On Progress in Science and Metaphysics

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Abstract

In a recent paper, Kerry McKenzie identifies theory change in science as a source for doubts about the value of engaging in metaphysics of science before a final theory is at hand. According to McKenzie, the basic problem is that naturalistically-inclined metaphysics lacks a concept of progress. More specifically, naturalistically-inclined metaphysics lacks a concept of progress as approximation that can easily be taken to correspond to the scientific sources of metaphysical inquiry. In this paper we criticise progress as approximation as too narrow a concept, notably, even in science. Instead, we propose an alternative notion of scientific progress that metaphysical investigations can and do latch on to, namely progress understood as exploring and constraining theory space. This understanding of progress draws on common practice in particle physics, translates nicely to metaphysics, and leads to a convincing reply to McKenzie's argument, as we shall argue. Furthermore, our proposal speaks in favour of a more lenient version of naturalistically-inclined metaphysics, namely inductive metaphysics.

Keywords: Scientific progress, metaphysical progress, theory space, naturalized metaphysics, inductive metaphysics

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1 Introduction

Here is a popular meta-metaphysical view: metaphysical theories should be firmly based on the natural sciences. By closely examining our best current physical theories, for example, we can gain valuable insight into the fundamental structure of the world. As our scientific knowledge grows, so does our metaphysical understanding of the world. We are now in a position to develop better metaphysical theories than we were 500 years ago, because we now have better scientific theories than we had 500 years ago. What is more, we will, hopefully, be in an even better position in 500 years from now, since certain errors of our current scientific theories will be eliminated by then. Progress in metaphysics goes hand in hand with progress in the natural sciences. Call this view *naturalistically-inclined metaphysics*.

Examples for naturalistically-inclined metaphysics or "science-guided metaphysics" (McKenzie, 2021) arguably include the standard Quinean prescription, modern naturalized or scientific metaphysics (for example, Ladyman et al. (2007) and Chakravartty (2017)), and the recent proposal of inductive metaphysics (Engelhard et al., 2021). It may even be taken to include more generally any metaphysical position that wants to stay in touch with scientific findings – what Nina Emery (2023) dubs "content naturalism".[1] According to Quine, metaphysicians have to paraphrase the best scientific theories in terms of first order logic and can then read off the ontological commitments. According to Ladyman and Ross, metaphysicians should exlusively focus on unifying hypotheses from current physics and other sciences, with a direct reference to such scientific hypotheses. According to Anjan Chakravartty, 'closeness to the sciences' usefully distinguishes the good kind from the bad kind of metaphysics, but might be a matter of degree rather an all-or-nothing affair. Inductive metaphysics takes this further and wants naturalistically-inclined metaphysics to also employ a priori methods. Furthermore, inductive metaphysicians emphasize abduction as a central method of both science and metaphysics. Content naturalism, on the other hand, only requires metaphysics to be consistent with scientific results.

[1] According to Emery (2023), taking the content of science seriously for metaphysics implies the need to take scientific methodology seriously for metaphysics as well; content naturalism implies methodological naturalism.

In a recent paper, Kerry McKenzie identifies theory change in science as a problem for these views. If metaphysical claims build on specific scientific theories, as naturalistically-inclined metaphysics has it, theory change in science will trigger theory change in metaphysics. Of course, naturalistically-inclined metaphysicians are aware of this: "we expect that our particular positive account of the nature of the world will be deemed mainly or perhaps even entirely incorrect by future philosophers who will know future science" (Ladyman et al., 2007, vii). However, McKenzie argues, old scientific theories may still be viewed as approximations of their successor theories, such that a notion of *scientific* progress can be latched on to it. On the contrary, "canonical metaphysical claims ... cannot meaningfully be regarded as 'approximately true'", such that "the epistemic progress that science arguably enjoys through episodes of theory change cannot be expected to transfer to its metaphysics" (McKenzie, 2020, 1). In other words, although the ever-changing scientific theories are smoothly continuous with each other (in the sense that old scientific theories are approximations of their successor theories), they will discontinuously corroborate very different metaphysical theories. The change in metaphysics is not a smooth function of the change in science. While the change in science comes as a progressive chain of approximations, the change in metaphysics does not. Scientific progress does not imply metaphysical progress. In turn, this raises doubts on the value of engaging in *any* metaphysics of science before a final theory is at hand.

In this paper, we criticise progress as approximation as too narrow a concept, notably, even in science, and propose an alternative notion of scientific[2] progress to which metaphysical investigations can and do latch on to, namely progress understood as *exploring and constraining theory space*. We argue that this notion of progress leads to a convincing reply to McKenzie's argument. We do not contest that there are cases in physics where scientific progress can be understood in accordance with McKenzie, but there are important cases where physics' practice proceeds differently than McKenzie assumes. In general, progress in science is better understood as exploring theory space and excluding which theories, i.e., which parts of theory space remain compatible with the available empirical data. In particle physics, for example, theories of beyond standard model physics are developed, tested, and eventually eliminated by empirically constraining the parameters of a plethora of theories at the same time (for example, Chall et al. (2021)).

This practice of physics and the scientific progress that comes with it cannot be accounted for in terms of approximation, since (1) the theories that are explored will generally not be more accurate or more general successors of previous theories, and (2) the theories that are eliminated as empirically inadequate will generally not be less accurate predecessors of the true theory (or a limit of the

[2]Just as McKenzie, we focus on physics. Thus, without further argumentation, our claims about *scientific* progress are, strictly speaking, restricted to *physical* progress specifically. We will nevertheless usually speak of *scientific* progress to stress the relevant contrast in the debate between science and metaphysics. We should also note that we do think that our view generalizes to the rest of science (and does so more easily than McKenzie's), although we do not argue for this here.

true theory). The true theory is what will survive this process of elimination, the other theories simply will not. On the other hand, McKenzie's approximation examples can be accounted for in terms of our notion of scientific progress. Whereas McKenzie offers a rather demanding notion of progress in physics – theory change brings about scientific progress only if we can point to a specific (mathematical) relation of the theories under consideration – we propose a more lenient notion of progress in physics: exploring candidate theories or excluding them is already about making scientific progress. Equipped with this twofold understanding of scientific progress, we can reevaluate McKenzie's verdict and argue that naturalistically-inclined metaphysics is able to make progress. Metaphysics is not doomed and engaging in metaphysics is a meaningful endeavour.

We will proceed as follows: first, we present and discuss McKenzie's argument in section 2 and sketch our response strategy in section 3. To make our central point more clear, we briefly criticise a reply to McKenzie by Nicholas Emmerson (section 4). Next, we turn to the case of particle physics and defend a concept of *scientific* progress in terms of exploring and constraining theory space (section 5). In section 6 this is generalised to a concept of *metaphysical* progress. Section 7 discusses three example cases from metaphysics. As a final side note, we argue in section 8 that our understanding of metaphysical progress suggests that a specific, non-standard form of naturalistically-inclined metaphysics, dubbed inductive metaphysics, is the preferred way of doing metaphysics. We then reply to a few potential objections in section 9 and conclude.

2 McKenzie's Argument

There are two ways to frame McKenzie's challenge. We can say that it is about the claim that we need a *final* scientific theory to meaningfully engage in metaphysics[3] or we can say that it is about the claim that standard versions of naturalistically-inclined metaphysics, like naturalized metaphysics, lack a concept of *progress* (as approximation) – which, in turn, renders naturalistically-inclined metaphysics meaningless. In our view, the second framing is more to the point. In fact, McKenzie herself has later dubbed the issue "the *progress problem*" (McKenzie, 2021, 436),[4]

> which focuses on the fact that the science upon which contemporary SGM [science-guided metaphysics] relies is overwhelmingly likely to be false, meaning that a metaphysics based on it is likely to be false also. Given that – unlike in science itself – there is also no clear sense in which metaphysical claims can at least be said to be 'making progress', the epistemic value of a present-day metaphysics

[3]Hirèche et al. (2021) criticise this perspective. Contra McKenzie, they make a case for the possibility of fundamental metaphysics based on what one could dub sophisticated meta-induction, which includes past, present, and future physics.

[4]Others have recently begun to explore philosophical progress more generally, see Dellsén et al. (2021, 2024).

> that is based in current science becomes very difficult to discern" (McKenzie, 2021, 436).

In other words, there is a sense in which lacking a final scientific theory is unproblematic, namely if our metaphysical endeavours do at least make some kind of progress – similar to the situation in science. For, say, physics, the fact that we do not have a final theory yet is unproblematic because physics does make progress. In particular, false physical theories often stand in approximation relations to their not-yet-refuted successor theories: an 'old' theory T_{old} approximates a 'new' theory T_{new}, if T_{new} 'contains' T_{old} in some (mathematical) limit. For example, Newtonian mechanics is an approximation (or limit) of general relativity, which is expected to be an approximation (or limit) of some theory of quantum gravity, which, again, is probably an approximation (or limit) of some unknown final or true theory. For McKenzie, the (mathematical) approximation relations between subsequent theories are key for physics' ability to make progress. Hence, according to McKenzie, saving a notion of metaphysical progress means pointing out that also metaphysical theories *approximate* their successors.[5] However, this prompts a severe problem for naturalistically-inclined metaphysics, since the approximation notion of progress simply does not carry over to metaphysics, as McKenzie observes. Typically, metaphysical theories do not stand in approximation relations – often already due to the fact that metaphysical theories do not have mathematical representations. So the question arises how to make sense of progress in naturalistically-inclined metaphysics (NI-Metaphysics). Here is a more careful reconstruction of McKenzie's central argument:

(A.1) NI-Metaphysics is valuable only if it makes progress.

(A.2) NI-Metaphysics makes progress only if it approximates truth.

(A.3) NI-Metaphysics approximates truth only if its central claims can be approximately true.

(A.4) The central claims of NI-Metaphysics cannot be approximately true.

(A.C) Therefore, NI-Metaphysics is not valuable.

Premise (A.4) is at the center of her proposal. The underlying idea seems to be that metaphysical assertions are often dichotomous in nature. More concretely, one can give the following argument to support premise (A.4):

(B.1) The central claims of NI-Metaphysics can be approximately true only if they can be

  (i) true about approximately everything or

  (ii) approximately true about everything or

[5] So, arguably, McKenzie assumes a semantic account of progress (see Bird (2007)) for both science and metaphysics.

(iii) related to subsequent metaphysical claims as some mathematical limit (just as the relevant physical claims).

(B.2) The central claims of NI-Metaphysics can be none of these.

(B.C) Therefore, the central claims of NI-Metaphysics cannot be approximately true.

For clarification consider the following example, also used by McKenzie (2020, 19–20): 'Structural realism understood as the claim that all properties are extrinsic is approximately true'. Then the different options in (B.1) read as follows: First, structural realism is true about approximately everything, *if* approximately all properties are extrinsic – but, argues McKenzie, there being also intrinsic properties arguably will not be accepted as support for structural realism being approximately true, but rather as support for its refutation. Second, it is approximately true about everything, *if* all properties are approximately extrinsic – but by "saying that the property is 'approximately extrinsic', we transpose it into exactly that which the structuralist needs to avoid" (McKenzie, 2020, 20), namely an *intrinsic* property. Lastly, note that the third option does not add anything here.[6]

3 Direct versus Modal Approximation

The crucial problem with McKenzie's analysis, as we see it, is that all options offered to naturalistically-inclined metaphysics in (B.1) concern *direct* (truth) approximation relations holding between subsequent theories (or claims): for McKenzie, truth approximation means (1) to be a candidate for a true theory *and* (2) to stand in approximation relations to previous and subsequent candidate theories. According to McKenzie, this is what naturalistically-inclined metaphysics would have to copy from science to be able to make progress. So, the reasoning is that there is progress in science because there is truth approximation in science in the following sense: the (unknown) true scientific theory is approximated by a partially ordered chain of scientific theories, where the partial order stems from direct approximation relations between the different scientific theories; scientific theories approximate the truth because they can be integrated into such a chain of scientific theories that (supposedly) approximate the unknown true scientific theory. And there is no progress in metaphysics because there is no truth approximation in metaphysics in a similar sense: the

[6] One potential reply to McKenzie may contest premise (A.3) – 'NI-Metaphysics approximates truth only if its central claims can be approximately true' – by distinguishing between metaphysical *theories* and metaphysical *claims*. Even if metaphysical claims (like 'all properties are extrinsic') cannot be approximately true, there remains a sense in which metaphysical theories, which essentially are sets of such claims, can still be approximately true: a metaphysical theory is approximately true, if most of its claims are true. This account of progress is still semantic, but employs some kind of verisimilitude (or truthlikeness) account. Dylan Goldman (2025) pursues this option in a very recent response to McKenzie (see also Bird (2007) and Niiniluoto (2020)). Such a reply focuses on the relata of the progress relation. We will instead focus on the concept of progress itself.

(unknown) true metaphysical theory is not approximated by a partially ordered chain of metaphysical theories, where the partial order stems from direct approximation relations between the different metaphysical theories; metaphysical theories do not approximate the truth because they cannot be integrated into such a chain of metaphysical theories that (supposedly) approximate the unknown true metaphysical theory.

In contrast, the proposal we argue for in this paper essentially pushes the concept of truth approximation to a meta-level. Instead of direct truth approximation by a chain of theories which *stand in approximation relations themselves*, we propose to relax the direct approximation relation requirement to *modal* truth approximation. As a result, all candidate theories, regardless of whether they stand in approximation relations, are taken into account when considering truth approximation. Truth approximation is reinterpreted modally: the theories which have not been excluded on empirical grounds and the relations between them (for example, approximation relations) encircle the true theory. As a result, truth approximation is detached from considering approximations between candidate theories and rather taken to be about finding, situating, and excluding candidate theories as such. Finding candidate theories provides the list of potentially true theories. Gathering information about the various relations between the candidate theories suggests to promote the list to a multidimensional network of theories – the characteristics of the different candidate theories situate them somewhere in *theory space*.[7] Excluding candidate theories narrows down the set of viable theories to certain parts of this network (certain parts of theory space) and thereby encircles the true theory. Thereby, progress is detached from formulating truer and truer theories (in the sense of a chain of theories that stand in truth approximation relations themselves). As we shall argue in Sections 5 and 6, this proposal is, in fact, inspired by physics *and* is transferable to metaphysics.[8] What is more, with respect to science, our proposal does not rely on the (hopeful) assumption that the unknown true theory is actually the end point of the currently empirically favoured and theoretically most worked-out chain of theories.

It should also be noted that the process of encircling the true theory is unlikely to be linear or straightforward. It is not as if we already know the region of theory space where the true theory resides, and only need to explore this region. Instead, we will also need to explore possibilities that, from the perspective of the true theory, may ultimately appear quite far-fetched. Progress can sometimes lie in a quite detailed development of a false theory. Moreover, given the right input, we may find ourselves returning to regions of theory space that we thought excluded before. As in life, so in science, progress is seldom

[7] We will make the concept of theory space more precise in Section 5. Essentially, the concept is supposed to capture information about the adjacency of theories: pairs of similar theories (for example, theories that stand in an approximation relation) are adjacent, random pairs are not. For example, if two theories share all characteristics but one, they are situated in the same subspaces of theory space except the ones that are defined by the distinguishing dimension. For many debates it is sufficient to consider projections into the relevant subspaces.

[8] Arguably, the proposal also better meets what we observe as common practice in other sciences apart from physics.

a straight sprint to the finish line. Sometimes we have to zigzag or backtrack before moving forward.

Before we spell out our proposal further, let us be clear that we do not doubt that there are cases in physics where scientific progress can also be understood in accordance with McKenzie. For example, some theory like Newtonian gravity is approximately true indeed, namely in the sense that the theory is a limit of an empirically more adequate successor theory, i.e., Einstein's general relativity, which is standardly expected to be an approximation of some theory of quantum gravity, which, again, is probably an approximation of some unknown final (or true) theory in this very sense. Progress understood as such does lend itself to a partial order of physical theories. And we agree: if such a partial order exists, it is a significant aspect of the progress made. What we criticize is that this is generally demanding too much – already for progress in physics. That a 'new' theory T_{new} is shown to 'contain' an 'old' theory T_{old} in some limit is not what signifies large parts of what can legitimately be called *progress* in science. That some approximation relation holds between two successive theories may be a sufficient condition for progress,[9] but it certainly is not necessary. There are important cases where physics practice proceeds differently than examples like the Newton–Einstein case suggest. Hence, we shall argue that the most general characterisation of scientific practice that incorporates the different examples of scientific progress – in physics, but, notably, in other sciences as well – is that science explores and then excludes which theories, i.e., which parts of theory space are compatible with the available empirical data.

4 Emmerson's Reply to McKenzie

Before we elaborate our view further, it may be instructive to contrast it with a proposal by Nicholas Emmerson, who has presented a reply to McKenzie in terms of deepening explanation.

Also Emmerson (manuscript) reads McKenzie as questioning the ability of NI-Metaphysics – tacitly understood as 'naturalized metaphysics' by Emmerson – to make progress. Emmerson points out that what most philosophers of science take to define *scientific* progress, namely providing better approximations to the truth, "cannot be meaningfully applied to metaphysical theses" (manuscript, 2), at least according to McKenzie. Emmerson is more optimistic. Essentially, his own account draws on an analysis of scientific progress in terms of understanding. According to his view, "progress is made when scientists and metaphysicians provide explanations of increasing depth, where the depth of an explanation is measured with respect to the range of interventions under which it is invariant" (Emmerson, manuscript, 1). Emmerson illustrates his proposal by help of Saunders' weak discernibility view in the context of similar quantum particles, which he deems progressive as it expands on the range of applicability of the previously dominant qualitative properties proposal. Importantly, also a notion of approximation lends itself: "since this wider range contains

[9] Arguably, this can be questioned as well.

the range of interventions under which the qualitative properties proposal is invariant, these metaphysical theories can meaningfully be said to correspond" (Emmerson, manuscript, 1).[10]

There are various ways to respond. One could offer the general critique that conceptions of progress that rely on understanding and explanation are building on rather controversial notions, and more specifically object that 'being invariant under a wider range of testing interventions' is a non-standard notion of progress. One may also contest that the weak discernibility view can serve as a good example: it is at least controversial whether the weak discernibility view provides, in fact, a 'deeper' explanation of identity or individuation, as Emmerson alleges.[11]

More importantly, however, the idea of progressing by 'deepening explanation' is in danger of still demanding too much. Neither in science, nor in metaphysics do we make progress only when something 'explains' – and further restrictions ('explains more deeply') only make it worse. Essentially, our criticism is that Emmerson's proposal resembles McKenzie's too closely: the deepening explanation account still centrally involves an immediate notion of approximation: some successor theory is directly related to some predecessor via some kind of direct approximation relation. The only difference is that one is not restricted to specific mathematical approximation relations anymore. Rather, approximations in terms of explanatory scope are sanctioned as well. Against both, we hold that already many cases of scientific progress do not meet these strong criteria, as we shall now argue in more detail.

5 The Case of Particle Physics

Consider the case of particle physics. Here, the plethora of candidate theories (or models[12]) of beyond standard model physics is tested (at the same time – as opposed to probing specific theories one after the other) by empirically constraining characteristic parameters. The theories of particle physics vary with respect to *qualitative* parameters, like their particle content, and *quantitative* parameters, like the particles' masses and coupling constants. As a consequence, the theories are sensitive to experiments that determine the values of such qualitative and quantitative parameters: whether some theory still has a chance of being empirically adequate is determined by experimentally constraining (allowed intervals for) the values of such parameters. The procedure yields *exclusion limits* with respect to the parameter in question. Any theory that is situated outside the exclusion limits is considered empirically ruled out.

[10] See also Emmerson (2024, 2098–2101).

[11] For example, Hawley (2009) and French and Krause (2006) point to a circularity regarding explaining identity or individuation. Moreover, there has recently been further general criticism of such orthodox views; for a review see Bigaj (2022), see also Bräutigam (2024).

[12] We do not distinguish between 'theory' and 'model (of a theory)' here. For example, the Standard Model of Particle Physics is a theory or model formulated in the theoretical framework of quantum field theory, and so are the various supersymmetric 'models' and other 'theories' of beyond standard model physics.

Higgs exclusion charts are a standard visualisation of this methodology, namely with respect to the information about which values for the Higgs mass are still empirically allowed. If certain collider experiments discover the Higgs boson and constrain its mass to $m_h = (125.10 \pm 0.14)$ GeV, the many theories which predict a Higgs mass of $m_h \leq 115$ GeV are empirically excluded. Call this the *exclusion mode* of the standard particle physics methodology.[13]

But this exclusion mode is just one of two modes. It is crucial to note that even prior to discovery, the Higgs exclusion charts with the Tevatron, LEP, and later ATLAS and CMS exclusion bands were important resources for *model building*, that is, for *developing new candidate theories*. By means of this second mode, particle physicists *explore* which theories are feasible. Call this the *exploration mode* of the standard particle physics methodology. So, new experimental results for such parameters help to *explore and constrain* which theories are still compatible with the growing body of empirical data.

Both modes of this methodology and the visualisations it inspires make use of (a low-dimensional subspace of) theory space.[14] Let us first focus on the constraining mode for explicating this. Say we have to consider N such parameters. The N parameters then span an N-dimensional theory space. In principle, each point in this theory space corresponds to a specific theory with specific values for each parameter.[15] What is arguably more relevant in practice: some region in this theory space corresponds to a set of theories with a certain range for the values for each parameter. Empirically constraining some or all of the parameters constrains which regions of theory space are still empirically viable and which are already ruled out. In this way, the set of candidates for a final (or true) theory (including the final theory itself) is encircled and narrowed down step by step.

Notably, N is always finite by stipulation for any given theory, since otherwise the theories under consideration would not be predictive – they would not be viable candidates in the first place. Still, the (most general) theory space itself may in principle be infinitely dimensional, since different theories (for different domains or aspects of the world, or within different theoretical frame-

[13] This is a simplification – just consider the well-understood difficulties regarding such 'naive' falsifications. In general, only measuring the values of various parameters will eventually lead to the acceptance that the Higgs has certain properties, ruling out disagreeing theories as empirically inadequate. It is also important to note that we do not adopt falsificationism *per se*. While we are generally sympathetic to taking some form of falsification as explicating the observed *modus operandi* of exclusion, we do not intend to argue that theories will only be falsified and not confirmed. There are other options available as well. In addition, there are two features that distinguish our proposal from falsification simpliciter. Thus, dubbing it falsification nevertheless carries the risk of muddying the waters. First, the process of exclusion we observe goes beyond classical falsification, as it is explicitly embedded in the larger context of possible theories and aims to reduce these possibilities. We thank an anonymous reviewer for this. Even more importantly, what could arguably still be dubbed falsification* is only one of the two *modi operandi* of scientific (and metaphysical) research, as we will continue to insist in the remainder of this paper: the mode of exploring theory space (see below) is not akin to falsification at all, but its opposite.

[14] In the case of the standard Higgs exclusion charts, the subspace is one-dimensional.

[15] Generally, not all combinations of parameter values (not all points in theory space) will yield sound theories.

works) will usually have non-congruent sets of parameters. Also, as already mentioned, there will typically be both qualitative and quantitative dimensions. Qualitative dimensions may, for example, order theories with respect to their posits (e.g., their particle content) or their 'type' (e.g., whether they are classical or quantum field theories, local or non-local theories, and so on).

It is crucial to note that by considering theory space one employs a richer structure than by simply considering a list of all candidate theories: the characteristics (or properties) of the theories and, thereby, the *relations* between them are taken into account. The theory space view is a way to *order* the plethora of theories on the list by exploiting information about the parameters that individuate them. Accordingly, also approximation relations are retained and relevant. In other words, also with an eye on further generalisations with respect to metaphysics, the theory space view exploits information about similarities and differences between the theories (e.g., whether different theories share certain characteristics according to the qualitative dimensions of theory space or whether they are, say, dual to each other) to situate the theories in theory space. Accordingly, cases that are usually discussed with respect to the approximation conception of progress can be incorporated into the constraining theory space conception of progress as well. Not only because we can simply point to the empirical exclusion of, say, Newtonian gravity, on the one hand, and, to the so far failed exclusion of general relativity, on the other hand, but because we can more explicitly take into account the relations between the two theories. These relations continue to be available in the theory space view, where approximation relations translate to topological relations.[16] What is more, not only are these specific theories ruled out or not ruled out yet, but – given further assumptions – whole regions of theory space, that is, sets or classes of theories, are excluded or still viable: for example, action at a distance theories, like Newtonian gravity, are ruled out, while local theories, like general relativity, are not.

Let us now also turn to the exploration mode. Here is an observation that adds an important aspect to what we have said about the constraining view above. Theories in particle physics are often formulated explicitly with that theory space of infinitely many theories and their relations in mind – physicists *explore* the theory space: they try to come up with new theories that are located in the non-excluded parts of theory space. By working out the various candidate theories, coming up with new candidates that have not been considered before, refining and modifying them in light of new empirical data or extra-empirical principles, and investigating relations between candidates (including whether two candidate theories are identical, isomorphic, dual and so on) physics explores theory space: exploratory investigations help to get a grip on what the different dimensions of theory space are and where the various candidate theories are situated. The particle physics' notion 'model building' captures that perfectly.

[16] Here is a brief plausibility argument. The approximation relation between Newton's and Einstein's theory is fully grounded in the characteristics of the two theories. The location of any theory in theory space is fully determined by all its characteristics. Hence, the information to reconstruct approximation relations from topological relations is fully available.

In fact, if some experiment fails to exclude a certain region in theory space, this typically triggers an increased interest in coming up with theories (or models) that sit in that region. For example, we had periods of increased interest in grand unified theories, various light Higgs or heavy Higgs models, or split SUSY models. Arguably, the exploratory mode is exemplified best by cases of 'false alarm', in which preliminary experimental 'results', that later turn out wrong, trigger investigations into regions of theory space that would have been preferred had these 'results' been confirmed; reports on superluminal neutrinos by the OPERA collaboration in 2011, or reports on primordial gravitational waves by the BICEP2 collaboration are recent examples of this.

Importantly, the exploratory research mode can either occur within a given theoretical framework, like supersymmetry or quantum field theory, or in terms of what has been dubbed *model-independent* searches (see Steinle (1997); Franklin (2005); Karaca (2017)), which explore theory space independently of specific theoretical background assumptions (and are therefore also called exploratory searches).[17]

Let us take stock. The above suggests that a philosophical theory of progress in particle physics should capture the practice of exploring and constraining theory space.[18] The lesson is that already in physics it becomes apparent that scientific progress is not only achieved by formulating theories that are closer to the truth than their predecessors (or provide increasingly deeper explanations), that is, by reference to direct approximation relations between subsequent scientific theories. Rather, an important way of achieving scientific progress is by plumbing the depths of theory space and identifying which regions of theory space contain candidate theories that still have a chance of being true. As mentioned, one can therefore categorize our proposal as a *modal* account of progress.[19]

This practice of physics and the scientific progress that comes with it cannot be accounted for in terms of direct approximation (neither in its mathematical, nor in its explanation-based version), since the candidate theories will generally not be less accurate or less general predecessors of the true theory (or predecessors that are special cases of the true theory). By contrast, our view can accommodate approximation cases, as argued above. Whereas McKenzie offers

[17] This demonstrates that the different tasks are not cleanly divided between theoretical and experimental physics.

[18] In fact, while there are certainly important differences between progress in physics and progress in other sciences, we take it as plausible that some form of such a very general exploratory–exclusionary methodology is at play in all sciences. Hence, a generalization to the rest of physics and the other sciences seems feasible, although we shall not explicitly argue for it here. We take it that such a generalization is less plausible for McKenzie's notion of progress which arguably implies progress to be linear and cumulative and, therefore, sits not so well with sciences that are 'messier' than physics.

[19] We intend to remain neutral to Bird's (2007) distinction between semantic, epistemic, and functional-intrinsic accounts of progress. There is a sense in which our proposal may be read either semantically (concerning truth) or epistemically (concerning knowledge), but strictly speaking our proposal is neither semantic (truth reference is developed differently), nor epistemic (which basically adds further criteria, ending up with a version of 'reliably formed justified true believe'), nor intrinsic-functional in Bird's sense.

a rather demanding notion of progress in physics – theory change brings about scientific progress, only if we can point to a specific (mathematical) relation of the theories under consideration – we propose a more lenient notion of progress in physics: excluding a theory is already about making scientific progress and, furthermore, exploring theory space is as well.

Now, one might object that we loose a great deal of information about what some progress is precisely progress about when switching from the approximation view to the theory space view. One might argue that the approximation relations between subsequent theories inform us about the precise sense in which adopting the new theory constitutes progress, for example, because they provide a measure of progress by making explicit where the truth approximation has been improved (e.g., relating to physical constants like the speed of light). However, this is arguably sufficiently similar in our view. First of all, the theory space view is still perfectly able to make sense of what it means that a theory is true (and this is arguably central to McKenzie with respect to her points about metaphysics): the true theory is the theory that will survive the process of elimination. In a sense, formulating and then excluding false theories in theory space and thereby encircling the true theory is an *indirect approximation* of the true theory. When it comes to the generalization to metaphysics, this indirect approximation of the true theory avoids the problems of direct approximation accounts like the ones put forward by McKenzie and Emmerson.

Secondly, as mentioned, relations between different theories are available in our proposal as well: theory space *orders* the theories according to their characteristics. Hence, one is still able to extract information about why theories that share certain features are (probably) closer to the true theory than theories that share other features (e.g., why quantum field theories will be better candidates than theories of Aristotelian dynamics). The theory space view is not merely about writing theories on and crossing them off some shopping list. Rather, the dimensions of theory space provide a topological structure for the list of candidate theories.

6 Metaphysical Progress

We take it that the above concept of scientific progress can be utilised for metaphysics: also the practice of metaphysics is not about straightforwardly approximating a true theory (insofar we agree with McKenzie), but primarily about exploring and constraining (metaphysical) theory space. It is then plausible that metaphysics makes progress and that metaphysical progress goes hand in hand with scientific progress.

Also the characteristic aspects and parameters of metaphysical theories can be thought of as dimensions that span an abstract space in which all (known and unknown) metaphysical theories can be situated. In other words, we can order the various metaphysical candidate theories with respect to their content, just as we can order scientific theories. Arguably, the complexity further increases in metaphysics, especially when we do not separate scientific and metaphysical

theories, but think of both populating the same theory space. For example, it may be the case that most parameters used to characterize the dimensions of metaphysical theory space are qualitative and, if McKenzie is right, many subspaces may be two-dimensional (dichotomies). Again, qualitative parameters also play a crucial role in physical theory space (or scientific theory space in general): for example, one qualitative dimension of physical theory space subdivides the theories in local and non-local theories, other dimensions give the particle content. Regarding biology, this may be even more obvious: there are subspaces for evolutionary theories and, say, intelligent design theories, other dimensions give the species content.

Thinking about the plethora of all kinds of conceivable metaphysical theories in this way suggests that, like in science, progress in metaphysics is achieved by both exploring and constraining metaphysical theory space. By working out the various candidate theories, coming up with new candidates that have not been considered before, refining and defending them against objections, and investigating relations between candidates (including whether two candidate theories are identical, dual, isomorphic etc.) metaphysics explores theory space: exploratory metaphysical investigations help to get a grip on what the different dimensions of theory space are and where the various candidate theories are situated. Borrowing a metaphor from Dellsén et al. (2021), when trying to find a needle, it is just helpful to have an overview of the entire haystack, and even better, to only have to search through part of it. By assessing candidate theories especially with respect to internal (logical) consistency and external compatibility with scientific evidence, metaphysics constrains theory space: exclusionary metaphysical investigations help to determine what the serious candidate theories currently are; this can be understood as an indirect approximation ('encircling') of the true theory.

Thus, metaphysics is automatically and fruitfully tied to science and its progress, because metaphysics is continuously tested and inspired by the currently best available scientific evidence (including experimental as well as theoretical results). First, metaphysical claims that directly follow from a scientific theory in a one-to-one correspondence are eliminated when the respective scientific theory is ruled out. So, in this case, scientific progress is tantamount to metaphysical progress. Second, more general metaphysical claims (such as the claim that every property is extrinsic) are not directly eliminated in this way, as they are typically compatible with many possible scientific theories. However, just like in physics, progress can still be made by formulating and then probing candidate theories in order to explore and ultimately constrain the theory space of metaphysics. In addition, something as mundane as the Higgs discovery can have interesting metaphysical implications, like mass likely being an extrinsic property. Since mass is a standard example of an intrinsic property, this is relevant for defending extrinsic theories in general.

So, the content of metaphysics is automatically tied to science in two ways: (1) via the exclusion-part of testing metaphysical theories, and (2) via exploration – scientific theories may inspire new metaphysical theories or the refinement of extant ones. Hence, our science-inspired account of metaphysical

progress shows how and why metaphysical progress goes hand in hand with scientific progress. Moreover, also the methodology of metaphysics is tied to science: ultimately, metaphysics adopts a very similar model building methodology that explores and constrains metaphysical theory space.[20]

Given that we distinguish two aspects of progress, the question arises how they are related. In particular, is there a tension between exploring and constraining?[21] As we see it, exploring and constraining represent different stages of progress. There is a sense in which one can only constrain what has been formulated in the first place. (Sometimes this might happen in parallel to formulating.) So, in the constraining mode one essentially revisits the results of an exploratory endeavour. It is true that exploring expands the space of live possibilities, whereas constraining narrows it down by ruling options out. In that sense, constraining can be said to veto exploration. But this does not mean that the two aspects are in tension: constraining is just the next dialectical step. Conversely, once some region of theory space has been excluded, what remains comes into focus as especially promising and deserving of further exploration. From this perspective, exploring and constraining are complementary: exploration generates candidate possibilities and thereby sets the stage for constraints, while constraints delineate which parts of theory space are worth exploring in more detail.

Before we try to make the above more concrete, note that our proposal does not have to conceive of progress as cumulative: viewing theory space as ever-changing makes it open for revisions, which is helpful when taking into account theories that touch on, say, medical or psychological aspects of the world. Here, (scientific and metaphysical) progress is often constituted by revising central concepts or notions, such that a cumulative understanding of progress does not seem apt. For instance, some years ago, the standard psychological classification of mental disorders would have included homosexuality. And its inclusion as a mental disorder would have "accumulatively contributed" to progress in psychology and the respective metaphysical theories. However, real progress was made when this classification was later abolished.

7 Three Examples

Here are three concrete ways in which scientific progress can bring about metaphysical progress.

First, scientific progress can *(re-)inspire* the formulation of novel candidate theories in metaphysics. For example, theories of quantum gravity may cast doubts on the received view in the philosophy of spacetime that some version of substantivalism is correct and (re-)inspire metaphysical positions like relationalism or spacetime eliminativism. Dependent on the fact that this arguably

[20] Unexplored regions of theory space can be thought of as (so far) unconceived alternatives. The existence of such regions is compatible with our account, and progress can be made by exploring them. We thank an anonymous reviewer for requesting this clarification.

[21] Thanks to an anonymous reviewer for inviting this clarification.

concerns the (rather speculative) scientific frontier, this will mostly concern the exploratory mode of metaphysical progress. The constraining mode is present in terms of internal consistency checks (e.g., concerning semi-classical theories).

Second, scientific progress can boost *further development* of existing candidates by subjecting them to detailed tests. In particular, scientific progress can raise new problems for metaphysics (e.g., the issue of indiscernibility in quantum mechanics) – arguably concerning both modes – or prompt refinement of extant metaphysical theories (e.g. entanglement as world-making relation for Lewisian metaphysics; see Jaksland (2021)) – mostly concerning the exploratory mode. Similarly, lessons from physics on, say, the fact that spatiotemporal structure comes in various ways, will result in respective refinements in the metaphysics of spacetime (Jaksland and Salimkhani, Forthcoming).

Third, scientific progress can lead to *novel arguments* for and against extant candidates (e.g., quantum mechanics and structural realism), both being part of the constraining mode of metaphysical progress. Potentially, scientific progress can even eliminate metaphysical claims that are in conflict with the remaining theoretical possibilities in physics (or other sciences). Relevant examples will usually be controversial, but probably include cases like the following: quantum mechanics can be viewed as excluding (certain versions of) classical Humeanism, and many think that special relativity excludes standard versions of presentism – see section 9 for more details. Also, the very debate about the different interpretations of quantum mechanics emphasizes that classical metaphysics needs to be modified. First of all, the debate reveals that there are only a few viable candidate metaphysical interpretations of quantum mechanics. We can't just attach any metaphysics to quantum mechanics, but instead have to choose between a couple of serious candidate interpretations. That is already a significant constraint on metaphysics. Second, all of these interpretations diverge significantly from classical metaphysics. We cannot just dig in our heels and hold on to our classical metaphysical views, *pace* our best physical theories.[22]

Interestingly, the model building methodology in physics can also be applied quite straightforwardly in metaphysics, with or without a strong link to science. Similarly to the exploratory scientific methodology in particle physics, which can involve various non-empirical or not yet empirical considerations, this exploratory mode of metaphysics will often involve general metaphysical considerations. Here the focus is first and foremost on conceivability. Therefore, such work will look more like traditional a priori approaches.[23] The scientific data will, however, be relevant along the way for deciding on what to pursue further.

[22] An anonymous reviewer worries that this merely establishes that physical *theories* constrain metaphysics, rather than that *physics itself* does. However, if a dominant physical theory such as quantum mechanics significantly constrains metaphysical theory space, it is perfectly appropriate to say that physics constrains metaphysics. In any case, for the purposes of our argument about the connection between physical and metaphysical progress, all that is required is that our best physical theories constrain metaphysical theorizing. Metaphysics benefits from advances in physics because improved physical theories both impose constraints on viable metaphysical views and open up new avenues for metaphysical inquiry.

[23] One could indeed make the point that exploratory model building in particle physics is more akin to a priori reasoning.

For example, Näger (manuscript) explores the metaphysics of entanglement by constructing different metaphysical models and only then assessing them (constraining mode) with respect to certain criteria, like (a priori) metaphysical virtues and with an eye on the science.

8 Inductive Metaphysics

The observation that even a priori elements may come into play suggests to add the following side note.[24] If metaphysical progress is about exploring and then excluding metaphysical theories, part of this progress consists in actually constructing the plethora of metaphysical theories – at least potentially without an immediate inspiration from science. Arguably, this is in conflict with the programme of naturalized metaphysics as explicitly stated by Ladyman (2017) and similarly restrictive varieties of naturalistically-inclined metaphysics. Accordingly, we see a preference for what has been called inductive metaphysics (see Engelhard et al. (2021)) over standard naturalized metaphysics.

Inductive metaphysics is a promising alternative to naturalized metaphysics that captures the main idea of naturalistically-inclined metaphysics while avoiding the more radical conclusions of naturalized metaphysics. As naturalized metaphysics, inductive metaphysics takes the sciences seriously, both as a source for metaphysical knowledge and as a source for methodological tools in metaphysics. But at the same time and unlike naturalized metaphysics, inductive metaphysics also allows for abductive methods and more 'traditional' sources of metaphysical knowledge and methods, like a priori reasoning. In this way, inductive metaphysics can be regarded as a reconciliation between naturalistic metaphysics and a priori metaphysics.

Recall that naturalized metaphysicians claim that metaphysical theories must be firmly based on the natural sciences, and especially physics, in order to be at all valuable. This is what McKenzie calls the 'negative claim' of naturalized metaphysics: metaphysical theorizing that does not pay heed to current scientific theories is not worth doing. But naturalized metaphysicians do not give up on metaphysics entirely. Instead, they claim that we can gain substantive metaphysical insight by closely studying our best scientific theories. This is what McKenzie calls the 'positive claim' of naturalized metaphysics: metaphysical theorizing that is based on current scientific theories is worth doing. Both the negative and the positive claim can be interpreted in various ways, depending on what it means to be 'based on' a scientific theory. Weak interpretations might spell out the notion that a metaphysical theory is based on a scientific theory in terms of mere compatibility, for example. This will render the negative claim uncontentiously true and the positive claim dependent on the worth of classical a priori metaphysics. Strong interpretations, on the other hand, might spell out the notion that a metaphysical theory is based on a scientific theory in terms of direct ontological commitments of specific scientific theories. In this

[24] As mentioned, a priori elements arguably play a role in physics as well (e.g., exploratory model building, checks for consistency).

case, the negative claim will be much more controversial, as it would plausibly ban any reasoning that is not the result of a thorough investigation of specific theories from the metaphysician's toolbox.

We do not defend the negative claim. On the contrary, we think that valuable inquiry of the furniture of the world can be done without (immediate) reference to the sciences at least in terms of metaphysical model building and restricted to some areas of inquiry. (For example, we do not think that theories of free will, of responsibility or of the metaphysics of morality in any strong sense need to be based on scientific theories in order to be at all valuable. This, of course, does not mean that such theories cannot still profit from engagement with the sciences.)

However, we do defend the positive claim: We hold that science-based metaphysics is worth doing. As we have argued above, this is compatible with scientific theory change. What is more, from the perspective of inductive metaphysics, scientific theory change or situations where science has not settled for one out of several candidate theories (yet), like it is currently the case for quantum gravity research, can actually be put to use in metaphysics by investigating whether the different theories suggest any common core. *Prima facie*, all theories and all tenable interpretations of theories that are not ruled out yet are relevant for inductive metaphysical inferences. For example, the relevant theories of spacetime include the various theories of quantum gravity and also general relativity in its different interpretations. In this context, inductive metaphysical inquiry consists in, among other things, working out what is the common core constraint of all these vastly different sources for a metaphysics of spacetime.[25]

On the contrary, for Ladyman and Ross, the only way to properly argue for a metaphysical thesis like structural realism is by arguing that our best current physical theories suggest that it is true. The central objective of naturalized metaphysics is to make metaphysics a part of science. According to (Kincaid, 2013, 3), naturalized metaphysics proceeds "only by means of scientific results and scientific methods", i.e., science itself is supposed to do all the metaphysical work needed or feasible. In particular, no additional (philosophical) methods are used. Thus, an argument via scientific theory change would, strictly speaking, be inacceptable from their methodological standpoint: empirical data about the development of the physical sciences is not itself subject to explanation by physics, and therefore not apt to figure in metaphysical reasoning. Similarly, naturalized metaphysics has no resources to work out input from scientific rival theories. Inductive metaphysics is less restrictive. For inductive metaphysics arguments based on theory change are perfectly fine, or even encouraged, as inductive metaphysics allows for various kinds of empirical sources of knowledge.

In fact, the programme of inductive metaphysics quite directly relates to our concept of progress via the two kinds of abductive inferences it encompasses, namely *creative abduction* and *selective abduction* (Schurz, 2020). Creative abductive inferences form explanatory hypotheses that contain new concepts,

[25] A first attempt that also discusses the limitations of this has been put forward in Salimkhani (2024).

which can be thought of as corresponding to the mode of exploring theory space. Selective abductive inferences, on the other hand, select the best explanatory hypotheses from a set of candidates based on empirical and theoretical explanatory virtues, which can be understood to correspond to the mode of constraining theory space. Accordingly, inductive metaphysics and progress as exploring and constraining theory space are a good fit.

To summarize, there are two key advantages of inductive metaphysics over naturalized metaphysics and a priori metaphysics in the face of McKenzie's challenge. First, inductive metaphysics is more encompassing with regard to its sources: any source of knowledge is in principle relevant. As inductive metaphysics is not based solely on the physical sciences, its progress is not fully dependent on the progress of the physical sciences either. Second, inductive metaphysics is more flexible and fitting with regard to methodology: it allows for a priori and two kinds of abductive methods, which nicely relate to our concept of progress. Thus, inductive metaphysics can combine different methods depending on what is most reliable in the respective context.

9 Some Potential Objections

In the following, we respond to a few potential objections. First of all, one may worry whether it is actually possible to exclude metaphysical theories, call this the *exclusion concern*. We agree that it will often be controversial whether a specific metaphysical theory is excluded in a strict sense by scientific results. Essentially, this is because the underdetermination by data is more severe for metaphysics than science, since metaphysical claims are more abstract. Nevertheless, many metaphysicians at least act as if exclusion is possible when they argue against some metaphysical claim on the basis of physics, and some metaphysicians also explicitly argue that exclusion is possible and abundant. For example, Nina Emery writes:

> I think there are quite a number of metaphysical debates where the content of our best science does clearly and straightforwardly determine that some of the otherwise open positions in those debates are ruled out. (Emery, 2023, 51)

We fully agree with Emery that the content of scientific theories does often help to constrain and rule out metaphysical inferences. Here are a few examples. First and second, quantum mechanics has ruled out, at least, all naive versions of classical Humeanism and Leibnizian individuation. First, classical Humeanism à la David Lewis faces the challenge of quantum-mechanical holism (e.g., Teller (1989), Maudlin (2007), and Schaffer (2010)). For example, the non-separability due to quantum entanglement threatens "the reductive conviction that the complete physical state of the world supervenes on the intrinsic properties of and spatiotemporal relations between its point-sized constituents" (Miller, 2014). While defences of Lewisian metaphysics may still be feasible, they will have to respond to these threats – either by modifying traditional

Lewisian metaphysics or by showing how quantum mechanics can ultimately be made compatible with Lewis, e.g., by adopting a non-standard interpretation of it, like Bohmian mechanics (Miller, 2014). Notably, even proponents of the latter, optimistic approach do acknowledge that other worries persist, which points to the fact that even Lewisian-friendly Bohmian mechanics does have distinctly non-classical features, like the holistic character of the pilot wave (Miller, 2014). These worries, too, need to be addressed by refining the position even further. As a result, our claim that at least naive versions of classical Humeanism are out of the picture due to quantum mechanics is validated. It is simply not possible to just sit out quantum mechanics as a Lewisian metaphysician. Second, maintaining some form of Leibnizian individuation – in terms of the principle of the identity of indiscernibles (PII) – after the discovery of quantum mechanics has to answer to various challenges concerning, for example, problems with similar bosons and entangled states of similar fermions that all require significant modifications of the metaphysics. For example, according to orthodox views, PII is violated (French and Redhead, 1988) or, at best, valid in a very weak sense (Saunders, 2003, 2006). By contrast, PII is valid in a strong sense according to heterodox views, at least for some states (Bigaj, 2022). For the remaining states, significant metaphysical adjustments are necessary – the summing defence (Hawley, 2009; Friebe, 2014), for example, merges the allegedly two objects that seem to defy the PII into a single object with summable properties (such as mass) being added. Third, it seems fair to say that there is almost unanimous consensus that special relativity ruled out all plausible versions of presentism (Emery, 2023, 12–14 and Chapter 6). While there are certain options for the presentist, for example, due to specific solution classes of general relativity, the general perception is that this does not change too much (Read and Qureshi-Hurst, 2021). Fourth, to add one more, think of how general relativity has forced substantivalists to substantially modify their default assertions and move from manifold substantivalism toward sophisticated versions that include the metric field (e.g., Pooley (2013)).

To the unbothered skeptic we say the following. First, if your claim is that the content of scientific theories does not help to constrain and rule out metaphysical inferences, please elaborate. We see the burden of proof on those who disagree with our argumentation above. Second, the central claim of our argumentation is that we can make progress in metaphysics. The admitted difficulty to present uncontroversial cases of clear-cut exclusion in metaphysics does not break this claim, but is precisely why we draw attention to progress by exploration. Granted that obtaining strict exclusions is not a realistic expectation to have in metaphysics, and even assuming, against our own argumentation above, that the exclusion concern is fully valid, we do retain a form of making progress – which is all we need. Especially in metaphysics, it is of value to investigate into what is possible. It is a metaphysical insight to understand that certain worlds can or cannot exist. If physics says that presentism is probably not true in our actual world, it may still be true in a different world with features to be specified. Therefore, exploration as progress is a mode in its own right. Notably, we do see this in physics itself: different solutions of, say, Einstein's field equations

in general relativity can (and should) be understood as representing different worlds. New empirical findings may change what we consider the most relevant solutions for describing our world. Thus, it makes sense to find and investigate all kinds of different solutions of Einstein's field equations. The exploration of its solution space *is (scientific and metaphysical) progress*.

So, generally, worries regarding the exclusion of metaphysical theories seem exaggerated, especially when invoked to cast doubt on whether we can make *any* progress in metaphysics. Granted that the underdetermination problem is more severe in metaphysics, we maintain that there is no qualitative difference to science. Rather, it is a matter of degree (see also Chakravartty (2017)).[26] Strategies to deal with underdetermination are the same also: as in the sciences, underdetermination may be tamed by use of extra-empirical principles or continuity conditions (e.g., Haack (2007)). Overall, it seems hardly plausible to argue that underdetermination in metaphysics is catastrophic, while accepting underdetermination in science as unproblematic.[27]

Here is another objection, call it the *triviality concern*: relaxing McKenzie's requirement that subsequent theories stand in approximation relations themselves, as we proposed, is in danger of trivialising scientific and metaphysical progress – especially given that we take any kind of addition to or exclusion from theory space as a progressive result. For example, one could introduce a parameter of kobold-including versus non-kobold including, where kobold-including theories are those that randomly postulate the existence of invisible kobolds. One could then explore the region of kobold-including theories, and make progress by developing several more detailed theories of what the kobolds do and how they interact with other stuff and so on.

This objection shows that we need to impose an additional constraint that distinguishes the 'bad' cases illustrated by the exploration of the kobold-including region of theory space from the 'good' cases illustrated by paradigm cases like the exploration of interpretations of quantum mechanics. Not just any exploration will constitute (valuable) progress.

One way of drawing that distinction relies on quality criteria for theories. It is a widely held, and we think rightly uncontroversial, assumption that some theories are worse than others. Kobold-including theories are just bad: First, they will generally not satisfy certain theoretical virtues like parsimony. Kobold-including theories are less parsimonious than their non-kobold-including counterparts in a straightforward sense: they postulate entities not needed to explain anything that needs to be explained. Hence, we have excellent reason not to take them seriously. Second, kobold-including theories will generally not be motivated by live scientific theories. For example, the metaphysical theories that

[26] This may be because science and metaphysics themselves are continuous to each other regarding content and methodology. We are sympathetic to this view, but do not presuppose it here.

[27] What is more, the underdetermination problem is compatible with scientific theories constraining metaphysical theory space. While quantum mechanics does not determine a specific metaphysical theory, it still excludes or at least discourages certain metaphysical assumptions (see above).

are (or include) interpretations of quantum mechanics are to be taken seriously because they are sanctioned by science – your favourite kobold-including theory is not and, therefore, not to be taken seriously. The latter links to Nina Emery's point on the importance of scientific methodology for naturalistically-inclined metaphysics.

The details of the criteria need not concern us here. The central point is just that such criteria are likely available and widely employed in both science and metaphysics. Any plausible account of them can then just be plugged into our account of progress (see Brenner (2017) and Brenner (2023) for recent discussions of theoretical virtues in science and metaphysics).

Now, there are also a number of different ways to integrate such criteria in our account. First, one could simply stipulate that only exploration of good theories constitutes progress. Second, one could leverage the criteria to exclude certain parameters from theory space, such that there simply are no kobold-including theories in theory space. Third, one could admit that exploration of kobold-including theories is progress, but distinguish between relevant and irrelevant progress. It seems like the choice between these options is not very deep. They are simply terminological variants of the core distinction between 'good' and 'bad' cases.

There might still remain the worry that we cannot distinguish between more or less valuable progress concerning the good theories. Here, community judgements can come in. This is widely accepted for science nowadays. A metaphysics based on and linked to science profits from this immediately. But in principle, there are two options: Either community judgements get in only at the scientific level, or also at the metaphysical level. For now, we propose to leave open whether there might also be community judgements in metaphysics. Let us also stress again that we do understand progress as a gradual concept, with even some explorations and exclusions amongst the good theories not adding much progress. But just because we also accept rather trivial results as progressive does not mean that we are unable to distinguish them from important cases of scientific or metaphysical progress. Exploring or excluding a large chunk of some part of theory space may be significantly less informative than exploring or excluding a small region in what is agreed to be a highly relevant part of theory space (according to current best science). In other words, exploring or excluding many implausible theories is less important than exploring or excluding a highly plausible candidate theory like general relativity. Take an analogy from physics: exploring a bunch of string theories at vast but empirically inaccessible energy scales may be less relevant than exploring a very specific low-energy theory. This hints at the following: assessing what is more or less relevant progress depends on further background assumptions or background information about what the serious candidate theories amongst the 'good' theories are. But we usually do have good (though fallible) reasons to expect that certain regions of theory space are more relevant than others – for example, empirical data and consistency conditions. Second, it will often be highly non-trivial to assess the relevance of some scientific or metaphysical result, in the first place: a rather minor ontological change by adding a new particle may turn out as groundbreaking

progress much later, conversely, what has been viewed as a crucial insight may turn out moot. We take it as unproblematic that progress is generally easily achievable, because progress is indeed gradual and the fact that there are more crucial results is not affected by there also being trivial ones. Accepting this only takes seriously that many sciences, like zoology, will arguably often "just" be about 'collecting stamps', they often "just" inform about what is on the list of what there is – but this is relevant.

A related worry stems from the observation that we take both exploring and constraining as sufficient for progress. Consequently, neither aspect is necessary. This is another sense in which our account is rather liberal: When a metaphysician develops a new theory of, e.g., modality, or ontic vagueness, they thereby contribute to metaphysical progress. They don't need to exclude other candidates as well. Or, when a metaphysician makes a merely negative point against an existing theory without suggesting a better alternative, they still count as contributing to metaphysical progress. Perhaps, however, it would be more plausible to require that both aspects must be present for genuine progress. After all, if one can already make progress by exploring, why bother constraining as well?[28]

In response, we can again invoke the notion that progress is a gradual concept. As we see it, it is independently plausible that developing new theories is progress just as criticising existing ones is. We see this result not as a bug but as a feature of our account: Metaphysics indeed makes progress due to the careful development of various theories of, say, modality or ontic vagueness. At the same time, this does not imply that there is no need to constrain as well. The idea is not that once we've made progress, we can sit back and relax. There is more or less – and more or less relevant – progress. To be sure, someone who only explores but does not bother constraining *does* contribute to progress. But someone who explores and then constrains contributes more, and more is better.

Besides the exclusion and triviality concerns, a third class of objections might worry that 'theory space' is not sufficiently well defined; dub this the *theory space worry*. This one can come in different forms. First, some might be generally irritated by the spatial talk. As we see it, 'theory space' is a very general and widely applicable concept used to represent the complex structure of relations to other theories in terms of locations in a corresponding, generalized space.[29] Second, others might wonder whether theories from different frameworks can stand in relations, such that they can occupy different locations in the same theory space. There is a lot going on, so let us unpack this. Although the dimensions and relevant relations will certainly differ, we take it that there is no fundamental difference when it comes to the general applicability of the theory space view. Now, a critical insistence could allege an incommensurability problem, which is interesting. Theories from different frameworks not being comparable in any way, indeed speaks against using a common theory space. Thus, our account seems committed to a rejection of incommensurability. We find this rejection

[28] Thanks to an anonymous reviewer for raising this concern.

[29] We agree with philosophers like Peter Simons (2004, 342) that "wherever we find objects and relations we find structure and therefore locations within the structure".

plausible: Newtonian physics and general relativity or quantum mechanics are comparable. There are even parameters, like c or $\hbar$, that facilitate ordering such allegedly incommensurable theories. Accordingly, changes of framework look less thorny. In our view, the above should sufficiently address the concern, but we are prepared to give – even favour – a more heretic response: our notion of progress does not even require that different frameworks can be seamlessly combined into one big theory space. The conception of progress as exploring and constraining theory space is compatible with having a compartmentalized theory space along the lines of, for example, theoretical frameworks, like a stack of boxes. Then again, why not treat this stack of framework-indexed theory (sub-)spaces as the one big theory space? Especially, when theory space is a rather amorphous structure anyways – arguably even in the technical sense of lacking a fixed long-range order – in that it will change when explored (the dimensions and, possibly, their best systematization will be revised).[30]

According to a fourth worry, there may be forms of scientific progress that cannot be accounted for by our proposal. Perhaps our account models *theoretical* scientific progress, but other forms include *technological* and *methodological* scientific progress, as an anonymous reviewer has objected. We agree that those are important achievements in science. But here are our two replies: First, be that as it may, the core claim required for our argument still stands: constraining or exploring theory space are sufficient for making progress (as opposed to McKenzie's stronger concept). Second, our central objective is to present a concept of *metaphysical* progress (not scientific progress). It is a standard working assumption in metaphysics that science connects to metaphysics specifically via its theories, not so much via its technological progress. In our view, exploring the limitations of this assumption is a very interesting but different project.

Lastly, one might worry that our account is just falsificationism in a new guise. We basically already addressed this worry above, but since it continues to come up in one way or another, let us bring up our responses once more. First, exclusion does not imply falsificationism. Falsificationism is just one model of how exclusion of theories might take place. We are sympathetic but not committed to it. Specifically, we are not committed to the idea that theories are only falsified but never confirmed. Second, and more importantly, exclusion is just one part of our account of progress. Exploration of theory space is the other part. This other part, which has little to do with falsificationism, is arguably key for metaphysics. Hence, our account clearly goes beyond falsificationism.

10 Conclusion

We have seen that theory change is a potential challenge for conceptualising scientific and, hence, metaphysical progress. But we have argued that this

[30] Similarly, and we hope the reader forgives the heretic mood we talked us into, we can embrace a related worry that all this could just be metaphorical. What would make such a proposal non-metaphorical in the first place? Given that theory space certainly is an abstract concept, what would be lost, if theory space was a metaphor?

challenge can be met. In short, our diagnosis of McKenzie's challenge for naturalistically-inclined metaphysics is that it relies on an inappropriately narrow notion of scientific progress, namely the (direct) approximation account. Replacing this account by a more appropriate alternative, namely the theory space account, leads to a convincing refutation of McKenzie's argument. Metaphysics can and does make progress.

More specifically, we have defended the following three claims: (1) progress in science is better understood as exploring and excluding theory space, (2) this conception of scientific progress inspires a generalisation to a notion of metaphysical progress, and (3) our understanding of metaphysical progress prefers inductive metaphysics over naturalized metaphysics.

The upshot is as tedious as it is painful: We make scientific and metaphysical progress by formulating false theories – a tedious task indeed. But there is no shortcut. At least so much is true of both the sciences and metaphysics.

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References

Tomasz Bigaj. *Identity and Indiscernibility in Quantum Mechanics*. Palgrave, 2022.

Alexander Bird. What is scientific progress? *Noûs*, 41(1):64–89, 2007.

Andrew Brenner. Simplicity as a criterion of theory choice in metaphysics. *Philosophical Studies*, 174(11):2687–2707, 2017. doi: 10.1007/s11098-016-0805-1.

Andrew Brenner. Theoretical virtues and the methodological analogy between science and metaphysics. *Synthese*, 201(2):1–19, 2023. doi: 10.1007/s11229-023-04047-z.

Maren Bräutigam. Heterodox underdetermination: Metaphysical options for discernibility and (non-)entanglement. *Studies in History and Philosophy of Science*, 103:77–84, 2024. doi: 10.1016/j.shpsa.2023.09.005.

Anjan Chakravartty. *Scientific Ontology*. Oxford University Press, Oxford, 2017.

C. Chall, M. King, P. Mättig, and M. Stöltzner. From a boson to the standard model higgs: a case study in confirmation and model dynamics. *Synthese*, 198:3779–3811, 2021. DOI: 10.1007/s11229-019-02216-7.

Finnur Dellsén, Insa Lawler, and James Norton. Thinking about progress: From science to philosophy. *Noûs*, 2021. DOI: 10.1111/nous.12383.

Finnur Dellsén, Tina Firing, Insa Lawler, and James Norton. What is philosophical progress? *Philosophy and Phenomenological Research*, 109(2):663–693, 2024. doi: 10.1111/phpr.13067.

Nina Emery. *Naturalism Beyond the Limits of Science. How Scientific Methodology Can and Should Shape Philosophical Theorizing*. Oxford University Press, Oxford, 2023.

Nicholas Emmerson. Plumbing metaphysical explanatory depth. *Philosophical Studies*, 181:2091–2112, 2024. doi: 10.1007/s11098-022-01886-3.

Nicholas Emmerson. It ain't that deep: Metaphysics and the problem of progress, manuscript.

Kristina Engelhard, Christian J. Feldbacher-Escamilla, Alexander Gebharter, and Ansgar Seide. Inductive metaphysics: Editors' introduction. *Grazer Philosophische Studien*, 98(1):1–26, 2021. DOI: 10.1163/18756735-00000129.

L. R. Franklin. Exploratory experiments. *Philosophy of Science*, 72(5):888–899, 2005. DOI: 10.1086/508117.

S. French and D. Krause. *Identity in Physics: A historical, philosophical and formal analysis*. Clarendon Press, Oxford, 2006.

Steven French and Michael Redhead. Quantum physics and the identity of indiscernibles. *The British Journal for the Philosophy of Science*, 39(2), 1988.

Cord Friebe. Individuality, distinguishability, and (non-)entanglement: A defense of leibniz's principle. *Studies in History and Philosophy of Modern Physics*, 48:89–98, 2014.

Dylan Goldman. Truthlikeness and progress in naturalistic metaphysics. *Synthese*, 206(212), 2025. doi: 10.1007/s11229-025-05270-6.

Susan Haack. *Defending Science – within reason. Between Scientism and cynicism*. Prometheus Books, 2007.

Katherine Hawley. Identity and indiscernibility. *Mind*, 118:101–119, 2009.

Salim Hirèche, Niels Linnemann, Robert Michels, and Lisa Voigt. The strong arm of the law: a unified account of necessary and contingent laws of nature. *Synthese*, 199, 2021. doi: 10.1007/s11229-021-03243-z.

Rasmus Jaksland. Entanglement as the world-making relation: distance from entanglement. *Synthese*, 198:9661–9693, 2021. DOI: 10.1007/s11229-020-02671-7.

Rasmus Jaksland and Kian Salimkhani. The many problems of spacetime emergence in quantum gravity. *The British Journal for the Philosophy of Science*, 0(ja):null, Forthcoming. doi: 10.1086/727052.

K. Karaca. A case study in experimental exploration: exploratory data selection at the large hadron collider. *Synthese*, 194:333–354, 2017. DOI: 10.1007/s11229-016-1206-x.

Harold Kincaid. *Introduction: Pursuing a Naturalist Metaphysics*, pages 1–26. Oxford University Press, 2013.

James Ladyman. *An Apology for Naturalized Metaphysics*, pages 141–161. Oxford University Press, 2017.

James Ladyman, Don Ross with David Spurrett, and John Collier. *Every Thing Must Go: Metaphysics Naturalized*. Oxford University Press, 2007.

Tim Maudlin. *The Metaphysics within Physics*. Oxford University Press, Oxford, 2007.

Kerry McKenzie. A curse on both houses: Naturalistic versus a priori metaphysics and the problem of progress. *Res Philosophica*, 97(1):1–29, 2020. DOI: 10.11612/resphil.1868.

Kerry McKenzie. Science-guided metaphysics. In Ricki Bliss and JTM Miller, editors, *The Routledge Handbook of Metametaphysics*, pages 435–446. Routledge, London/New York, 2021.

Elizabeth Miller. Quantum entanglement, bohmian mechanics, and humean supervenience. *Australasian Journal of Philosophy*, 92(3), 2014. doi: 10.1080/00048402.2013.832786.

Ilkka Niiniluoto. Truthlikeness: Old and new debates. *Synthese*, 197, 2020. doi: 10.1007/s11229-018-01975-z.

Paul Näger. The mereological problem of entanglement. https://philarchive.org/rec/NGETMP, manuscript.

Oliver Pooley. Substantivalist and relationalist approaches to spacetime. In Robert Batterman, editor, *The Oxford Handbook of Philosophy of Physics*. Oxford University Press, Oxford, 2013.

James Read and Emily Qureshi-Hurst. Getting tense about relativity. *Synthese*, 198, 2021. doi: 10.1007/s11229-020-02560-z.

Kian Salimkhani. *The Non-Fundamentality of Spacetime. General Relativity, Quantum Gravity, and Metaphysics*. Routledge, London/New York, 2024.

Simon Saunders. Physics and leibniz's principles. In K. Brading and E. Castellani, editors, *Symmetries in Physics: Philosophical Reflections*. Cambridge University Press, 2003.

Simon Saunders. Are quantum particles objects? *Analysis*, 66, 2006.

Jonathan Schaffer. Monism: The priority of the whole. *Philosophical Review*, 119(1), 2010.

Gerhard Schurz. Abduction as a method of inductive metaphysics. *Grazer Philosophische Studien*, 98(1), 2020. doi: 10.1163/18756735000098.

Peter Simons. Location. *Dialectica*, 58(3), 2004. Special issue: Formal Concepts.

Friedrich Steinle. Entering new fields: Exploratory uses of experimentation. *Philosophy of Science*, 64:S65–S74, 1997. DOI: 10.1086/392587.

Paul Teller. Relativity, relational holism, and the bell inequalities. In *Philosophical Consequences of Quantum Theory: Reflections on Bell's Theorem*. University of Notre Dame Press, 1989.