become interested in that theory thanks to the understanding the theory brings about. For the reasons like this, P4 may look like a non-

[17] For the people who advocate or at least assume the connection between explanation and understanding, see Friedman (1974), Hempel (1965), Kim (1994), and Wilkenfeld (2014).

starter to some people. But others may think that there is something right about P4. If people are completely uninterested in the things presented to them to the extent that they are not attentive to the things at all, no understanding may be generated in their minds.

Perhaps the truth of P4 turns on the details about human psychology and cognition, such as when one can be seen as being interested to know about something, what happens when one is or is not interested to know about something, etc. Instead of examining these questions *in extenso*, however, I will consider the truth of P4 in a rather indirect way. I will argue that P4 is false on the ground that, were the premise true, it would conflict with some aspects of scientific practice.

Let me first examine what P4 precisely means. P4 says that a type of cause generates understanding only to a researcher whose research interest is about that type of cause. If this means that a cause does not generate any understanding whatsoever to the researchers who are not interested in that cause, then P4 seems to contradict the way scientists usually think about the research programs other than their own. The kind of causes scientists are interested to know would usually be the kind of causes the research programs they are part of. In that respect, the kind of causes studied and found by other research programs are typically not the type of causes of their interest. But just because a cause is not of their research interest, scientists would not simply think that the cause does not generate understanding to people including themselves, unless the research program that studies and finds the cause is incompatible with their own or known to be wrongheaded or suspicious.

Also, think about a research program that has been deemed successful and thus well-established in the whole scientific community. If such a research program were able to

shed light on why a phenomenon occurs only to the people belonging to the research program, it would have not enjoyed its status in the whole scientific community or at least its status would have been hard to be justified. Of course, the people who may be able to appreciate and show why the research program is successful would be the people part of that program. But it is one thing who can apprehend something the best. And it is quite another whether the thing is apprehensible to people. And the place of a successful research program in the scientific community seems to depend on the latter; its status is based on or at least justified by its ability to enhance people's understanding of certain things and thus to promote scientific progress in general, no matter what each person is particularly interested to know.

P4 also seems to contradict how an unexpected or novel discovery is construed in practice. For instance, classical conditioning in psychology was discovered accidentally by Ivan Pavlov whose research interest, as a physiologist, concerns how a dog's salivation works. Even though his research interest was not how humans and comparatively intelligent conscious beings learn things unconsciously, the experiment Pavlov conducted for his original research interest actually provided him with an understanding of the learning process, which eventually led him to formulate the theory of learning by association. Accidental discoveries like Pavlov's case are pervasive in the history of science and show why P4 seems to be false. Were P4 true, accidental discoveries would not have generated an understanding of the things observed and thus have not resulted in a scientific breakthrough as they have done.

Furthermore, it is neither that scientists know all the time what type of thing they should find out for what they want to understand and thus should be interested to know, nor that scientific discoveries have always been made because scientists knew what they would want to investigate to achieve the desired understanding. Sometimes, especially in the dawn of a research program or in the case of a burgeoning research area, researchers initiate their research about a phenomenon they want to understand, not knowing what exactly they should examine to understand the phenomenon. In such a case, people debate over what would explain the phenomenon in question, e.g., whether the phenomenon can be explained by what is postulated or allowed by the current theories, or whether a new theory positing new objects or properties is needed to understand the phenomenon, etc. And from time to time, advances in science have been made by achieving an understanding of the phenomena under study, despite the absence of knowing in advance what kind of thing should be sought to achieve the understanding of the phenomena. Think about novel discoveries. Many scientific understandings, throughout the history of science, have been achieved by finding out new things that could not be captured by and cashed out in terms of the previous research interests and projects. Both an unexpected discovery and a novel discovery in scientific practice then serve as a counterexample to P4. They show that an understanding will still be generated even though one's research interest was not actually about the things that bring about the understanding.

I have argued that P4 is too strong to say because of some aspects of scientific practices that are contradictory with or at least in tension with P4. Those aspects are what attitudes scientists usually seem to have towards research programs other than their own, why the

research programs accepted in the whole scientific community can enjoy their status, and how an unexpected or novel discovery can contribute to scientific progress. Given the implausibility of P4, perhaps what we can say more reasonably and similarly to P4 should be something weaker as follows: A cause brings about not just any understanding but *the kind of understanding* a researcher wants to have only when she is interested to know about that cause (P4'). A certain type of cause such as phenotypic plasticity will bring about the kind of understanding of how vampire bats have evolved the trait of selective food sharing rather than not sharing to a researcher only when she wishes to achieve the said kind of understanding and thus are interested to know about the related type of causes. Perhaps the weaker claim is what Potochnik might actually have in mind when she says a type of cause is enlightening only to those researchers interested to know about that cause.

P4' seems weak enough to be safe. However, it is too weak for the conclusion of Potochnik's argument to follow. P4' implies that a cause does not generate the kind of understanding a researcher wants to achieve if the cause does not match her research interest. However, it does not follow from this that the cause does generate any understanding at all to the researcher. It is just that the cause cannot generate the kind of understanding the researcher is after. But if this is the case, then a research interest can no longer determine whether something is genuinely explanatory. All that would follow from P4' is not P5 which says that a cause is an explanation to a researcher only when the cause is what she is interested to know, but that a cause is *the kind of explanation* a researcher wants to have only when the cause is what the researcher is interested to know. Nowhere

in this picture plays a research interest a determining role in whether a cause is an explanation in the first place.

So, P4 seems to be false, which makes Potochnik's argument unsound. P4', on the other hand, seems to be true, but it will render her argument invalid because P5 does not follow from P3 and P4'. The only option left, if Potochnik or anyone else wants to defend P5 based on P4' and something like P3, is then to modify P3 and the related part of the argument as follows:

3'. A type of cause is an explanation to a researcher *R* only when the type of cause (when represented) brings about to *R* the kind of understanding *R* wants to achieve.

4'. A type of cause (when represented) brings about to *R* the kind of understanding *R* wants to achieve only when the type of cause is what *R* is interested to know.

5. A type of cause is an explanation to *R* only when the type of cause is what *R* is interested to know.

P5 does follow from P3' and P4'. But now the problem is P3'. I will present two reasons why P3' seems to be false.

First, it seems possible for a type of cause to be a genuine explanation to a researcher even though the cause does not bring about the kind of understanding the researcher pursues as her research aim. Think about the cases in which a type of cause may not be the research aim of a researcher. One such case is when a researcher already knows well about the type of cause *C* and how certain things come about due to *C*. Since she knows well

about *C*, she may pursue a different type of *C'* as her research aim. That being said, this does not seem to render *C* a nonexplanation to her. Rather, the researcher is in a good position to know why *C* is an explanation and to use it when needed, such as teaching it to her students or using it when it is related to studying *C'*, all of which would have not been possible if *C* were literally a nonexplanation to the researcher.

Second, the explanatory status of a cause would become more variable than it actually seems to be, if the status were dependent on whether a cause generates the kind of understanding a researcher wants to achieve. The kind of understanding one is looking for may change. The question is whether the explanatory status of a cause shifts whenever one's research aim does or at least whether that is how the explanatory status of something is construed in practice. Suppose that a researcher's aim was to achieve a kind of understanding at time *t*. If P3' is true, then a cause that generates the kind of understanding is an explanation to her at time *t*. The researcher then starts a new research project with a different research aim at time *t'*. Then, the cause that was once an explanation to her at *t* is no longer an explanation to her at *t'*.

It seems that we usually do not think that the explanatory status of something shifts as easily and frequently as described above. Some may even think that the explanatory status of something is permanent. If something is an explanation, then it remains as an explanation for good no matter what our epistemic situation is like. The proponents of the ontic conception would think this way.[18] To them, what explains ultimately depends on

[18] Pincock (2018) challenges the contextualist approach to explanation according to which whether something is an explanation varies from context to context, based on the permanence of the

facts and facts do not change as our epistemic situations do. In the first place, what the world is like is distinct from what we know. But even though one thinks that the explanatory status of something is not permanent as the ontic view says and yet is relative to our epistemic situation and thus may be subject to change, one may still resist the idea that the status is as variable as P3' implies. One may think that depending on what we have discovered and confirmed, what is accepted as an explanation and thus acquires the status of explanation may change. The history of science seems to be a witness of this kind of change in some sense. Science has evolved by finding out what was once accepted and worked as an explanation is turned out not to be true and eventually replaced by a different and presumably better explanation. Note that the explanatory status of something is variable in this picture as well. However, the status changes only when the accepted theories change or at least when there is good evidence to attest that the explanatory status of something should be reconsidered. As long as the explanatory status of something depends on what our current best science tells us, whether something is explanatory can change, but not as often as the research aim of an individual researcher or research program pursues can.

The point is this. Whether the explanatory status of something is permanent or variable depends on how one thinks about explanation, i.e., whether an explanation is based on worldly factors only or (also) on some epistemic factors. Either way, however, the explanatory status of something is thought to be more stable than it could have been by depending on whether it generates the kind of understanding a particular researcher or

explanatory status of something.

research program is after. And I think this way of looking at the matter is closer to scientific practice. What really happens in the practice is that once something is accepted as an explanation, it enjoys its status in a relatively stable way, while what a researcher wants to study can be more variable. If so, there is something wrong about thinking that whether *X* is explanatory is subject to whether *X* generates the kind of understanding a researcher wants to attain.

To sum up, Potochnik argues whether a cause is an ontic explanation depends on whether the cause is what a researcher is interested to know. Her view rests on two premises, one of which says that explanations must generate understanding and the other says that the relevant cognitive factor for something to generate understanding is a research interest. In this section, I examined various possible ways that Potochnik's view may follow from the premises like these two and argued against each way.

That there is no possible way for Potochnik's view to be maintained then leaves us with two options. One option is to give up the premise saying that explanations must generate understanding and thereby give up the idea that whether something is explanatory is partly determined by some cognitive factor. This option then points us to the two possible ways to go: Either the ontic conception about explanatory relations is correct, or one must provide a reason other than the connection between understanding and explanation if one wants to argue that explanatory relation is not entirely determined by what the world is like. Another option is to keep the premise on the connection between explanation and understanding but give up Potochnik's premise that the relevant cognitive factor for understanding is a research interest. Then, the remaining task would be to identify a

different cognitive factor. In what follows, I will take this last option and sketch a way forward to an alternative view of explanatory relations.

4. Toward an alternative non-ontic approach to scientific explanation

Given the connection between explanation and understanding, I think Potochnik rightly points out that whether something is explanatory must at least partly depend on some cognitive factor of an explanation's audience. Understanding may mean the mental state of understanding or a content one should have to be in the state of understanding. Either way, understanding seems to inevitably have something to do with a cognizer and her cognition. As a mental state, understanding is the matter of *someone*'s understanding something, while as an epistemic achievement, understanding is the achievement of *human cognition*. If this is right, which cognitive factor is relevant in determining whether something is explanatory seems to be a genuine question to ask.

The things I discussed in the previous section help us identify what may be such a cognitive factor. Arguing against Potochnik's view, I argued that a cause brings about understanding, if it does, not just to a particular researcher or research program interested in that cause but also to any other people uninterested in that cause. This point implies two things. One is that if a cause generates understanding, it does to someone regardless of her research interest. Another is that if a cause generates understanding, a cause brings about understanding to anyone in the whole scientific community. I focused on the first implication in the previous section to show that a research interest is not the right kind of cognitive factor for understanding and thus for explanations. It is the second implication

that can be particularly helpful in this section. It tells us *whose* cognitive factor is relevant to explanation: It is not a particular researcher or a group of researcher but *anyone in the scientific community*.

At this point, a few more things need to be said about "anyone in the scientific community", i.e., whether it means any scientists, or means any scientists *and* laypersons. It seems to me that scientific understanding is not limited to scientists. Understanding is a gradable notion and the experts would usually have a better understanding of their field of research than non-experts would. The scientific understanding non-experts would have may then be less good or complete compared to the understanding experts have. Still, non-experts including laypersons also seem to be able to have scientific understanding to some extent. If this is correct, "anyone" should include not just any scientists but also any laypersons. Still, not just anyone in this sense may be able to have a scientific understanding. What about babies or cognitively impaired people? Or those who lack some necessary background knowledge and training of thinking in a scientific way? It seems that no understanding will be generated in these people's minds, at least with their current mental states. This then shows anyone needs to be restricted. For this, I suggest the following, which may still be rough but captures the foregoing consideration to some extent. By anyone, I mean anyone who satisfies the following counterfactual: Had one possessed, at least to some extent, the relevant background knowledge and skills experts have for *X*, she would have achieved, at least to some degree, the understanding of *X* experts have.

Concerning whose cognitive feature has to be taken into consideration for understanding and explanation, I proposed any human being in the scientific community meeting the foregoing counterfactual. For brevity, I will just say human beings to mean anyone in the restricted sense from now on. The next question to ask is then *what* cognitive feature of such human beings has to do with understanding and explanation. Such a feature should not be a research interest nor something that only some people have. Rather, it should be something general that all those people have or can have. Then, what would such a general cognitive feature be? I think the relevant feature is the cognitive ability and limitations humans in general have as human beings. Let me motivate this view and say more about how this feature shapes the cognitive factor for understanding and explanation.

In his 2003 book, James Woodward argues against the DN account and Peter Railton's ideal text account of explanation on the basis of *epistemic accessibility*. He argues that some underlying hidden structure that is epistemically inaccessible to those who use explanations, whether it be a DN argument or ideal explanatory text, has no explanatory significance to the people and thus cannot be part of explanations. To Woodward, that something is not explanatory if it is epistemically inaccessible is based on the connection of understanding and explanation. He says,

> It is a plausible constraint on what an explanation is that it must be something that provides understanding. To say that certain information is "part" of an explanation or contributes to its explanatory import is to say that this information contributes to the understanding provided by the explanation. This in turn imposes an epistemic constraint

> on what information can be part of an explanation and can contribute to its explanatory import: such information must be epistemically accessible to those who use the explanation. Put slightly differently, the idea is that the features of the explanation that endow it with explanatory import - that make it an explanation - must be features that can be known or grasped or recognized by those who use the explanation; if not, it isn't in virtue of possessing those features that the explanation produces understanding.[19]

According to Woodward, explanations must provide understanding. And to provide understanding, the things that are supposed to provide understanding should be epistemically accessible. That is why some underlying structures hidden from us, epistemically speaking, is not explanatory in Woodward's picture. How can something that we as humans cannot epistemically access possibly bring about understanding to us? Based on this idea, Woodward thinks that the theory of explanation must have an adequate epistemological basis in the following sense: "If the theory tells us that an explanation works by conveying certain information or by possessing a certain structure, then there should be some plausible accompanying epistemological story that makes it clear how people who use the explanation can learn about this information or structure, how they can check whether the claims embedded in the explanation are correct, and so on".[20] In other words, it is not just what kind of things in the world may be relevant to explaining the theory of explanation should say about. The theory also must say about how the things that

[19] Woodward (2003), p. 179.

[20] Ibid., p. 23.

are relevant to explaining are accessible to people so that they can check and learn about them.

I agree with Woodward that for something to be explanatory, it must be epistemically accessible to those who seek and use explanation. Epistemic accessibility seems to be a plausible epistemic constraint to explanation, given that explanations must provide understanding. Still, there is a difference between me and Woodward, at least in what we place an emphasis on in light of epistemic accessibility. Woodward focuses on *what* should be conveyed to be explanatory. Hidden underlying structures are not the proper thing to be conveyed, let alone whether they can ever be because they are inaccessible objects to us epistemically speaking. Such structures may obtain and also have to do with why a target of explanation occurs. But because they obtain "independently of anyone's awareness of its existence", such structures lack explanatory import.[21] In this regard, what can be explanatory is only the things whose existence is epistemically accessible to us.

However, I think what should be conveyed is only one part of the story of epistemic accessibility for understanding. As Woodward points out in the above quotes, for something to provide understanding to people, people should be able to learn about the thing and check whether what that thing says is correct as well as they can know, grasp, or recognize the thing. And for people to be able to conduct these epistemic activities, I think *how* things should be conveyed also matters because of the complexity of the world and human cognitive limitations.

[21] Ibid., 179.

Many philosophers have highlighted the complexity of the world and human cognitive limitations and discussed their implications for scientific practice.[22] Potochnik is also one of them. Not only that, but she tries to advance her view about explanation based on these facts about the world and human cognition. Although where she arrives at from the two facts is the view that what explains is determined by a research interest which I argued against in the previous section, I agree with Potochnik with respect to her starting point. As long as the theory of explanation should be based on scientific practice, and as long as explanations must provide understanding, how human beings with limited cognitive capacities can achieve an understanding of the complex world has to be part of what an explanation is. Now let me spell out how this consideration makes the way things should be conveyed also matter when it comes to understanding and explanation.

Presumably, there are multiple dimensions in which the world is complex. Potochnik lists four such ways, two of which are particularly relevant to the present concern. The world is complex in the way that "there is an extensive range of influences on any phenomenon".[23] It is complex also in the way that "there is even complexity in how individual influences affect a phenomenon".[24] For a single phenomenon to be explained, then, there is not just numerous causes but also the complicated relations among the causes. If this is what the causal facts of a target of explanation looks like, one does not seem to be

[22] For example, Bechtel and Richardson (1993), Cartwright (1999), Dupré (1993), Mitchell (2012), and Wimsatt (2007) emphasize and advance their views on various topics based on the complexity of the world science studies.

[23] Potochnik (2017), p. 14.

[24] Ibid., p.14.

able to learn about and check the causes and their relations as much as an understanding is generated, even though they are epistemically accessible in Woodward's sense. It would rather be like looking for a needle in a haystack or presenting a quantum phenomenon as it is to kids. If this is correct, then the mere accessibility of *X* in the sense that the human mind can access its existence is not enough. For *X* to generate understanding to people, it must be accessible also in the sense that people can manage to see through, despite its complexity, how the phenomenon to be explained comes about by *X*. How things are represented then matters for this latter sense of epistemic accessibility. Things need to be represented in a way that the human mind can grasp and recognize their relations and workings. Otherwise, *X* does not generate understanding and thus cannot be explanatory.

Based on that human cognitive limitations are the relevant cognitive feature for understanding and explanation due to the complexity of the world and the richer notion of epistemic accessibility, I suggest a view called a *cognitive approach to explanation*, which identifies the following cognitive factor for understanding and explanation: A cause provides understanding and thus can be explanatory only when it can be represented in a *cognitively manageable way*. By a cause's being represented in a cognitively manageable way, I mean a cause can be represented in the way that the human mind can work on in the sense that it can see and grasp why a target of explanation occurs by the cause. Then, in what way does a cause need to be represented for this purpose? I think two things matter in virtue of the two ways the world can be complex I previously mentioned. One concerns the number or range of causes to be represented. Representing more things than the finite human mind can handle is not cognitively manageable and thus would fail to generate

understanding. The other concerns the level of complexity of causal relations to be represented. For the complexity to be cognitively manageable to a human mind, some degree of simplification, whether it be a form of abstraction or distortion, can be necessary. Otherwise, again, a cause would fail to generate an understanding to us human mind and thus would lack explanatory import.

For the rest of this section, I will compare my view with Potochnik's, clarify how my view avoids the problems I raised against Potochnik's view, and briefly discuss an issue concerning what my view implies.

The first point of comparison has to do with what to be represented and how it should be represented to explain. Both Potochnik and I take these representational considerations seriously. Not all the causes responsible for the occurrence of a target of explanation are to be represented. There are just too many causes, at least potentially, for a given target, while human mind is limited. A kind of focal representation in the sense that one must select some causes to represent is thus required. Otherwise, the representation can be misleading to the human mind in that one may get the causal relations wrong.[25] In addition, not all the

[25] A similar line of thinking, although Potochnik attributes the cause of a representation's being misleading to its failing to represent things in line with what an explanation's audience wishes to know, is the most apparent when she argues why integrated explanations are bad to argue against Lewis's ontic view (1986). According to Lewis, all the causes on which a target of explanation depends are the whole or just the explanation. If all the causes are explanatory, then all of them should be represented to explain a target, irrespective of the research interests a researcher or a research program has. However, such an explanation would not be genuine, according to Potochnik. This is because a non-focal representation of causes would get people wrong about ontic explanation. See Potochnik (2016), p. 728.

causal factors that are closely related to the occurrence of a given target are represented in the same manner. Due to the complexity of the causal relations, the causes of focus are typically represented in detail, while the other causal factors are represented in a simplified way.[26]

Although Potochnik and I coincide in the foregoing issues about representational decisions, there is also a subtle but considerable difference between our views. First, Potochnik argues that what is to be represented to explain should be a cause a researcher is interested to know. However, my view does not require that a cause to be represented has to be what those seeking an explanation are interested to know because a cause still generates understanding to people irrespective of their specific research interests. Similarly, Potochnik argues that it is the causes of interest that must be represented in detail, for only those causes of interest generates understanding and thus can be explanatory. In contrast, the reason why the way things should be represented matters is different in my view. It is not because of the connection between a research interest and understanding but because of the causal complexity and the limited human mind. In other words, a selective and simplified representation is needed not because a cause generates understanding only when it is what a researcher is interested to know, but because a cause generates understanding only when it is represented in a cognitively manageable way. The difference between her view and my view is subtle in that we may end up agreeing with what a genuine explanatory representation would look like. I even think that a research

[26] On what Potochnik says about how the audience influences not just what to be represented but also how things should be represented, see Potochnik (2016), p. 727.

interest can be useful in making a representational decision to represent things in a focal and simplified way. Nonetheless, the difference between her view and my view is considerable in that what we agree may only be the end result and not *why* the end result should look like in the way we think it should be. And for the theory of how it is determined whether something is explanatory, why whether something is explanatory is determined this or that way is important.

The second point of comparison is similar to the first point, although the second one is specifically about the explanatory role of idealizations. For those who think that idealized models are explanatory or at least explanatorily relevant, the task is to explain how and why they have such an explanatory role. One of the main issues concerning idealizations is how falsity can explain, for idealized models are literally speaking false representations of the target systems or phenomena. That being said, the focus here is why simplified and distorted representations may be explanatory if they are. On this matter, there is again something Potochnik and I agree: Idealized models have an explanatory role because they can facilitate our understanding of a target of explanation. But we disagree with the reason why idealized models can facilitate our understanding. While it is because idealized models focus on the causes of research interest in Potochnik's picture, it is because the models represent the causes and their relations in a cognitively manageable way in my picture.

Let me recap the two points of comparison by diagnosing the source of the difference between my view and Potochnik's view. Both Potochnik and I start from the connection between understanding and explanation, the complexity of the world, and human cognitive limitations. And yet, we depart when Potochnik introduces a research interest as a cognitive

factor that determines whether something generates understanding. On the contrary, my view directly relates the cognitive factor to human cognitive limitations and says that because human cognition is limited while the world is complicated, things should be represented in the way that human cognition can handle.

A cognitive account I propose also avoids the problems I raised against Potochnik's communicative approach. The main point of my criticism was that it is not that a cause generates understanding only to the people who are interested to know about that cause. And I argued that Potochnik's view about a research interest and understanding is wrong in that what it implies contradicts some aspects of scientific practice, such as how scientists usually think about research programs other than their own, why a successful research program in the whole scientific community can enjoy its status, and how an unexpected or novel discovery can contribute to scientific progress. However, since my view neither claims that a cause generates understanding only to some people with a particular research interest nor identifies some cognitive feature only some people have, my view does not have the problems Potochnik's view has. Instead, my view rests on some common cognitive feature anyone has or can have. So, even though a cause is not what people are interested to know as in the case of unexpected or novel discoveries, it still provides understanding and thus be explanatory, as long as it is represented in a way that people can see how it brings about a target to be explained. And even though people may be different in terms of some particular cognitive features they have such as what they are interested to know, this does not render a cause not to generate understanding to some people in my

picture, which is consistent with how people think about other research programs and how a successful research program enjoys its status in the whole scientific community.

Lastly, recall that I proposed that a cause is explanatory to anyone in the whole scientific community if it is and defined anyone as those who can satisfy the following counterfactual: Had one possessed, at least to some extent, the relevant background knowledge and skills experts have for *X*, she would have achieved, at least to some degree, an understanding of *X* experts have. Since my view says that a cause provides understanding, if properly represented, to anyone who *can* have the common cognitive feature, a cause is still explanatory to those who do not currently have the feature. As long as they can have such a feature, a cause is explanatory to them as well. This coheres well with why the explanatory status of a cause seems to be more stable compared to how easily some particular cognitive needs an individual cognizer has can change, even though the explanatory status of something is at least partly determined by some epistemic situation of people. As long as the explanatory status of a cause rests on the cognitive feature people can have, its status does not vary by what feature those people currently have or do not have.

Let me conclude this section by briefly thinking about one thing that my view implies. Since I argue that whether a cause is explanatory depends on whether it can be represented in a cognitively manageable way, my view implies that the same cause may or may not be explanatory depending on how it is represented. Some people may find this implication problematic or at least questionable. They may think that there is something wrong or weird about thinking that a cause becomes explanatory or non-explanatory just by changing the

manner of representing it and its relation to other factors, even though nothing really changes in the cause itself and its relation to a target of explanation. Sometimes such a change in representation can be very minor in that the change may be on the borderline of what human cognition can know, grasp, or recognize. But I think even a small change in how things are represented does make a difference in whether something is explanatory. As long as explanations must produce understanding and thus cannot but depend on what the human mind can or cannot work on, a small change is in fact not so small. Just like whether one will see things accurately or experience an optical illusion can be determined by a small change made in the environment where perception occurs, one may or may not achieve an understanding if what is presented to her is not optimal to how her mind works.

The same worry also can be put in terms of what methodological and theoretical tools we currently have. Depending on what methodological and theoretical tools are available, how a cause can be represented can differ. Thus, depending on the availability of such tools, the same cause may or may not be explanatory. Putting this way, however, I think it is more apparent to see why this line of worry is not a real challenge to my view. Even though people have observed and studied the same phenomenon over a long period, some may have an explanation while others do not. For example, some causes and their relations had not been graspable until the advent of a modeling technique. In this case, the same cause was not an explanation to the people before the technique was invented, while the same cause is an explanation to the people after the technique was invented. Also, sometimes the same cause was not an explanation to people due to the lack of appropriate theoretical tools even though they were epistemically accessible to its existence. All these

cases show that whether a cause is explanatory is contingent on whether we have a proper representational tool. And I think there is nothing weird about these cases. We often start to explain and understand a phenomenon, while our ancestors did not by failing to see precisely how a given cause brings about a phenomenon. And to me, this is just the way science has progressed.

To sum up, my view indeed implies that the explanatory status of a cause is contingent on how it is represented, and thus such status may change depending on how it is represented. But I think this is not a defect but rather a strength of my view unless something can be an explanation independently of whether it is cognitively useful to us and thus whether we can use it or learn about the world from it. Such a view about explanation is possible, but the view would need to show what it has to do with what people really do and can do with explanation and why explanation is useful and valuable to us. Otherwise, it is not clear to me why we need such a notion of explanation independent of human cognition.

5. Concluding remarks

One of the key questions that need to be asked to understand the nature of explanatory relations is how it is determined whether something is explanatory. According to the ontic conception, it is wholly determined by what the relevant part of the world is like. According to Potochnik, it is determined partly by the world and partly by the cognitive needs of those seeking an explanation. Following Potochnik, I also think that whether something is explanatory is not entirely determined by the world but also by some cognitive factor of an

explanation's audience. If an explanation must generate understanding, then whether something is explanatory has to be at least partly determined by some cognitive factor that determines whether something generates understanding. However, I disagree with Potochnik regarding what she identifies as such a cognitive factor. So, in this chapter, I argued against her view according to which it is a research interest that determines whether, say, a cause is explanatory. I raised several objections to show why a research interest is not the right kind of factor for understanding and explanation. Then, based on some implications of the objections, I proposed an alternative view of explanatory relations called a cognitive approach, according to which whether a cause is explanatory is determined by whether it can be represented in a cognitively manageable way. One of the central pillars of the motivation of my view is the complexity of the world and human cognitive limitations. The other is epistemic accessibility as the epistemic constraint of explanation due to the connection between explanation and understanding. Lastly, I compared my view with Potochnik's view, examined an implication of my view which can be a possible worry to my view, and replied to the worry. Overall, I aimed to propose a new way of thinking about how it is determined whether something is explanatory. One thing that I set aside in this chapter, despite its importance, is to justify the connection between understanding and explanation. I proceeded by assuming the connection, but not everyone would agree that explanation must provide understanding, no matter how obvious the connection may seem to some people. In this respect, the view I provided in this chapter is conditional, but I will leave the task of justifying the connection between explanation and understanding for future study.

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CHAPTER 3. A NEW EPISTEMIC CONCEPTION OF SCIENTIFIC EXPLANATION

According to the ontic conception of scientific explanation, a representation explains a target of explanation if and only if it accurately describes the part of the world responsible for the occurrence of the target. For a proposition that is truth-apt, the view says that a proposition explains a target of explanation if and only if it is a true proposition about the part of the world relevant to the target. In this chapter, I challenge this claim with a focus on the truth requirement of the claim, namely that *a proposition is genuinely explanatory only if it is true.* I argue against the truth requirement based on the indirect and fallibilistic nature of scientific inquiries. In the course of doing that, I show how fallibilism makes the truth requirement too demanding to be correct and why such demandingness matters from the perspective of what the explanatory genuineness should be about. Then, I motivate and provide a functional analysis of explanatory genuineness, according to which whether a proposition is explanatory is a matter of whether it plays the role of explanations in scientific practice. Based on the functional analysis, I propose and defend the following requirement a proposition must meet to be genuinely explanatory: *A proposition is genuinely explanatory only if it is true for all we know*. I then clarify what I mean by this alternative condition, how a proposition that is true for all we know plays the explanatory roles in practice, and what my proposal implies about explanation.

1. Introduction

Conceptions of scientific explanation concern some broad ontological questions about scientific explanations. Two questions have been investigated: (1) What type of entity explains? (2) In virtue of what, does a thing of that type explain? The ontic conception gives the following answers to the questions: (a) A type of thing that explains is primarily the ontic structure in the world that is responsible for the occurrence of a target of explanation (*ontic explanation*), and (b) a type of entity explains a target of explanation if and only if it is either the ontic explanation relevant to the occurrence of the target or accurately represents the relevant ontic explanation (*ontic determination*). [1] Two clarifications about these answers from the ontic conception. First, the ontic conception also allows representations - such as models, theories, diagrams, graphs, mental representations, etc. – to be explanatory. Still, ontic explanations - such as causes, mechanisms, or laws of nature, etc. - explain in the first place in the sense that they are explanatory by being themselves while representations can be explanatory only by virtue of representing ontic explanations. This is what "primarily" means in (a). Second, by claiming (b), the ontic view says that whether something explains is determined wholly mind-independently, i.e., by what the relevant part of the world is like only. No factors other than the world come into play in determining whether something explains or not.

A conception is then *non-ontic* if it denies either (a) or (b) or both in one way or the other. For instance, a view is non-ontic if it denies ontic explanations and says that

[1] The proponents of the ontic conception are Salmon (1989), Craver (2014), Strevens (2008), and Povich (2018).

representations are the only type of entity that explains.[2] A view can also be non-ontic by denying (b). Some people disagree with the ontic determination and argue that some representations explain even though they represent the relevant parts of the world inaccurately.[3] While these people take issue with the accuracy condition that concerns *how* a relevant ontic structure is to be represented to explain, others take issue with *what* is to be represented to explain. They argue that some representations explain by representing something other than the ontic structures.[4] There are also some views denying the ontic determination by arguing that whether an ontic structure or a representation explains is determined not just by what the world is like but also by some facts about human investigators or research programs.[5]

Within this background of the debates over conceptions of scientific explanation, I have argued against some parts of the ontic conception and provided the non-ontic answers to those parts in chapter 1 and chapter 2. In this last chapter, I examine the part of the ontic conception that I did not discuss in the previous chapters. This will bring me one step closer to completing my own non-ontic conception of scientific explanation. Let me briefly

[2] For this type of a non-ontic conception, see Bechtel and Abrahamsen (2005), Bechtel and Wright (2007), Wright (2012), and Bokulich (2016, 2018).

[3] Those who argue that false models such as idealized models or fictional models are explanatory advocate this type of a non-ontic conception. See Bokulich (2009, 2011, 2016), Elgin (2009), Potochnik (2017), and Woody (2015).

[4] See Batterman and Rice (2014), and Kostic and Khalifa (2021).

[5] See Illari (2013), Glennan (2017) Sheredos (2016), van Eck (2015), and Potochnik (2015a, 2016, 2017).

review what I tried to show in the first two chapters and how they are related to the topic I will discuss in this chapter.

Let me start with Chapter 2. Chapter 2 focuses on question (2) of conceptions of scientific explanation, i.e., in virtue of what a thing of a certain type explains. Disagreeing with the ontic conception, Potochnik provides the following non-ontic answer to question (2): An ontic structure is explanatory if and only if it is the ontic structure responsible for a target of explanation and it is what those seeking an explanation are interested to know. I agree with Potochnik that whether something is explanatory is determined not just by the world but also by some facts about human cognition, provided that explanations must generate understanding. And yet, I disagree with Potochnik in terms of the cognitive factor she identifies. So, in Chapter 2, I show why her view is wrong in this respect. Then, I propose an alternative cognitive factor and present the following answer to question (2): An ontic structure is genuinely explanatory if and only if it is the ontic structure responsible for a target of explanation and it can be represented in a cognitively manageable way.

While Chapter 2 focuses on question (2) of conceptions of scientific explanation, chapter 1 focuses on the answer the ontic conception provides for question (1), i.e., what type of entity explains. The point of disagreement between the ontic conception and the non-ontic conception is whether there are ontic explanations. So, from the non-ontic point of view, it is legitimate to ask why we should believe in ontic explanations in addition to explanatory representations. To this end, I examine the reasons that have been put forward in defense of ontic explanations and argue against them. Although I am more inclined to think that there is no ontic explanation, Chapter 1 does not prove that there is no ontic explanation.

Instead, chapter 1 concludes that at least for now we had better not commit ourselves to ontic explanations based on the ontological parsimony and the absence of a good reason to believe in ontic explanations. This conclusion is tentative. And yet, it still can serve as a good reason to focus on representations as a type of entity that explains.

To sum up, chapter 1 and Chapter 2 provide the answers to each of the two questions of conceptions in a non-ontic way. And in light of the conclusion of Chapter 1, the view presented and advocated in Chapter 2 can be rephrased about representations: A representation is genuinely explanatory if and only if it represents the ontic structure relevant to a target of explanation and it represents the ontic structure in a cognitively manageable way. This view is non-ontic in the sense that whether a representation is explanatory is not claimed to depend solely on whether it represents a relevant ontic structure. Still, the view retains some similarity with the ontic conception in that it requires a representation to be about a relevant ontic structure. Given that a representation cannot be completely inaccurate about an ontic structure to be about that structure, that a representation must be about an ontic structure commits to the accuracy requirement of the ontic determination at least to some extent. And it is this accuracy condition I will put into question in this chapter.

The accuracy requirement has not been free from criticism. One of the prominent criticisms is based on some explanatory models in scientific practice. Given that the models in question consist of propositions that are truth-apt, the argument is typically put in terms of truth, which runs as follows: Some models are explanatory. And yet, such models usually distort the relevant part of the world it represents. Thus, the models are strictly

speaking false. Therefore, it is not the case that models must be true to be explanatory. The point of a dispute concerning the accuracy condition has then been predominantly about whether truth is a necessary condition for a proposition to be explanatory.[6]

Although what I am going to argue in this chapter will also be applied to the accuracy requirement in general, let me focus on the propositions that are truth-apt as a type of thing that can explain and thus the truth requirement for simplicity.[7] And although I am sympathetic to the non-ontic challenge based on false models, the reason I will provide in this chapter against the truth requirement is a different kind of reason. It is more about the epistemic nature of scientific inquiries and a pragmatist way of understanding explanatory genuineness. And based on this reason, I will propose and defend a non-ontic requirement alternative to the truth requirement. Before presenting my view, let me first show why I think the truth requirement is wrong.

2. Against the truth requirement

The thought that seems hard to be denied is that a genuine explanation must be based on what the world is like at least to some extent. It seems that an explanation must have some

[6] For those who argue that falsity can explain, see footnote 3. Recently, Pincock (2021) advances a way to defend the ontic view in response to the non-ontic challenge from false explanatory models.

[7] There can be the things that may explain and yet not truth-apt, such as diagrams, graphs, physical models, etc. For them, accuracy rather than truth should be an apt notion.

connection to the world in one way or the other to be genuinely explanatory. Let me call this as the *minimal objectivity requirement*.[8]

> **The minimal objectivity requirement (MOR)**: A proposition is genuinely explanatory only if it is based on what the world is like.

MOR says that an explanation cannot be entirely dissociated with what the world is like, even if an explanation may have some epistemic or context-sensitive nature. Even though an explanation is a matter of making what is to be explained expected, showing why an explanandum is to be expected to happen depends on some nomic nexus in the world.[9] And even though an explanation is considered as nothing but an answer to a why-question and thus what is explanatory depends on the background knowledge and the interest the person asking a why-question has, this does not mean that what the world is like is completely out of the picture of explaining.[10] In the first place, there seems something weird about thinking

[8] Note that I rely on one sense of objectivity here, while there are many different ways to define scientific objectivity. See Reiss, J. & Sprenger, J. (2017) for the various meanings of scientific objectivity.

[9] This is Hempel's account of scientific explanation (1965). Because of the notion of expectability in Hempel's account, Salmon (1989) classifies his view as the epistemic conception of scientific explanation.

[10] This is a pragmatic account of explanation. van Fraassen (1980) is one of the advocates of the view. Although potentially controversial, one way of reading his view is this. Even though it varies from context to context which relation in the world is the answer to a why-question and thus explanatorily relevant, it is still the objective relation in the world that is explanatorily relevant.

that something can explain why a phenomenon in the world occurs without recourse to what the world is like.

In the context of MOR, it is then natural to ask what a proposition must be like in order to meet the requirement. The requirement itself is fairly weak and unspecific enough to leave open the various ways for an explanation to be objective. That is why the requirement is called minimal. Some may think that an explanation has an objective feature in the sense of empirical adequacy. From this perspective, a proposition must match the empirical data or observation we have in order to be genuinely explanatory. Others may advocate a stronger sense of objectivity such as correspondence with the world. The ontic conception is based on this stronger notion of objectivity, which leads it to hold the following version of MOR:

> **The truth requirement (TR)**: A proposition is genuinely explanatory only if it is true.

Although TR is one way of satisfying MOR, there seems an initial appeal in TR. For instance, if what we believe as a genuine explanation turns out to be based on a wrong way of thinking about the world and thus is false in that sense, then it seems that the explanation is actually not genuinely explanatory but fails to be explanatory. Our intuition does seem to tell us that falsity cannot explain, so something must be true to explain.

Nevertheless, there is a reason to doubt TR. The reason concerns the epistemic nature of our scientific inquiries. Arguably, the objects of our scientific inquiries are typically the

things that we human beings cannot know directly. Those things range from the underlying causes or structures to the things that are unobservable in principle.[11] Because of this indirectness, scientific inquiries cannot but rely on some methods that are supposed to lead us to the truth by mediating us and the object of inquiries. And yet, even though such methods seem generally reliable, they cannot but be defeasible due to the limitations we have. Let me spell out what I mean by the methods, what the limitations are, and why the limitations make the methods inherently defeasible.

The tools science uses to know about the world can be classified into two kinds. One is a theoretical tool. When explaining, scientists construct a hypothesis or a set of possible hypotheses to see why something happens. And when they construct a hypothesis, it is not the case that the hypothesis comes from nowhere. It relies on the existing relevant theories and theoretical posits. This is also the case when they posit something novel. If the existing theories or theoretical posits do not seem to work for the case under study, then scientists start to come up with something new or different. Still, what is novel depends on the ways that things might have not yet been thought of, which in turn depends on the ways that things have been thought of and the problems the ways have. Just like what could be an alternative option relies on what the existing options and the problems or shortcoming of those existing options are. In this regard, the theoretical tools are bound to have a limitation

[11] Defining precisely when something is "in principle" unobservable is not an easy task. For the purpose of this chapter, however, a rough understanding of in-principle unobservability should be fine: e.g., an entity is in principle unobservable if it is not directly perceptible to us with our naked sense organs or even with an aid of instruments.

that stems from the limitations we human beings have. Our cognition does not work in a void but in the context of a background knowledge.

Accordingly, what is conceivable is contingent on what is known at a given time. And for this reason, the products of our cognitive activity also do not come from a void but from a context of available background knowledge. In this respect, the theoretical tools available at a given point in time are the tools that have come into existence by virtue of the previous theoretical tools. And they are the tools that are available up until now. The current theoretical tools are neither immune to change nor exhaust all the theoretical tools that there ever can be and will possibly be.

The same goes for the other type of method. It is a methodological tool, such as various techniques and technologies scientists use for observation and modeling. These tools also have a limitation in that they rely partly on the existing theoretical tools to be constructed and partly on the level of technology we have developed. In this regard, what scientists can use to construct a hypothesis and put a hypothesis to a test at a given point in time are the ones that have become available by virtue of what we have found and devised until the given point in time. So, just like the theoretical tools, the current methodological tools are also neither immune to change nor exhaust all the methods we can possibly utilize.

So, the way scientists think and conduct research relies on what they can employ at the time of their inquiries. Scientific inquiries have been conducted based on the then-available theoretical and methodological tools. And advances in science have been made by expanding or replacing the existing methods of inquiry. Still, since the methods are based on what we have found and developed, they do not exhaust all the possible ways to think

about and work with the objects of inquiry. As we learn more about the world by coming to have a new set of evidence and as our technology develops in a way that allows us to do the things that we were not able to do in the past, the methods of inquiry are subject to change or be replaced. Maybe someday there are no limitations left so that the theoretical and methodological tools exhaust all the possible ways of thinking about and working with the world. Still, that seems to be a distant future if it is ever possible. And our focus is on how science has been done and will be done until the conditions of our scientific inquiries radically change.

What the limitations of the methods of inquiry indicate is this. They can take us as far as they can now. And whatever the methods tell us, that should be the best we can get at a given point in time. That being said, this does not mean that such methods are indefeasible. With the advancement of technology and the advent of new evidence, what we think is true based on the available methods may turn out to be false, as the history of science attests. In other words, what scientific inquiries offer and accept, thus explanations as well, are inevitably fallible. Then, it is not the case that the explanations science offers, accepts, and uses, however good they may look to us now, are simply speaking true so that the world is exactly like what the explanations formulated, accepted, and used by science depict.

To put what I have said so far into an argument against TR:

1. The explanations that are offered, accepted, and used by scientific practice may or may not be true due to the indirect and fallibilistic nature of scientific inquiries.
2. Thus, they are not simply speaking true.

3. Therefore, it is not the case that something must be true to be explanatory.

This argument has a similar form as that of the argument from false models: Some models are explanatory. And yet they are strictly speaking false. Therefore, it is not the case that something must be true to be explanatory. Unlike the argument from false models, however, my argument relies on the epistemic status of scientific inquiries. In this light, I will call my argument an *epistemological argument against TR*. I will revisit the epistemic reason the argument is based on when I propose and defend a non-ontic requirement alternative to TR in the next section. But before that, let me consider a possible worry to the epistemological argument, answering to which is also crucial for the view I develop in the next section.

A worry that can be raised in favor of TR and I think is worth examining is this. Some may doubt whether the conclusion does follow from the premises. Even granted that the explanations offered, accepted, and used in scientific practice are fallible as premise 1 says, one may wonder whether all such explanations are genuine explanations. They may think that the epistemological argument has an implicit assumption, which is premise 3 in the following argument.

1. The explanations that are offered, accepted, and used by scientific practice may or may not be true due to the indirect and fallibilistic nature of scientific inquiries.
2. Thus, they are not simply speaking true.
3. Yet, the explanations are still genuinely explanatory.

4. Therefore, it is not the case that explanations must be true to be genuinely explanatory.

The truth of premise 3 can be questioned for the following reason. Scientific inquiries are fallibilistic even though we do our best. But from this, why not think that science does not always succeed in providing and accepting genuine explanations? If so, not all the explanations scientific practice offers, accepts, and uses to make scientific progress would be genuinely explanatory. Thus, premise 3 is false.

The foregoing objection to premise 3 can also be put in the following way in tandem with TR. Even though we do our best, we can get things wrong. We can certainly be erroneous in providing explanations and accepting some of them as genuine. This is our epistemic reality and what P1 says is just about this reality. And yet, whether an explanation is genuine is an objective matter in need of an objective criterion independent of there being a chance of our getting things wrong, i.e., independent of our epistemic fallibility. So, independent from the fact that we are fallible and thus we may offer and accept something wrong, the criterion is supposed to say when we actually succeed in providing and accepting explanations that genuinely explain. And this is what exactly TR is meant to be about. Science can fail to provide and accept genuine explanations by providing and accepting false explanations. And it succeeds in providing and accepting genuine explanations when providing and accepting true explanations. So, even though some explanations are counted as genuine and thus used in scientific practice, this does not necessarily mean nor indicate that they are genuinely explanatory.

I think the above objection is a kind of objection that the proponents of the ontic conception would raise in response to the epistemological argument. To them, whether something is genuinely explanatory is nothing but a matter of what the world is like and thus a mind-independent matter. So, if what is going on in practice departs from what the world is like, it is the fault or defect of the side of the practice. Likewise, if the explanations scientific practice offers, accepts, and uses do not correspond to the world, then it is those explanations that are faulty. I think this line of objection does have some plausibility. And yet, it is worth thinking about whether the genuineness of an explanation is really an entirely objective matter independent of the epistemic feature of scientific inquiries and what is considered genuinely explanatory in practice.

First, think about what would possibly be the case if explanatory genuineness is a matter of truth or falsity as TR says. If a scientific inquiry is defeasible so that the explanations it provides, accepts, and uses are inherently fallible and yet whether an explanation is genuine depends on whether it is true or not, then it is possible that many things that are considered explanatory and play some important role in scientific practice have to be considered as nonexplanations. In other words, were TR true, then many of our explanation ascriptions and judgments about what is an explanation and what is not could be largely wrong. Just like many knowledge ascriptions and judgments about when we know or do not know would be wrong if the condition for knowledge is too demanding. And TR makes the criterion of explanatory genuineness demanding because it is a condition that is hard to be met due to the fallibilistic nature of scientific inquiries. Nevertheless, maybe there is nothing wrong about a criterion for X to be too demanding in the sense that it can render

many of our ascriptions and judgments about X and thus the way we use the notion about X wrong. But it is worth asking whether what we philosophers want is such a demanding notion that can greatly deviate from how we use the notion. If what we want is a criterion for explanations that captures well what we do with the notion of explanation, demandingness is a good reason to reconsider the appropriateness of the criterion for explanation TR suggests.

Putting the above way, the real problem of demandingness is this. Many explanations scientists currently count as genuinely explanatory may or may not be true. Yet, those explanations still play an important role in scientific inquiries, at least until they turn out to be false. But TR can make something that plays the role of explanations in practice as a non-explanation. This is what is peculiar about TR, or more precisely speaking the notion of genuineness TR is based on. Of course, the notion of genuine explanations that can make something that plays the role of explanations in practice as not genuinely explanatory is certainly possible. But it is not clear to me whether that notion has anything to do with understanding our scientific and explanatory practice. Consider what the object of explanatory genuineness should be to better capture the practice. Is it an explanation that is accepted and counted as a genuine explanation in practice? Or the explanation that is genuine whether or not it is accepted and counted as genuine in practice? If the object of explanatory genuineness is the latter, then TR may be fine as the criterion for genuine explanations. But I take it that the object of analysis is the former. We philosophers want to understand the scientific practice better. That is why we want to understand explanations better too. What scientists refer to using the notion of explanation and what the referred

things are like then take precedence over how a notion of explanation could be used and what an explanation may be like no matter how the notion of explanation is actually used in practice.

Let me conclude this section with an analogy that may be helpful. One issue in political philosophy is the ideal and non-ideal distinction. There has been a debate about whether the notion of justice is to be understood non-ideally in the sense that it is a matter of respecting people's rights under existing laws, rules, practices, and conventions, or whether the notion is to be understood ideally in the sense that it is based on positing some ideal principle of distribution, equality, etc. While those advocating the non-ideal notion of justice are concerned with what can be said about justice under the existing norms and practices, those advocating the ideal notion of justice are concerned with reforming the existing norms and practices if they are not ideal.

To me, TR seems similar to the ideal notion of justice. TR provides an ideal standard for explanatory genuineness by demanding genuine explanations to be true. And yet, we human beings are not flawless cognitively speaking. So is science as a human inquiry. Accordingly, even though scientists do their best, they are still fallible and so are the explanations they provide and legitimize. The actual scientific practice is not like the world run as the ideal notion of explanatory genuineness requires. In this respect, the ideal notion of explanatory genuineness is not the right kind of notion to use to understand the practice, as long as the goal of the philosophical inquiry about explanation is descriptive and not prescriptive about the scientific practice. For the ideal notion of genuine explanations can dismiss the things considered as explanations and what they do for us in practice as not

genuinely explanatory. Nevertheless, some scientists may think that they aim at finding true explanations. The ideal notion of explanatory genuineness may be suitable for making sense of this aspiration. But other than that, the notion does not seem suitable to capture what is really going on in the practice with respect to explanations. So, if what we philosophers are interested to understand is the explanations considered genuine in practice and such explanations are fallibilistic, then the ontic claim that something must be true to be explanatory should be rethought.

3. From the truth requirement to the truth-for-all-we-know requirement

In section 2, I argued against TR, the truth requirement for genuine explanations. In this section, I will provide and defend a non-ontic requirement in replacement of TR. For this purpose, let me start where section 2 ends, i.e., the issue of what it is for an explanation to be genuine. This consideration comes from examining a possible response from the ontic conception to the epistemological argument. The defenders of TR may be unfazed by the fact that the explanations science offers, accepts, and uses may or may not be true. This is because they think that the genuineness of an explanation is an objective matter independent of our epistemic fallibility and that of scientific inquiries. In response to this, I argued that such a notion of explanatory genuineness was not suitable for philosophical investigations about explanation. As long as what we philosophers want to understand is how scientists use the notion of explanation and what the thing referred to as an explanation is supposed to do for them, the object of explanatory genuineness should be the explanations considered and accepted as explanatory in practice, or so I argued. In

comparison to the ontic way of thinking about explanatory genuineness, the way of thinking about explanatory genuineness I propose here may be described as a pragmatist view, provided that a view is pragmatist if it focuses on the way people use a notion and what the notion does for them. If this is one way for a view to be pragmatist, my proposal certainly has a pragmatist flavor. For my purpose, however, what is more important is the way of thinking about the explanatory genuineness I propose is different from the ontic way of thinking about it.

Given that the target of the philosophical analysis of explanatory genuineness is the things that are considered and accepted as genuine explanations in scientific practice, the next question to ask is based on what something is considered and accepted as genuinely explanatory in practice. Not all explanations offered by scientific research are considered and accepted as genuine. Accordingly, we would want to know what distinguishes those that are considered and accepted as genuinely explanatory from those that are not. What is it that constitutes genuine explanations and thus makes them distinguished from nonexplanations?

Although there can be a few possible answers for the question, my suggestion is to find the answer from the roles scientific explanations play in practice. Presumably, explanations matter because of the crucial roles they play in scientific inquiries. Scientists want explanations because of the things they can do for them. From this perspective, whether something is genuinely explanatory can be seen as a matter of whether that thing plays the role(s) expected for explanations. This way of thinking about explanatory genuineness then gives us the following structure for the criterion for explanatory genuineness: If *X* plays

the role(s) an explanation is supposed to play, then *X* is genuinely explanatory. If *X* fails to play the role(s) explanation is supposed to play, then *X* is not genuinely explanatory.

Note that the explanatory role in the above schema is not just evidence with which we identify genuine explanations but the one that constitutes genuine explanations. The thought that the role explanations play is constitutive of the genuineness of an explanation can be motivated by the following consideration. Philosophers talk about the aim(s) of science. They have made various proposals about what the aim(s) of science is. Given that there are multiple aims of science, some of the aims are classified as epistemic aims, such as truth, understanding, knowledge, etc.[12] Others are classified as non-epistemic aims, such as prediction, description, manipulation, guiding actions, and policy makings, etc.[13] Explanations are typically associated with the epistemic aim. And although people dispute about what is the epistemic aim of science – whether it is truth, understanding, or knowledge – explanations are typically construed as a/the method for the epistemic aim.[14] From this perspective, explanations are in the first place a *tool* that we use to achieve the epistemic aim. I think this way of thinking about explanations matches well why scientists seek and value explanations. Of course, they may want and value explanations because

[12] Traditional realists can be seen as the people who think that the aim of science is truth. For those who think that the aim of science is understanding rather than truth, see de Regt (2020), Elgin (2017), and Potochnik (2015b). For those who think that the aim of science is knowledge, see Bird (2023).

[13] See Douglas (2009), Elliott (2013), and Elliott (2011) for this type of non-epistemic aims of science.

[14] There is a debate over whether understanding is achieved by explanation only. See Lipton (2009) and Strevens (2013) on this dispute.

explanations are themselves the aim of science or have some intrinsic value. Still, given the things that explanations do for scientific inquiries and the aims of science such as truth, understanding, or knowledge, I think there is something plausible about considering explanations as a means rather than itself as an aim or an end.

Based on the idea that explanation is a tool and the thought that what defines a tool and distinguishes it from other tools is the distinctive role it plays, we can define explanatory genuineness as follows:

> **A functional analysis of explanatory genuineness**: A proposition is genuinely explanatory if and only if it plays the role(s) of explanations in scientific practice.

Besides the thoughts that motivate the view, the functional analysis also has some benefits. First, the analysis leaves it open what specific features a genuine explanation must have. In this regard, the analysis itself is neutral to the ontic conception and the non-ontic conception. If the proposition that plays the explanatory role in practice is true and only such propositions play the roles, then TR would be true. If not, TR would not be true but some other requirement would be true. Second, the functional approach renders a proposition to be genuinely explanatory as long as it does what explanations do or are expected to do in scientific practices. This brings the explanatory genuineness back to practice, rather than making it a matter independent of scientific practice.

So, the functional analysis defines explanatory genuineness in terms of the roles that explanations play. Then what are the roles that explanations play? Although debatable,

following the traditional realists, I assume that the epistemic aim of science is truth and an explanation is a tool for achieving the truth.[15] Also arguably, explanations can be considered to play a role in achieving the truth supposedly in two ways. One is bringing about scientific understanding, provided that understanding of a phenomenon is generated when one is told why the phenomenon occurs, i.e., the truth related to the occurrence of the phenomenon. The other is licensing inferences for the purpose of theory choice by telling us which theory or hypothesis out of many potential rivals is the most likely to be true and thus rationally preferable. By bringing about an understanding of a phenomenon and enabling a theory choice, explanations can then be seen as a tool we use to get to the truth or at least closer to the truth, i.e., the true picture of the world with the true understanding and the true theories. Note that the foregoing views about the role of explanations are not free from controversy, not to mention seeing truth as the epistemic aim of science. Nevertheless, in this section, I will assume that the two roles I identified are the roles that explanations play in practice based on what scientists do with explanations. Scientists do use explanations to understand the phenomena under study. And they do justify their theories or hypotheses by appealing to the explanatory power their views have.

Granted that explanations play the roles identified above to help us get to the truth or at least closer to the truth, now let me think about when a proposition plays such roles so that

[15] This assumption about the aim of science is indeed contentious, especially to those who think that the epistemic aim of science is understanding and understanding is not just a matter of having true knowledge. See Elgin (2004) and de Regt (2009).

it is genuinely explanatory according to the functional analysis. One may think of TR at this point: Provided that the epistemic aim of science is the truth, a proposition plays the explanatory roles geared toward the truth only when it itself is true. Although I think explanation needs to be associated with truth in one way or the other for the said aim of science and its roles for the aim, TR is not the requirement for a proposition to satisfy to play the explanatory roles and thus to be genuinely explanatory. The reason is this. All TR requires is that a proposition be true. And yet what about a proposition that is true but no one is aware of? Obviously, such a proposition cannot play a role in scientific practice, even though it is true and thus may indicate truth to us. Such a proposition may potentially play the roles and thus potentially be genuinely explanatory. Still, it is not actually genuinely explanatory according to the functional analysis, until it becomes epistemically available to us and thus becomes a tool we can actually use. Until then, such a proposition is epistemically insignificant and useless to us, and thus cannot play explanatory roles in practice.

The foregoing point shows us what is wrong about the ontic conception and TR it subscribes to, at least from the point of view according to which explanation is basically a tool we use to achieve a goal of science and whether something is explanatory is the matter of whether it functions as a tool. If TR is right, then the following holds: (a) *X is an explanation because X is true*. (a) allows there to be an explanation that is unknown to us even in principle. A proposition is genuinely explanatory only if it is true, regardless of whether we have ever found it or can ever find it. Again, this kind of notion of explanation may be fine from a certain point of view. But as long as what we concern as genuine

explanations are the ones that do the explanatory work in scientific practice, the existence of such explanations and their genuineness based on TR seems to have little or no bearing on our current concern. Furthermore, if an explanation is basically a tool to uncover the truth, then there is something odd about (a). We use explanation because we do not know what is true. That is, we use explanations to find out the truth, not the other way around. So, the opposite of (a) seems to be the right thing to say: (b) *X is true because X explains*. Or more precisely speaking, *we believe or know that X is true because X explains*, given that an explanation as a tool tells us what is true or most likely to be true and thus helps us form scientific knowledge.

So, if the functional analysis is right, then TR seems to be inadequate as the requirement a proposition must satisfy to be genuinely explanatory. Just being a true proposition is not sufficient for the proposition to work as a tool to tell us about the truth. For a proposition to function as a tool, it must be epistemically available to us in the first place. In other words, even though a proposition may be able to indicate truth, it is no use if the proposition is not within our reach epistemically speaking. Accordingly, something is not an explanation unless it is epistemically available to us; there is no genuine explanation that exists independently of our awareness. This shows that some kind of epistemic constraint needs to be imposed for a proposition to play explanatory roles. For a proposition to play explanatory roles and thus to be genuinely explanatory, it must be the case that we either know or believe that a proposition is true. The question is then which is the case: Should a proposition be known to be true or believed to be true to be explanatory?

Let me consider the first option:

The known truth requirement (KTR): A proposition is genuinely explanatory only if it is known to be true.

Given that knowledge is factive, a proposition that is known to be true would certainly be the best candidate for playing explanatory roles in achieving the truth. That said, KTR suffers a similar problem as TR does. It is too strong for many explanations that are offered, accepted, and used by the scientific practice to satisfy, given the indirect and fallibilistic nature of scientific inquiries. Many explanations are rather true on a fallibilistic basis. Thus, they may or may not be true strictly speaking, rather than known to be true. If so, KTR is too demanding to make many explanation ascriptions in practice correct. And KTR is too demanding to be an adequate requirement in that it can make many explanations that are used in practice and play an important role in the practice as nonexplanations.

Note that I am denying neither that there can be propositions that are known to be true nor that such propositions are genuinely explanatory if there are any. I am not entirely dismissive of the possibility that there may be some propositions that are known to be true or known to be true in the sense that it is unreasonable for us not to believe that they are true.[16] Also, I think that such propositions would be genuinely explanatory if there are any. My point is rather this. Even though that there may be some scientific explanations that are

[16] The later sense of knowing the things science has offered is what Vickers (2022) advocates in his recent book. He argues that there are some scientific claims or ideas, which he calls as future-proof, that we are so certain that we can confidently say that we know them to be true.

known to be true, many explanations do not seem to enjoy such an epistemic status due to the fallibilistic nature inherent to scientific inquiries. And as long as we do not want to make many explanations that are considered and accepted as genuine in practice as not genuinely explanatory, KTR does not fit for our consideration.

If it is not the case that a proposition plays the explanatory role and thus is genuinely explanatory only when it is known to be true, then the only option left would be that a proposition has to be believed to be true to be explanatory. And this is the condition I think is adequate for genuine explanations, or so I will argue. To be clear, I think that not any propositions that we merely believe as true but only those propositions that we are justified in believing as true are the propositions that play explanatory roles. And by the propositions that we are justified in believing as true, I mean the propositions that are the most reasonable things for us to believe as true, given what we have found so far. So, simply speaking, I suggest that the propositions that are true for all we know are the ones that are genuinely explanatory.

> **The justified truth requirement (JTR)**: A proposition is genuinely explanatory only if it is true for all we know.

I think it is JTR that the explanations that are offered, accepted, and used by the scientific practice to get us to the truth or at least closer to the truth do in fact satisfy. And in that respect, it is the condition that any proposition must satisfy in order to be genuinely explanatory. Here is why. Unlike TR, JTR requires a proposition to be epistemically

available to us. A proposition must be the thing that we actually form a belief attitude about. That way, JTR makes only those propositions that we can actually use for the epistemic aim of science as explanatory. In comparison to KTR, JTR is a weaker condition. A proposition that is known to be true will also satisfy JTR, but a proposition does not have to satisfy KTR in order to satisfy JTR. This is because JTR does not require a proposition to be actually true to be genuinely explanatory. So, among the propositions that satisfy JTR, there can be some propositions that satisfy KTR but not all propositions may satisfy KTR. It is possible that some propositions are just the ones that are the most reasonable things for us to believe as true, not that we know them to be true. This means that among some propositions that satisfy JTR, there can be some propositions that are actually false.[17] For this reason, JTR may look too weak to some people. But I think it is actually the benefit JTR has. By being a weaker claim than KTR, it is the condition that many explanations that are offered, accepted, and used in practice can satisfy and do in fact seem to satisfy. Such explanations are fallibilistic, so they may or may not be true. So, they cannot be the ones that are known to be true, strictly speaking. Still, they can be the ones that are true for all we know at a given point in time. In this regard, JTR does not suffer from the problems both TR and KTR do. It is neither too demanding nor overly restrictive so that many of the

[17] In this respect, "justified truth" may not be the best phrase to use for my view. It may be read as the things that (i) are true and (ii) we also have good reason to believe as true. But that is not what I mean by the phrase. What I mean by the phrase is just the things that we are justified in believing as true. So, although it is potentially misleading, I will use the expression "justified truth" with the meaning I have in mind.

explanations that play the explanatory role in current scientific practice can still be construed as genuine explanations according to JTR.

Note that while JTR allows a false proposition to be genuinely explanatory as long as it is the most reasonable thing for us to believe as true, JTR does not allow a proposition that is known to be false to be genuinely explanatory. And the proposition that we have good reason to believe as false. For such propositions are not true for all we know. This aspect of JTR can be a potential worry to some people who think some knowingly false propositions are genuinely explanatory, such as an ideal gas law (PV=nRT).[18] I think this is a genuine challenge to my view that I need to address, as long as I maintain only (known or justified) truth can explain while (known or justified) falsity cannot explain as the proponents of the ontic conception do. That being said, since the aim of this chapter is to find out a requirement that replaces TR, I will leave the said challenge against JTR for a future task.

Let me summarize what I have shown so far. We philosophers want to know what condition a proposition must meet to be genuinely explanatory. In the course of providing the answer, I first argued that genuine explanations should be the explanations that are considered and accepted as genuine in scientific practice. Then, I offered a functional analysis of explanatory genuineness, according to which an explanation is considered and accepted as genuine in practice if and only if it plays explanatory roles in practice. Given that an explanation is a tool to achieve the epistemic aim of science and the epistemic aim of science for which explanations are used is truth, I claimed that the explanatory roles are

[18] See, for example, Potochnik (2017) and Woody (2015).

concerned with understanding and theory choice. Then, I examined when a proposition plays such explanatory roles and argued that it is when the propositions are true for all we know (JTR), not that they are true (TR) or known to be true (KTR). I argued that JTR is the condition that many explanations playing the explanatory roles in practice can actually satisfy and do satisfy on the ground that it respects the fallibilistic nature of scientific inquiries.

Given that JTR is the condition that a proposition must satisfy to be genuinely explanatory, I will specify the following things for the rest of this section: (i) when a proposition is true for all we know, (ii) how such a proposition plays the explanatory roles, and (iii) what my view implies about the explanatory status and the role of evidence in such a status.

By a proposition that is true for all we know, I mean a proposition that is the most reasonable for us to believe as true given what we currently know, i.e., given the set of evidence, and the theoretical and methodological tools we currently have. We can think of this proposition as the best explanation we currently have or can currently come up with. When is then a proposition true for all we know/the best explanation? Here I propose the two requirements for a proposition to meet to be qualified as being true for all we know: the objectivity requirement and the explanatory virtue requirement. I claim that a proposition is true for all we know when and only when it satisfies these two conditions at least to some extent and satisfies the two conditions better than the other available propositions.

Let me say about the objectivity requirement first. Recall that at the beginning of section 2, I said that a proposition must meet MOR, the minimal objectivity requirement, to be genuinely explanatory. MOR says that a proposition is genuinely explanatory only if it is based on what the world is like. TR is one version of MOR, but I argued that TR was too demanding to be correct. So, we need a different version of MOR. Given the indirect and fallibilistic nature of scientific inquiries, I suggest a weaker version of MOR, such that a proposition is genuinely explanatory only if it is consistent with the available empirical evidence. This version of the objectivity requirement is certainly weaker than TR because it does not require a proposition to be true. Still, it makes a proposition objective by making it based on what the world is known to be like. One may worry if the said objectivity requirement is too weak for a proposition that meets the condition to be objective. But this depends on what one means by objectivity. If by objectivity one means truth, then a proposition that meets the objectivity requirement I propose may possibly not be objective. But if by objectivity one means something like matching the data and evidence we collect from the world, the said objectivity requirement is strong enough to make a proposition that meets the condition objective.

Nonetheless, the objectivity requirement may not be able to single out a proposition that is true for all we know. Typically, there is not just one but several hypotheses that we can come up with, using the available theoretical and methodological tools and in line with the empirical evidence we have. Given that the hypotheses scientists can come up with at a given point in time are underdetermined in this sense, we need some mechanism that weighs the likelihood of the empirically equivalent hypotheses. Here, I think the

explanatory virtues – such as simplicity, scope, fruitfulness, coherence, unifying power, etc. – may serve as such a mechanism. In fact, it is a topic that is worth another chapter that why the explanations with more explanatory virtues are more likely to be true than the ones with less explanatory virtues. Nevertheless, given that scientists do appeal to these virtues when two or more hypotheses are empirically equivalent, I will just proceed with the claim that explanatory virtues are a reliable indicator of truth in this chapter.

So far, I maintained that a proposition is true for all we know just in case it satisfies both the objectivity requirement and the explanatory virtue requirement at least to some extent and satisfies the two conditions better than the other available propositions. Thus, according to my account, not just any explanation science offers can be a genuine explanation. Only those that are the best explanation given what we know can be explanatorily genuine. That is, my account distinguishes genuine and non-genuine explanations.

Also, it should be clear by the best explanation I do not simply mean the best of all we have got. In other words, I do not use "the best" purely in a relative sense. Suppose that we have an explanation that looks more plausible than any other available explanations in whatever sense. So, in some sense of the word, such an explanation is the best explanation of all we have. But this is not the way I use the word "the best". In my view, if such an explanation fails to meet the two requirements, then it is not the best and thus cannot be true for all we know. This will then be a situation in which we lack a genuine explanation for a phenomenon under study, i.e., the situation we make the explanatory judgment that

we do not have an explanation for the phenomenon under study and thus we still have not figured out why it is the case.

In what sense does a proposition that is true for all we know play the explanatory roles then? According to JTR, a genuine explanation is not simply speaking true. Still, a genuine explanation is a matter of what seems to be the most reasonably construed as true. So, JTR tells us which theory we should choose. We should choose the theory that gives us the explanation that is true for all we know. And by telling us what is the most reasonable thing to believe as the thing that is responsible for a phenomenon under study, a proposition that satisfies JTR helps us understand why the phenomenon occurs. Note that just as a genuine explanation may turn out to be false, the understanding it brings about may also turn out to be wrong. So may the theory that is chosen by the best explanation. Perhaps this possibility may serve as a reason for some people to doubt whether a proposition that is true for all we know can really play the explanatory role for the epistemic aim. Yet, I think whether an explanation generates understanding and helps us figure out which theory to believe as true may also have to be understood on a fallibilistic basis. Just because we cannot be sure about whether an explanation is true, the understanding we can actually achieve and the theory we actually choose to adopt also cannot but be fallibilistic. In the end, as human beings, we are just doing our best to achieve true understanding and a true theory at each given time. And yet, as human beings, no matter how best we try, we are not in a position to be magically connected to true propositions all the time or even most of the time. That is, we are not in a position where we always come up with a true hypothesis among other possible potential hypotheses and choose a true hypothesis. But because of this reason, thinking that

a fallibilistic explanation does not enhance our understanding at all nor help us with theory choice at least for the time being when it is the best explanation seems to make all the explanatory efforts to little or no avail. Rather, to me, it seems better to think that in terms of understanding and theory choice as well, we are also achieving as the best understanding and the best theory as we can.

Let me finish this section by briefly clarifying the two implications of my view. First, my view implies that what is a genuine explanation may change over time. As the empirical evidence, theoretical tools, and methodological tools available may change over time, what is the most reasonable thing for us to believe as true may also change. Accordingly, an explanation at a time may be genuinely explanatory if it is true for all we know during that time, while the same explanation at a later time may no longer be genuinely explanatory if it is no longer true for all we know at that time. For instance, aether theory was genuinely explanatory in the past for a time being when it is the most reasonable thing to believe as true. However, it is no longer a genuine explanation these days, for we know that it is not the best explanation anymore.

Some people - especially the proponents of the ontic conception and those who are ontic-friendly – may find the foregoing implication of my view as weird. They may think that the true story is as follows. The aether theory *was believed as genuine* during a certain period of time in the past. However, it turned out that the theory was false. Therefore, the theory *was in fact not genuine* even though and even when it was believed as genuine. This way of thinking about genuine explanations is based on the two things I tried to reject in this chapter. One is the idea that truth is necessary for genuine explanations. And the other

is that the genuineness of an explanation is independent of what is considered and accepted as genuine in scientific practice, thus what is epistemically available in scientific practice at a given point in time. In replacement of these two ideas, I proposed that the genuineness of an explanation is not independent of what is considered and accepted as genuine in scientific practice but rather determined by what the practice considers as explanatorily genuine. Then, I argued that the practice determines whether an explanation is genuine based on whether it plays the role of explanation, which is then contingent on whether it is true for all we know. In this alternative picture that I suggest, what the practice determines as explanatorily genuine is explanatory genuine, not that the practice merely believes something as genuine when it may actually not. This view is possible because the explanatory genuineness is understood functionally. Think about this way. Consider that person *X* is elected as a department chair for a given period of time. *X* is elected as a chair because she is thought of as the candidate who can take the role of chair the best for that time being. *X* then works as a chair until she is superseded by someone else *Y*. Suppose that *Y* is a chair now and plays the role of a chair. Still, this does not make *X* be not a chair in the past. *X* is no longer a chair, but *X* was indeed a chair in the past. The same goes for genuine explanations. Something is a genuine explanation when it is construed as the most reasonable thing to believe as true and thus plays the role of explanation. But things may change and it may no longer be a genuine explanation. But this does not mean that we were mistaken in the past in the sense that we thought of something that is not genuinely explanatory as genuinely explanatory.

The other implication of my view I want to highlight is related to the first one. Given that my view says that a proposition must be true for all we know to be genuinely explanatory, the view implies which is a genuine explanation is not independent of the evidence we have about genuine explanations. Rather, the evidence that something is a genuine explanation is what constitutes a genuine explanation. This is because according to my view, what our current evidence says as the best explanation *is* the genuine explanation, not merely the explanation we believe as genuine. Some may worry about this implication based on that the evidence we have can sometimes be erroneous. The set of evidence we have may tell us a false proposition as a genuine explanation. Although my view allows a false proposition to be genuinely explanatory as long as it is true for all we know, what these people worry about should be the discrepancy between what our evidence tells us to believe as genuinely explanatory and what is genuinely explanatory. Such a discrepancy would matter if the explanatory genuineness were understood as something independent of our epistemic evidence and judgment. But that is not my view. My view rather suggests thinking about whether an explanation is genuine as the matter of whether it is the best explanation that we can come up with the evidence available to us at a given time. Sometimes we manage to license something that is true as genuinely explanatory. And sometimes we may end up accepting something that is false as genuinely explanatory. But that is just how science is actually done, or so I think. Science proceeds by making mistakes and correcting mistakes. Above all else, science proceeds by doing what it can do the best at each time. It is just that such a process is not free from errors and chances of errors. And even though such a process is not flawless, it would be too much to think that

genuine scientific inquiries are thus not happening. What my view basically suggests is to apply the foregoing way of thinking about scientific inquiries to genuine explanations as well.

4. Conclusion

In this chapter, I focused on a claim of the ontic conception, namely that a proposition is genuinely explanatory only if it is true (TR). In section 2, I argued against TR based on the fallibilistic nature of scientific inquiries and the problematic notion of explanatory genuineness TR is based on. Then in section 3, I proposed a functional analysis of explanatory genuineness. And based on that analysis, I put forward and argued for a non-ontic requirement alternative to TR, according to which a proposition is genuinely explanatory only if it is true for all we know (JTR). I clarified what I mean by JTR, how a proposition that satisfies JTR plays explanatory roles, and some implications of my view.

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