# Spacetime Quietism in Quantum Gravity

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forthcoming in
*The Foundations of Spacetime Physics: Philosophical Perspectives*,
A. Vassallo (ed.), Routledge

**Abstract**

The existence and fundamentality of spacetime has been questioned in quantum gravity where spacetime is frequently described as emerging from a more fundamental non-spatiotemporal ontology. This is supposed to lead to various philosophical issues such as the problem of empirical coherence. Yet those issues assume beforehand that we actually understand and agree on the nature of spacetime. Reviewing popular conceptions of spacetime, we find that there is substantial disagreement on this matter, and little hope of resolving it. However, we argue that this should not trouble us as these issues, which seem to suggest the need for an account of spacetime in quantum gravity, can be addressed without one.

## 1 Introduction

Recent philosophical work on quantum gravity has focused on the notion of spacetime emergence: the idea that spacetime, as found in our most fundamental and successful theories at the moment—*general relativity* and *quantum field theory*—arises at some non-fundamental level from a more fundamental, non-spatiotemporal, reality (see e.g. Butterfield and Isham 2001, Crowther 2018, Huggett and Wüthrich, forthcoming). The fundamental level is expected to be the purview of a theory of quantum gravity, such as *string theory*, *loop quantum gravity* or *causal set theory*, which have all been claimed to question the very existence of a fundamental spacetime.

The focus on spacetime emergence has had an invigorating effect on existing philosophical disputes concerning the nature of spacetime. In order to say that spacetime arises at some non-fundamental level, and in order to identify some fundamental level as spacetime-free, it seems we first need an account of what spacetime is. Accordingly, the question 'what is spacetime?' has been tackled as one aspect of the broader quest to understand the many approaches to quantum gravity currently being developed within physics.

We believe however that the focus on *spacetime* emergence in this context, while understandable, is misguided. It would be better to avoid entirely the question of what spacetime is. In order to make this case, we develop two tranches of argument. First, we show that there is substantial disagreement about what spacetime is, and not much hope of sorting it out. Second, we argue that the philosophical issues arising from the quest to understand quantum gravity that seem to suggest the need for an account of what spacetime is can be addressed without one.

The paper is structured as follows. We begin by situating the various accounts of spacetime that have been offered to date within a broad framework (§2–3). We then discuss what to do in light of the many accounts of spacetime that there are, and conclude that a form of pluralism is the best bet (§4). However, we then show that in order to answer one of the most discussed issues in the philosophical literature on quantum gravity—namely, the problem of empirical incoherence—we don't need an understanding of the nature of spacetime that goes beyond this pluralistic outlook. We can get by, instead, with an account of how various features commonly associated with, but potentially independent of, spacetime arise (§5). We close with concluding remarks on related issues which have been raised in the literature (§6).

In the end, we propose a philosophical approach to quantum gravity that is quite close to the spacetime functionalist positions we review in §2. However, rather than focusing on the identification of a functional role for spacetime (and then checking to see whether that role is filled in the context of a more fundamental theory) we recommend identifying theoretical functions or explanatory roles that must be performed if we are to have a viable physics. The right approach to quantum gravity emphasises the functional roles of observer and observable, rather than functionalism as a metaphysical thesis about the nature of spacetime.

# 2 Two Approaches to Spacetime

Current discussion of spacetime seems to centre around two approaches to understanding spacetime, what we call the 'narrow' approach and the 'broad' approach respectively. To a first approximation, the narrow approach to spacetime anchors spacetime to a particular theory, or theoretical framework: most obviously special relativity and general relativity, but also other theories with a special relation to relativistic physics, for instance *Newton-Cartan theory* or *string theory*. The broad approach to spacetime, by contrast, does not. Rather, spacetime is conceived of in a more or less theory-independent manner. These different approaches serve to identify a specific concept that we can then subject to further analysis. The approaches themselves do not constitute an analysis of that concept, however, and nor do they constitute a complete account of what spacetime is. We can sharpen up this initial characterisation as follows:

> **The Narrow Approach:** Provide an account of spacetime, where spacetime is something that is only found within the ontology of general relativity, and within theories that approximate general relativity sufficiently well.
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> **The Broad Approach:** Provide an account of spacetime, where spacetime is something that is found within the ontology of general relativity and within theories that approximate general relativity sufficiently well, but not only: it is found in the ontology of theories that don't approximate general relativity.[1]

To give this distinction some substance, it is important to say a bit about what it means for something to appear within the ontology of a theory, as well as what it takes to approximate a theory. With respect to the former, we take appearance in the ontology of a theory to be a matter of commitment. Spacetime is one of the ontological commitments of general relativity, which is to say that if one adopts a realist attitude toward that theory (whatever that might mean in then end) then one should accept the existence of spacetime. The narrow conception thus dictates that belief in the existence of spacetime is only warranted for a specific cluster of theories: namely general relativity, and those theories that can approximate it. The broad conception, by contrast, allows that one may be warranted in believing spacetime exists even if one does not adopt a realist attitude

[1] We use the notion of 'theory' in a fairly liberal sense as meaning a collection of pointedly grouped propositions: propositions that are grouped together for a specific purpose (cf. Vickers 2013). Importantly, theory should not be restricted to physical theories in this context. What we are aiming at is a difference between the concept of spacetime as anchored in general relativity, and the concept of spacetime as it can be found elsewhere in views that do not approximate general relativity—other scientific theories but also potentially folk theories.

toward general relativity (but instead, adopts a realist attitude toward some other theory that brings with it an ontological commitment to spacetime, in a broad sense).

Approximation is understood in the sense used by physicists (as characterised by Butterfield and Isham 1999, 2001): a theory T approximates a theory T* when, by neglecting certain degrees of freedom or certain quantities in T, T and T* numerically agree with only a very small margin of error. So, for instance, general relativity will numerically agree with Newtonian mechanics for a group of particles moving slowly (relative to the speed of light), in a weak, unchanging gravitational field. In this sense general relativity approximates a Newtonian theory. Similarly, a theory may approximate general relativity, when certain relativistic degrees of freedom are factored out in an analogous manner.

We take approximation to be a matter of degree: one theory T can be a better or worse approximation to a theory T* compared to a third theory T'. In some sense, just about any two theories can stand in an approximation relation so long as we are willing to neglect enough degrees of freedom, or factor out specific quantities. That is why, for the narrow conception of spacetime, a certain threshold for approximation must be passed by a theory T with respect to general relativity before we can say that something within T qualifies as spacetime. We can understand this threshold in terms of empirical equivalence: a theory T approximates general relativity well enough for the ontology of T to satisfy the narrow conception of spacetime when every confirmed empirical prediction of general relativity is a confirmed empirical prediction of T as well.

The distinction between the broad and narrow approaches can be further developed by comparing two accounts of what spacetime is that fall on either side of the divide. Consider, first, the *functionalist conception of spacetime* offered by Yates (2021) and endorsed by Chalmers (2021). According to this conception of spacetime, spacetime is any $n$-tuple in any theory that satisfies the Ramsey sentence for general relativity either exactly, or well-enough. A Ramsey sentence for general relativity is, presumably, produced in the usual way. We start by treating 'spacetime' as a theoretical term. We then formulate a sentence that defines spacetime via a range of predicates within the context of general relativity. The Ramsey sentence is then produced by stripping out any mention of spacetime, and replacing it with a variable that is bound within the scope of one or more quantifiers.

In order to work out whether spacetime appears in another theory, we check to see whether something satisfies the Ramsey sentence. If something does satisfy it, well and good. If nothing satisfies the Ramsey sentence exactly, but the theory nonetheless manages to approximate general relativity in the manner described above (or perhaps, in some other way if a different approach to approximation is favoured), then the sentence is satisfied well enough. For theories that don't feature anything that satisfies the Ramsey sentence well-enough, spacetime does not make an appearance. In this way spacetime is narrowly construed since it is unlikely to feature in any theories that don't have a great deal in common with general relativity. Newtonian theories, for instance, are unlikely to feature spacetime in the narrow sense.[2]

Contrast this Ramsey-style functionalism with Knox's *inertial frame functionalism.* Knox (2019) builds on Brown's dynamical view of Minkowski spacetime. Brown's view supports two quite natural metaphysical pictures: a new form of relationism about spacetime, and a form of spacetime functionalism. Knox (2019) takes the second road and views spacetime as the theoretical entity that plays a certain role in defining inertial frames within any theory. These inertial frames are defined in turn in terms of preferred coordinates that maximally simplify, locally, the laws associated to all the non-gravitational interactions (Brown, 2005, p. 169). More intuitively, what this means is that the distinc-

[2] *Newton-Cartan theory*—a geometrical reformulation and generalisation of Newtonian mechanics as a field theory (Bain, 2004) that features spacetime—might be viewed as conflicting with this claim. As above, this depends on what 'approximation' means. Newton-Cartan theory won't approximate general relativity in the sense described above (involving empirical recapture) but it might on some other conception of approximation.

tion between inertial and accelerated bodies is not a matter of relations between bodies and a background structure, or even a matter of relations between the bodies themselves, but rather of symmetries in the laws that dictate how the bodies move.

For Knox, then, any theory that features something within its ontology that satisfies the minimal condition she specifies will feature spacetime. This condition is satisfied within general relativity but, importantly, it is also satisfied within many theories that neither feature something that satisfies the Ramsey sentence for general relativity, nor approximate general relativity more generally. Knox's conception of spacetime is thus quite likely to be satisfied in Newtonian theories. Indeed, it is likely to be satisfied in a very wide range of theories.

We have used the contrast between two versions of spacetime functionalism to illustrate the distinction between the broad and narrow approaches to spacetime. This, however, should not be read as implying that the distinction itself is a distinction internal to a functionalist approach to spacetime. Rather, the question of whether spacetime is a functional kind (or not) cross-cuts the broad/narrow distinction. All that the broad/narrow distinction aims to capture is a difference in the theoretical anchorage for spacetime. Various different debates about what spacetime is can then be formulated on the basis of either the broad or the narrow conception.

Consider, for instance, the debate between relationism and substantivalism about spacetime, that can be traced back to discussions of Newtonian mechanics by Leibniz, Newton and Clark. Substantivalism is the view that spacetime is a substance on its own, which is not essentially connected to material objects. Relationism is the view that spacetime is a network of relations between material entities that could not exist in the absence of material entities and hence, is not fundamental. Of course, what this means exactly will depend on what one takes a substance to be and it is hard to find a consensus on how the two positions should exactly be characterised.

What we want to emphasise here is that the debate over whether relationism or substantivalism is true can be had in two ways. The first—and we take it, standard—way of having the debate involves thinking of spacetime along the lines of the narrow approach. Thus, the goal is to determine whether spacetime in general relativity is to be identified with a network of relations between material objects located in space and time or whether—if we take seriously its mathematical representation—an ontology of three structures: a *manifold* of points, the *metric field* and the *matter fields*. Without going into the details, some have suggested identifying spacetime to the manifold of points (a view sometimes called *manifold substantivalism* or *sophisticated substantivalism* in its more recent and refined version, see e.g. Teitel, forthcoming), others to the metric field, a view naturally dubbed *metric field substantivalism* (Hoefer, 1996).

The second way of conducting the relationist/substantivalist debate focuses on the notion of spacetime at issue in the broad approach. In this case, it may pay to work out what spacetime in general relativity is (since that may help to determine the nature of spacetime more generally), but that is certainly not the only way, and may be potentially misleading insofar as one ends up focusing on features that are peculiar to the relativistic context. Under a broad conception of spacetime, the question is whether the notion of spacetime focused on within the broad approach is relationist or substantivalist. Thus, if one thinks that the ontology of a Newtonian theory counts as spacetime, then one can discuss relationist and substantivalist approaches to spacetime in Newtonian mechanics and relativistic physics in the same breath.

Other metaphysical approaches to spacetime cross-cut the broad/narrow divide in the same way. For instance, there is the mereological approach to spacetime (originally advocated by Paul 2012, and more recently by Le Bihan 2018 and Baron and Le Bihan, forthcoming in the context of quantum gravity). On this view, spacetime—whatever it is—is mereologically composed of parts. One way of developing this view is to treat spacetime as something that can be composed of non-spatiotemporal parts (Paul 2012, pp.

242–242, for instance, proposes to build spacetime from bundles of properties, including location properties, which need not be spatiotemporal locations). This view can be held about spacetime in the broad sense, in which case anything that counts as spacetime broadly (perhaps by virtue of providing a structure for inertial frames) may be subject to a mereological analysis. Equally, however, the mereological approach can be held about spacetime in the narrow sense. Thus, one might hold that it is only spacetime anchored to general relativity that is to be treated mereologically, leaving it open as to whether other structures that might be spacetime in a broader sense are to receive a mereological treatment.

No doubt there are other accounts that one might offer concerning the nature of spacetime. It should be clear, however, from what we've said that such accounts are likely to work for broad or narrow conceptions of spacetime, and thus that within each way of thinking about what spacetime is, there is a substantive debate to be had about its nature.

# 3 Sources of Disagreement

So far we have focused on the distinction between the broad and narrow approaches to spacetime, and on cross-cutting accounts of what spacetime is given this distinction. We want to now draw attention to two sources of disagreement. First, one might disagree about whether the broad approach to spacetime, or the narrow approach is the 'correct' approach to understanding spacetime. Thus, one might argue that the broad approach is too broad, or the narrow approach too narrow. Or one might argue that one or other of these approaches has pride of place in developing a metaphysical or physical understanding of spacetime, and the other is to be discarded. Call the question of which approach to understanding spacetime is to be preferred (if any) the *indexing question*, since what's at stake is whether we should prefer an approach that treats spacetime as something that is essentially indexed to relativistic physics.

Second, one can also disagree about what the 'correct' account of spacetime might be assuming either the broad or narrow approaches. Call this the *nature question*, since it is really the question of what the nature of spacetime might be. With respect to the narrow approach, one might debate about what spacetime within general relativity is. The relationist/substantivalist debate is one example of a debate along these lines, as is the question of whether the causal theory of spacetime is true (which, arguably, is a question internal to a relationist program).

Similarly, one might debate about the correct account of spacetime under the broad approach. Knox (2019), Read and Menon (2021) and Baker (forthcoming) all seem to engage in a debate along these lines. None of them are interested in a narrow approach to spacetime. Instead, they argue that spacetime in some sense that goes beyond general relativity is a structure of inertial frames (Knox); that which is measured by rods and clocks (Read and Menon) or a cluster of different notions, including a fundamentality constraint to the effect that the most fundamental things are the best candidates to be spacetimes (Baker).

In the process of providing an account of spacetime emergence in the context of quantum gravity, philosophers end up answering both the indexing and nature questions. For instance, Lam and Wüthrich (2018, 2021) advocate for a functionalist approach to spacetime as a philosophical approach to a number of programs in quantum gravity. In so doing, they seem to take a stand on both the indexing and nature questions. They tie their analysis closely to general relativity, and so seem to adopt the narrow approach. Their stated goal is to show how realism about spacetime in the context of general relativity is compatible with the emergence of spacetime from a fundamental, non-spatiotemporal structure. They deliberately set aside Knox's inertial frame functionalism, because it is a departure from the narrow conception. Additionally, they offer a functional analysis of what spacetime in the narrow sense is, thereby providing an answer to the nature question.

We are not particularly interested in criticising Lam and Wüthrich's approach and others like it. Nor do we think that Lam and Wüthrich have erred in answering both the indexing and nature questions. Given their starting assumption, namely that spacetime is an emergent entity, it does seem that an answer to both questions is required, on pain of rendering the emergence of spacetime metaphysically obscure. Rather, what we are interested in is whether the starting assumption is a good jumping-off point for thinking about quantum gravity. Should we work within a framework of spacetime emergence at all?

# 4 Spacetime Scepticism

Our goal in this section is to defend a sceptical approach toward questions of spacetime emergence. Simply put, we don't think that the prospects for answering the indexing or nature questions are very good. Since answering these questions would seem to be a necessary step toward giving an account of spacetime emergence, spacetime emergence is thus shown to be a troubled notion.

Let's start with the indexing question: the question of whether a broad or a narrow approach to understanding spacetime is the correct approach. In order to show that one of these approaches is 'correct', one would need to argue that the concept of spacetime is, in fact, essentially indexed to relativistic physics, or that it is not. It is, however, very difficult to see how one might make the case that the concept of spacetime has any specific features. It is, of course, possible that there is some other way to defend an answer to the indexing question, and we invite suggestions for arguments along these lines.

First, one might take a historical approach. The idea here is that 'spacetime' was introduced in a very specific context, namely as a way to interpret relativistic physics. Accordingly, the way spacetime ought to be understood is anchored to its initial introduction into the world of physics. A view along these lines is suggested by Chalmers, who writes:

> Spacetime as understood here is an essentially theoretical concept, one that emerges especially from the general theory of relativity. (Chalmers, 2021, p. 172)

Although Chalmers does not argue for the broad or narrow approaches, what he says can be formed into a historical argument in this direction. The basic idea is that the way the notion was historically introduced fully justifies a narrow conception of spacetime. In so far as there might be a notion of spacetime that is detachable from relativistic physics, that notion is, strictly speaking, a perversion of the core concept.

We don't think this historical argument carries much weight. Perhaps spacetime was introduced in the context of relativity originally, but concepts shift and change during their lives within science. The concept of mass, for instance, has changed in important ways, since its original introduction with Newtonian mechanics. We see no reason to suppose that this couldn't be true for spacetime as well.

A second approach to the indexing question appeals instead to contemporary physics. If we look into current physics, one might argue, we will find conclusive evidence for exactly one of the broad or narrow approaches to understanding spacetime being the correct approach. What would this look like exactly? Well, when we look into physics as currently practised, we will see that the notion of spacetime being used is, in every case, one that is linked to general relativity in the manner demanded by the narrow conception. Alternatively, we may look and see that the notion of spacetime is used much more liberally than that, thereby signalling that the broad conception of spacetime is correct. Either way, the indexing question gets its answer.

Full disclosure: we have not conducted a full and detailed analysis of the way in which spacetime is discussed within physics. By the same token, we know of no such analysis. That limits the extent to which we can evaluate this way of answering the external question. But this limitation cuts both ways: without a detailed analysis of how physicists think of spacetime, one can't argue in favour of any particular monistic answer to the external question either.

We also think it would be shocking if all physicists think about spacetime in the same way. We suspect that some physicists will see spacetime as anchored to general relativity, as per the narrow conception, while others will take a more liberal approach, as per the broad conception. Variation in how physicists talk about spacetime underdetermines whether they all adopt the broad conception, or whether only some do. There would, presumably, be a very similar pattern of responses either way. In short, there is little reason to suppose that the disagreement around what spacetime is, as captured by the distinction between the narrow and broad approaches to understanding spacetime is localised to philosophy only. Indeed, philosophers are, in part, responding to the way that physicists are conceiving of, and using, spacetime. So we don't see why the disagreement over the indexing question wouldn't find a home inside physics as well. The difference being, perhaps, that physicists don't really care about the philosophical issues at stake, and so are happy enough to live with the disagreement unresolved.

A third way to answer the indexing question is to argue that either the broad or narrow approaches to understanding spacetime line up with some 'pre-theoretical' notion. Thus, rather than focusing on what physicists think about spacetime, we might instead focus on what the 'folk' think. However, we take it to be fairly clear that the way the folk think about spacetime is a poor guide to what spacetime is, or how we should think about it. Absent some influence from the physics, the folk are unlikely to have any concept of spacetime that differs from a simple conjunction of the concepts of space and time. Thus, assessing folk semantic intuitions about spacetime will require preliminary work to introduce some concept of spacetime—which certainly counts as a form of theoretical contamination undermining any hope to gain substantive insight this way. Thus, even though the folk might be a good guide to other concepts of philosophical interest that do not essentially depend on scientific activity (like pain or colour), they will be poor guides to theoretical concepts like spacetime.

A fourth answer to the indexing question might appeal to background metaphysical facts. Spacetime, one might argue, has certain essential features. The correct account of spacetime is the one that attributes all and only these features to spacetime. This might seem obviously circular in a bad way: in order to say what the features of spacetime are, we first need an answer to the nature question. However, answering the nature question presupposes that we first answer the indexing question, since one cannot settle on an account of the nature of spacetime without first settling the question of whether spacetime is essentially indexed to relativity. Perhaps, however, the circularity can be avoided, if we combine the current approach with something like the historical approach discussed above.

Here's the idea. The notion of spacetime has its roots in the work of Minkowski, who put forward spacetime as a natural geometrical interpretation of special relativity (Minkowski, 1908).[3] This spacetime is four-dimensional, meaning that four numbers are required to mathematically ascribe any position within the manifold. This four-dimensionalist picture differs from a 3+1 ontology that would take the four-dimensional manifold to be simply the addition of two manifolds: a 1-dimensional time and a 3-dimensional space. Central to the notion of spacetime thus, is the view that spacetime cannot, ontologically, be decomposed into two distinct structures: space *and* time. It is

[3]Minkowski introduces spacetime *points* that are then used to define spacetime *vectors*, *lines* and *filaments*. The concept of spacetime is not explicitly introduced but it's natural to think of it as the totality of spacetime lines.

fairly standard to take special relativity to be essentially tied to Minkowski spacetime (but some have resisted the view and tried to develop an ontology of relative facts between three-dimensional frames of reference). Core to the notion of spacetime as Minkowski thought of it, then, is the entanglement of space and time into a single unified object.

Now, consider once again the point made above about conceptual change. It is standard for notions within science to shift over time. This, in turn, undermines any strong reason for taking the way spacetime is understood now to be determined by the historical introduction of that notion into physics. One might argue, however, that this is a bit quick. Sure, concepts change, but while concepts change they must also stay the same in order for us to be able to say that we are dealing with the same concept. So it could be argued that while the current notion of spacetime does not need to be the same as the notion that Minkowski introduced, it should be continuous with it in the following minimal sense: the two concepts should overlap in some way. Given that Minkowski took the weaving of space and time together to be a deep feature of spacetime, we might suppose that it is this feature that should survive, above all else, through conceptual shifts in our understanding of spacetime.

If that's right, then we can, at the very least, require that a reasonable account of spacetime should be one according to which space and time are woven together in a deep sense. In this way, one can provide a metaphysical demand on what a viable notion of spacetime should require, in a non-circular fashion. This is fine as far as it goes, but it doesn't go far enough. Even if the weaving of space and time together is a necessary feature of spacetime, that is still not enough information to answer the indexing question. For it is compatible with both the narrow and broad approaches to understanding spacetime, that spacetime features a woven aspect.

At this point we have run out of ideas concerning how the indexing question might be answered. None of the options seem very promising. Suppose, however, that we do manage to settle on an answer to the indexing question. This at least gives us the capacity to begin answering the nature question, since we know whether spacetime is essentially linked to relativity or not.

The prospects for answering the nature question are better, but even here there are problems. The prospects are perhaps best for answering the nature question if the narrow approach to understanding spacetime is the correct approach. For in this case, one has the theoretical structure of general relativity to use as a basis for determining what spacetime is. Indeed, we hold out hope that the nature question for the narrow conception is answerable, and thus that we can (for instance) determine whether spacetime in general relativity is best captured as relationalist, substantival or something else, and whether it is to be understood in causal terms or not (and so on). Indeed, we don't see any problems for answering the nature question under a narrow approach to understanding spacetime that aren't just problems with doing the metaphysics of a specific physical theory more generally.

Matters are a bit less certain when it comes to the nature question for the broad conception of spacetime. Here we don't have the structure of general relativity to use as a guide, at least not in the same way. But then it becomes unclear how we might determine what the right notion of spacetime might be. Take the debate between Knox, on the one hand, and Read and Menon, on the other. To over-simplify the debate somewhat, Knox argues that spacetime is a structure of inertial frames. Read and Menon demur because, in some sense, inertial structure won't capture causal structure in the right way. But what, exactly, are the rules of the game here? How do we determine whether causal structure is an important feature of spacetime or not? Without a background theory like general relativity to constrain our metaphysical theorising, it is unclear what considerations might speak for or against the relevant proposals.

Here, again, the community of physicists might play a role. Perhaps there is some use to which spacetime is put in physics such that capturing causal structure is necessary for capturing that use. Or perhaps there is some way that physicists talk about spacetime that would strongly suggest that inertial structure is both necessary and sufficient for spatiotemporal structure. However, the problems already identified for appealing to physics in this way when it comes to the indexing question are likely to re-emerge. What physicists say or do when it comes to spacetime may not be much of a guide to the nature of spacetime.

In the section thus far we have been arguing that the prospects for answering the indexing and nature questions are not good. It is thus difficult to see how one might settle the question of what the correct account of spacetime is. An obvious response to the difficulties we have highlighted so far, however, is to challenge the conceptual foundations of our argument. We have been assuming, rightly or wrongly, that there is just one correct conception of spacetime, and thus there is pressure to determine what that conception is in order to give substance to the notion of spacetime emergence. It is only given this assumption that a choice between the narrow and broad approaches is forced. For it is only if there is a single concept of spacetime that one of these approaches must be selected over the other. Similarly, it is only if there is a single concept of spacetime that we must settle on a particular account of the nature of spacetime.

In short, everything we've said so far assumes conceptual monism about spacetime. One can thus take our arguments as evidence against conceptual monism. There isn't just one concept of spacetime, there are multiple concepts. This enables one to simply reject the indexing question outright. There is no need to determine whether the broad or narrow approach is 'correct', they are both correct approaches to distinction spacetime concepts, one that is essentially indexed spacetime and one that is not. One can also reject the nature question: we have lots of different accounts of what spacetime is, and they are all equally good. We don't need to privilege one as the correct account. In short, the pluralist simply says: let a thousand spatiotemporal flowers bloom.[4]

Ultimately, we don't think the shift to pluralism automatically acquits one of the need to say what spacetime is, and so the difficulties we have identified will arise anew. To see this, it is useful to separate pluralism into two forms: weak and strong. Both the strong and weak pluralist maintain that there are many different, viable notions of spacetime. The strong pluralist, however, adds to this that all notions of spacetime have something substantive in common such that they count as viable notions of spacetime in the first place. The weak pluralist, by contrast, denies this: it is not the case that all notions of spacetime have something substantive in common. Note that by 'substantive' we mean: more than the label. Thus a non-substantive commonality between the various notions of spacetime is just that we use the term 'spacetime' for each. A substantive commonality is some feature that is common to all notions of spacetime that qualify them as such.

Strong pluralism requires an account of what the feature might be that is held in common between differing conceptions of spacetime. Specifying what this feature is looks about as difficult as answering the indexing and nature questions. For it is unclear what considerations might be brought to bear that would allow us to determine even a single common feature. Indeed, it would seem that the kinds of strategies discussed that might be used to answer the indexing or nature questions are the very strategies one would have available, were one to try and settle on a core feature to be used as the basis for strong pluralism. For this reason, we don't see strong pluralism as offering much in terms of benefit over the monistic alternative.

The same issue does not arise for weak pluralism. According to the weak pluralist, the only thing that different conceptions of spacetime have in common is the name. Moreover, the way the label is used is just an accident, based on various historical contingencies

[4]Note that the broad answer to the indexing question simply implies that the concept of spacetime must be broad enough to apply to non-relativistic contexts. It is then another question whether or not the spacetime concepts involved in these non-relativistic contexts share a common minimal core with the relativistic context. Only if these different concepts do not share a common core will the broad answer involve a form of pluralism.

concerning the development of physics, and perhaps philosophy and mathematics too. Weak pluralism is a view that does indeed avoid the need to answer the indexing and nature questions, and in a way that avoids having to specify a basis for strong pluralism.

Given how difficult the indexing and nature questions are to answer, we recommend abandoning them. One then has the option of adopting weak pluralism about spacetime, or something a bit more radical. One could, instead, seek to eradicate the term 'spacetime' replacing it with more specific notions. We don't have a view on what the best option might be, and so we leave the matter open.

If we abandon the indexing and nature questions, then we are giving up on the quest to say what spacetime is (or what it is to be a spacetime, as under strong pluralism). This, in turn, renders questions about whether spacetime exists effectively unanswerable. We can't really say whether spacetime exists or not, because we don't have a stable conception of what it is. Giving up on the indexing and nature questions might thus seem like a mistake. In the context of quantum gravity, the existence of spacetime is linked to the viability of specific theories. Schematically, the idea is that there are certain features that a theory of quantum gravity must possess in order for that theory to yield a viable physics. Spacetime delivers those features in virtue of what it is. Thus, by demonstrating the emergence of spacetime from an underlying theory of quantum gravity, one is thereby able to show that the theory possesses the right features for viability.

Something of a dilemma is starting to form: either we find a way to answer the indexing and nature questions, or we abandon them. The first option, as we've argued, is difficult to make work; the second option threatens to leave us without a way to establish the viability of various approaches to quantum gravity. In the last section, we embrace the second horn of this dilemma and show that the viability of an approach to quantum gravity can be established without demonstrating the existence of spacetime. Once we see this we can also see that focusing too much on spacetime emergence in quantum gravity may in fact be counterproductive.

# 5 No Need for Spacetime

In this section our goal is to show that the existence of spacetime is not needed to establish the viability of a given approach to quantum gravity. Note that we are not arguing for the stronger view that spacetime does not exist. A view along those lines has been introduced by Le Bihan (2018) and defended by Baron (forthcoming).[5] Indeed, given that we think the internal and external questions about spacetime should be abandoned, spacetime eliminativism is the kind of view that is unavailable to us (given that it involves saying that spacetime does not exist and thus agreeing beforehand on what exactly reality is denied to). Rather, we are arguing that the viability of an approach to quantum gravity can be upheld on the basis of a kind of *quietism about spacetime*, whereby one refuses to say one way or another whether spacetime exists.

To show this, we will focus, in the first instance, on the so-called *problem of empirical incoherence* (Huggett and Wüthrich, 2013). We focus on this problem because we see it as being the main philosophical threat to the viability of a number of approaches to quantum gravity. The problem is typically posed as follows. A number of approaches to quantum gravity seem to lack spatiotemporal structure. However, spatiotemporal structure, one might argue, is necessary for empirical confirmation to occur. That's because empirical confirmation is always a matter of gathering observations of local beables. A local beable, however, is just an object that is localised in spacetime. If spacetime does not exist, then it seems nothing can be localised in the manner require for observation. From there it seems to follow that if a theory lacks spacetime, then it cannot support observation. Thus if a theory of quantum gravity that lacks spacetime is true, then the truth of that theory

[5] See also Ismael (2021) for discussion.

would seem to undermine any prospect for empirically confirming it. Conversely, any empirical evidence gathered for such a theory would demonstrate that the theory is false. As Barrett puts it, such a theory would be empirically incoherent (Barrett, 2001, pp. 116-117).

A theory of quantum gravity is thus viable when it is empirically coherent. A number of philosophers maintain that viability in this sense is secured with the existence spacetime. For, one might argue, we know that the existence of spacetime would support the observation of local beables (indeed the problem is set up this way, more on that in a moment). Accordingly, if the existence of spacetime can be demonstrated, then it would follow that a theory of quantum gravity is empirically coherent and thus viable. The perhaps most straightforward way to understand the existence of spacetime in this context is to claim that spacetime does not exist fundamentally but it exists in a derivative way—just as table and chairs can be viewed as being less fundamental than the matter they are made of (Wüthrich, 2017, p. 298). In other words, one way to solve the problem of empirical incoherence is to develop a rich ontology with different levels of reality, the level of empirical confirmation of a theory being less fundamental than the level at which lives the ontology of the theory.

Clearly, we can't rely on the existence of spacetime in the same way. But we also don't think that there is any need to give up our quietist take on spacetime to solve the problem. The way in which the problem of empirical coherence is often set up can make it seem like this is not so. As noted, the problem is often set up in spatiotemporal terms, which can make it seem as though a spatiotemporal answer is required. But the appeal to spacetime in the statement of the problem is tendentious. To see this, we need to take a step back and consider what would in fact be sufficient for observation. Of course, exactly how observation works is a vexing issue, and not one that we can hope to fully address here. However, one thing seems fairly clear. If space and time exist then that seems sufficient for entities to be observable.

A similar point has been made in the context of a particular approach to quantum mechanics by Ney (2015). One interpretative issue with quantum mechanics is that the wave function used to describe physical systems is not defined on the ordinary three-dimensional space, but on a so-called configuration space from which the ordinary space is taken, one way or another, to emerge. Ney defends *wave function monism*, the view that reality is a universal wave function located in a physical configuration space, raising the question of how to interpret philosophically the emergence of space from the configuration space. In this context, Ney argues that what's at stake to ensure the coherence of our theory is not space, but the local observers and observables. Although our proposal belongs to the same family's as Ney approach, there are at less three important differences worth emphasising.

First, the context of quantum mechanics differs greatly from the context of quantum gravity by focusing on space instead of spacetime. Wave function monism is formulated in the context of non-relativistic quantum mechanics, where time is considered classical, and not brought into the picture. This has consequences for the problem of empirical coherence, as the issue is not only to situate observers and observations in space, but also in time, with enough structure to account for the empirical process of theory confirmation via well-connected sequences of observations.

Second, Ney, like Huggett and Wuthrich (2013), denies the need to analyse evidence in terms of local beables. They point out that our theories should tell us what the evidence is; and this may not include local beables in the light of our best physics. If our best physical theories do not contain local beables, then we should not argue that evidence is constituted of local beables. We present a different picture: the existence of local beables can be preserved, in non-spatiotemporal contexts, at the cost of a slight tweak of the notion of local beable. This revision concerns the concept of locality: 'local' can be redefined as a broader notion than 'spatiotemporally local'. Indeed, the idea is that the concept of locality can be analysed functionally—or grounded —in non-spatiotemporal terms.

A third major difference between our proposal and Ney's is that her account denies that we should place pre-theoretical constraints on our theory of scientific confirmation. Our scientific theories describe to us how confirmation works, and this sometimes means that pre-theoretical notions involved in our naive theory of confirmation—such as space or the observer—have to be discarded. Our view instead allows a role for pre-theoretical constraints. In our view, we start with pre-theoretical constraints and move back and forth between our theory and our pre-theoretical notion of confirmation to bring the two into a reflexive equilibrium. So our scientific theories can change the way we conceptualise confirmation. But they cannot lead to a complete abandonment of all pre-theoretical constraints on the nature of confirmation. In our view, there must be such constraints, otherwise we would never be able to embark on the scientific enterprise. If we rely on theorising to tell us how confirmation works, and if we allow that in general, then we will never be able to theorise, because we will not be able to agree on a picture of confirmation before we do science.

This presents a straightforward approach to demonstrating the viability of a theory of quantum gravity without having to say anything about spacetime at all. Rather than focusing on spacetime we can, instead, focus on space and time and show how these aspects emerge from an underlying physics of quantum gravity. Granted, showing that our fundamental theories of quantum gravity support these notions is a non-trivial task. The point, however, is that we can abandon the internal and external questions about spacetime, and abandon entirely the question of whether spacetime exists and still secure the viability of our physical theories.

One might respond that the very reasons that drove us toward quietism about spacetime may drive us toward quietism about these other space and time as well. Take time, for instance. It is unclear what the 'correct' account of time might be. So too for space, one might argue. If not being able to settle on the correct account of spacetime is enough to abandon questions about what spacetime is, then surely the same should be true for space and time as well. But if we abandon the questions of whether space and time exist, we won't be able to demonstrate the viability of theories of quantum gravity in the manner described here.

It may well be that we can't settle on the correct account of space and time either. And perhaps this does license a similar quietist attitude towards them. But even if we can't determine what the correct account of space or time might be, we can still solve the problem of empirical coherence. We can do this by taking a functionalist approach to observables and observers. The idea is that being an observable—being the kind of thing that can be observed—is to play a certain functional role. Similarly, being an observer—being the kind of thing that can gather an observations—is to play a distinct functional role. Together, observer and observable enter into a relationship, characterised by the interplay between the two functional specifications.

Having specified the functional roles of observable and observer, we can then look into a theory of quantum gravity and see whether it features any entities that satisfy the relevant functional roles. In this way we avoid the question of whether the underlying theories have space, time or, indeed, spacetime in them, replacing those questions with questions about whether the functional demands of observation are met. Of course, it might turn out that the functional roles for observable and observer have aspects that some are inclined to call spatial, temporal or spatiotemporal. Nothing we say is supposed to constitute a blanket ban on appealing to features that go by those labels. The point is just that we don't need to settle any deep questions about the nature of space, time or spacetime in order to establish the viability of a theory. We just need to look for structure enough for the demands of observation to be met, where those demands are given by the functional characterisation of observer and observable.

An important question thus emerges: namely, what are the functional roles of observation and observable? Answering that question would take us too far afield. However, we will note that the answer is unlikely to come from science alone. That's because the two functional roles—of observer and observable—are roles that should, ideally, be specified independently of any particular scientific theory. For if the functional roles are specified in terms of a specific theory, then it will be unclear how to apply the notion of observation to that very theory in a non-circular fashion. This doesn't mean, of course, that science is irrelevant to the specification of the roles. Indeed, it is likely to be highly relevant: it is the preconditions for successful science that likely determine the functional roles for observable and observer. However, determining what those preconditions are involves a deep consideration of the foundations of science itself and, we suspect, that is a job for philosophers.

So far in this section we have argued that the problem of empirical coherence can be addressed in a manner that upholds quietism about spacetime. This, it will be recalled, is important, since empirical coherence is needed to establish the viability of a number of approaches to quantum gravity. One might argue, however, that empirical coherence is not the *only* dimension of viability to be taken into account.

Any theory of quantum gravity aims at accounting for the predictive success of our best physical theories at the moment. General relativity is especially important as it is our best theory of spacetime. It is likely that accounting for the predictive success of general relativity requires approximating general relativity in the manner described in §2. Is there not, then, some connection between the narrow conception of spacetime and the viability of quantum gravity? And if so, doesn't that demonstrate that the viability of a theory of quantum gravity can't be had without settling on a particular account of spacetime after all?

We don't see why that should be so. The approximation of general relativity generally involves finding a mathematical connection between a more fundamental theory of quantum gravity and general relativity. That mathematical connection can be found without settling either the internal or the external questions. That is, one need not take any view regarding what spacetime is in order for the approximation relation to be in good standing. So while it is true that approximating general relativity is a constraint on the viability of various approaches to quantum gravity, this provides no pressure at all to give up our quietist attitude toward the nature and existence of spacetime.

# 6 Conclusion

By way of concluding, we will briefly sketch a couple of advantages of the quietist approach to spacetime that we are recommending. First, it dissolves what has been called the ontological problem of spacetime (Le Bihan, 2021). The ontological problem consists in asking about the ontology behind spacetime emergence: is it a monist ontology, or a dualist one with the fundamental non-spatiotemporal entities on the one hand, and the non-fundamental spatiotemporal entities on the other hand, the latter being less fundamental than the former? The ontological problem is premised on the view that the non-fundamental ontology is spatiotemporal, a problematic fact to be explained further. If we set aside spacetime emergence, however, and approach quantum gravity without it, then there is no ontological problem to answer. The central ontological question worth asking is whether a theory contains enough in its ontology to support structures that play the functional roles of observable and observer.

Second, our approach dissolves the explanatory gap or hard problem of spacetime that has been introduced in analogy with the hard problem of consciousness (Le Bihan, 2021): there is something psychologically puzzling in the difference between spatiotemporal and non-spatiotemporal entities such that the notion of spacetime emergence from a non-spatiotemporal reality triggers a form of cognitive dissonance. This dissonance is analogous to the dissonance experienced when trying to bridge the explanatory gap between body and mind, though may not have quite the same philosophical implications.

By doing away with spacetime emergence entirely, the cognitive dissonance fades away and, with it, any threat of an explanatory gap. That being said, we may be left with other potential explanatory gap issues that have to do with the features needed for observation. For instance, it may be that specific spatial and temporal features are needed for something to play the beable role. If those features are not in the fundamental ontology of a theory of quantum gravity, then some account of their emergence may be needed. Thus, the explanatory gap issue could be reframed as an issue about how to relate space and time to a non-spatial and non-temporal ontology.

Furthermore, our approach also finds support from the difficulty inherent to answering the internal and external questions. In the context of quantum gravity, at least, we've shown that there's no need to answer those questions, so we can avoid them. That's good: we don't need to argue about what spacetime is in any deep sense, since it doesn't matter. Nothing much seems to be lost by simply conceding that the term 'spacetime' has escaped semantic control, and now picks out a hodgepodge of different things, which don't bear much, if anything, in common.

# Acknowledgements

We are grateful to the reviewer for very helpful comments. The work of Sam Baron was supported by the Australian Research Council through a Discovery Early Career Researcher Award (DE180100414). The work of Baptiste Le Bihan was supported by the Swiss National Science Foundation via his Ambizione project 'Composing the world out of nowhere'.

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