May 2019

Nominalization and Interpretation: a Critique of Global Nominalization Criteria

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NOMINALIZATION AND INTERPRETATION:

A CRITIQUE OF GLOBAL NOMINALIZATION CRITERIA

by

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A Thesis Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Master of Arts

in Philosophy

at

The University of Wisconsin-Milwaukee

May 2019

ABSTRACT

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The University of Wisconsin-Milwaukee, 2019
Under the Supervision of Professor Michael Liston

Nominalization is the process which removes abstract objects from our scientific theories. But what makes a proposed nominalization a good or successful one? In the paper "Is It Possible to Nominalize Quantum Mechanics," Otávio Bueno develops criteria for any successful nominalization. In the present work, I discuss one of these criteria that I call the "interpretation criterion." It claims that a nominalization of a scientific theory should be neutral with regards to the interpretations of that theory. I argue that the interpretation criterion is problematic, and that it should be replaced with an alternative criterion of nominalization. I first explicate the background for understanding Bueno's goal in establishing his criteria for nominalization programs and describe the criteria themselves. Then, I launch my critique against the interpretation criterion by arguing that it makes nominalization impossible, even when specified in its best form. Lastly, I offer my positive picture of the appropriate relationship between nominalization and interpretation. The positive picture is, roughly, that we should not seek global nominalization criteria as Bueno does, but instead should try to nominalize our scientific theories in a piecemeal fashion.

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ACKNOWLEDGEMENTS

There are many to thank for help on this thesis and for support through my time at UW-Milwaukee. I'd like to extend my deepest thanks to my advisor Michael Liston for many long talks, several last minute email exchanges, and incalculable advice throughout my Master's degree. I'd also like to thank Bob Schwartz, Blain Neufeld, Peter van Elswyk, and Joshua Spencer. They all, in various combinations, helped with aspects of the thesis, wrote letters of recommendation, served on my committee, and, generally, taught me a lot of great philosophy. Joshua, in particular, did all of these things and, moreover, inspires me to be a great teacher of philosophy. I also extend my thanks to audiences at the 2018 WMU Graduate Philosophy Conference and at the 2018 Minnesota Philosophical Society Conference for tips and suggestions. I'd like to also thank the members of my cohort. Each one of them gave me great substantial and writing advice both within and outside of the writing workshop. In particular, Steven Canet dedicated a lot of time to helping me work through my ideas; the amount of times we worked together on our whiteboard must be at least countably infinite. Savannah Marciezyk was an amazing line of support throughout the process, in every possible way. She read this thesis more than anyone else and I could not have done it without her. I'd like to dedicate this thesis to my parents: Linda and Jeff. They have both supported me to the utmost my entire life and I'm proud and lucky to have them as my parents.

I. Introduction

Nominalization is the process which removes abstract objects from our scientific theories. But what makes a proposed nominalization a good or successful one? In the paper "Is It Possible to Nominalize Quantum Mechanics," Otávio Bueno develops criteria for any successful nominalization. One of these criteria I will call the "interpretation criterion." It claims that a nominalization of a scientific theory should be neutral with regards to the interpretations of that theory. In this paper, I argue that the interpretation criterion is problematic, and that it should be replaced with an alternative criterion of nominalization.

In the following section, I explicate the background for understanding Bueno's goal in establishing his criteria for nominalization programs and describe the criteria themselves. In section three, I launch my critique against the interpretation criterion by arguing that it makes nominalization impossible, even when specified in its best form. In section four, I offer my positive picture of the appropriate relationship between nominalization and interpretation. The positive picture is, roughly, that we should not seek global nominalization criteria as Bueno does, but instead should try to nominalize our scientific theories in a piecemeal fashion.

II. Background

In this section, I will briefly describe abstract objects and why one may wish to rid them from one's ontology. Then, I will describe the dialectic that starts with the Quine-Putnam indispensability argument and ends with Bueno's nominalization criteria in an effort to show why Bueno introduced his criteria.

Abstract objects are traditionally characterized as acausal and aspatiotemporal entities. They occupy one side of the *abstracta*/*concreta* distinction, where concrete objects

are any objects that are causal and spatiotemporal. Some philosophers dispute the tenability of this distinction and others disagree with the traditional characterization of abstract objects as acausal and aspatiotemporal.[1] These debates will not be taken up in the present work. Some candidate abstract objects include possible worlds, propositions, musical works, and mathematical entities. The abstract objects focused on in this paper are mathematical entities, like numbers, sets, and vector spaces. Platonists accept abstract objects into their ontology, nominalists reject them.

Why would one want to reject them? There have been a few reasons put forward to reject mathematical objects. Firstly, mathematical objects seem to be epistemologically inaccessible, so we should not countenance them.[2] This epistemological argument against mathematical objects has been made in two forms, but the most developed form (Hartry Field's) proceeds in the following way:

1. Mathematicians are reliable, in the sense that for almost every mathematical sentence *S*, if mathematicians accept *S*, then *S* is true.
2. For a belief in mathematics to be justified, it must at least in principle be possible to explain the reliability described in Premise 1.
3. If mathematical platonism is true, then this reliability cannot be explained, even in principle.[3]

That is, given that mathematical objects are causally isolated from us, the reliability of mathematicians' mathematical beliefs is inexplicable. Given this inexplicability, our beliefs in mathematics are unjustified.[4] Since we want to preserve the justification of our beliefs in mathematics, this epistemological argument is taken as a strike against the platonist view.

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[1] For an example of someone who questions the distinction see Lewis (1986), pp. 81-90.
[2] See Benacerraf (1973) and Field (1989).
[3] Adapted from Section 3.1. of Linnebo (2018).
[4] This, of course, assumes a tight connection between the inexplicability of reliability and a lack of justification (premise 2 above). I do not necessarily endorse this premise, but I will include Linnebo's (2018) defense of it: "If the reliability of some belief formation procedure could not even

Secondly, since abstract objects are acausal "they are causally gratuitous in standard physical explanations."[5] That is, since abstract objects are acausal and scientific explanations should be causal, mathematical objects are gratuitous in scientific explanations. Thirdly, mathematical objects are arbitrary "since units, frames, etc., are entirely conventional and may vary from one representation to the other, so long as certain lawlike features remain invariant."[6] Given the arbitrariness of what mathematical objects we choose to employ in scientific explanation, mathematical objects seem to be doing little to no explanatory work and therefore do not need to be posited. These second and third problems are very closely related: because intrinsic, non-arbitrary, causal explanations are preferable, *ceteris paribus*, to extrinsic, arbitrary, non-causal ones, nominalist explanations are preferable to standard ones appealing to mathematical entities. Because of problems like these many philosophers have viewed abstract objects as worrisome entities to be rejected if possible. I will not discuss these arguments in any more detail; they are present merely to provide an understanding of why one may wish to be a nominalist. Now, I will present what many take to be the best reason to be a *platonist* in an effort to show the import of Bueno's nominalization criteria.

In his 1980 *Science without Numbers*, Hartry Field began the contemporary nominalist program in the philosophy of mathematics. His goal was to argue for nominalism by arguing against what he and many others took to be the strongest argument

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in principle be explained, then the procedure would seem to work purely by chance, thus undercutting any justification we have for the beliefs produced in this way."

[5] Liston (1993), pp. 454.. This is based on Field (1980), pp. 43-46 .

[6] Ibid. This is based on Field (1980), pp. 45-46.

to the contrary — the Quine-Putnam indispensability argument. The Quine-Putnam indispensability argument states:

1. Our best scientific theories employ mathematical objects indispensably.
2. We should believe in the existence of what our best scientific theories employ indispensably.
3. Therefore, we should believe that mathematical objects exist.[7]

Field argued for nominalism by rejecting premise 1. He attempted to show that mathematical objects are dispensable in science by providing a *nominalization* of science. To begin the process of nominalizing the whole of science, and to show that such a task is possible, he successfully nominalized one part of classical mechanics: Newtonian Gravitation Theory.[8]

It might be useful at this point, to offer a quick example of nominalization so that the reader may more fully understand what Field partially accomplished with regards to classical mechanics. Take a scientific theory that references the real numbers when describing the distances between physical objects. A nominalization will get rid of the real numbers in the distance-talk by employing (as Field does) Hilbert's synthetic (axiomatic, coordinate-free) geometry. Taking *point, betweeness,* and *congruence* as primitive relations, one can build a geometry that allows one to state, without real numbers, all the distance relations one could state using real numbers. Hence, once this sort of nominalization is

[7] See Quine (1948) and Putnam (1975).
[8] Specifically, Field nominalized Newtonian Gravitation Theory as presented in the Poisson Equation.

accomplished one can make a scientific theory that does the same scientific work as the former without the need to quantify over real numbers.[9]

Soon after the publication of *Science without Numbers*, however, David Malament objected to Field's project by claiming, among other things, that Field's nominalist strategy could not be extended to quantum mechanics (hereafter QM) because of the nature of QM and its fundamental mathematical framework — the Hilbert space. As Malament writes:

> Quantum mechanics is even a more recalcitrant example than Hamiltonian mechanics. Here I do not really see how Field can get started at all. I suppose one can think of a theory as determining a set of models — each a Hilbert space. But what form would the recovery (i.e., representation) theorem take? The only possibility that comes to mind is a theorem of the sort sought by Jauch, Piron, *et al*. They start with "propositions" (or "eventualities") and lattice-theoretic relations as primitive, and then seek to prove that the lattice of propositions is necessarily isomorphic to the lattice of subspaces of some Hilbert space. But of course no theorem of this sort would be of any use to Field. What could be worse than *propositions* (or *eventualities*).[10]

The Hilbert space is a phase space which provides a distinctive challenge to Field's program because the unit vectors represent the *possible* states (pure states) of a quantum mechanical system. Malament claimed that Field's nominalization strategy could not be extended to QM because Field would have to find some nominalistically acceptable entity to replace these possibility-related subspaces of the Hilbert space. But the only obvious things which could be used to accomplish that task are "propositions" or "eventualities," which are just as abstract, and thus just as problematic to the nominalist, as mathematical objects.

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[9] The success of a nominalization like this is contingent on a representation theorem being proved. A representation theorem is a theorem that states all of the abstract structures are isomorphic to the concrete structures being employed.

[10] Malament, (1982): pp. 533-534. Italics are Malament's.

In 1998, Mark Balaguer developed a partial nominalization of QM taking into account Malament's objection. He removed propositions and eventualities and claimed that "quantum probability statements are about physically real propensities of quantum systems."[11] He replaced abstract objects in QM with physically real properties — propensities of, and propensity-relations between, quantum systems. These propensities are nominalistically acceptable (unlike propositions and eventualities), Balaguer claimed, just like any other physically real property such as spin, charge, or mass.

This brings us to Bueno's 2003 paper, "Is It Possible To Nominalize Quantum Mechanics?" In it, Bueno claims that Balaguer's proposed nominalization of QM fails because it faces a dilemma given two criteria for nominalization introduced by Bueno. Here are those criteria:

> (1)A nominalization strategy should be neutral. That is, the nominalistic version of a theory T' should not settle issues left open by T. Otherwise, instead of providing a nominalization of T, we may end up developing a *rival theory* T'—if new empirical consequences are obtained from T'. Alternatively, if no new empirical consequences are obtained, but T' settles issues that T leaves open, T' ends up providing a *different interpretation* of T, instead of simply developing a *nominalistic version* of T (that is, a version of T that does not presuppose the existence of abstract entities). (2) A nominalization strategy should be *ontologically parsimonious*. That is, it should not presuppose nominalistically unacceptable items.[12]

Bueno claims that Balaguer's proposed nominalization faces a dilemma. It either presupposes entities which some interpretations of QM would deny or at least not presuppose, (specifically, Bueno has in mind: Bohmian mechanics, van Fraassen's modal interpretation, and hidden variables views), or it does not presuppose entities that these

[11] Balaguer, (1998): pp. 120.
[12] Bueno, (2003): pp. 1425. Italics are Bueno's.

interpretations would deny.[13] As it stands, Balaguer's nominalization *does presuppose* entities which these interpretations would reject, because each of them explains the probabilistic nature of QM in a way that differs from relying on physically real propensities being the *explanantia*. Since Balaguer's nominalization makes these illegitimate presuppositions and commitments with regards to these interpretations, it fails to "capture the underdetermination of interpretations typical of QM" and it will therefore be a new interpretation of QM, and not merely a nominalistic version of QM. That is, Balaguer's nominalization fails the interpretation criterion. Moreover, according to Bueno, in order for Balaguer's nominalization to be made neutral with regards to these interpretations, Balaguer would have to find some concrete counterpart other than physically real propensities to do the nominalizing work; and what could those be? Bueno's point is that Balaguer cannot make a nominalization that is interpretatively neutral with respect to all of these interpretations without invoking something like propositions or eventualities. Therefore, Balaguer's proposed nominalization is caught in a dilemma. This is Bueno's argument against Balaguer's nominalization, but let us return to the criteria that support the argument.[14]

Notice Bueno's first criterion comes in two parts. The first part claims that a nominalization, T', should not deliver empirical results that differ from the non-nominalized scientific theory, T, that is to be nominalized. This could mean that *T' should*

[13] The use of "presupposition" language will become clear in the following section. I'm focusing my exegesis of Bueno's interpretation criterion based on his employment of it on Bueno (2003), pp. 1433-1435.

[14] I accept the second criterion (the ontologically parsimonious one), so I will not go into further detail or offer a critique of it.

not offer a new empirical result that T was silent with respect to or it could mean that *T' should not offer an empirical result that contradicts T*.[15]

Either way, this part of the criterion is plausible. This part of the criterion simply amounts to Field's claim that the mathematical theory being nominalized must be a *conservative* extension of the nominalization. This means that any good nominalization *T'* of any standard platonistic theory *T* will be such that *E* is an empirical consequence of *T* iff the nominalistic counterpart of *E* is a consequence of *T'*.[16] When Field nominalized Newtonian Gravitation Theory, it would have been exceedingly problematic if his nominalization offered empirical results about gravity that were not already present in classical mechanics or that contradicted the empirical results of our extended experimentation with classical mechanics.

However, Bueno's first criterion also comes with a second part:

> [I]f no new empirical consequences are obtained, but T' settles issues that T leaves open, T' ends up providing a *different interpretation* of T, instead of simply developing a *nominalistic version* of T (that is, a version of T that does not presuppose the existence of abstract entities).[17]

This second part of this criterion says that the nominalization of a theory must be interpretively neutral with respect to the original theory, because if not, then the

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[15] What do I mean by claiming a nominalization can *yield* an empirical result? One might think that nominalizations are (plausibly) *a priori* or non-empirical endeavors and so a nominalization should not yield an empirical result. Nominalizations can yield empirical results in the following way: T' yields all and only the nominalistic counterparts of the empirical consequences of T. The point in the text is just that T' should neither yield a nominalistic version of an empirical result not originally present in the theory nor should T' yield a nominalistic version of an empirical result that contradicts T.

[16] Field describes the conservative property by saying that mathematics is conservative in that: "any inference from nominalistic premises to a nominalistic conclusion that can be made with the help of mathematics could be made (usually more long-windedly) without it." See Field (1980), pp. x-xi.

[17] Bueno, (2003): pp. 1425. Italics are Bueno's.

nominalization is a new interpretation of the scientific theory and not merely a nominalistic *version* of it. I will call this thesis the *interpretation criterion*. I think this criterion is problematic and why I think so will come to light in the following section.

III. The Interpretation Criterion Asks the Impossible

What does it mean to say that a nominalization of a scientific theory cannot settle issues that the theory leaves open? Specifically, what does it mean to say that a nominalization of QM cannot settle issues that QM leaves open? The interpretation criterion is too underspecified in Bueno's own work, so in this section, I will briefly identify some things Bueno cannot mean by the interpretation criterion before identifying the most charitable way the interpretation criterion can be read.[18] I will then argue that this most charitable specification of the criterion makes nominalization an impossible task, and therefore it should be replaced with an alternative criterion of nominalization.

If the interpretation criterion is too strong, it rules out nominalization, in the most obvious way, from the beginning. This is because a theory without abstract objects is interpretatively different from a theory with abstract objects. If this is what Bueno means by the interpretation criterion, then nominalization is ruled out from the start. This, of course, is not what Bueno means given that he wants to accept the possibility of merely *nominalistic versions* of theories.

If the interpretation criterion is too weak, then it allows Balaguer's proposed nominalization to succeed. But, of course, Bueno developed the criterion to argue against Balaguer's nominalization. This is obviously not what Bueno has in mind with the

[18] I've already hinted at what I take to be the best reading of Bueno's criterion in my description of his dilemma against Balaguer in the previous section. It says a neutral interpretation will not presuppose any entities other interpretations may deny (or deny the fundamentality of).

interpretation criterion. I include mention of a weak version of the interpretation criterion here just to show that the most charitable specification of Bueno's interpretation criterion must be, in terms of logical strength, between the too strong and too weak versions I have just offered. Let me now offer what I take to be the most charitable reading of Bueno's interpretation criterion.[19]

I will call the most charitable specification of the interpretation criterion the "core theory" specification. The core theory specification says that a good nominalization of QM is one that nominalizes the "core theory" of QM, while remaining silent with respect to all of the issues that the interpretations of QM disagree about. There are two clarificatory points which need to be addressed before moving on. One, which interpretations are included in this specification of the criterion? I think Bueno's criterion would have to include all of the currently defensible interpretations of QM (Bohmian mechanics, GRW, Everettian mechanics, van Fraassen's modal interpretation, etc.) for the criterion to do the work it is intended to do against Balaguer. Two, what is this core theory? The core theory (hereafter Q) is the minimally interpreted shared core of QM. It has as its parts some postulates, and a minimal interpretation of those postulates that assigns them a physical world meaning.[20] Q

[19] There are also a few other uncharitable specifications of the interpretation criterion in the logical space that will not be discussed in the body of the work. For example, one possible specification of the criterion says a nominalization should be interpretation-free. But, this specification is also obviously faulty given the definitions of theory on either the syntactic or semantic views of theory structure: a *scientific* theory on either conception must include an interpretive element.

[20] The standard textbook statement of Q is that Q is a set of the following 4 statements:

1. Every physical system is associated with a Hilbert Space, every unit vector in the space corresponds to a possible pure state of the system, and every possible pure state, to some vector in the space.
2. Hermitian operators in the Hilbert space associated with a system represent physical quantities, and their eigenvalues represent the possible results of measurements of those quantities.

would have to, minimally, say something about the probabilistic structures of quantum events (since Q is partially represented by the platonistic Hilbert space). Let Qi_n represent the currently defensible interpretations of QM (for example, Qi_1 could represent the Bohmian interpretation, Qi_2 could represent the modal interpretation, etc.). Each Qi_n extends Q in different ways for each interpretation; that is, each Qi_n embeds Q in a richer world with more mathematical formalism and physical interpretation of that formalism than what is present in Q. Suppose now that we can nominalize Q as a theory, QN, such that for any nominalistic sentence ϕ: if $(QN+M) \vdash \phi$ then $QN \vdash \phi$ (where M is the original mathematics present in Q). Then, Bueno's criterion (under this best specification I am offering) claims that QN must be compatible with every Qi_n (except for not having the mathematical consequences of the latter) in the following sense: QN must not presuppose any entities that any Qi_n would deny. And since Q must say something about the event-probabilities of quantum systems, QN must tell a story about event-probabilities of quantum systems in a way that does not presuppose any entities any Qi_n may deny.[21]

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3. The Hilbert space associated with a complex system is the tensor product of those associated with the simple systems (in the standard, non-relativistic, theory: the individual particles of which it is composed).
4. Given the state of a system at t and the forces and constraints to which it is subject, there is an equation, Schrödinger's equation, that (deterministically) gives the state at any other time $U|\nu t\rangle \rightarrow |\nu t'\rangle$.

Some interpretations share a 5th statement:

5. Collapse postulate: Carrying out a "measurement" of an observable B on a system in a state $|A\rangle$ has the effect of collapsing the system into a B-eigenstate corresponding to the eigenvalue observed.

I take this formulation of the statements almost exactly from Ismael's "Quantum Mechanics," (2015).

Not every currently defensible interpretation of QM will agree with all of these statements as explicitly stated, but most do, and all of them agree with most of it.

[21] What do I mean by "event-probabilities"? I mean probabilities that a quantum system will be in a particular state when measured. (The soon-to-be-made point in the main text is that some QM interpretations claim that these are fundamental features of the world and other interpretations

Balaguer's nominalization fails, according to Bueno, because the things it introduces to nominalize Q (that is, to solve Malament's worry), *propensities*, are posits that several other QM interpretations would deny the existence of. That is, Balaguer's QN introduces a thing that some Qi_n's do not presuppose. More precisely, according to Bueno, Balaguer's nominalization fails because it introduces propensities as the things which nominalistically underwrite the probabilistic structure of QM, but Bohmian mechanics, the modal interpretation, and hidden variables views each deal with the probabilistic structure of QM in ways that deny that propensities exist or do the fundamental work Balaguer claims they do. That is, these interpretations do not presuppose the existence of real propensities in nature. So, putting the pieces together, the best reading of Bueno's criterion claims that a good nominalization of QM is a nominalization which nominalizes the core of QM by explaining the event-probabilities in QM (recovering the Hilbert space in nominalistically acceptable terms) without introducing things that other interpretations would deny the existence of. A good QN is one that nominalizes Q without introducing entities any Qi_n would not presuppose.

Now I'd like to introduce a dilemma for the core theory specification. Either there is a core theory or there is not. If there is a core theory, then it would, as mentioned above, minimally, need to capture the event-probabilities of quantum states. So, QN must give a story about the event-probabilities of quantum events in Q without presupposing entities that any Qi_n would question.

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will explain them away by saying, for one example, that event-probabilities are merely epistemic as opposed to being physically real).

The problem, however, is this: each of the Qi_n's either accept that there are fundamental event-probabilities in the world or they do not accept this. The interpretations that accept fundamental event-probabilities in the world presuppose some entities that the opposing interpretations would deny — namely, fundamental event-probabilities. The interpretations that deny the existence of fundamental event-probabilities deny the fundamental existence of event-probabilities by introducing further entities. For example, take Bohmian mechanics. Bohmian mechanics claims that the probabilistic nature of QM is merely epistemic. The reality is there is a guiding field or pilot wave which explains away the probabilistic nature of quantum events; there are no fundamental probabilities in nature. For another example, take Everettian mechanics. Everettian mechanics posits that we live in a multiverse and it is the multitude of universes that ground the probabilistic events in QM. It is not the case, for Everett or Bohm (or perhaps, for other QM interpretations) that event-probabilities are a fundamental feature of the world. At most, event-probabilities are features of the world on these interpretations only because they "fall out", or are results of the more fundamental wave function.

Therefore, Bueno's interpretation criterion is asking for something that cannot be achieved (at least with regards to QM). It is asking, on this best specification, for a nominalization of a theory that gives a story about QM event-probabilities consistent with every interpretation. However, this nominalization would either have to accept or deny that fundamental event-probabilities exist (because it must give some story about event-probabilities). To accept fundamental event-probabilities would be a failure of neutrality with respect to some interpretations (Bohm's and Everett's, for example). On the other hand, denying fundamental event-probabilities would require introducing controversial

entities (as when Bohmian mechanics introduces a pilot wave to explain away the seeming fundamentality of event-probabilities). Any seemingly successful nominalization will explain event-probabilities in a nominalistically acceptable fashion, but recall: any nominalization which introduces a thing into the world that other interpretations do not presuppose makes that seemingly successful nominalization fail. Some interpretations deny that nature is fundamentally probabilistic by presupposing further entities and others accept that nature has fundamental event-probabilities, and therefore, nominalization is an impossible task on this specification of the interpretation criterion.

Eddy Chen makes a similar point when criticizing Balaguer specifically. He claims that "realist" interpretations (like Bohmian mechanics, GRW spontaneous collapse theories, and Everettian mechanics that "involve the quantum states as represented by a wave function, and not a function from events to probabilities")[22] cannot endorse the existence of event-probabilities as fundamental. Chen's nominalization, since it crucially relies on wave-function realism itself, would also fail Bueno's interpretation criterion as Chen's nominalization presupposes the existence of a real wave-function in the world (something that interpretations like van Fraassen's modal interpretation would deny).[23]

Continuing the dilemma, suppose instead that there is no core Q. There are reasons to think this. Firstly, different interpretations differ in their formal features. For example, Bohmian mechanics contains an added formalism for the pilot wave and GRW adds a distinctly changed Schrödinger equation. And an addition of formalism is not merely a

[22] Chen (forthcoming).
[23] However Chen's nominalization is an example of a good nominalization effort on my own positive view offered in the next section, as he simply endeavors to nominalize the class of wave-functional realist interpretations and not the whole of QM.

difference in interpretation; it is a difference in theory. This is because on either of the dominant views of the structure of scientific theories, the syntactic or semantic views, a substantive difference in formalism would result in a different set of sentences that constitute the theory on the syntactic view or that characterize the models that constitute the theory on the semantic view. You cannot have an addition of formalism without a difference of theory on either of these major views of scientific theory structure.

Secondly, the different interpretations have different pictures of the concrete world and seem more akin to different (rival) theories than to different interpretations of one theory that represents part of a single world. For examples, Bohmian mechanics adds a concrete pilot wave to the world, and Everettian mechanics adds a concrete multiverse. If these interpretations have such a different picture of the concrete, physical world, why think they are mere interpretations of one theory, and not theories in their own right? As Myrvold writes:

> Two of the major approaches ["interpretations"], hidden-variables ["interpretations"] and collapse ["interpretations], involve formulation of physical theories distinct from standard quantum mechanics; this renders the terminology of "interpretation" even more *inappropriate*.[24]

For these two reasons, we should not even expect a common core theory of QM.[25]

If there is no Q, then, at best, *classes* of QM have a common core. The most Bueno can say with his criterion, then, is that a nominalization works (or does not work) for a particular class of interpretations. If there is no core theory, then no global, general criterion for the nominalization of QM, like Bueno's, is available. Just because a given

[24] Myrvold (2016), sec. 1.
[25] Tim Maudlin agrees. He claims there is no quantum theory, instead only a "quantum recipe" throughout his (2019) book.

nominalization does not work for a particular class of QM interpretations, nothing follows for the nominalizations of another class.

To summarize this section: Bueno's interpretation criterion is underspecified in his own work. But, the most charitable specification of the criterion in logical space says that a nominalization of QM is good if it nominalizes core QM, and is silent with respect to the issues that the different interpretations disagree about. However, there are reasons to doubt the existence of this core theory, and if a core theory does not exist, then the interpretation criterion makes nominalization impossible. But, even if there is a core theory of QM, then a nominalization of the core theory would have to, minimally, tell a story about the event-probabilities in QM. However, that story would either invole an acceptance of fundamental event-probabilities or a rejection of them. If it involves an acceptance of them, then the proposed nominalization fails to be neutral with regards to interpretations like Bohmian mechanics and Everettian mechanics. If the nominalization rejects fundamental event-probabilities, then it should do so by invoking some further entities, in which case it then fails the interpretation criterion with regards to other interpretations that do not presuppose the entities invoked to explain away event-probabilities. Therefore, the best specification of Bueno's interpretation criterion asks the nominalist to accomplish an impossible task. Perhaps this would not prove to be a strike against Bueno's interpretation criterion if Bueno was a platonist, but Bueno himself is a nominalist who wants to engage meaningfully with proposed nominalizations.[26]

[26] I take it Bueno does not want to say Balaguer's nominalization fails because nominalization is impossible. Rather, Bueno seems to think that Balaguer's nominalization is simply not a successful *instance* of nominalization.

We can, however, nominalize classes of interpretations. In fact, Balaguer's proposed nominalization is proof. So, instead of employing a global criterion as Bueno does, I think we should seek a much more piecemeal approach to nominalization. But what sort of view should we replace Bueno's with that would govern piecemeal nominalization? In the next section, I offer a positive view on the relationship between interpretation and nominalization.

IV. The Positive Picture

I think Bueno has been looking at the relation between nominalization and interpretation in the wrong way. Instead of viewing a nominalization that is interpretatively neutral as the valuable sort of nominalization, I think that if nominalization is of any value, then it applies to all scientific theories and interpretations in the following sense: if we consider any scientific theory T (or interpretation I), and its nominalistic counterpart, NT (NI), provided it has one, then NT (NI) is, *ceteris paribus,* preferable to T (I).[27] This is because NT (NI) does the same scientific work as T (I) and has the further theoretical value of ontological simplicity.

Of course, most nominalized theories are much more ontologically simple than their abstract counterparts because they drop abstract entities. But this gain in ontological parsimony is procured at the cost of a less parsimonious ideology. For example, in our example of nominalizing distance relations, the nominalist must posit a few primitive

[27] Why *ceteris paribus*? If two interpretations or theories, one platonistic and one nominalistic, are equal with respect to all of the theoretical values except ontological simplicity, then the simpler one should prevail. If they aren't equal with respect to all other theoretical values (except for ideological parsimony, which I discuss in the body), then ontological simplicity alone will likely not give us a clear theory choice. The theoretical values I'm referring to here are Quine's (1955): simplicity, familiarity, scope, fecundity, conformity to experience, and conservatism.

distance relations to capture all the relations that were captured by use of the real numbers (in addition to positing some concrete counterparts to the real numbers, in Field's case: spacetime points). This picture of the value of nominalization that I am offering, admittedly, depends on weighing ontological parsimony as more important than ideological parsimony. However, I'm not sure how controversial this assumption is within this debate. The Field-style nominalist already apparently shares this assumption, given how nominalizations, like our distance-nominalization example, are carried out. And philosophers already unfriendly to robust ideology over robust ontology will simply disagree with my conditional above — that nominalization is of any value. My picture just is that *if* nominalization is of any value it applies to interpretations and theories in the way detailed here.

For any theory (like QM) that has multiple conflicting interpretations, one would just have to rank conflicting not-yet-nominalized interpretations in order of plausibility/defensibility, then try to nominalize each; if the top ranked one has a nominalistic counterpart, then, *ceteris paribus*, that would be the best theory (or interpretation) choice. If not, then matters are more complicated because ontological simplicity might not trump the other (non-simplicity-related) theoretical values.

For clarity's sake, let me examine my proposed picture of what makes a good nominalization of a theory in light of some examples. Let us say we find out that the modal interpretation (Im) of QM is our best interpretation and the Everettian interpretation (Ie) is the second best. Instead of seeking a nominalization consistent with both interpretations of QM (as it seems Bueno wants us to do, and Balaguer seems to attempt), we should seek nominalizations of both interpretations so that we have a NIm and NIe. NIm is preferable to

the original, platonistic Im and NIe is preferable to Ie for reasons of ontological simplicity. Of the two, NIm is the best interpretation of QM we have *full stop*, because Im was the best not-yet-nominalized interpretation and it is also now nominalistic. Instead of thinking a good nominalization is one that is consistent or neutral with respect to *all* the interpretations of a theory, a good nominalization of a theory is the nominalistic variant of the most successful member of the stock of not-yet-nominalized interpretations.

To summarize these points: Bueno maintains, on the best specification of his criterion, that a successful nominalization is one that nominalizes the core of a theory without introducing anything an interpretation of that core would reject or question. However, given the dilemma developed in the previous section, his criterion makes nominalization impossible. This shows his criterion is unemployable in any meaningful way against a proposed nominalization, and it hints at the fact that such a criterion might have been viewing the relationship between nominalization and interpretation in an unfruitful way from the beginning. I submit we should, instead, view nominalistic counterparts of each interpretation of a theory as competing against their platonistic match. We should rank the plausibility of each not-yet-nominalized interpretation of the theory, see if they have a nominalistic variant, and if there is a highest ranked interpretation that also has a nominalistic variant, then we should accept that interpretation because it is the most successful interpretation simpliciter and it also has the advantages of ontological simplicity. If our ranking of not-yet-nominalized interpretations is not so clear, then our theory choice becomes messier, as we may not want to accept the nominalistic counterpart of the fourth most plausible interpretation of QM just because it is

nominalistic. That is, instead of trying to nominalize our scientific theories by nominalizing all of a theory's interpretations at once, we should instead seek piecemeal nominalization.

V. Conclusion

Bueno's interpretation criterion claims that a nominalization of a scientific theory should be interpretatively neutral with respect to the scientific theory that is being nominalized. However, I think this criterion faces a crucial problem.

My critique of the criterion asks for the proper specification of it with regards to QM. The most charitable specification of the criterion asks the nominalist to create a nominalization that is just of the core theory and does not introduce any entities in nominalizing the core that any interpretation would not presuppose. This best specification of the interpretation criterion makes nominalization impossible whether there is a core theory or not. This is problematic for Bueno's criterion, because for it to do any meaningful work against proposed nominalizations, it should not rule out the possibility of nominalization from the start. If nominalization is impossible on the best reading of Bueno's criterion, then this undermines Bueno's interpretation criterion.

After challenging Bueno's criterion, I submit that our strategy for nominalizing needs to be rethought. Bueno thinks we should have a simple set of criteria, *global in scope*, that reject or deny whole sets of nominalizations. While I think Balaguer's proposed nominalization succeeds to a degree because it works for some interpretations of QM, Balaguer *also* seems to want to present a nominalization that is consistent with *every*, or almost every, QM interpretation.[28] Both dissenters about the possibility of nominalizing QM

[28] Balaguer, (1998), pp. 120.

(like Malament, Bueno, Dummett and Putnam)[29] and assenters (Balaguer) all seem to be pushing for an overextension; they all think that a nominalization should be consistent or neutral among *all*, or almost all, of the viable interpretations. Instead, I think we should look at the process of nominalization by seeking *piecemeal* nominalizations of our theories. Hartry Field, to his credit, did conceive of nominalization as a piecemeal project, and I think we should return to his modest and positive outlook on the nominalization of science.[30]

This new positive picture I have offered on what counts as a good nominalization of a theory allows us to proceed with the nominalization of different interpretations of QM, while we wait for physicists and philosophers of physics to arbitrate among the best interpretations. When they have chosen a favorite, the nominalists will be there to give them the best nominalization of QM.

[29] Dummett, (1991). And Putnam (2012), especially pg,194-195.
[30] Steiner (2007) explicitly calls Field's approach a "piecemeal approach". Also, Dummett (1991) rejected Field's program because of its piecemeal nature.

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