The Noetic Approach: Progress as Enabling Understanding

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Abstract: Roughly, the noetic account characterizes scientific progress in terms of increased understanding. This chapter outlines a version of the noetic account according to which scientific progress on some phenomenon consists in making scientific information publicly available so as to enable relevant members of society to increase their understanding of that phenomenon. This version of the noetic account is briefly compared with four rival accounts of scientific progress, viz. the truthlikeness account, the problem-solving account, the new functional account, and the epistemic account. In addition, the chapter seeks to precisify the question that accounts of scientific progress are (or should be) aiming to answer, viz. "What type of cognitive change with respect to a given topic or phenomenon *X* constitutes a (greater or lesser degree of) scientific improvement with respect to *X*?"

1. Introduction

What is it for science to make progress? When does a cognitive change in science, such as the replacement of one theory with another, constitute an improvement on what came before?

Consider, for example, the five successive models of the atom proposed by John Dalton, J.J. Thomson, Ernest Rutherford, Niels Bohr, and Erwin Schrödinger, respectively. According to Dalton's original atomism, atoms were considered the smallest possible units of matter, and thus indivisible. This was revised by Thomson, whose work on electricity led him to adopt a version of Lord Kelvin's hypothesis that atoms contain negatively charged electrons as well as a positively charged substrate that pervaded the atom. Rutherford then suggested that the positively charged part of

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the atom was highly concentrated in the atom's center, i.e. in its nucleus. Bohr, with his quasi-quantum model of the atom, subsequently conjectured that the electrons were located on various orbits at fixed distances from the nucleus. Schrödinger revised Bohr's model by suggesting that although electrons are most likely to be found around Bohr's orbits, their locations are undefined prior to being observed.

Even if only Schrödinger's model is considered close to fully accurate at this point, each one of these models was an improvement on the previous one. But why? What exactly makes each development an instance of scientific progress? This question should be of interest to philosophers of science in part because it is almost universally agreed that science frequently makes progress, and that significant regress (the opposite of progress) rarely occurs in science. In many other human endeavors, e.g. arts and politics, many of us are less optimistic that humankind is generally making progress and very rarely regressing.[2] So the question 'What is scientific progress?' is in part an attempt to understand what makes science so successful as compared to other human endeavors.

However, while it is widely agreed that scientific progress is prevalent, there is much less agreement on what scientific progress consists in. Until relatively recently, philosophers had mostly given three main types of answers to this question.[3] One of these answers is that progress amounts to getting closer to the truth, i.e. in increasing the truthlikeness (verisimilitude) of accepted theories. This is *the truthlikeness account*, a.k.a. the verisimilitudinarian account (Popper 1963; Niiniluoto 1984, 2014). Another answer is that progress amounts to having fewer or less important unsolved scientific problems, either by solving problems that arise within science or by eliminating or downgrading the importance of problems that perhaps cannot be solved. This is *the problem-solving account* (Kuhn 1970; Laudan 1977; see also Shan 2019).[4] The third answer

[2] This sentiment is expressed by authors such as Sarton (1936: 5) and Kuhn (1970: 160).

[3] For an opinionated overview of the following accounts, see Dellsén 2018b.

[4] A note on terminology: Bird labels the problem-solving account 'the functional-internalist account', while Shan (2019, 2022) uses 'functional account' to refer to a more general class of accounts which include Kuhn's and Laudan's problem-solving account as well as falsificationist ideas about scientific progress put forward by Popper (1963) and Lakatos (1978). I am happy to reserve the term 'problem-solving account' for Kuhn and Laudan's accounts specifically, as per Shan's suggestion. I am less happy to use the term 'functional account' in the way suggested by Shan, since it seems to me that just about *any*

is that progress consists in accumulating knowledge, where 'knowledge' – as per epistemological orthodoxy – minimally requires truth, belief, and some sort of epistemic justification. This is *the epistemic account* (Bird 2007b, 2016).

Although all of these accounts contain valuable insights into the nature of scientific progress, I maintain that they are only plausible in so far as they approximate a fourth account of scientific progress. On this account, scientific progress is defined in terms of increasing *understanding*: roughly, scientific progress regarding some phenomenon occurs when, and to the extent that, scientific research enables relevant members of society to better understand that phenomenon. Since the Greek word 'nous' is sometimes translated as 'understanding' (just as 'episteme' is often translated as 'knowledge'), I have called this view *the noetic account* of scientific progress.[5]

The main aim of this chapter is to articulate what I consider to be the most plausible version of the noetic account, and an associated view of scientific understanding. I will focus here on the positive project of building the account, as opposed to arguing against rival accounts – in part because I have done enough of the latter elsewhere (Dellsén 2016, 2018c, 2021b, 2022), in part because this will make it easier to rigorously evaluate the account (giving my opponents a better chance of refuting it!), and in part because I hope that discussions of various more concrete aspects of scientific progress (such as those considered in much of this volume) would benefit from being able to draw upon the details of a relatively fleshed-out account of scientific progress.

2. What We (Ought to) Talk About When We Talk About Scientific Progress

account of scientific progress identifies progress with "the fulfilment of a certain function" (Shan 2019: 739). (These accounts just differ in what they take the relevant function of science to be; for example, the epistemic account can be said to identify scientific progress with the fulfilment of the function of accumulating knowledge.)

[5] The noetic account is not the only account of scientific progress that appeals to 'understanding' in some sense of the term. For example, Rowbottom (2019: 19-21, 110-127) argues that science progresses, *inter alia*, through increases in 'empirical understanding', and McCoy (2022) develops a version of the problem-solving account in which 'understanding' features centrally. So, in a sense, the noetic account developed here is just one among many understanding-based accounts of scientific progress. Note also that the noetic account *of scientific progress* should not be confused with Bengson's (2015) noetic account *of understanding*, which is an alternative to the dependency modeling account of understanding discussed below (see §3.1).

The truthlikeness, functional, epistemic, and noetic accounts are competing accounts. But what is that these accounts are meant to be accounts of? What is the question to which an account of scientific progress is meant to be the answer? There is some unfortunate confusion on this point in the literature, which in turn fuels an even more unfortunate skepticism about the topic itself. We are therefore forced to precisify what exactly accounts of scientific progress are meant to address before proceeding to build such an account. Accordingly, I will start my discussion with several preliminary points about the nature of our topic (see Dellsén 2021b for a fuller discussion of these).

First, accounts of scientific progress are meant to capture the ways in which various *mental states* (e.g. beliefs) and/or *representational devices* (e.g. theories) improve over time. It is difficult to be more precise than this, since different accounts of scientific progress will to some extent take quite different types of mental states/representational devices to be driving scientific progress. For example, while the epistemic account focuses on accumulation of a specific kind of mental state, viz. knowledge, the truthlikeness account is normally formulated in terms of improvement in certain representational devices, viz. theories. Even so, it should be clear that there are many ways in which science might improve that are not meant to be captured by extant accounts of scientific progress. Note, for example, that a scientific discipline might improve – and thus make progress, in a perfectly legitimate sense of the term – by becoming better funded than it was before, or by increasing opportunities for minorities and underprivileged groups. Although these types of improvements in science are certainly forms of progress in science, they are not our topic here since they don't concern changes in mental states and/or representational devices. For short, we may say that we are concerned only with *cognitive* scientific progress.

Second, it's important to keep in mind that progress is a partially evaluative concept – it refers to *improvement* over time, as opposed to mere change. It follows that accounts of scientific progress are at bottom normative claims, and that accepting a given account has normative implications for how science should proceed. To illustrate with a simple example, if an account of scientific progress implies that a given research project would not add at all to scientific progress even if it were successful, then, other things being equal, progress-seeking scientists should pursue other projects according to that account. More generally, since scientific progress is clearly something that comes in degrees (i.e., there can be *more* and *less* progress over a given episode), an account of scientific progress will deliver normative verdicts about how much progress would be made by a given research project if successful. These normative verdicts can then be used, in conjunction with the scientists' (degrees of) beliefs about whether a given project will be successful, as grounds for choosing which research projects to pursue.

Third, a related point is that accounts of scientific progress are not accounts of the meaning or use of the *words* 'scientific progress' or any of their cognates, in English or any other language. Due presumably to the influence of ordinary language philosophy, philosophers have an unfortunate tendency to test philosophical views against their linguistic intuitions, e.g. (in the current case) by asking whether we would be inclined or disinclined to describe a given episode with the words 'scientific progress'. Although there may be a role for pre-theoretic judgments (or 'intuitions') in debates about scientific progress, the relevant subset of these will not be concerned with meaning or usage of specific words. To see this most clearly, note that even if there were no such words as 'scientific progress' (in English or some other language), we could still debate (in that language) which kinds of cognitive changes in science are genuinely improvements on what came before.

Fourth, any account of scientific progress should be consistent with the truism that scientific progress can be made in many ways. This might seem to automatically invalidate all four accounts mentioned above, since each such account identifies a single type of cognitive change as scientifically progressive. Not so. To see why, let us introduce a distinction between promoting and constituting progress. A cognitive change *promotes* progress when the change is an improvement only in so far it brings about, or raises the probability of, progress at some later time.[6] By contrast, a cognitive change *constitutes* progress when the change is an improvement regardless of what other changes are thereby brought about, or are made more likely to be brought about, at some later time. This distinction mirrors that between *instrumental* and *intrinsic* value,

[6] See Sharadin and Dellsén 2019 for a detailed formal account of the promotion-relation that can be applied, *mutatis mutandis*, to flesh out the notion of promoting progress.

where instrumentally valuable things are valuable in so far as they (eventually) lead to something of intrinsic value.[7]

Finally, it is often helpful to distinguish a general notion of *overall progress*, i.e. progress with respect to all topics or phenomena studied in science, from a more specific notion of *progress-on-X*, i.e. progress with respect to some particular topic or phenomenon *X*.[8] Although many authors sometimes write as if they are concerned with the former,[9] the examples and arguments they give often betray that it is the latter that is their immediate concern. In particular, when they put forward a particular episode of cognitive change as a putative instance of scientific progress, these authors do not usually (if indeed ever) consider the possibility that science has regressed on other topics or phenomena, leading to an overall regress or flatlining of science during the period in question. In my opinion, this is just as well, since we should indeed be most directly concerned with accounting for progress on a particular topic or phenomenon (progress-on-*X*) rather than progress on all topics or phenomena (overall progress). This is partly because discussing scientific progress would otherwise be rather unmanageable, since we would have to consider all scientific changes that occur at over a given time period in order to say whether the episode is progressive.

Another reason to focus on progress-on-*X* rather than overall progress is that it allows us to set aside, for the time being at least, difficult questions about how to balance progress on one topic or phenomenon, with progress on another, in an account of the overall progress during some period. For example, making scientific progress on COVID-19 is (at the time of writing) presumably much more significant than making progress on *misophonia*, the obsessive preoccupation with noises made by other humans (e.g. chewing sounds). Thus, it seems plausible that a given amount of progress on COVID-19 should be taken to contribute more to overall progress than would the same

[7] Indeed, were it not for the fact that the most prominent accounts in the literature are clearly only meant to account for what constitutes progress, I would have been inclined to mark the distinction between promoting and constituting progress with the terms 'instrumental progress' and 'intrinsic progress'.

[8] In addition, one might distinguish these two notions of progress from *progress-in-a-discipline*, i.e. the progress of a particular scientific field. However, the reasons I give for not focusing on overall progress apply to progress-in-a-discipline as well, so I do not consider this notion specifically below.

[9] For example, it is common for authors in the debate to state their accounts using phrases which refer to science as a whole, e.g. "an episode in science is progressive when…" (Bird 2007b: 64) and "science makes progress by…" (Niiniluoto 2014: 75).

amount of progress made on misophonia, simply because COVID-19 is (currently) the much more significant topic.[10] But why exactly is the former more significant than the latter, and how much more does the former therefore contribute to overall progress? There may be no universally correct answer to such questions, and I suggest we set them aside by focusing – at least for now – on the narrower issue of what constitutes progress on a particular topic or phenomenon.

In brief, then, I suggest that the question 'What is scientific progress?' can be reformulated in a clearer and more precise manner as follows:

> (Q) What type of cognitive change with respect to a given topic or phenomenon *X* constitutes a (greater or lesser degree of) scientific improvement with respect to *X*?

If I am right, this captures in a nutshell what debates about the nature of scientific progress are about. To be sure, there are various related and follow-up questions that could be asked as well, e.g. regarding what promotes progress on each account, and what constitutes overall progress (rather than progress-on-*X*). But (Q), I suggest, is the primary question that any adequate account of scientific progress must address.

So what's the answer?

3. The Noetic Account of Scientific Progress

The noetic account of scientific progress can be divided into two parts. The first part specifies, roughly, *what type of* cognitive achievement is relevant for progress (see §3.1). The second part specifies, roughly, *whose* cognitive achievements are relevant for progress (see §3.2). Jointly, these two claims constitute a revamped noetic account of scientific progress (see §3.3).

3.1. Understanding as Dependency Modeling

[10] See Kitcher (2001, 2011) for an influential discussion of this issue and an attempt at defining the notion of "significant truths".

As I have noted, the noetic account takes scientific progress to be explicable in terms of *understanding*. But what, exactly, is understanding?[11]

Understanding is closely related to *explanation*: when we understand something to a reasonably high degree we are normally in a position to explain it or several aspects of it. But, as I argue in detail elsewhere (Dellsén 2020), understanding and explanation can also come apart in important ways. For example, we can increase our understanding of phenomena by learning things that *rule out* explanations of those phenomena. For a case in point, consider the fact that in classical physics the gravitational acceleration of a given object is, somewhat surprisingly, independent of the object's mass. At the surface of the Earth, for example, the gravitational acceleration of any object is $g \approx 9.8\ m/s^2$ regardless of the object's mass. When we learn this fact, our understanding of gravitational acceleration increases, and yet it does not supply us with any explanation of the object's gravitational acceleration. On the contrary, we now know that no explanation of an object's gravitational acceleration could possibly appeal to the object's mass.

Another way in which understanding can come apart from explanation concerns the *direction* of explanation. A typical causal explanation of some fact or event *X* cites the (salient) *causes*, rather than the *effects*, of X. For example, the explanation of the car's crashing into the tree cites the driver's mistake, the bald tires, the icy road, and so forth, as opposed to citing the injuries sustained by the driver or the fact that she was unable to attend a meeting scheduled later that day. By contrast, a relatively complete understanding of a fact or event might partly consist in a representation of its (salient) effects.[12] For example, grasping how the car crash caused the driver's injuries, or how it made her unable to attend the meeting, might well form part of one's understanding of

[11] The notion of understanding that I discuss here is canonically ascribed to a subject S with a sentence of the form 'S understands *X*', where *X* is an object or phenomenon. In the philosophical literature, this is often referred to as 'objectual understanding', to distinguish it from 'understanding-why' (a.k.a. 'explanatory understanding'), which is canonically ascribed with 'S understands why *P*', where *P* is a proposition.

[12] Note that this is a claim about (objectual) understanding, not a claim about understanding-why (explanatory understanding).

the crash.[13] In sum, while (causal) explanation is arguably backward-looking, understanding looks both ways.[14]

In order to capture these ways in which understanding differs from explanation, and yet respect the idea that the two notions are tightly connected, I have developed a view of understanding that directly refers to the dependence relations, such as causation, constitution or grounding, that are often associated with explanation. More specifically, this view defines understanding in terms of *modeling* such dependence relations, where a 'model' of a phenomenon is just an information structure that represents the dependence relations, or the lack thereof, in which the phenomenon and its aspects stand to other aspects or phenomena. Someone's degree of understanding at a given time is then determined by the accuracy (the extent to which its claims are correct) and comprehensiveness (the extent to which it is informative) of their dependency model (Dellsén 2020: 1268):

> An agent *understands* X if and only if they grasp a sufficiently accurate and comprehensive dependency model of X; and the agent's *degree of understanding* of X is proportional to the accuracy and comprehensiveness of their dependency model of X.

To avoid circularity, the notion of 'grasping' used in this definition cannot itself be defined in terms of the same notion of understanding as the definiendum. Fortunately, if 'grasping' is a type of understanding, it is so in a quite different sense of 'understanding' (see Strevens 2013: 511-512).[15]

In many sciences, the most efficient way to convey understanding is through equations or sets thereof. To illustrate with a familiar example, consider a simple gravity pendulum swinging from side to side, where the pendulum's length is much

[13] Of course, it will be a highly contextual matter *which* effects are relevant to understanding a given fact or event. But the same is true of its causes.

[14] Similarly, a constitutive explanation is 'downward-looking': such an explanation of X cites the grounds of X as opposed to what X grounds. By contrast, understanding looks both up and down: we gain understand of H_2O by considering its molecular structure and subatomic composition (i.e., H_2O's grounds) as well as by considering its macro-level properties such as its transparency and freezing point (i.e., what H_2O grounds).

[15] See also Bourget 2017 for an extended discussion of how to define 'grasping' in a way that avoids this type of circularity.

greater than its swing and its mass is concentrated at the bottom of the pendulum. Christiaan Huygens discovered that the period of such a pendulum is approximately given by $T \approx 2\pi\sqrt{L/g}$, where L is the length of the pendulum and g is the gravitational acceleration at its location. This tells us not just *what* the pendulum's period depends on, viz. its length and the gravitational acceleration at its location; it also tells us *how* the pendulum's period depends on these variables, i.e. what T would be for other possible values of L and g. Furthermore, Huygens' law also tells us a great deal about what T does *not* depend on – for example, that the period does not (significantly) depend on the pendulum's mass or the amplitude of its swings. So an equation like Huygens' law conveys a great deal of understanding in a condensed form.[16]

As noted, the concept of understanding thus defined is closely connected to explanation. If, as many believe, explanation always works by somehow citing or exploiting dependence relations, such as causal relations, then discovering or proposing (approximately) correct explanations always increases our understanding of the explained phenomena. But there are also ways of having (some degree of) understanding that don't directly involve explanation – including, importantly, reliable prediction. This important feature of scientific practice also relies on us latching onto dependence relations in one way or another. For example, when I use the barometer to successfully predict upcoming storms, I rely on a representation of the disjunctive fact that there is *either* a chain of dependence relations between barometer readings and the occurrences of storms *or* between each of these and some third variable that explains them both (i.e., a common cause). By contrast, if I thought there was no dependence relations whatsoever between barometer readings and occurrences of storms, or between each of these and some common cause, then I would have no reason whatsoever to think that barometer readings would help to predict storms.

In sum, then, explanation and prediction are both activities that require us to have at least somewhat accurate and comprehensive dependency models. Thus, on the account of understanding sketched here, gaining an ability to correctly explain or reliably predict some phenomenon inevitably involves increasing one's understanding.

[16] See Rowbottom 2019: 8-16 for an account of how Huygens' law provides us with a different type of understanding, viz. what he calls 'empirical understanding'.

This in turn implies that on accounts of scientific progress that appeal to understanding (in this sense of the term), correctly explaining and reliably predicting a phenomenon *X* are both ways of contributing to scientific progress with respect to *X*.[17]

3.2. Enabling Understanding with Public Information

So far I have said that scientific progress can be 'defined in terms of' increased understanding. But *whose* understanding must increase when scientific progress is made? This question is rather more difficult to answer than one might think. In this section, I will address this question as it arises for understanding-based accounts, but it's worth noting that one could ask analogous questions regarding rival accounts. For example, *whose* knowledge must accumulate on the epistemic account in order for scientific progress to occur?

Since scientific progress is made *by scientists* it might seem obvious that an understanding-based account of scientific progress should define progress in terms of increasing the understanding *of scientists*. However, there are two problems with this answer. The first is that it is not clear what exactly 'the understanding of scientists' would be. To spell that out would require us to delineate the extension of 'scientists' in some way, which seemingly requires both a solution to the notoriously impenetrable demarcation problem (which disciplines count as 'science'?), and some principled way of drawing a line between genuine members of a given science and those who play various auxiliary roles (e.g. lab assistants, graduate students, janitors). It would also require an account of what it would be for *a collection of scientists*, rather than individual scientists, to increase their understanding. After all, it is surely insufficient for scientific progress that a single scientist increases her understanding, even significantly, since other scientists might simultaneously decrease their understanding.

The other problem with defining progress as increasing the understanding of scientists is deeper – and darker. Note that a group of scientists who gain

[17] In previous work on scientific progress, I defined understanding operationally roughly as being able to correctly explain and reliably predict the understood phenomenon (Dellsén 2016: 74-75). I now prefer to define understanding as the underlying state that normally undergirds such abilities. Although this shift makes little extensional difference, it highlights the underlying unity of understanding – and thus the unity of scientific progress, according to the noetic account.

understanding of some phenomenon, e.g. by obtaining some experimental results, may for whatever reason decide to keep the relevant result secret, temporarily or even permanently. This happens frequently in 'research and development' at private companies, where making information publicly available would blunt one's own company's competitive edge. It happens occasionally in science as well, although usually not without being met with considerable resistance.[18] Now, when scientific results are kept secret in this way, does obtaining them nevertheless constitute scientific progress? According to the conception of scientific progress on which it is determined by the increasing understanding of scientists themselves, the answer appears to be 'yes' – at least if sufficiently many scientists are in on the secret. This seems to me to be the wrong thing to say. Not because it would be counterintuitive or even unusual to describe such episodes with the words 'scientific progress',[19] but because our account of scientific progress should not encourage secrecy of this kind by counting such episodes as progressive. Results that are kept secret in this way are not (better: should not be classified as) genuine improvements in or of science.

In my view, the fundamental issue underlying both problems is that we are in the grips of a framework that focuses on the *producers* rather than the *users* of scientific results. Scientific progress is not (better: ought not be) determined exclusively by the cognitive benefits it brings to scientists themselves, e.g. in terms of their increased understanding; rather, it is (ought to be) determined also by the cognitive benefits it brings to various groups non-scientists who consume scientific information. Accordingly, I suggest that progress should be defined in terms of the information that is made publicly available in scientific research, e.g. in journal articles and research repositories, on the basis of which various relevant members of society – including scientists themselves but not excluding various non-scientists – may increase their understanding (see Dellsén ms-a).

This is emphatically not to deny that in many cases (especially in 'basic' or 'pure' research), it is appropriate for scientific results to be primarily communicated to other

[18] For example, Merton (1973: 273) notes that secrecy violates 'communism', i.e. the common ownership of scientific results, which is one of his four norms constituting the ethos of modern science.

[19] Recall (from §2) that the central question of scientific progress is not concerned with the meaning or usage of particular words.

scientists. After all, those other scientists are normally those who have the most use for the relevant information. The lay public, by contrast, may not care much at all, or have much direct use for, such information. In cases of this sort, scientists are both the users and the produces of scientific information. In other cases, however, scientific results are highly relevant to various groups of non-scientists, e.g. engineers, medical professionals, and policy makers, whose role in society could not be successfully carried out without such information. In those cases, the conception of scientific progress as determined by making information publicly available for the benefit of the potential consumers of such information requires that those non-scientists have access to the relevant results as well.

To summarize, I am suggesting that scientific progress should be defined not in terms of the increased understanding of those *by whom* scientific progress is made, but in terms of enabling increased understanding among those *for whom* scientific progress is made. In concrete terms, this means that progress is determined not by the actual cognitive states of some particular group of people, viz. 'scientists', but by changes or additions to public information that has been made available by scientific research.

3.3. A (Re-)Statement of the Noetic Account

We are now finally in a position to formulate a more precise version of the idea that progress can be defined in terms of increasing understanding:

> *The noetic account (restated):* Scientific progress is made with respect to a given phenomenon *X* just in case, and to the extent that, changes in publicly available scientific information enable relevant members of society to increase their understanding of *X*, i.e. to increase the accuracy and/or comprehensiveness of their dependency models of *X*.[20]

More colloquially, the noetic account thus reformulated holds that scientific progress on some phenomenon consists in making scientific information publicly available so as to enable relevant members of society to better understand that phenomenon.

[20] As noted above (footnote 16), this is a restatement – or, development, if you will – of the original noetic account (Dellsén 2016).

As emphasized above (see §2), any account of scientific progress, including the noetic account, is in the first instance an attempt to say what *constitutes* scientific progress. But any such account also has direct implications for what *promotes* scientific progress. In particular, the noetic account implies that to promote progress on some phenomenon *X* is to cause or probabilify scientific activities that ultimately help us understand *X*. Consider, for example, the quintessentially scientific activity of collecting empirical data to serve as evidence for or against scientific theories. Since an uninterpreted data set arguably does not by itself convey any understanding, the mere collection of data evidently does not *constitute* progress on the noetic account. However, on the noetic account, collecting data strongly *promotes* progress if and in so far as it leads us to accept true hypotheses and reject false ones, since that in turn enables us to increase our understanding via developing more accurate and/or more comprehensive dependency models than we would otherwise have had.

This might seem harsh on those scientists whose main contribution to scientific progress is empirical as opposed to theoretical. I have two things to say in response. First, this objection conflates the distinction between constituting and promoting progress with different extents to which something contributes to progress. A purely progress-promoting episode may promote much more progress than a purely progress-constituting episode constitutes, in which case the latter contributes much more to progress than the former. Second, the alternative position – according to which collecting data constitutes rather than promotes progress – is, on reflection, quite implausible. To see why, just consider cases in which collecting data would not promote progress, e.g. because the relevant data, although accurate, was collected in such an unsystematic manner that no inferences can be drawn from it.[21] If collecting data constitutes progress, then such cases would have to be classified as progressive.

4. Connections to Rival Accounts

As noted in the introduction, I will not be defending the noetic account by arguing against rival accounts (for that, see Dellsén 2016, 2018c, 2021b, 2022). In this final

[21] See Dellsén 2016: 78 for some concrete examples of this kind.

section, I will instead explore certain points of similarity and dissimilarity between the noetic account and its most prominent rivals, viz. the truthlikeness account, the problem-solving account (including its recent reincarnation in Shan's new functional account), and finally the epistemic account.

4.1. The Truthlikeness Account

Of the three rival accounts described above, the noetic account is arguably most similar to the truthlikeness account. The truthlikeness account identifies scientific progress with increases in the truthlikeness of accepted theories, where truthlikeness measures the extent to which a given theory captures the whole truth about some topic or phenomenon (or indeed the entire world). The noetic account identifies scientific progress with enabling increased understanding, where (degrees of) understanding are determined by a combination of *accuracy* and *comprehensiveness* in one's dependency models. These two criteria for understanding are closely related to truthlikeness, for a theory is more truthlike to the extent that the claims that it does make approximate the truth (≈accuracy) and to the extent that those claims cover more of the whole truth (≈comprehensiveness).

There are, however, two important ways in which the noetic account comes apart from the truthlikeness account (see Dellsén 2021b for a more detailed discussion). Firstly, the truthlikeness account counts all increases in truthlikeness as progressive, whereas the noetic account counts some of them as non-progressive. In particular, note that accepting a sufficiently truthlike correlation, even if entirely spurious, would increase the truthlikeness of accepted theories and thus constitute progress on the truthlikeness account. For example, the discovery of a close correlation between margarine consumption and divorce rates in Maine in 2000-2009 (Vigen 2015: 18-20) amounts to an increase in the truthlikeness of our theories. But this discovery conveys no understanding whatsoever, since it fails to tell us anything about what either of the correlated phenomena do or don't depend on. Thus it would not count as progressive on the noetic account.[22]

On the other hand, the noetic account counts as progressive some episodes in which there is no change at all in the truthlikeness of accepted theories. For example, consider how a set of theories (including theories about the state of various initial conditions) is often used to explain a familiar phenomenon by a simple derivation from theories to phenomena, as in Newton's explanation of Kepler's laws of planetary motion. In cases where the theories were already accepted prior to the explanation, such developments cannot constitute progress on the truthlikeness account. This is so for the simple logical reason that if $T_1,\ldots,T_n$ logically entail C, then the conjunction $T_1\&\ldots\&T_n\&C$ is logically equivalent to $T_1\&\ldots\&T_n$, so the addition of C cannot increase the truthlikeness of accepted theories. By contrast, an explanation of this type would increase understanding in so far as it reveals, or helps to reveal, what the explained phenomenon depends on – which is what ordinary, garden-variety explanations do. Thus the noetic account straightforwardly counts as progressive developments that don't increase the truthlikeness of accepted theories, but rather involve the application of (previously accepted) theories to explain (previously known) phenomena.

4.2. The Problem-Solving and New Funtional Accounts

Problem-solving accounts of scientific progress define progress in one way or another in terms of scientific problems or puzzles and their solutions. According to the most influential version of this account, viz. Laudan's problem-solving account (1977, 1981; see also Kuhn 1970), scientific progress amounts to decreasing the number or importance of unsolved problems, either by solving such problems, or by eliminating or downgrading the importance of the problems that perhaps cannot be solved. But what exactly is a *problem*, and what is involved in *solving* it? On Laudan's view, these terms can only be understood with reference to a particular *research tradition* (corresponding

[22] At most, the discovery of a spurious correlation of this type might *promote* progress, if and in so far as it leads to progress at a later time. For example, if awareness of this correlation were to lead social scientists to discover that consuming margarine and filing for divorce has a common (probabilistic) cause, e.g. suffering from depression, then discovering the correlation would have promoted progress on the noetic account.

roughly to Kuhn's notion of a 'paradigm'/'disciplinary matrix'), which Laudan defines as a set of assumptions about the entities and processes in some domain and the appropriate methods for studying them (Laudan 1977: 81-95). These assumptions entirely determine not only what counts as a 'problem' at a given time (and which problems are more and less 'important'), but also what counts as a 'solution' to such a problem.

There is a certain relativism inherent in Laudan's problem-solving account. Given two distinct research traditions, e.g. successive traditions within some discipline, the questions and answers that count as problems and solutions relative to the first tradition may not count as problems or solutions relative to the second. Moreover, there are no factive standards whatsoever for what counts as a problem, or a solution, on the problem-solving account. If the assumptions of a given research tradition are completely misguided, e.g. in implying that a radically false theory would provide a solution to an entirely spurious problem, then this 'solution' will still count as progressive according to the problem-solving account. For example, medieval theories of the various medical benefits of bloodletting, although now known to be false, were progressive at the time according to the problem-solving account. After all, the research traditions of the day considered them to be 'solutions' to genuine 'problems', such as why bloodletting (allegedly!) cures most diseases (Laudan 1977: 16).

The noetic account, by contrast, does not relativize scientific progress to 'research traditions' – or, indeed, to the assumptions or beliefs of scientists at a given time. Whether some development enables increased understanding is an objective matter, in that understanding requires one to grasp dependency models that are in fact *accurate* (rather than, say, models that are merely *assumed* or *believed* to be accurate).[23] For example, since most diseases are not in fact cured or even alleviated by bloodletting, i.e. since there is no causal relation (or other dependence relation) between bloodletting and the termination or alleviation of most diseases, bloodletting theories do not convey

[23] Indeed, whether or not some model or theory is *believed* to be accurate or true is quite irrelevant to whether it enables increased understanding in my view, since understanding is compatible with lack of belief in the propositions on the basis of which one understands (see Dellsén 2017: 247-251).

any understanding of those diseases. Accordingly, medieval bloodletting theories do not contribute to scientific progress regarding these diseases.[24]

Let me end my discussion of Laudan's account on a conciliatory note. In my view, there is an important kernel of truth in Laudan's emphasis on problem-solving in science. To wit, much of scientific progress consists not in discovering, formulating, or accepting *new theories*; rather, it consists in *applying theories* to specific phenomena in various concrete situations. Now, the problem-solving account refers to this process of applying theories to phenomena as 'problem-solving', and analyzes problem-solving in terms of what counts as a problem/solution relative to a research tradition. The noetic account, by contrast, focuses on how theories are used to *understand* phenomena, which is an achievement for which there are objective success conditions. With that said, the two accounts share the basic conviction that theories, by themselves, do not constitute scientific progress; rather, progress occurs when theories are applied to various specific targets of scientific interest.

With Laudan's account out of the way, let me also briefly address a more recent development of the idea that scientific progress has something to do with problems, viz. Shan's *new functional account* (2019, 2022). Shan's account identifies progress with proposing more useful exemplary practices, where an exemplary practice is 'useful' just in case it (i) provides a repeatable way of solving and defining research problems, (ii) provides a reliable framework for solving problems, and (iii) generates more testable research problems across different areas or disciplines. If I understand Shan's account correctly, [25] I suspect it is both too demanding and not demanding enough.

I suspect it is too demanding because there are surely ways of making progress that don't involve any exemplary practices being proposed at all. In particular, it seems to me that progress can be made by simply utilizing previously-proposed exemplary practices in various ways. For example, it seems to me that progress was made each

[24] There are some rare cases of diseases which bloodletting does in fact help to alleviate, e.g. *hemochromatosis* (a condition that causes excess iron to be stored in one's organs). A theory that accurately explains this would of course count as progressive on the noetic account, since it would reveal the causal relationship between bloodletting and alleviation of hemochromatosis.

[25] Shan's account is quite complex, appealing to a number of elusive terms that are left undefined (e.g. 'framework', 'exemplary', 'practices', and 'problem'). So my objections may be based on a misunderstanding of Shan's intentions; if so, I apologize and hope that the current discussion may prompt clarifications of the account going forward.

time Newtonian mechanics and its associated methodology was applied to increase our understanding of yet another physical phenomenon during the 18th and 19th centuries. Such applications of Newtonian mechanics seemingly did not involve proposing any new exemplary practices, since the relevant exemplary practice had already been proposed years earlier. Hence they would not count as progressive on Shan's account.

To see why I suspect Shan's account is also not demanding enough, note that Shan's account resembles Laudan's problem-solving account in that the there is no requirement that the problem-definitions and problem-solutions that a useful exemplary practice is meant to provide must be factive, e.g. in that the 'problems' must be based on correct assumptions about which things actually exist. Accordingly, it seems to me that Shan's account opens the door for all sorts of deeply mistaken practices to constitute contributions to scientific progress. Indeed, returning to our earlier example of bloodletting, it seems to me that the medieval practices of bloodletting would count as contributions to scientific progress on Shan's account, since these practices provided an ambitious framework for 'defining' and 'solving' various 'problems'. At the very least, a proponent of Shan's account cannot say that the problem with these practices is that bloodletting theories were radically false/inaccurate, since truth(likeness)/accuracy is not a requirement for progress on Shan's account.[26]

4.3. The Epistemic Account

The epistemic account identifies scientific progress with accumulation of knowledge, where 'knowledge' is understood to require truth, belief, and some form of justification (e.g. reliability, safety, or evidential support). This is not to say that knowledge can be

[26] In response to an objection that resembles the one pushed here, Shan says that "usefulness of exemplary practices is also explicable in terms of truth *to some extent*. In particular, it is well explained by the 'contextualist' theory of truth..." (Shan, 2022: 7). Shan's point seems to be that one could adopt a notion of truth that counts certain theories as false *in our context* while counting the same theories as true *in another context*, presumably in such a way that now-discarded theories that are false in our current context were true in the context in which they were accepted. I find this 'contextualist' notion of truth problematic for the usual reasons, but I won't argue the point here. Instead, I'll just note that adopting this theory of truth fails to address the current objection. After all, *in our context*, bloodletting theories are simply false. Thus, bloodletting theories arguably do not contribute to progress *in our context*. Shan's account, however, is forced to say that they do contribute to progress *in our context*. (Whether or not bloodletting theories might count as true in another context is neither here nor there as far as this argument is concerned, since the argument does not hinge on whether something counts as progress in some context other than the current context.)

identified with justified true belief, since the infamous Gettier-cases suggest that truth, belief and justification are not jointly sufficient for knowledge.[27] Nevertheless, knowledge uncontroversially *requires* truth, belief and some form of justification, in the sense that S cannot know that P if P is false, not believed by S, or epistemically unjustified for S. It follows that, on the epistemic account, science makes progress only when there is accumulation of justified true beliefs. Put differently, whenever some scientific claim is put forward, it cannot constitute progress on the epistemic account unless it is (i) true, (ii) believed, and (iii) epistemically justified. Whenever one of the requirements (i)-(iii) fails, there is no progress on the epistemic account.

There are some similarities between the epistemic and noetic accounts. In particular, the truth-requirement of the epistemic account resembles the accuracy-criterion of the noetic account. We might say that the epistemic and noetic accounts are both broadly *veritistic* – like the truthlikeness account, but unlike the problem-solving account. In addition, the belief-requirement of the epistemic account is in some ways mirrored in the grasping-requirement on understanding, in that both define progress with respect to a specific mental state. With that said, Bird's epistemic account seems to require that scientists themselves, or perhaps communities thereof (see Bird 2019), *be in* the relevant mental state (i.e. knowledge/belief). The noetic account, by contrast, instead requires that scientists *enable* various agents – some but not all of which are themselves scientists – to come to be in the relevant mental state (i.e. understanding/grasping). So the noetic account, unlike the epistemic account, does not really concern itself with what goes on in the minds of scientists, or communities thereof; rather, what matters are the *products* of scientific research, such as published journal articles.

The main difference between the epistemic and noetic accounts concerns the epistemic account's requirement that scientific claims be epistemically justified in order for their accumulation to constitute progress. The noetic account, by contrast, does not require epistemic justification for progress, since justification is not required for

[27] Indeed, Williamson (2000) argues that knowledge is not analyzable at all in terms of necessary and sufficient conditions. Bird (2007a) endorses this view.

understanding according to the definition with which it operates (see §3.1).[28] What difference does this make?

One might think that imposing a justification-requirement on progress would help to explain the value of various practices in which scientific claims are justified, e.g. through experimentation, observation and theoretical argument. Indeed, an account of scientific progress that does not impose a justification-requirement might seem to imply that scientists would have no reason to engage in such justificatory activities, since making scientific progress would be perfectly possible without it. But this line of thought is too quick. Any veritistic account of scientific progress implies that justificatory activities *promote* scientific progress in so far as they cause, or raise the probability, of making scientific progress. After all, the whole point of justificatory activities is to separate fact from fiction, accuracy from error. In so far as these justificatory activities are successful, they ensure that the cognitive changes that are made in science (e.g. replacing one theory with another), constitute progress rather than regress or flatlining. Given this straightforward instrumental value to justificatory activities on any veritistic account, there is no need to also impose a justification-requirement on scientific progress in order to explain the scientific value of justificatory activities.[29]

Moreover, as I argue in much more detail elsewhere (Dellsén 2022), there are several independent reasons not to impose a justification condition on scientific progress. Consider, for example, the fact that in a gradual transition from a scientific consensus on a theory T_1 to a consensus on a rival theory T_2, there will inevitably be a period of time during which those scientists who are most knowledgeable with respect to T_1 and T_2 disagree about which theory is more accurate (or more likely to be accurate). Given widely accepted views in the epistemology of disagreement, at least

[28] Some epistemologists suggest that justification is required for understanding as well as for knowledge, e.g. on the grounds that understanding is a species of knowledge (e.g., Sliwa 2015, Khalifa 2017). I argue otherwise (Dellsén 2017, 2018a, 2021a; see also Hills 2016). But more importantly, we can set these views aside here since our current concern is not with explicating the concept of *understanding*, but that of *scientific progress*. For these purposes, we can simply stipulate that the term 'understanding', as it is used here, does not require justification. (If this sounds incoherent to some readers, they may mentally replace 'understanding' with 'understanding-*sans*-justification'.)

[29] Here I am in agreement with Rowbottom (2008), who was the first to argue, against Bird's epistemic account, that justification is instrumental for, rather than constitutive of, scientific progress.

part of this period will be such that very few, if any, of the relevant scientists are epistemically justified (i.e., justified in the sense, and to the degree, required for knowledge) in believing either T_1 or T_2, roughly because the justification they would normally have for T_1/T_2 is undercut by their awareness of the widespread disagreement on T_1/T_2 among the relevant experts. Thus the epistemic account, and indeed any account that imposes a similar justification-requirement, implies that the progress which had previously been made with the introduction of T_1 disappears, or is at least sharply reduced, during this period of widespread disagreement, only to re-emerge once the disagreement abates in favor of T_2.

Awkward consequences of this kind suggest that we shouldn't *require* justification for progress. This does not imply that scientific claims are typically unjustified, or that justification is unimportant for the progress of science. It implies only that it is *possible* to make scientific progress in the absence of the type of justification required for knowledge. This is no doubt a rare occurrence, because the ethos of science dictates that one shouldn't present something as true unless one has evidence to back it up. But rare things do happen occasionally (see, e.g., Dellsén 2016: 76-77).

5. Conclusion

I have articulated a version of the idea that scientific progress can be defined in terms of increasing understanding. The account I favor, the noetic account, holds that scientific progress on some phenomenon consists in making scientific information publicly available so as to enable relevant members of society to increase their understanding of that phenomenon. Within this account, 'understanding' is defined in terms of the accuracy and the comprehensiveness of one's representation of the dependence relations, e.g. the causal relations, in which the target of understanding stands to other things. Since dependence relations undergird correct explanation and reliable prediction (among other things), explanation and prediction are some of the central ways in which scientific progress manifests itself on the noetic account.[30]

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