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A Pragmatist Reboot of William Whewell's Theory of Scientific Progress

Abstract

William Whewell's philosophy of science is often overlooked as a relic of 19th century Whiggism. I argue however that his view – suitably modified – can contribute to contemporary philosophy of science, particularly to debates around scientific progress. The reason Whewell's view needs modification is that he makes the following problematic claim: as science progresses, it reveals necessarily truths and thereby grants a glimpse of the mind of God. Modifying Whewell's view will involve reinventing his notion of necessary truth as the pragmatist notion of superassertibility. And, if scientific progress does not uncover necessary truths, then it does not reveal the mind of God. The result is an outline of an account of scientific progress that is piecemeal and fallibilist in nature, yet at the same time maintains key Whewellian themes of consilience and the unity of science.

Key words

Consilience; unity of science; scientific method; scientific truth; scientific understanding; scientific progress

Introduction

What can 19th century philosophy of science teach us about scientific progress? Some would say not much. Contemporary philosophers of science are largely dismissive of the 'march to truth' motif prevalent in post-Newtonian, pre-Einsteinian philosophy of science. Triumphalist statements like this one from William Whewell may sound decidedly outdated:

> The certainty and the constant progress of science are things so unquestioned, that we are at least engaged in an intelligible inquiry, when we are examining the grounds and nature of that certainty, the causes and laws of that progress (1840, I, 16-17).

In this paper, I aim to show that behind such dialectical bravado, Whewell, in fact, developed a subtle and thought-provoking account of scientific progress. There are nonetheless problems with his account, and I therefore modify it appropriately. The product is a pragmatist reinvention, features of which can shed light on the contemporary debate around the nature of scientific progress.

Whewell's philosophy of science is often glossed over as a footnote to Kant or ignored as part of an obsolete tradition of Whiggish scientism (see Snyder 2006). My reboot of Whewell's theory of scientific progress therefore makes a novel contribution to the literature. His notions of *consilience* and the *entwined subject/object* in particular nicely capture the cumulative yet evolutionary nature of scientific progress.

It is important to mention up front that Whewell considers there to be three different kinds of truth involved in scientific inquiry: he calls these (1) scientific or *a posteriori* truth, (2) necessary or *a priori* truth, and (3) final and universal or divine truth.[1]

> (1) occurs in success empirical inquiry; it is a weak, fallibilistic, and pragmatic kind of truth similar to Popper's (2002) notion of *corroboration* or van Fraassen's (1980) notion of *empirical adequacy*. A scientific law or theory is *a posteriori* true when it makes successful predictions and unifies a diversity of facts[2]. *A posteriori* truth comes in degrees: the more empirical success a law or theory enjoys, the more it increases in its degree of *a posteriori* truth.
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> (2) occurs in the mind. When a scientific law or theory has survived repeated empirical tests and unified ever more facts (as in (1)) we become unable to conceive of its falsity. The law or theory transforms from being *a posteriori* true to being *necessarily* true.[3]
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> (3) is an ideal and absolute notion of truth. Divine truth equates to the complete world picture contained in the mind of God. Like Peirce's ideal end of inquiry, we aspire to and

[1] See Walsh (1962) and Fisch (1984) for detailed expositions of Whewell's three types of truth.

[2] Whewell uses the term 'fact' to denote a datum generated in empirical inquiry (roughly, a sense datum). I follow Whewell's convention here.

[3] This is not a typo. As we will see, Whewell does indeed argue that successful empirical inquiry can render scientific theories *necessarily* true.

progress towards it during successful scientific inquiry. When we come to know a necessary truth (as in (2)) we are granted a glimpse, but not the whole, of divine truth.

Further, engaging in scientific inquiry allows us to progress from (1) to (2) to (3). It will become clear through the rest of the paper why Whewell thinks that there three kinds of truth, and why he thinks that engaging in scientific inquiry leads from (1) to (2) to (3).

Some provisos should be noted. I will touch on contemporary views that consider the unit of scientific progress to be either truth(likeness), knowledge, or understanding. I will however not take a side in this debate. Instead, I argue that Whewell's account – suitably modified – has something to add to either of these conceptions of scientific progress. I will also not engage in the debate over whether there is a scientific method or whether science progresses. *Pace* Feyerabendian anarchism, I assume that there is some vaguely discernible method operant in science and that science is progressive in some way. What I will focus on are questions related to what a scientific method may entail and in what sense science progresses. Specifically, I am concerned with whether these notions should be conceived of in unitary or pluralistic terms. I will also not attempt to define what constitutes a scientific theory, a measuring instrument, or similar constituents utilised during scientific inquiry. My aim is not to work out a comprehensive account of science in practice. Instead, my aim is more modest in attempting to draw certain salient features from Whewell's view, features that can shed light on specific issues in the contemporary debate around scientific progress.

In section 1, I discuss three Whewellian notions that require explication prior to introducing Whewell's account of scientific progress. These are (1) the entwined subject/object, (2) fundamental ideas, and (3) conceptions.

In section 2, I detail Whewell's three-stage scientific method, which forms an integral part of his overall account of scientific progress: (1) colligation of facts, (2) verification of the colligation, and (3) consilience of inductions. I pay special attention to (3).

In section 3, I critique and reconceive two further stages that putatively follow from Whewell's scientific method. These are (4) successful empirical inquiry can render scientific theories necessarily true, and (5) stage 4 grants us a glimpse of divine truth contained in the mind of God. For Whewell, stages 4 and 5 putatively follow from his scientific method (stages 1 to 3). Whewell's account of scientific progress thus consists of five stages: stages 1 to 3 are methodological; stages 4 and 5 are transcendental.[4]

In section 4, I outline my reinvention – my pragmatisation – of Whewell's account of scientific progress. This involves stripping away Whewell's last two transcendental stages and drawing out key themes from the remaining three methodological stages.

In section 5, I engage with possible objections scientific pluralists may level against my endorsement of Whewell's convergentist notion of consilience.

1. Preliminaries

[4] Whewell does not explicitly divide his account of scientific progress into five stages. I am doing so for the sake of parsimony and clarity.

Whewell's philosophy of science centres around his notion of the *consilience of inductions* (COI). Ilkka Niiniluoto sums up COI nicely:

> [COI] takes place when 'inductive' steps from different classes of facts lead to the same results, that is, when two separate generalizations or laws are found to be consequences or special cases of the same comprehensive theory (1984, 22-23).

Niiniluoto puts 'inductive' in scare quotes because what Whewell calls induction is what we would now standardly call abduction (see Laudan 1971). This will become clear in Section 2. Following Whewell, I will nonetheless continue to use the term 'induction'.

Whewell (notably 1840, I, bk. III; 1840, II, bk. XII, ch. 12; 1858a, 1858b) uses the example of Newton's unification of Kepler's laws of planetary motion. Kepler's laws "jump together" when shown to be a consequence of Newton's laws of motion and his law of universal gravitation. Not only did Newton show Kepler's laws to be a limiting case, but he also unified the celestial motion of planets with the terrestrial motion of falling bodies. Facts previously thought to be governed by different laws and explained by different theories are, in fact, subsumed under Newton's unificatory framework (see Ruse 1979 for detail). Before consilience,

> the facts are seen as detached, separate, lawless; afterwards, they are seen as connected, simple, regular; as parts of one general fact, and thereby possessing innumerable new relations before unseen (Whewell in Fisch 1984, 281).

There are however some preliminary Whewellian concepts needing explication before COI can be properly understood. These are his notions of the entwined subject/object, fundamental ideas, and conceptions. I now discuss each of these three notions in turn.

The Entwined Subject/Object

For Whewell, empirical inquiry involves both a subjective and an objective component, that is, a theoretical and a factual component or a mental and a worldly component.[5] Following Kant (1929), we do not perceive solid objects, for example; we only perceive shapes, colours, and shades. Solidity is a unifying element provided by the mind. Predating contemporary theory-ladenness of observation theses (e.g. Quine 1960; Kuhn 1962), Whewell thinks of facts as "idea laden"; "some act of the mind accompanies the reception of our most tranquil perceptions" (1840, I, 28). According to Gerd Buchdahl, Whewell thus emphasises

> the Kantian doctrine that it is not possible to make a sharp distinction between the 'sensational' and the 'intellectual' aspects of knowledge; that the division between 'data' and 'inference' is artificial (1971, 350).

[5] Whewell considers mind and theory to be constitutive of the *subject*, and world and fact to be constitutive of the *object*. I will follow his convention here.

Margaret Morrison calls this Whewell's "antithesis" of subject and object; it is "an attempt to illuminate the relation between epistemology and ontology by stressing their interactive nature" (1997, 419-420). I will call Whewell's antithesis of subject and object *subject/object entwinement* (SOE).

Despite being underwhelmed by Hegel's philosophy of science (Whewell 1860 ch. 24), Whewell plainly expresses a dialectical motif in SOE (Fisch 1984, 290-291; Snyder 2006, 38-39). Scientific (or *a posteriori*) truths are neither strictly discovered nor strictly constructed. They are not a property of a mind-independent proposition that we might discover 'out there', nor are they something *we* create and project onto the world. Instead, scientific (or *a posteriori*) truth is a property that a scientific theory takes on as a function of the synthesis of subject and object mutually engaged in successful empirical inquiry. This is a cumulative, even dialectical, process that generates progress in science (I return to this topic in Section 2).

Fundamental Ideas

Scientific progress is made possible by what Whewell calls "Fundamental Ideas".[6] Fundamental ideas, says Whewell, are "certain comprehensive forms of thought… which we apply to the phenomena which we contemplate" (1858b, 71). These include 'space', 'time', 'motion', 'causation', 'number', 'substance', 'life', 'polarity', and 'symmetry'. According to Harold Walsh, these fundamental ideas are "posited *hypothetically*, as being the best ways of organizing the science in question, rather than being presupposed by it", as Kant might suggest (1962, 141 original emphasis). Fundamental ideas thus begin as conceptual, taxonomic postulates. If they then match the structure of the world revealed in empirical inquiry, they can be considered faithful representations of the world. Fundamental ideas are those of our classificatory concepts that, as it turns out, were necessary all along. We can however only know as much after rigorous empirical testing. We can think of fundamental ideas as forming the nodes in a theoretical network, a network that, according to Whewell, constitutes the creation plan God used when creating the universe (I discuss Whewell's theology further in Section 3).

Although similar to Kantian categories, fundamental ideas are not given; they are not pretheoretically distinct in the mind. Instead, fundamental ideas are pretheoretically "imbedded" in our cognition. They lie dormant until they become defined through their role in making conceptual sense of facts generated in empirical inquiry. Fundamental ideas are resident in the mind *a priori*, but only arise to conscious awareness during successful *a posteriori* inquiry. They can then play an active role in further inquiry, and so on (see Walsh 1962; Harré 1969; Snyder 2006 for detail).

Conceptions

Conceptions, says Whewell, are the "special modifications" of fundamental ideas "which are exemplified in particular facts" (1858b, 71). We can think of a conception as that which obtains when a fundamental idea is applied to the world. Conceptions, as Whewell puts it, "colligate" or "bind together" the facts. They are the terms we apply when attempting to carve nature at the joints, when we sort and classify empirical data into natural kinds according to some

[6] As was common at the time, Whewell capitalises key words in his texts. I will quote Whewell *verbatim*, but not adopt this convention in my own writing.

fundamental idea (see Walsh 1962; Harré 1969; Snyder 2006 for detail). Examples include 'circle', 'square number', 'accelerating force', and 'species'. In application, we use the fundamental idea of 'life', for example, to classify certain facts into the conceptions 'species', 'genus', 'family', 'order', and so on up the hierarchy of life. This creates a conceptual, taxonomic order in which a fundamental idea resides at the top, and the various conceptions serve to sort and classify the relevant facts below.

SOE, fundamental ideas ,and conceptions play key roles in Whewell's scientific method. As mentioned, Whewell's scientific method makes up the first three stages of his five-stage theory of scientific progress.

2. Whewell's Scientific Method: Stages 1 to 3

Although I describe the stages in Whewell's scientific method as occurring in temporal order, stages 1 and 2 are, in fact, interrelated and iterative in producing stage 3.

Stage 1: Colligation of Facts

For Whewell, engaging in science involves firstly analysing, sorting, and clarifying our fundamental ideas and the facts at hand. Once our ideas and the facts are clear, we construct a conception by generalising over the facts. Fundamental ideas, conceptions, and facts are "rendered more complete"; "Conceptions are made more clear in themselves" and they "more strictly bind together [or *colligate*] the Facts" (Whewell 1858b, 29 original emphases removed). Jutta Schickore summarises this first stage in Whewell's method as follows:

> [It] is an extended process. It involves, on the one hand, the specification of facts through systematic observation, measurements and experiment, and on the other hand, the clarification of [fundamental] ideas through the exposition of the definitions and axioms that are tacitly implied in those ideas. This process is iterative. The scientists go back and forth between binding together the facts, clarifying the idea, rendering the facts more exact, and so forth (2018, np; see also Walsh 1962).

In deriving his fist law of motion, Newton, for example, started with the fundamental ideas of change, motion, reaction, and most importantly *cause*. Careful observations of the facts then led him to posit the conception of *force*, defined as "any cause of change in a body's motion". The conception of force is what Laura Snyder calls a "modification" of the fundamental idea of cause "applied specifically to the case of motion" (1994, 788 fn. 21).

Once a conception colligates some facts, we perform an *induction* (in the Whewellian sense), we extrapolate the conception to new and unknown facts. This involves the verification of the colligation.

Stage 2: Verification of the Colligation

Inducing a conception to unknown facts first involves incorporating it into a hypothesis that makes a prediction. This hypothesis can then either be "verified or contradicted by observation

of the facts" (Whewell 1840, II, 45).[7] Hypotheses form connections between previously dislocated facts. These connections are then tested by correlating independent measurements. Successful correlation confirms that our conception applies to, and thereby unifies, the previously dislocated facts. We have then performed a successful induction. Local conceptions and tentative hypotheses are thus transformed into *general* laws. Hypotheses that fail to be verified are discarded, while those that survive can be used in further inductions to new empirical domains, and so on.

After colligating the facts, Newton put forward the hypothesis "every change has a cause". Successful induction to unknown cases then allowed this hypothesis to be suitably modified into his first law: "an object will remain at rest or in uniform motion in a straight line unless acted upon by an external force". The first law then serves as one of the pillars of Newton's general theory of mechanics.

What Whewell calls a consilience of inductions (COI) occurs when inductions from different domains of scientific inquiry converge.

Stage 3: Consilience of Inductions (COI)

Recall that

> [COI] takes place when 'inductive' steps from different classes of facts lead to the same results, that is, when two separate generalizations or laws are found to be consequences or special cases of the same comprehensive theory (Niiniluoto 1984, 22-23).

COI occurs when successful verifications of the colligation (stage 2) from different domains are subsumed under a unifying theory. That theory can then be merged with other similarly subsuming theories, and so on. COI is cumulative and progressive. Laws or theories previously applied to separate classes of facts come to be understood as parts of the same overarching law or theory. We come to understand previously diverse facts as manifestations of underlying unifying facts. Citing Whewell, Michael Ruse states that

> a good scientific theory is *consilient*… a good scientific theory explains in many different diverse areas, drawing all together and unifying under one single hypothesis. A good theory does not simply explain that which it was invoked to explain (1979, 531-532 original emphasis).

[7] Whewell repeatedly talks of "hypotheses" (or "propositions" or "doctrines") as being "verified" in empirical inquiry. Post-Popper, we do not usually think of scientific hypotheses as being verified, even when they make successful novel predictions. Popper's weaker notion of *corroboration* seems more apt. On my reading, Whewell has something like Popperian corroboration in mind. Whewell states, for example, that a verified hypothesis – i.e. a scientific law – is "right and useful", while a *bona fida* scientific theory is "valuable and, at least to a great extent, true" (1840, II, 63). This suggests that when Whewell talks of verification in empirical inquiry, he has something weaker and more pragmatic in mind than verification.

A consilient theory brings together and integrates "many different areas of knowledge" (Ruse 1979, 532). For Whewell, the ongoing unification of both theories and facts fuels the progress of science. Science grows, evolves and converges towards a final state of completion, a state that is something like what Peircean pragmatists would call an "ideal end of inquiry" or what physicists might call a theory of everything (TOE). Looking back, Whewell's optimism seems justified given the consilient promise Newtonian theory displayed at the time.[8]

Regarding truth, Whewell states as follows:

> That rules [or laws] springing from remote and unconnected quarters should thus leap, to the same point, can only arise from that being the point where truth resides… No accident could give rise to such an extraordinary co-incidence (1840, II, 65).

For Whewell, the more consilience a theory displays, the more it becomes *a posteriori* true be degrees (as defined in the introduction). There is what he calls a "gradation of propositions, proceeding from the most special facts to the most general theoretical assertions"; there is a "gradation of truths [that] converge to unity" (Whewell 1840, II, 75-76). True scientific theories "tend to simplicity and harmony", while in "false theories, the contrary is the case" (Whewell 1858b: 91). Unificatory and consilient theories are simple and harmonious, and those that are the most simple and harmonious possess the highest degrees of *a posteriori* truth.

Whewell thinks of science as a "genealogical tree": there are various branches of science that are "uniting their ramifications so as to form larger branches, these again uniting in a single trunk" (1840, I, 241; see also Popper 1972, 262-263 for a similar metaphor).[9] Larry Laudan, who interprets Whewell as an early Popperian falsificationist,[10] states that in Whewell's method "theories which are retained but modified must ascend to higher and higher levels of generality… whilst converging towards systemic simplicity and unity" (Laudan 1971, 386; see Whewell 1858b, 96). However, "(and this is crucial) increased generality is only a gain insofar as that greater generality is *experimentally confirmed*" (Laudan 1971, 372 original emphasis; see also Buchdahl 1971; van der Merwe forthcoming-a, forthcoming-b).

However, unlike Popper, Whewell thinks it is possible for theories that are repeatedly experimentally confirmed (theories that survive repeated attempts at falsification) to transform from being *a posteriori* true into being necessarily true.

3. Whewell's Transcendentalism: Stages 4 and 5

As mentioned, there are two further stages in Whewell's account of scientific progress: stage 4 (the transformation of *a posteriori* truth into necessary truth) and stage 5 (a proceeding glimpse of the complete and final truth contained in the mind of God). Whewell intends that stages 4 and

[8] Post-Einstein and the development of quantum mechanics, few (particularly in the philosophy of science) are so optimistic. Something like what Steven Weinberg (1992) calls the "dream of a final theory" does nonetheless seem to motivate and steer the course of progress in fundamental physics.

[9] Each branch of science relies on a different fundamental idea (Section 1).

[10] See Niiniluoto (1984 ch. 3) for an informative discussion of the commonalities between Kant, Whewell, and Popper.

5 transform fallible scientific practice into something that can reveal eternal and universal certainty. However, as various commentators have noted, this supposed transformation involves some logical sleights of hand. I therefore reinvent stages 4 and 5 in pragmatist terms. This renders Whewell's theory of scientific progress more amenable to the contemporary debate. Regarding stage 4, I propose that we do away with the idea that empirical inquiry can reveal necessary truth, and instead think of truth in terms of Crispin Wright's notion of superassertibility. Since stage 5 is premised on stage 4, the idea that we can glimpse the mind of God simply falls away if empirical inquiry does not reveal necessary truth.

Stage 4: The Transformation of the *A Posteriori* into the *A Priori*

For Whewell, *a posteriori* truths (revealed in stages 1-3) transform into necessary truths when empirically verified theories become so ingrained in the understanding that we cannot "conceive it possible to doubt" their truth (Whewell 1840, II, 286). "We learn by observation truths of which we afterwards see the necessity" (Whewell 1860, 529). Menachem Fisch (1984) calls this transformation of the *a posteriori* into the *a priori* Whewell's "transcendental inference". It occurs when relevant fundamental ideas and conceptions are seen to be deductively interconnected. Theories once partial and provisional can become universal. Laws are clarified as logical necessities; they come to be understood as self-evident.

Whewell is aware of the apparent *non sequitur* involved in stating that *a priori* truth is revealed by – i.e. comes after – *a posteriori* truth. He ostensibly gets around this problem by positing that *a priori* truths – like fundamental ideas (recall Section 1) – are pre-embedded in our cognition (by God). *A priori* truths can then be 'awakened' during successful empirical inquiry. *A priori* truths exist prior to experience, but they only 'emerge' – they are only revealed to us – through ongoing COI.[11] Whewell calls stage 4 of his theory of scientific progress the logic of induction: "The Logic of Induction is the Criterion of Truth inferred from Facts, as the Logic of Deduction is the Criterion of Truth deduced from necessary Principles" (Whewell 1840, I, xl-xli emphasis removed).

Further, for Whewell, once *a priori* truths obtain in the understanding, we should be able to discard the empirical 'scaffold' used to construct them. Truths at first only knowable through experiment can now be known through pure reason. As Snyder explains, Whewell thinks that it is in principle "possible to idealize all experiential [*a posteriori*] truths into necessary truths knowable *a priori*"; it is in principle possible for

> all science to become purely deductive, like the mathematical sciences. That is, once all the axiomatic laws of a particular science are knowable *a priori* (seen as being analytic consequences of the fully explicated Fundamental Idea(s) of that science), the only task left for the scientist would be to deduce further theorems from these laws (Snyder 1994, 804).

[11] It is, in any event, debatable whether Whewell uses the terms '*a priori*' and '*a posteriori*' in a coherent and consistent manner (see Snyder 2006).

Although transformation of Newton's hypothesis into his first law originally required empirical inquiry, the law is, in fact, knowable *a priori*:

> Intercourse with the external world is requisite for developing our [Fundamental] Ideas; measurement of phenomena is needed to fix our conceptions and render them precise: but the result of our experimental studies is, that we reach a position in which our convictions do not rest upon experiment. We learn by observation truths of which we afterwards see the necessity (Whewell 1860, 529).

This is because once the conception of *force* as "any cause of change in a body's motion" and the associated hypothesis "every change has a cause" are empirically verified, it follows deductively that "every change in motion of a body has a cause". From this it follows deductively that "any change in speed and direction of a body requires a force". Newton's first law of motion is then derivable: "an object will remain at rest or in uniform motion in a straight line unless acted upon by an external force" (see Whewell 1860 ch. 18; Snyder 1994, 798-803 for detail). Snyder explains that we apply the fundamental idea of cause to the facts to "form the empirical laws of motion – and it is from the universality and certainty of the [Fundamental] Idea and its axioms that the laws derive their universality and certainty" (1994, 798).

Stage 4 involves a logical jump from the practical to the ideal – from the empirical to the transcendental – that has puzzled Whewellian scholars. Laudan states that COI is "manifestly an experiential matter" and "experience, no matter how extensive, cannot be used as evidence for the necessary character of scientific truths" (1971, 383; see also Buchdahl 1971, 352-354; Fisch 1984, 304-310; Niiniluoto 1984 ch. 3). Further, if subject and object or theory and fact are always entwined (SOE from Section 1), then how can science become a purely deductive enterprise? Despite stressing SOE, Whewell ultimately severs truth from the factual domain rendering it purely theoretical. Whewell never adequately explains how theory can become detached from facts in this way when the two are supposed to be inextricably entwined.

Moreover, like Kant, Whewell thinks of Newtonian physics as *the* complete science. We have however since witnessed the Einsteinian and quantum revolutions which, at best, render Newtonian physics a limiting case (and there may be similarly disruptive Kuhnian revolutions to come [Laudan 1981]). The received view among contemporary philosophers of science (whether realists or anti-realists) is that we must be fallibilists about the truth-status of even our best scientific theories. Theories can perhaps be corroborated, empirically adequate, truthlike, approximately true, or *a posteriori* true (in the Whewellian sense). However, as Hume (1748) and Popper (1959) have stressed, no theory can be *necessarily* true given that unexpected new evidence might falsify the theory in the future (see also Fine 1986; Stanford 2006). The fact that we cannot "conceive it possible to doubt" a theory, does not render that theory necessarily true. Conceivability is not a benchmark for truth, not in science anyway.

Given the above, we may want to strip away the *a priori* layer that Whewell adds to empirical science. This will render scientific theories only capable of being *a posteriori* true. Whewell is however not always clear on what *a posteriori* truth entails. I therefore propose that we follow Crispin Wright in adopting the notion of *superassertibility*. According to Wright, superassertibity

applies "wherever our discourse displays some measure of *convergence* about what is warrantedly assertible" (2021, 583 emphasis added).

> A statement is superassertible… if and only if it is, or can be, warranted and some warrant for it would survive arbitrarily close scrutiny of its pedigree and arbitrarily extensive increments to or other forms of improvement of our information (Wright 1992, 48).

According to Julian Dodd, "⟨*p*⟩ is superassertible if and only if ⟨*p*⟩ is warranted without defeat at some stage of enquiry, and would remain so at every successive stage of enquiry" (2013, 29 fn. 4; see also Lynch 2009; van der Merwe 2020: 508-509). Superassertibility is a fallibilist or weak sort of pragmatic truth similar to Whewell's notion of *a posteriori* truth. Scientific theories can become increasingly superassertible as a function of ongoing COI (*viz*. their ability to survive repeated empirical tests and to demonstrate ongoing consilience). [12] Theories can become increasingly superassertible, but they never become necessarily true. We need not invoke truth to make sense of scientific progress if truth equates to *a priori* certainty (I will discuss superassertibility in more detail in Section 4).

I now critique the second transcendental layer Whewell adds to his scientific method: a revelation of the divine.

Stage 5: A Revelation of the Divine

As outlined in the introduction, Whewell has three kinds of truth operant in his theory of scientific progress: (1) scientific or *a posteriori* truth, (2) necessary or *a priori* truth and (3) final and universal truth. The first kind of truth unveils the second kind, which, in turn, unveils the third and most valuable kind. The third kind of truth – the final and universal truth – remains elusive without appeal to the divine. Science can reveal instances or fragments of the final and universal truth (as in the case of Newton's laws) but it only obtains in its entirety in the mind of God. In the end, "the propositions of space and number and the like, must be supposed to be what they are by an act of the Divine Mind" (Whewell in Snyder 2006, 89).

Whewell thus considers stage 5 to be the apogee of scientific progress. This endmost step proceeding Whewell's scientific method involves a divine revelation of sorts. Our minds mirror parts of the mind of God when we understand the necessary truth of our best scientific theories and their associated laws. Whewell's final justification of necessity, says Robert Butts, involves an appeal to "an unquestioned, literally ontological, Christian theism" (1965, 179; see also Snyder 2006 chs. 1 and 3). Butts calls this Whewell's "theological deduction":

> There must be some principle of unity… some 'third man' [and only] if this third man can be located can we in point of ontological fact be convinced that what we intuit as

[12] Wright (e.g. 2003) states that superassertibility is not a convergent or progressive kind of truth. As far as I can tell, he does not rule out the possibility, however. He merely claims that it need not be the case.

> necessary is a form of *something*, rather than a mere logical phantom (Butts 1965, 179 original emphasis).

In other words, Whewell thinks that there must be some perfect first fundamental idea that gives rise to our innate fundamental ideas; there must be some genetic source of necessity. The final and universal truth contained in the mind of God is the ground and the wellspring of necessary truths, and adherence to Whewell's scientific method is supposed to grant us access to it. We do not know God's mind (pending perhaps the end of inquiry), but we can glimpse parts of it.

Few contemporary philosophers of science, I take it, would endorse the idea that the culmination of scientific progress resembles Whewell's theological deduction. I will anyhow not engage with Whewell's theology. Given that stage 5 is premised on stage 4, stage 5 simply falls away if stage 4 is blocked. If science does not reveal necessary truth (as argued in Section 3), then *a fortiori* it does not reveal divine truth.

4. What's the Use of a Pragmatised Version of Whewell's Theory of Scientific Progress?

I have outlined Whewell's theory of scientific progress, and I have argued that we should strip it of its transcendental layers. The result is a Whewell-inspired outline for a pragmatist account of scientific progress. I now suggest how such an account might contribute to contemporary philosophy of science. A detailed exposition will require book-length treatment. In this section, I only discuss three of the features of such a view that might inform the current debate around the nature of scientific progress. These are: (1) SOE, (2) COI, and (3) superassertibility. I discuss each of these three notions in turn in this section.

Note that I am not concerned with the subjectivist kind of pragmatism advanced by Rorty (e.g. 1991), nor the linguistically oriented pragmatism advanced by Brandom (e.g. 1994). Rorty and Brandom would presumably reject both SOE and COI (even if they may be sympathetic to superassertibility). Rorty and Brandom's internalism about key notions like truth, knowledge, and even reality is inconsistent with SOE's postulation that subject and object are inextricably entwined. For Rorty and Brandom, there are only intersubjective or intralinguistic standards of truth. In similar vein, COI appeals to experimental predictive success and to the colligation of facts, both of which suggest a reality external to both subjects and language.

My stripped-down version of Whewell's theory of scientific progress is nonetheless closely related to Peirce's (1931-1958) convergent pragmatism and to the experience pragmatism of Steven Levine (2010, 2019) and Cheryl Misak (2014, 2021). There are also notable similarities to Popper's philosophy of science, particularly when it comes to his key notions of corroboration and falsification. I discuss Popper in Section 4.

SOE (Subject/Object Entwinement)

Several writers, particularly in the Kantian and pragmatist traditions, have endorsed the hylomorphic idea that subject and object or mind and world are inextricably entwined. Subject and object are not separated by a metaphysical correspondence relationship. Instead, analogous to Aristotle's notion that form and matter jointly constitute all things, so subject and object are conjoined in generating truth, knowledge, and even reality. The locus of this entwinement between subject and object is however debated. For Kantians, subject and object entwine in

perception (Kant 1929); for experience pragmatists, like Levine and Misak, subject and object entwine in experience. For Whewell however, subject and object entwine – they are "harmonious" – during the successful empirical inquiry practiced in our best science (Section 1).

I have presented a lengthy argument elsewhere for Whewell's hylomorphism as a suitable way to make sense of the interaction between mind and world (van der Merwe 2023), and will not repeat it here. Whewell's notion that SOE obtains in successful empirical inquiry may nonetheless be employable by philosophers of science grappling with the question of how some subjective or mental stuff (e.g. thoughts or beliefs) relates to some worldly stuff (e.g. the phenomena or the facts). SOE should be particularly appealing to those who are sceptical of the so-called "correspondence intuition" (Horwich 1998): the idea that subject and object constitute separate metaphysical domains linked by a correspondence relation. If we follow Whewell, then subject and object are analogous to form and matter. Subject and object are symbiotic and co-evolving, and they conjointly generate *a posteriori* truths during scientific progress.

COI (Consilience of Inductions)

Much of the contemporary debate about scientific progress centres around whether the unit of scientific progress is truth(likeness) (Niiniluoto 2014), knowledge (Bird 2007), or understanding (Dellsén 2016). COI can potentially inform each of these interpretations. COI can be thought of as the underlying 'mechanism' that generates truth(likeness), knowledge, or understanding. If we want to know *how* science progresses, we can appeal to ongoing COI as that empirically centred practice 'driving' truth(likeness), knowledge, or understanding forwards through time. This suggests that *increasing* truth(likeness), knowledge, or understanding may be grounded in COI. Such a notion of grounding would however not resemble a strong kind of metaphysical grounding (see Bliss and Trogdon 2021 for an overview). It would instead resemble a weak kind of pragmatist grounding – 'grounding' – centred around the empirical testing and successful prediction practices at the heart of COI. Further detail is required, of course; but COI does show potential as a possible explanans for how truth(likeness), knowledge, or understanding in science increases.

Increasing truth(likeness), knowledge, or understanding are often thought of as displaying a convergence of sorts towards epistemic unity (see Baumberger, Beisbart et al. 2017). As with the merging and unification of theories in COI, truths, knowledge systems, or understandings merge and unify over time. Michael Friedman, for example, writes,

> science increases our understanding of the world by reducing the total number of independent phenomena that we have to accept as ultimate or given. A world with fewer independent phenomena is, other things equal, more comprehensible than one with more (1974, 15; see also Mayr 1990; Grimm 2011; Gijsbers 2013; cf. De Regt 2017).

Peircean pragmatists (e.g. Hookway 2012; Misak 2014, 2021) and advocates for the so-called unity of science (e.g. Ladyman and Ross 2007; Tahko 2021) hold similarly convergentist convictions. Invoking COI may provide them with a powerful argumentative tool in support of their views.

COI in contemporary scientific practice is exemplified in the work of Syukuro Manabe, Klaus Hasselmann, and Giorgio Parisi, work that won them the 2021 Nobel Prize in Physics. Manabe and Hasselmann developed models of the Earth's climate capable of predicting how increasing levels of carbon dioxide in the atmosphere raise global temperatures over time. Parisi, by studying the interplay of disorder and fluctuations in complex systems, developed models that predict the long-term behaviour of those systems. These scientists' research suggests that short-term weather models can be suitably adapted for long-term climate predictions (see Nobel Prize Outreach AB: 2021 for detail).

The theory of human-caused climate change that Manabe et al's work supports does not stand apart from the rest of science. Rather, it can be thought of as a consilient meta-theory, one that relies on the unification of theories in several diverse scientific fields. These include meteorology, oceanography, physics, chemistry, and complexity science (see Parker 2018 for detail). Over time, theories in diverse 'low-level' sciences have merged – conciliated – into the theory of human-caused climate change, a theory expressed in the 'high-level' science we call climate science.[13] Now (as discussed in Section 3) we cannot be certain that some future discovery will not falsify the theory of human-caused climate change. Our (fallible) commitment to the theory is nonetheless justified due to its consilience (see also Alvargonzález 2013).

Superassertibility and Increasing Confidence

There is a notably dialectical element to my Whewellian pragmatism. It is however a weak, empirically centred dialecticism directed at theoretical unity and increasing superassertibility, rather than at TOE or universal truth. We are not invoking the Whiggish notion of a 'march to truth' that receives widespread derision in the contemporary literature. We may nonetheless wish to maintain universal truth (whether resident in God's mind or not) as a *regulative ideal* or what Popper calls a "regulative principle":

> one great advantage of the theory of objective or absolute truth is that it allows us to say that we search for truth, but may not know when we have found it; that we have no criterion of truth, but are nevertheless guided by the idea of truth as a *regulative principle* (as Kant or Peirce might have said)… (2002, 226 original emphasis).

Similarly, for Henrik Rydenfelt, Peirce's ideal end of inquiry "animates and makes concrete the possibility that scientific inquiry may, ultimately, lead to some stable conclusions" (2021, 2909). Some may however question why we should pursue an unattainable goal. Howard Sankey, citing Rescher (1982), answers with the following analogy:

> Moral perfection may be beyond our reach, for example, but striving for such perfection may make one a better person. Similarly, truth may function in the manner of a 'regulative ideal' for science. For, while it may be impossible for science to achieve

[13] This process is closely related to what is commonly referred to as *triangulation of evidence* (see Kuorikoski and Marchionni 2016).

> perfection, the idea of a perfectly true theory may serve to maintain the self-corrective, evolutionary character of the scientific enterprise (2000, 222).

Thus, we can say that scientific theories become superassertible by degrees (due to COI), while universal truth remains a regulative ideal we can aspire to, and approach incrementally, yet are unlikely to ever attain.

There are however well-known problems with conceiving of absolute or universal truth as a regulative ideal (see Johansson 2017). Specifically, how can our inquiry be regulated by something we do not know? I will not enter into this debate here. My pragmatised version of Whewell's theory of scientific progress can work without universal truth serving as a regulative ideal.[14] Explicating how universal truth might serve as a regulative ideal within my pragmatised Whewellian framework is an ongoing project. I have nonetheless suggested that the notions of SOE, COI, and increasing superassertibility may provide some of the tools to do so.

As mentioned in Section 3, Whewell associates truth with conceivability. Necessary truth obtains when we cannot conceive it possible to doubt a theory. In contrast, superassertibility can be associated with the degree to which we have *confidence* in a scientific theory. Laudan is thinking along these lines when he states that

> Whewell makes a very plausible case for regarding consiliences as giving us greater *confidence* in the truth of [a] theory… What his specific arguments utterly and obviously fail to establish is that [theories] which achieve a consilience are true and can be known with certainty to be true (1971, 380-381 emphasis added).

Similarly, for Fisch, "many would share the intuition that although consilience cannot be regarded as a mark of truth, one does (and should) feel more *confident* in a consilient theory" (1985, 249-241 emphasis added; see also Fisch 1984).

Thus, COI does not produce certainty in the understanding, but rather increases our confidence in a consilient theory, where 'confidence' can be understood in terms of the degree to which we believe that a theory is superassertible. Increasing confidence and increasing superassertibility go hand in hand. That said, theories do not increase in superassertibility *because of* our confidence in them. Instead, superassertibility *and* our confidence increase because of the progressive nature of COI. Whewell grounds truth in the credulity of the subject. On my account, truth (or superassertibility) is instead 'grounded' in the successful empirical inquiry entailed in COI.

Although there are important differences, there are also notable similarities to Popper's falsificationism here. Roughly, for Popper, scientific theories that survive repeated attempts at falsification become increasingly corroborated, where a corroborated theory is a theory that

[14] Kitcher (1993) develops an incremental account of scientific progress without invoking a Popperian regulative ideal or Peircean end of inquiry.

could be, but has not yet been, falsified.[15] A corroborated theory can be provisionally accepted by the scientific community pending its falsification or replacement by a more empirically successful theory (see Shea 2016 for detail). Corroboration is therefore closely analogous superassertibility. A statement is superassertible if we have warrant for believing it indefeasible (Section 3). Likewise, a superassertible theory is one that has survived repeated attempts at falsification, and that we are warranted in believing will survive future attempts at falsification (thereby increasing our confidence in the theory). Further, although Whewell talks of consilient theories as being verified, I have suggested that he probably had something more like corroboration in mind (footnote 7).

In sum, I have suggested that there are important similarities between the views of Whewell, Peirce, and Popper. Contemporary Peirceans and Popperians may therefore want to pay attention to Whewell's account of scientific progress (*sans* the transcendental layers). There are features of Whewell's SOE and COI – not to mention superassertibility and increasing confidence – that Peirceans and Popperians might find useful in making sense of (1) the relationship between subject and object in empirical inquiry and (2) the mechanism by which scientific truth(likeness), knowledge, or understanding increases over time.

5. Pluralism and the Value of Unity

I now engage with what Thomas Tahko (2021) and others consider to be the presiding paradigm in contemporary philosophy of science: scientific pluralism. Scientific pluralists will be sceptical of the unitary and convergent themes in my Whewellian pragmatism. I now argue that the two views need not stand in conflict. I will engage with both methodological pluralism and epistemic pluralism, focusing on anticipated objections to COI.

Methodological Pluralism and the Problem of Goals

There is no doubt that, descriptively speaking, scientists pursue different methodological strategies (see Sankey 2000 for an overview). COI does not state otherwise. COI describes how scientific theories and their concomitant truths tend to converge to unity. This can occur whether scientists pursue different methodological strategies or not (recall the climate science example from Section 4; see also Niiniluoto 1984; Alvargonzález 2013).

Scientific pluralists are however often concerned with whether scientists *should* pursue different methodological strategies. They might encourage the pursuit of a variety of methodological strategies, and argue against the pursuit of unitary ones. The former encourages diversity and freedom perhaps, while the latter encourages conformity and dogmatism (see e.g. Harding 2015; Mitchell 2020). Again, this prescriptive kind of methodological pluralism need not conflict with COI. Even staunch methodological pluralists like Arthur Fine (1986) and Larry Laudan (1996) argue for pluralism because they consider it to be the best way to accomplish some further unitary goal, a goal like the progress of science or the growth of knowledge. Even Feyerabend's (1975) infamous methodological anarchism is ultimately intended to promote a kind of unity.

[15] There is, of course, much nuance around Popper's notions of falsification and corroboration that I am ignoring here. A detailed analysis is outside the scope of this paper (see however Thornton 2022). My goal here is merely to note the similarities between Whewell and Popper's views, and how the former may be informative to those who subscribe to the latter.

Feyerabend thinks of anarchism as a short-term strategy – a kind of "opportunism" – ultimately conducive to scientists' long-term search for theoretical convergence (see Shaw 2017).

It is, after all, not clear what purpose would be served by encouraging scientists to pull in radically different directions. Unity need not imply conformity and dogmatism; it can instead encourage *prima facie* desirables like co-operation and collaboration. It is common wisdom that collective enterprises (like science) function best when participants align around a common goal, and that they are prone to failure when participants have conflicting goals. Methodological pluralism only makes sense if it is a provisional means to some unitary end.

Epistemic Pluralism and the Problem of Understanding

Whewellian pragmatism seems quite easily consistent with methodological pluralism. This may not obviously be the case when it comes to epistemic pluralism, however. As with methodological pluralism, there is both a descriptive and a prescriptive element to epistemic pluralism. Descriptively, epistemic pluralists claim that there is a variety of equally warranted but different epistemic perspectives (or paradigms or stances) towards scientific subject matters. Prescriptively, epistemic pluralists may claim that we *should* pursue different epistemic perspectives (or paradigms or stances) towards scientific subject matters. In both cases, this is because different scientific models, laws, theories or claims putatively apply in different contexts.

Sandra Mitchell's Integrative Pluralism is exemplary of epistemic pluralism.[16] We can, she says, describe water at the macroscopic level as "fluid in the oceans", but we can also describe water at the microscopic level as "H_2O"; "[d]ifferent representations and different levels of specificity work for different purposes" (Mitchell 2009, 115; see also Chang 2012). Each has utility relative to a context. Mitchell nonetheless recognises that there is, and should be, *integration* between these two levels of analysis (hence *Integrative* Pluralism). The two descriptions are interrelated and complementary. Mitchell however goes on to state that how such descriptions are "combined into an integrated explanation is itself context sensitive" (Mitchell 2009, 114-115). This is a case of contextuality all the way down; "there is no privileged level to which all explanations must be directed..." (Mitchell 2009, 115; see also 2020). Thus, even integration (which we can think of as a kind of consilience between descriptions or explanations) is pluralistic in nature. This view, concludes Mitchell,

> signals the end of a once noble reductionist quest but also outlines the beginning of efforts that will lead to a better understanding and more effective interventions in our complex world (Mitchell 2009, 115).

Thus, for Mitchell, we should adopt Integrative Pluralism because it leads to "better understanding and more effective interventions".

Now, effective interventions may be context relative, but I do not think that understanding is. Gaining understanding, I now argue, involves a form of epistemic unification. As with

[16] Similarly pluralistic views have recently been defended in the philosophy of science by Helen Longino (2013), Stéphanie Ruphy (2016), Anjan Chakravartty (2017), Angela Potochnik (2017), and Michela Massimi (2022).

Feyerbend's anarchism, Mitchell (tacitly, at least) justifies her Integrative Pluralism by appeal to a unitary goal; in this case, understanding. Even if this does not involve COI-style unification of scientific theories, it does involve a theoretical unification of sorts. If so, then (descriptive and prescriptive) epistemic pluralism may be compatible with COI.

Descriptively or prescriptively speaking, Mitchell is correct that descriptions of water can be context relative. However, this does not appear to be the case when it comes to *understanding* water. Surely someone who understands both descriptions (and how they can be integrated) enjoys a better understanding than someone who only understands one description. Both descriptions can thus be *unified* in the understanding. Someone who understands both descriptions of water has developed a theory – a mental theory – that *integrates* or *consiliates* those descriptions.[17] As in COI, such a theory may, in turn, be merged with outlying theories, and so on. This is plausibly how understanding increases through time (see Popper 1972; Morin 2008). If so, then only someone who does not care for understanding, or who cares only for limited understanding, should actively pursue epistemic pluralism as an end in itself. If we want to understand water *simpliciter*, and not just some feature of it, then a general, rather than a local, theory is preferable.

Prima facie, when there is a multiplicity of theories about some facts, we are justified in enquiring into the explanation for this multiplicity. Conversely, if there is one and only one theory encompassing all contextual cases, then we can be satisfied that we have gained understanding. Understanding appears inherently unity-seeking; our curiosity remains piqued for as long as there is epistemic disunity. Whewell seems to support the kind of mental consilience I have been suggesting. He states, for example, that COI

> is not the mere *sum* of the Facts which are colligated. The Facts are not only brought together, but seen in a new point of view. A new mental Element is *superinduced*; and a peculiar constitution and discipline of mind are requisite in order to make this Induction (1840, I, xxxix original emphasis).

Consistent with SOE, the mind is thus actively involved in promulgating COI. The induction of a conception to unexplored phenomena, and the comprehension that can result when such an induction is successful occurs through an act of the mind (Section 2).

That said, not all cases of understanding are necessarily unitary (see de Regt 2017 chs. 3 and 4 for detail). Non-unitary understanding may apply when we seek to understand some local phenomenon for some practical or utilitarian purpose. Engineers and technologists utilise local, rather than general, understanding when they construct smartphones or generate weather forecasts, for example. Nonetheless, if we seek to understand some phenomenon (like water)

[17] Some think of understanding in terms of a mental *model* (e.g. Waskan 2006) or a mental *picture* (e.g. Meynell 2020) rather than a mental *theory*. I do not intend understanding to be strictly propositional. We can think of understanding in terms of models if we follow Ladyman and Ross (2007), for example, in thinking of scientific theories as collections of structural models, models that map onto parts of the world. Or we can think of understanding in terms of pictures if we follow van Fraassen (2008), for example, in thinking of scientific representation in terms of imaging, picturing, and occlusion.

simpliciter, then a unitary understanding seems appropriate.[18] This is the kind of understanding that Mitchell and like-minded epistemic pluralists are (at least, tacitly) concerned with, and it is the kind of understanding that COI can confer.[19]

In sum, the central features of COI – unification and convergence – are identifiable in Mitchell's epistemic pluralism. As mentioned in Section 4, it seems counterproductive to encourage scientists to pull in radically different directions. This is the case whether we are discussing methodological or epistemic pluralism. We can instead be short-term epistemic pluralists in the pursuit of long-term and unitary epistemic goals. Like methodological pluralism, epistemic pluralism then involves a kind of Feyerabendian opportunism (Section 4). If we care about general understanding – as many of us surely do – then we should aim to merge short-term contextualities into long-term unifications.

Conclusion

I have explicated the five stages in Whewell's theory of scientific progress: (1) colligation of facts, (2) verification of the colligation, (3) COI, (4) the transcendental inference, and (5) the theological deduction. I then did away with stages 4 and 5 by collapsing Whewell's three kinds of truth – scientific truth, necessary truth and divine truth – into superassertibility. This presents an outline for a novel pragmatist account of scientific progress, one that maintains key Whewellian themes of unification and convergence. Moreover, scientific theories that display consilience are not necessarily true because we cannot conceive of their falsity. Instead, scientific theories that display consilience increase our confidence in those theories. I also engaged with potential pluralist objections to the unificatory and convergentist motifs in my Whewellian pragmatism. I argued that both methodological pluralism and epistemic pluralism are compatible with my view.

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[18] Duncan Pritchard (2010) refers to what I have called unitary or general understanding as "holistic" understanding.

[19] One also wonders whether epistemic pluralism is not itself an attempt to unify that which appears to be diverse. The epistemic pluralist ostensibly aims at a unified understanding of different epistemic theories by grouping them under the umbrella concept 'epistemic pluralism' (see Sankey 2000).

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