Analytic Metaphysics versus Naturalized Metaphysics:

The Relevance of Applied Ontology

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Abstract: *The relevance of analytic metaphysics has come under criticism: Ladyman & Ross, for instance, have suggested do discontinue the field. French & McKenzie have argued in defense of analytic metaphysics that it develops tools that could turn out to be useful for philosophy of physics. In this article, we show first that this heuristic defense of metaphysics can be extended to the scientific field of applied ontology, which uses constructs from analytic metaphysics. Second, we elaborate on a parallel by French & McKenzie between mathematics and metaphysics to show that the whole field of analytic metaphysics, being useful not only for philosophy but also for science, should continue to exist as a largely autonomous field.*

Keywords: *analytic metaphysics, naturalized metaphysics, applied ontology, philosophy of physics, biomedical ontology*.

1. Introduction

According to Ladyman & Ross (2007) ("L&R" hereafter) analytic metaphysics should be discontinued because of its lack of emphasis on scientific knowledge that makes it a waste of intellectual resources. Although most analytic metaphysicians[1] would

[1] Here, we do not take stock on the nature of the relation between analytic metaphysics and naturalized metaphysics (e.g. the question of whether the latter is actually a part of the former according to some definitions of the fields), although we will argue at the end that analytic metaphysics should not be discontinued and can evolve largely independently from metaphysics of science.

presumably believe that their discipline has intrinsic value insofar as it describes the actual world or the field of possibilities, L&R deny this. They focus especially on the appeal of intuitions, and argue that intuitions are the "product of cultural learning" and that many philosophers "do not share as many intuitions with the folk as they usually suppose" (Ross, Ladyman & Spurret, 2007, 12). But they do not condemn only the kind of analytic metaphysics based on intuitions (cf. *ibid*. 17-27). The scope of their criticism is broader, and they seem to despise any form of metaphysics which is not firmly empirically grounded – as when they ask: "Metaphysicians seek to understand the general composition relation itself. But why suppose that there is any such thing?" (*ibid.*, 21). Asking when such a thing obtains or not, and whether it is restricted or universal, would then be a waste of time. In short, according to them "Mathematics and science have undoubtedly borne fruits of great value; a priori metaphysics has achieved nothing remotely comparable, if it has achieved anything at all" (*ibid*., 16). From this, they conclude that: "No scientist has any reason to be interested in most of the conversation that now goes on under the rubric of metaphysics" (*ibid.*, 26).

A popular answer to this charge is the *heuristic approach to metaphysics* offered by French & McKenzie (2015) ("F&M" hereafter). According to them, analytic metaphysics develops many methods and tools that already turned out to be useful for philosophy of physics. Independently of whether Ladyman & Ross (2007) are right that analytic metaphysics lacks any intrinsic value when it comes to the truth[2], analytic metaphysics thereby remains a fruitful enterprise[3]. Therefore, because of its *heuristic value* for philosophy of physics, analytic metaphysics should not be discontinued. For instance, philosophers of physics working on loop quantum gravity or string theory (e.g. Huggett & Wüthrich, 2013), trying to explain what it could mean that space and time, or

[2] One could argue that metaphysics has intrinsic value, but that this intrinsic value has nothing to do with truth – see for instance Benovsky (2016) who defends the claim that metaphysical views do have values grounded in their beauty. But we will not consider these forms of value not grounded in truth within the scope of this paper.

[3] Our only disagreement with Ladyman & Ross in this article is about their claim that analytic metaphysics should be discontinued. We are otherwise sympathetic to their claim that special sciences must be taken into account in order to address metaphysical questions. They raise in particular another interesting issue, that we do not address here, about the status of folk metaphysics and what they call "notional worlds".

relativistic spacetime, are not fundamentally real, will build on theories about emergence, fundamentality, or metaphysical views on space or time.

The heuristic approach strikes us as a good motivation to accept that we should not discontinue analytic metaphysics. In this article, we do not defend, or argue against, the intrinsic value of analytic metaphysics; we only discuss the extent of the value of metaphysics for other domains, and whether constraining research in metaphysics could maximize this heuristic value. In particular, we complement French's and McKenzie's argument by showing why the heuristic value of metaphysics depends not only on the way it is presently used, or could be used in the future by philosophers of contemporary physics[4], but also on the way it is or could be used in applied ontology. Therefore, our first goal – in section 2 – is to offer new examples of the utility of analytic metaphysics for other fields. Our second goal – in section 3 – is, taking the first conclusion into account, to elaborate on a parallel between the heuristic justification of analytic metaphysics and the instrumental justification of mathematics, in order to argue that analytic metaphysics could continue to exist as a largely autonomous field.

2. A Toolbox for Applied Ontology

2.1 Applied Ontology

In this section, we argue that we may extend the heuristic justification of analytic metaphysics beyond philosophy of physics[5]. We agree with French and McKenzie that ana-

[4] "Philosophy of contemporary physics" will denote here the set of philosophical investigations on our most fundamental empirically confirmed physical theories since the quantum and relativistic revolutions (general relativity, quantum field theory) and all the philosophical investigations on the research programs aiming at making at least a step towards a theory of quantum gravity (string theory, loop quantum gravity, non-commutative geometries, causal set theory, etc.).

[5] Special sciences played a crucial role in this debate since Ladyman & Ross (2007) includes a chapter devoted to special sciences (see Ross, Ladyman & Collier, chapter 4). The crux of its content is that special science ontologies always have, *in fine*, to be *consistent* with the ontology of physics. As they write (Ross, Ladyman & Collier, 2007, 190): "failure of an interpretation of special science generalizations to respect negative implications of physical theory is grounds for rejecting such generalizations". In this perspective, the role of metaphysics, according to them, is to offer a general unification of sciences, being granted that physics rules out some otherwise possible ontological interpretations of special sciences.

lytic metaphysics is an important toolbox for the philosophy of physics. But, as we shall see, analytic metaphysics has other applications in a field of information science named "applied ontology". The point is important as it shows that analytic metaphysics has many possible applications, and that the methodological constraints that some philosophers of physics may be eager to put on metaphysics are related to physics, and do not take into account other scientific practices. As we shall see, analytic metaphysics can be at the same time at odds with physics and extremely useful for applied ontology.

Applied ontologies are structured terminological frameworks that can be represented as computer files or more generally in a logical format. One of their aims is to enable semantic interoperability between data concerning the same domain: indeed, various information systems use different terminologies and vocabularies, which make their data often difficult to gather, share or re-use; ontologies aim at providing a unified, structured terminology that can serve as common language between those information systems. Applied ontologies are formal representations of the various categories of entities in a domain, and the relations that hold between them. For example, FMA (Foundational Model of Anatomy; cf. Rosse & Mejino, 2003) is an ontology of human anatomical entities and their relations; it contains a variety of terms among which *Organ*, *Mitral_valve* and *Pericardial_sac*. Those terms are organized along a taxonomic structure, with formal statements (commonly called "axioms" in the field) involving the *is_a* relation such as *Heart is_a Organ*, which means that every instance of heart is also an instance of organ. But the ontology also encompasses mereological relations such as *constitutional_part_of* or *attached_to*, that enable to formalize axioms such as *Mitral_valve constitutional_part_of Heart*. Moreover, the logical properties of these relations, such as transitivity or reflexivity of the relation *part_of*, are also specified.

Applied ontologies are nowadays developed and used in a large variety of domains such as education (Mitrovic & Devedzic 2004) or geography (Mark, Smith, Egenhofer & Hirtle, 2004). In particular, they are becoming more and more important in biomedical sciences, with a notable large initiative of building ontologies on common, rigorous metaphysical principles named the "OBO Foundry" (Smith & al., 2007). Such ontologies should enable the re-usability of biomedical information contained in journals, clinical trials and electronic health records by the clinicians and researchers of the domain. But they must be built on solid bases to enable interoperability, and philosophical ontology has an important role to play here. As a matter of fact, developing rigorous and exhaustive applied ontologies raises issues very similar to those that are classically raised by philosophical ontology, and it has become clear that the success of the former will depend on building upon the theories and methods of the latter. In many respects, building a coherent and solid *applied ontology of biomedicine* amounts to building a formalized, *philosophical ontology of biomedicine*.

We will now present two arguments with a focus on the OBO Foundry biomedical applied ontologies as a case study. First, we will argue that metaphysical principles that are not particularly associated with contemporary physics, but rather grounded in the work of analytic metaphysicians, can be helpful for building biomedical applied ontologies. Second, we will argue that it might be too difficult or even counter-productive to try to build an applied ontology of biomedicine on the basis of contemporary physics. As we will see, taken together, those arguments show that *analytic metaphysics* can have a high heuristic value for building an applied ontology, even if it was developed without taking into account the lessons of contemporary physics.

2.2 From analytic metaphysics to applied ontology

Applied ontologies are often based on metaphysical principles that are not inspired by contemporary physics. These principles are sometimes closer to common sense (and the naïve physics coming with it) or classical physics. This is especially obvious in the applied ontologies that explicitly claim to capture the ontological categories underlying human common sense and natural language, such as DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering; Gangemi & al., 2002), which is developed to ease interactions with human agents by “making already formed conceptualizations explicit” (Masolo & al. 2003).

Other applied ontologies do not rely as explicitly on human common sense but aim at providing an ontology compatible with some special sciences such as biomedicine, where the first aim is not to develop metaphysical principles inspired by contemporary physics. This is due to the fact that for their largest part, many special sciences such as biomedicine do not require the use of physical models more elaborate than naïve or classical physics (with a few possible exceptions such as quantum biology – cf. Lambert & al. 2013).

Consider the example of the Basic Formal Ontology (BFO; cf. Smith, Arp & Spear, 2015), which is used in particular in the context of the above-mentioned OBO Foundry project that aims at devising a set of interoperable biomedical ontologies. BFO introduces high-level categories[6] such as "occurrent" and "continuant". Occurrents are entities that persist through time by having temporal parts, such as the process of the life of a specific tree. Continuants are entities that persist through time by being wholly present at each time at which they exist. They are divided between independent continuants, namely entities whose existence does not depend on the existence of another entity (such as material objects, e.g. a leaf) and dependent continuants, namely entities whose existence depends on the existence of another entity (such as qualities – e.g. the green color of a leaf – or dispositions – e.g. the fragility of a twig). This distinction between occurrents and endurants can be traced back to William Johnson, the teacher of Bertrand Russell (Jansen, 2008), and has benefited in contemporary philosophy from Lewis' (1986) analysis of "endurance" and "perdurance".

BFO also rests on a distinction between universals and particulars – e.g. the universal of a tree versus this particular tree. Arguably, those distinctions are closer to the constructs that may be found in analytic metaphysics than to many forms of naturalized metaphysics; indeed, the broadly Aristotelian inspiration of such an ontology has been emphasized regularly (Jansen, 2008; Smith & Ceusters, 2010). Grenon (2003) speaks of Smith (1997) as a "neo-Aristotelian metaphysics of substances". Furthermore, definitions in the OBO Foundry are expected to take the "genus-species" form of so-called

6 In this text, we use "category" and "class of entities" as synonymous, with a broad understanding of the term "entities" that covers structures.

"Aristotelian definition", where an A is defined as a B that C's, where B is a parent class of A, and C is the difference characterizing the instances of B which are also instances of A (Smith & al., 2007) – on the model of Aristotle definition of "human" as an animal that is rational. Note however that the structured taxonomies developed in the OBO Foundry far exceed in terms of sophistication and complexity what Aristotle could have produced – as they capitalize on thousands of years of biomedical sciences.

Note that other ontologies – such as the ones developed in the DOLCE galaxy – do not endorse explicitly the same Aristotelian inspiration, but acknowledge their debt to philosophers such as Strawson, Searle, Simons, Varzi and Casati (Gangemi et al., 2002) or Quine, Goodman, Sider and Kit Fine (Bottazzi, Ferrario & Masolo, 2012) – many of which are also cited in the BFO-inspired literature. Finally, relations that are classically studied in analytic metaphysics have attracted considerable attention from the applied ontology community – such as mereology, sometimes combined with topology (Masolo & Vieu, 1999; Smith & Mark, 1998).

Such ontologies are then used for various scientific projects of data structuring and exchange. For example, the ontology CDIM (Clinical Data Integration Model) (Ethier & al., 2015), which is based on BFO and other OBO Foundry ontologies, has been used in the context of the TRANSFoRm project (Ethier et al., 2017), a proof of concept of a learning health system used to exchange data from five different clinical and genomical databases across four different countries, to support retrospective data analysis, prospective recruitment of patients for clinical data trials, and decision aid. This ontology avoided classical mistakes in classification by being based on BFO, which relies on sophisticated theories concerning e.g. persistence across time, inherence of properties and the ontological nature of information. Such uses also exist in other domains – for example, mereotopological theories have been used to support geographical information systems.

Interestingly for our purpose, the BFO ontology does not aim (yet) at addressing metaphysical issues raised by our most fundamental theories in contemporary physics.

According to quantum field theory, the basic units seem to be excitations of fields, and several problems appear for an ontology of particles in this context. For instance, the number of field excitations seems not to be constant through time and, therefore, if we want to identify particles with excitations of fields, we must accept that the number of particles within a physical system is not constant through time[7]. It shows that it is difficult to view particles as continuants that would endure across time for long periods (for a more general discussion of the issues raised by the category of object/particle in physics, see French 2014). However, an ontology of material objects persisting for a long time is consistent with the claim that these objects are composed of an always shifting number of particles. This shows that it could make sense in the macroscopic domain to conceive of material objects and their properties as enduring across time, as proposed by BFO.

Leaving QFT aside, BFO allows objects to have both well-defined positions and velocities[8] at a single time, which is at odds with quantum mechanics. However, the absence of mutual constraints between positions and velocities is an excellent approximation in the macroscopic realm. Furthermore, BFO endorses a "container view" of space, which holds that "spatial regions are entities in their own right" (Grenon & Smith, 2004) – a view related to the "substantivalist" view (cf. for instance Le Poidevin 2004, Benovsky 2011 in the metaphysical literature and for instance Earman & Norton 1987, Pooley 2013 in the philosophy of general relativity literature). According to this container view, endurants "can be located at or in them" (Grenon & Smith, 2004). BFO considers that a reference frame is implicitly defined out of the formal apparatus of the ontology (typically, the reference frame of the Earth), and that spatial and temporal regions are defined relatively to this reference frame (Arp, Smith & Spear, 2015). BFO's apparatus that includes such spatial and temporal regions (on top of spatiotemporal

[7] The compatibility of an ontology of particles with QFT is still debated – cf. for instance Halvorson and Clifton (2002) and Baker (2009). Also, Le Bihan (2015) argued that if we accept the reality of dispositions, then a description in terms of particles seem to be redundant with a description in terms of dispositions. In this section, we do not take stance on the reality of particles.

[8] In the sense that the process to which an object participates can have a well-defined instant velocity process profile (Smith, 2012). Note however that BFO does not *require* positions and velocities to be well-defined – so quantum mechanical constraints could be integrated in the future.

regions, which are more in line with general relativity) has proven to be highly efficient for formalizing special sciences like biomedicine.

Note also that the classical debate between substantivalism (the view that spacetime is a substance that can exist independently of its material content) and relationism (the view that spacetime is the name of the collection of material relations obtaining between objects or events) has taken a new direction with general relativity. Whatever the best ontological interpretation of general relativity and of any forthcoming theory of quantum gravity turns out to be, it will likely need to account for three kinds of entities: spacetime points, the metric field and matter fields[9]. However, such considerations are not useful for dealing with some special sciences such as biomedicine, and therefore are currently not yet integrated in BFO's ontological framework.

It is worthy of attention that applied ontologists engaged in the BFO project take those inputs from physics seriously, and BFO is engaged in a continuous process of modification to account for a larger portion of contemporary science. Thus, although BFO's ontological framework is based on principles drawn from analytic metaphysics, it aims at integrating progressively inputs from advanced science. But our point here is the following. Although some current features of BFO's formal framework (classical time and space, construal of material objects as independent continuants) may be classified as belonging to analytic metaphysics and are not yet fully aligned with contemporary physics, they are adequate for most of biomedical science – and, arguably, several other special sciences. Therefore, metaphysical principles found in analytic metaphysics have proven to have a high heuristic value not only for philosophy of physics but also for

[9] Any solution to Einstein's equations of general relativity is a triple $\langle M, g, T\rangle$, *M* being a manifold of points with coordinates and some weak topological structure, *g* being the metric field (which carries the information about the metric, i.e. the spatial, temporal and spatio-temporal relations between spacetime points, and the local curvature of spacetime) and *T* the stress-energy tensor that relates in particular the metric field *g* to the matter field Φ (the distribution of matter, from which we may derivate the gravitational field). In this framework, it is not clear whether spacetime should be identified with the *manifold*, with the *metric field*, or with the conjunction of the *manifold and the metric field*. In fact, there are two distinct debates, one about the relationship between the manifold *M* and the metric field *g* or, moving from the mathematical level of description to the physical level, between spacetime points and the physical metric field described by *g* (cf. for instance Esfeld & Lam 2006), the other one about the relationship between the manifold *M* and the metric field *g* on the one hand, and the matter field Φ on the other hand (see Pooley, 2016).

applied ontologies, even though these principles were developed to describe the natural world without engaging with contemporary physics.

Finally, note that some metaphysical theories have been used in both philosophy of physics and applied ontology. Consider for example the metaphysical theory of disposition, on which there has been a long string of investigations in analytic metaphysics, including milestones such as the influential work of Mumford (2003). Dispositions have been invoked for interpreting quantum mechanics (see e.g. Dorato & Esfeld, 2010). They also have been adapted in applied ontology to the framework of BFO by Röhl & Jansen (2011), who endorse Mumford's[10] realism about dispositions and retain his distinction between a disposition and its categorical base – a framework that has been refined by an analysis of the mereological structure of dispositions (Barton, Jansen & Ethier, 2018). This theory was then used to formalize various kinds of entities, such as diseases (Scheuermann, Ceusters & Smith, 2009), functions (Spear, Ceusters & Smith, 2016) or probabilities in medicine (Barton, Ethier, Duvauferrier & Burgun, 2017). Thus, a theory that was developed out of the field of naturalized metaphysics later found its way in both philosophy of physics and biomedical applied ontology.

2.3 Applied Ontology Sans Contemporary Physics

We now argue that views found in analytic metaphysics may have a higher heuristic value for biomedical applied ontology than views that would be founded on metaphysical principles related to contemporary physics, for two reasons.

First, an ontology built upon a non-physicalist methodology might facilitate computations. Automatic reasoners such as Hermit (Shearer, Motik, & Horrocks, 2008) or Pellet (Sirin, Parsia, Grau, Kalyanpur & Katz, 2007) are used to test the coherence of an ontology and its logical consequences, but the computation times quickly become too

[10] Note however that contrarily to Mumford who sees a disposition and its categorical base as identical at the token-level, Röhl & Jansen would see them as different entities that belong to two different categories, namely (set of) qualities vs. realizable entities.

long for any practical purpose if the ontology is too convoluted; using somewhat simpler metaphysical principles from analytic metaphysics (rather than a description based on contemporary physics) might be a way to ensure that the logical consequences remain computable in a reasonable time for practical purposes. Additionally, these principles enable human users to browse and use the ontology more easily than if it was based on e.g. quantum mechanical or relativistic principles. It is surely easier to use a description in terms of independent entities localized in spatial regions, bearers of properties, and that participate in processes spanning temporal regions, than a description in terms of excitation of a quantum field in a set of spacetime points accompanied by a metric field and a matter field – or any other descriptions more in line with our current knowledge in quantum gravity. Analytic metaphysics can provide the tools to articulate a description of the former kind, and has been largely used in this respect, as reminded above.

Second, we note that the task of reducing special sciences such as biology or even classical physics on the basis of contemporary physics is not fully articulated, and highly tentative since there are several physical views explaining different aspects of the world and taken to be fundamental, in the sense that we do not have a unique most fundamental description of the world; actually, Ross, Ladyman & Collier (2007) – among other philosophers of science – even think that there is no basis for supposing that such a reduction is possible. For instance, quantum field theory and general relativity are our most fundamental theories in this sense, and there is no reason to take one as being more fundamental than the other. The goal of finding one unified fundamental theory of physics might still be far away, and we cannot put in standby all the rest of science, waiting for this hypothetical next step in the history of theoretical physics to happen. It would thus be illusionary to pretend basing an ontology of biomedicine on *the* ontology of contemporary physics, as no such unique ontology has been found yet. As long as there is no reduction all the way down of all special science to fundamental physics, we must build applied ontologies of special sciences that stand independently of ontologies of fundamental physics, if we want to use them for practical purposes. Here again, analytic metaphysics can (and does) provide some tools for completing this goal, even if they were developed independently of considerations of contemporary physics.

Therefore, the heuristic justification of analytic metaphysics advocated by F&M does not hold only in reference to philosophy of physics: applied ontology offers a relevant use of analytic metaphysics not modeled on contemporary physics[11].

3. Sealing the Fate of Analytic Metaphysics

In this section, we review F&M's heuristic approach to metaphysics to alleviate some tension in their account. In sub-section 3.1, we expose their heuristic justification and their somewhat ambivalent attitude towards it, and extend it by taking into account the results of section 2. In sub-section 3.2, we propose an amendment to their distinction between "type I" and "type II" metaphysics. In sub-section 3.3, we examine what kind of value the heuristic approach might provide to analytic metaphysics. In sub-section 3.4, elaborating on an analogy provided by F&M between analytic metaphysics and mathematics, we argue that one does not need to be more ambivalent about the heuristic justification of analytic metaphysics than about the instrumental justification of mathematics, and that F&M's discomfort with the heuristic justification of metaphysics may thereby be eased to some extent.

3.1 French & McKenzie's heuristic justification

French & McKenzie's heuristic justification of analytic metaphysics runs as follows. First, some metaphysical tools have been used in philosophy of physics, such as Parfit's theory of personal identity in the Everett interpretation of quantum mechanics (Wallace, 2006) – although they have not been developed with this target discipline in mind. Second, the development of physics cannot be predicted: therefore, any metaphysical work might eventually be applicable to philosophy of physics in the future.

Similarly, as we argued, many theories that are now used in applied ontology were not developed with this objective in mind – consider e.g. endurantist and perdurantist theories

[11] We are thereby complementing French & McKenzie's work, who seem to be sympathetic to the idea of justifying the toolbox approach with applied ontology (private correspondence).

of trans-temporal identity (used in Grenon & Smith, 2004). Thus, metaphysical tools can be helpful not only for philosophy (namely philosophy of physics), but also for science (namely applied ontology; for other examples, see Bryant, 2017). By a direct adaptation of F&M's reasoning, since we do not know in which direction applied ontology will unfold in the future and what conceptual tools it will need, metaphysical works that presently find no application, or that may appear irrelevant to it, might eventually find such an application in applied ontology in the future. This is especially obvious for the kind of applied ontology that is the closest to empirical sciences: since the progress of science cannot be predicted, the development of applied ontology that aims at fostering data exchange in those sciences may not be fully anticipated. Therefore, any metaphysical work might eventually be applicable to it in the future.

F&M (49) express some ambivalence towards their conclusion though, emphasizing "how precarious [their] heuristic justification of metaphysics is", as it is conditionalized on its use in other disciplines: this support "will depend on the extent to which utilizing extant packages instead of making everything to order is not a grossly inefficient way to go about things". They also mention the possible objection that the heuristic justification of analytic metaphysical practice might make it similar to "monkeys at typewriters", in which only a vanishingly small part of the work in metaphysics might turn out to be useful. Right after this statement, though, they point out that "this is the case, at least to some extent, for science as well". And they conclude that the prospects on the efficiency of such practice are "not something that [they] feel anyone is in much a position to place bets on"[12].

[12] Another statement reflecting the somewhat ambivalent attitude of F&M towards the heuristic justification of analytic metaphysical practice is that "analytic metaphysics should not take place in a disciplinary vacuum". *Prima facie*, this appears to suggest that a change in methodology is required, namely that metaphysical practice should be constrained by other disciplines. However, the rest of F&M's article suggests instead that this statement should be interpreted as concerning the *justification* of analytic metaphysics, which lies in other disciplines, such as philosophy of physics (as emphasized by F&M) or applied ontology (as emphasized by us). Indeed, they say elsewhere that "all that metaphysicians have to accept is the occasional raiding party from philosophers of science, keen (we hope) to see what they're up to and what they can use for their own purposes" – suggesting that no methodological change is required for metaphysicians. Finally, they explicitly state their ambivalence when they recognize that "the picture [they] have painted is a complicated one, and that there are considerations pulling from both sides", and call for "more nuanced positions on the basis of which more productive engagement between the two factions might be achieved".

We will now clarify several points to reach the conclusion that the *heuristic justification of analytic metaphysics* is qualitatively similar to the *instrumental justification of mathematics*, and that one does not need to be ambivalent about the former if one is not ambivalent about the latter. As a first step, we need to analyze F&M's distinction between two types of metaphysics.

3.2 The normative definition of type II metaphysics

F&M distinguish two kinds of analytic metaphysics that they call "type I" and "type II":

> Definition 1: "Type I metaphysics is the metaphysics that is scientifically disinterested and that, at least *prima facie*, doesn't need to be so interested, or even that might have to be so disinterested."

> Definition 2: "Type II metaphysics is the metaphysics that is scientifically disinterested but that should not be so."

Note that definition 2 is "normatively charged" (using this term as Grill 2013): it defines type II metaphysics as being overall *normatively defective*, since it is scientifically disinterested when it *should not be*. But if type II metaphysics is defined as being overall normatively defective, then no argument could show it to be overall normatively acceptable. However, this possibility is left open by F&M, since they point out that support could "[…] be given to either Type I or Type II metaphysics via the heuristic approach […]"[13]. The fact that type II metaphysics is both normatively defective and (possibly) supported by the heuristic approach appears as a tension.

We see two possible strategies to address this tension. The first one is to leave untouched definition 2 of type II metaphysics. But then, the heuristics approach does not bring

[13] Note that they remain very careful about the kind of support that the heuristic approach does indeed provide to the type I and type II metaphysics (and specify that this support is significantly conditionalized). But the mere consideration that type II metaphysics *could* be given some support is problematic, given the fact that type II metaphysics is *defined* as being normatively defective.

support to type II metaphysics; rather, it entails that there is no type II metaphysics: indeed, any scientifically disinterested metaphysics might turn out, eventually, to be useful for other disciplines. Therefore, it is never the case that it *should be* (although it certainly *could be*) scientifically concerned. In this case, the metaphysical tools (theories, arguments, concepts) that were taken to belong to type II metaphysics actually belong to type I metaphysics. However, we then lose what seems to be a *bona fide* distinction between two kinds of analytic metaphysics, type I metaphysics being intuitively more justified than type II metaphysics because it does not directly contradict any scientific claim. The second possibility, which we favor, is to change the definition of type II metaphysics by adding a proviso as follows:

> Definition 2*: Type II metaphysics is the metaphysics that is scientifically disinterested but that should not be so *if it is aimed at describing reality adequately*.

Then, type II metaphysics is not normatively defective *per se*: it is only so when it claims to describe reality adequately. But it may be effective if it is regarded as fulfilling other tasks. If we replace definition 2 by definition 2* – as we will do in the remainder of the article – the heuristic argument does indeed provide support to type II metaphysics, which is allowed to remain scientifically disinterested when it only aims at fulfilling a heuristic purpose for other disciplines[14].

3.3 The value of analytic metaphysics

We return now to the question of whether analytic metaphysics, including type II metaphysics, is valuable, in the framework of the toolbox approach[15]. Note that, operating

[14] Note that by fulfilling this heuristic purpose, type II metaphysics can help other disciplines (such as philosophy of physics, or applied ontologies of special sciences) to describe reality adequately once its tools are appropriately contextualized by those disciplines. Therefore, in definition 2*, “if it is aimed at describing reality adequately” should be understood as “if it is *directly* aimed at describing reality adequately”.

[15] Again, we do not take stock here on whether analytic metaphysics is valuable for other reasons, unrelated to the toolbox approach.

under the assumption of the toolbox approach, it is clear that analytic metaphysics sometimes turns out to be valuable for other fields. But does it mean, as a consequence, that metaphysics is *always valuable simpliciter*? In this section, we clarify this point and show that the two possible answers to this question lead to the same practical consequences.

Ladyman & Ross and F&M provide many examples of analytic metaphysical theories that discount scientific knowledge although they intend to describe entities about which we have contradictory scientific knowledge; in these cases, analytic metaphysics fails to describe reality and as a consequence, is not valuable, at least when it comes to the value related to adequate descriptions of the world. However, the heuristic justification by F&M suggests that analytic metaphysics has, or *may have in the future* a different kind of value, namely *heuristic value*. At this point, one may ask whether a potential future heuristic value of analytic metaphysics grants it actual present value *simpliciter*. There are two possible answers to this question but, as we shall see, the two answers lead to the same practical consequences: analytic metaphysics should not be discontinued.

The first answer is not committed towards the existence of a current value of analytic metaphysics, grounded in a potential future heuristic value. Insofar as a metaphysical view, principle, concept, or argument has or could come to have a heuristic value in the future, this justifies the development of this artifact. According to the second, stronger, interpretation, any metaphysical view, concept, principle or argument *has value now* because it has or could have heuristic value in the future[16]. We do not need to commit here on whether we should accept this stronger statement: it is enough to accept the weaker statement that analytic metaphysics may turn out to have heuristic value in the future and that this sole fact justifies developing analytic metaphysics.

3.4 Building on the parallel with mathematics

[16] In this approach, this actual value is arguably intrinsic, since it holds even though it might never be used by another field. This *actual present intrinsic value* thereby depends on a *potential future extrinsic value*.

We are now in a better position to (hopefully) ease F&M's discomfort about the heuristic justification of analytic metaphysics. A comparison with mathematics will clarify this issue, elaborating on an analogy proposed by F&M themselves. Mathematics may have (at least) two kinds of value. First, it might be the case that mathematics describes a part of reality, as Platonists would claim – namely, mathematical reality – and therefore has value (and alternative frameworks in philosophy of mathematics, such as intuitionism or nominalism, may assign alternative kinds of value to mathematical practice). We will not take a position here on whether mathematics has such value. Second, mathematics is sometimes used as a tool in other sciences – physics being an obvious example – in which case it has some actual instrumental value; and because it might serve as a tool in the future, any mathematical construct has some potential instrumental future value. Similarly, as the heuristic justification goes, analytic metaphysics has some potential instrumental future value because of its potential use not only in philosophy of physics – as emphasized by F&M – but also in the scientific domain of applied ontology – as we emphasized in section 2. There is thus a strong parallel between the heuristic justification of both mathematics and analytic metaphysics.

Maybe it would be more psychologically reassuring to claim that both analytic metaphysics and mathematics, because they have potential future instrumental value, actually have value now – as we considered in subsection 3.3. However, this psychological reassurance has no normative bearing, and what matters is that this potential future instrumental value provides an instrumental justification for the development of mathematical or analytic metaphysical theories, whether or not we consider that this provide to them actual, present value.

This parallel between mathematics and analytic metaphysics implies that it is not at all obvious that analytic metaphysics should be constrained by the needs of other disciplines (such as philosophy of science or applied ontology). An external observer of mathematics a few centuries ago might have thought that in order to maximize the instrumental value of mathematics, it should evolve in a constrained – rather than free – manner. For example, one might have suggested that mathematical progress should answer to specific needs from other sciences. Some mathematical tools have indeed been developed to solve specific issues in physics, such as Fourier series to solve the heat equation. However, on other occasions, physics or other disciplines find already pre-existing tools in mathematics that were not developed to answer such issues. As mentioned by F&M (34), Riemannian geometry may have originally seemed to be empty of any instrumental value, but it later found an application with General Relativity. Similarly, some investigations in number theory may have seemed useless at first, but were later used in cryptography. It is not obvious that mathematics would have presently more instrumental value if it had been constrained by its applications rather than let free to evolve in a free-range manner. By analogy, it is not obvious that constrained metaphysics would have more instrumental value than unconstrained metaphysics.

We might add here some argument to make our case. If all metaphysics would become constrained, can we be sure that it would not dry the pool of ideas and tools in such a way as reducing the overall richness of the discipline and, thereby, its usefulness for target fields? To strengthen this idea, note that the two disciplinary fields of analytic metaphysics and philosophy of science rest on largely different (although partly overlapping) intellectual traditions. The organization of metaphysics as a mostly unconstrained field might thus enable the development and expression of specific skills in its practitioners – such as creativity in building new metaphysical tools, or familiarity in using them – the same way that the organization of mathematics as a dedicated field did. Unless more evidence is given to the opposite thesis, it is not obvious that a constrained metaphysics would have more future heuristic value than unconstrained metaphysics.

Another argument suggests ensuring the continuous existence of unconstrained analytic metaphysics, namely the impossibility to predict new – scientific, philosophical or other – fields that might emerge in the future. When metaphysics started to be largely applied to applied ontology, this came as a surprise: "We find it remarkable that an activity that traces its origins to the work of philosophers who lived more than two millennia ago has become central to the development of modern information technology" (Guarino & Musen, 2005). Who knows which other future fields might benefit from the progress of analytic metaphysics? Putting analytic metaphysics to order might skew it towards the needs of present customers (such as philosophy of physics and applied ontology) and restrict its potential applications to other as-yet-unforeseen fields[17].

Thus, we may summarize the lessons learned in section 3 as follows: the heuristic approach justifies the practice of both type I and type II metaphysics (as redefined with definition 2*), in the same way that the practice of mathematics is justified instrumentally. This is true independently of whether the potential use of any metaphysical tool or mathematical construct grants it some actual value. There are four caveats to this argument though. First, one could argue that although the heuristic/instrumental justification is qualitatively similar for both analytic metaphysics and mathematics, some quantitative differences may be relevant. For example, mathematics has been applied to a larger range of disciplines, and for a longer time, than analytic metaphysics. Second, the methodology of metaphysics might be more precarious than the methodology of mathematics: whereas the methods of mathematics are largely settled and well accepted, there is more disagreement about the methods of metaphysics. Maybe, for example, the appeal to intuitions or thought experiments makes metaphysics methodologically more fragile. And certainly, some metaphysical theories go wrong when they pretend to describe a portion of reality about which we do have relevant scientific knowledge, while not taking this knowledge adequately into account – as argued convincingly by L&R and F&M. Third, the structure of the academic field of mathematics has arguably evolved because of its applications; indeed, a whole field of "applied mathematics" has been developed next to "pure mathematics". Similarly,

[17] A reviewer objected that this argument could be "used to defend the allocation of academic resources to any fanciful speculation at all", such as "formal semantics for Klingon and Romulan. (After all, someone might someday decide to use Klingon for some currently unimagined purpose)". We have two replies to this argument. First, Klingon (to take one of these two fictional languages drawn from *Star Trek*) might indeed have some applications someday; for example, it might provide some insights in linguistics. If the study of Klingon would start to bring such insights (the same way that analytic metaphysics has brought important insights to philosophy of physics and applied ontology), then it might be justified, indeed, to allocate some academic resources to its study (in proportion to the magnitude of its expected results). Second, it seems to us intuitively more likely that the purported study of the general structures of reality (which is the object of analytic metaphysics), because of its highly general scope of inquiry, would bring more insights to other fields than the study of the structure of an imaginary language (such as Klingon) would. However, and as noted by the reviewer, a specific account of the circumstances in which a high degree of generality would maximize utility for other fields is still lacking, and could be investigated in future works.

analytic metaphysics might be divided into two fields: “pure” analytic metaphysics, and “applied” analytic metaphysics. But one might argue that this is already what has happened with the emergence of the field of applied ontology; and that for the same kind of reasons that motivate the continued existence of pure mathematics, “pure” analytic metaphysics deserves to continue an autonomous existence next to applied ontology. Fourth, pure mathematicians may be encouraged to periodically step down from their mathematical heavens and visit other scientific fields, to consider whether some of their tools could bring some worthy insight; similarly, analytic metaphysicians could be encouraged to wander out at times to consider whether some of their tools could bring valuable contributions to other philosophical or scientific fields.

But in a nutshell, as far as the instrumental justification goes, metaphysics and mathematics appear to be in qualitatively similar situations, and one therefore does not need to be ambivalent about the heuristic justification of the former if one does accept the instrumental justification of the latter. Thus, it might be a justification for those who think that metaphysics does not have satisfactory epistemic credentials (although we remain neutral here on this question) and that the metaphysician should stop its “bad faith” (Bryant, 2017). And it could be the case that analytic metaphysics makes possible the existence of some of the best naturalized metaphysics and applied ontologies, just like freely developed mathematics entitles the construction of some of the best scientific theories.

4. Conclusion

We have argued for two points in this article. First, French & McKenzie’s heuristic defense of analytic metaphysics can be extended to its utility for applied ontology. Second, a comparison with mathematics shows that the toolbox approach suggests not interfering with the whole field of analytic metaphysics even when it is inconsistent with what we know about the world, according to our best current science.

As a disclaimer, we do not claim that applied ontologies should remain based on analytic metaphysics foundations only. It may become useful, when dealing with data systems in the field of e.g. structural engineering, to develop ontologies based on metaphysical principles based on classical physics. It might even become useful to build them on metaphysical principles based on advanced physics principles if one wants to deal with e.g. particle physics or cosmological data. As mentioned earlier, ontologies such as BFO progressively incorporate such inputs from science. But given constraints of usability (as explained in 2.3) by domain experts such as medical doctors or biologists, we will anyway need ontologies using a level of description in terms of domain categories – although those categories could be connected with categories more in line with contemporary physics. Well-chosen principles inspired by both analytic and naturalized metaphysics could serve as common foundations for those categories.

At the end of the day, we share the main ideas of Steven French and Kerry McKenzie and want to warn against the temptation of scientific triage, namely that the intellectual resources should be distributed differently, according to expected usefulness, to help philosophy of physics to make its way. Philosophy of physics is not the only player in town, and we do not see any convincing reason to believe that an active redistribution of intellectual resources would be overall useful, either for the philosophy of physics, applied ontology or possible other yet-unexpected-fields.

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References

Arp, R., Smith, B., & Spear, A. D. (2015). *Building Ontologies with Basic Formal ontology*. Mit Press.

Baker, D. J. (2009). Against Field Interpretations of Quantum Field Theory, *British Journal for the Philosophy of Science* 60: 585–609.

Barton, A., Ethier, J. F., Duvauferrier, R., & Burgun, A. (2017). An Ontological Analysis of Medical Bayesian Indicators of Performance. *Journal of Biomedical Semantics* 8 (1): 1.

Barton, A., Jansen, L., & Ethier, J.-F. (2018). A taxonomy of disposition-parthood. *FOUST II: 2nd Workshop on Foundational Ontology*, Galton, A. & Neuhaus, F. (Eds), In: *Proceedings of the Joint Ontology Workshops 2017,* CEUR Workshop proceedings, Vol. 2050, 1-10.

Benovsky, J. (2016). *Meta-metaphysics: On Metaphysical Equivalence, Primitiveness, and Theory Choice*. Springer.

———. (2011). The Relationist and Substantivalist Theories of Time: Foes or Friends?. *The European Journal of Philosophy* 19 (4): 491-506.

Bottazzi, E., Ferrario, R., & Masolo, C. (2012). The Mysterious Appearance of Objects. *Proceedings of the 7th International Conference on Formal Ontology in Information Systems (FOIS)*, 59-72, M. Donnelly & G. Guizzardi (Eds.), Amsterdam: IOS Press.

Bryant, A. (2017). Keep the chickens cooped: the epistemic inadequacy of free range metaphysics. *Synthese*. https://doi.org/10.1007/s11229-017-1398-8.

Dorato, M., & Esfeld, M. (2010). GRW as an Ontology of Dispositions. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 41 (1), 41-49.

Esfeld, M., & Lam, V. (2006). Moderate Structural Realism about Spacetime. *Synthese* 160 (1): 27-46.

Ethier, J.-F., Curcin, V., Barton, A., McGilchrist, M., Bastiaens, H. et al. (2015). Clinical Data Integration Model: Core interoperability ontology for research using primary care data, *Methods of Information in Medicine, 54(1),* 16-23.

Ethier, J. F., McGilchrist, M., Barton, A., Cloutier, A. M., Curcin, V., Delaney, B. C., & Burgun, A. (2017). The TRANSFoRm project: Experience and lessons learned regarding functional and interoperability requirements to support primary care. *Learning Health Systems*. DOI 10.1002/lrh2.10037

French, S. (2014). *The Structure of the World: Metaphysics and Representation*. Oxford University Press.

French, S., & McKenzie, K. (2015). Rethinking Outside the Toolbox: Reflecting Again on the Relationship Between Philosophy of Science and Metaphysics. *Metaphysics in Contemporary Physics*, 25-54.

———. (2012). Thinking Outside the Toolbox: Towards a More Productive Engagement Between Metaphysics and Philosophy of Physics. *European Journal of Analytic Philosophy* 8 (1): 42–59.

Frigg, R., & Hoefer, C. (2007). Probability in GRW Theory. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 38 (2): 371-389.

Gangemi, A., Guarino, N., Masolo, C., Oltramari, A., & Schneider, L. (2002). Sweetening ontologies with DOLCE. In *International Conference on Knowledge Engineering and Knowledge Management*. Springer Berlin Heidelberg, 166-181.

Grenon, P., & Smith, B. (2004). SNAP and SPAN: Towards Dynamic Spatial Ontology. *Spatial Cognition and Computation* 4 (1): 69-104.

Grill, K. (2013). Normative and non-normative concepts: Paternalism and libertarian paternalism. In *Ethics in Public Health and Health Policy*. Springer, Dordrecht. 27-46.

Guarino, N. & Musen, M. (2005). Applied Ontology: Focusing on Content. *Applied Ontology*, 1: 1–5.

Halvorson, H. & Clifton, R. (2002). No Place for Particles in Relativistic Quantum Theories? *Philosophy of Science* 69: 1-28.

Huggett, N., & Wüthrich N. (2013). Emergent Spacetime and Empirical (In)Coherence. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 44 (3): 276–285.

Jansen, L. (2008). Categories: The top-level ontology. In *Applied ontology: An introduction*. Ed. Munn, K. and Smith, B. Ontos Verlag. 173-196.

Ladyman, J., & Ross D. (2009). *Every Thing Must Go: Metaphysics Naturalized*. Oxford University Press.

Lambert, N., Chen, Y. N., Cheng, Y. C., Li, C. M., Chen, G. Y., & Nori, F. (2013). Quantum Biology. *Nature Physics*, 9 (1): 10-18.

Le Bihan, B. (2015). No Physical Particles for a Dispositional Monist?. *Philosophical Papers* 44 (2): 207-232.

Le Poidevin, R. (2004). Space, Supervenience and Substantivalism, *Analysis* 64 (3): 191-198.

Lewis, D. (1986). *On the Plurality of Worlds*. Oxford: Blackwell Publishers.

Mark, D., Smith, B., Egenhofer, M., & Hirtle, S. (2004). A Research Agenda for Geographic Information Science. In R. B. McMaster & E. L. Usery (Éd.), *Ontological foundations for geographic information science.* CRC Press. 335-350.

Masolo, C., Borgo, S., Gangemi, A., Guarino, N., & Oltramari, A. (2003). Wonderweb deliverable d18, ontology library (final). *ICT project*, *33052*.

Masolo, C., & Vieu, L. (1999). Atomicity vs. infinite divisibility of space. In *International Conference on Spatial Information Theory*. Springer, Berlin, Heidelberg, 235-250.

Mitrovic, A., & Devedzic, V. (2004). A Model of Multitutor Ontology-based Learning Environments. *International Journal of Continuing Engineering Education and Life Long Learning* 14 (3): 229-245.

Mizoguchi, R., Kozaki, K., Kou, H, & al. (2011). River flow model of diseases. Proceedings of the 2nd International Conference on Biomedical Ontology (ICBO 2011). *CEUR Workshop Proceedings*, 63-70.

Mumford, S. (2003). *Dispositions*. Oxford University Press.

Pooley, O. (2016). Substantivalist and Relationist Approaches to Spacetime. In Batterman (ed.), *The Oxford Handbook of Philosophy of Physics*, Oxford University Press.

Röhl, J., & Jansen, L. (2011). Representing Dispositions. *Journal of Biomedical Semantics* 2 (4): S4.

Ross, D., Ladyman, J., & Spurrett, D. (2007). In Defence of Scientism. In Ladyman and Ross (2007), 1-65.

Ross, D., Ladyman, J., & Collier, J. (2007). Rainforest Realism and the Unity of Science. In Ladyman and Ross (2007). 190-257.

Rosse, C., & Mejino J. L. V. (2003). A Reference Ontology for Biomedical Informatics: the Foundational Model of Anatomy. *Journal of Biomedical Informatics* 36 (6): 478-500.

Scheuermann, R. H., Ceusters, W., & Smith, B. (2009). Toward an Ontological Treatment of Disease and Diagnosis. *Proceedings of the 2009 AMIA summit on translational bioinformatics*. 116-120.

Shearer, R., Motik, B., & Horrocks, I. (2008). HermiT: A Highly-efficient OWL Reasoner. *Proceedings of the 5th International Workshop on OWL: Experiences and Directions (OWLED 2008)*. 26–27.

Sirin, E., Parsia, B., Grau, B. C., Kalyanpur, A., & Katz, Y. (2007). Pellet: A Practical OWL-DL Reasoner. *Web Semantics: Science, Services and Agents on the World Wide Web*, Software Engineering and the Semantic Web, 5 (2): 51–53.

Smith, B. (2012). Classifying Processes: an Essay in Applied Ontology. *Ratio* 25 (4): 463-488.

Smith, B., Ashburner, M. Rosse, C., Bard, J., Bug, J, Ceusters, W. et al. (2007). The OBO Foundry: coordinated evolution of ontologies to support biomedical data integration. *Nature Biotechnology* 25: 1251–1255.

Smith, B., & Mark, D. M. (1998). Ontology and Geographic Kinds. *Proceedings, International Symposium on Spatial Data Handling*, Vancouver, Canada.

Spear, A. D., Ceusters, W., & Smith, B. (2016). Functions in Basic Formal Ontology. *Applied Ontology*, 11 (2): 103-128.

Wallace, D. (2006). Epistemology Quantized: Circumstances in which We Should Come to Believe in the Everett Interpretation. *The British Journal for the Philosophy of Science* 57 (4): 655-689.