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The world is either digital or analogue

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Abstract We address an argument by Floridi (Synthese 168(1):151–178, 2009; 2011a), to the effect that *digital* and *analogue* are not features of reality, only of modes of presentation of reality. One can therefore have an informational ontology, like Floridi's Informational Structural Realism, without commitment to a supposedly digital or analogue world. After introducing the topic in Sect. 1, in Sect. 2 we explain what the proposition expressed by the title of our paper means. In Sect. 3, we describe Floridi's argument. In the following three sections, we raise three difficulties for it, (i) an objection from intuitions: Floridi's view is not supported by the intuitions embedded in the scientific views he exploits (Sect. 4); (ii) an objection from mereology: the view is incompatible with the world's having parts (Sect. 5); (iii) an objection from counting: the view entails that the question of how many things there are doesn't make

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sense (Sect. 6). In Sect. 7, we outline two possible ways out for Floridi's position. Such ways out involve tampering with the logical properties of identity, and this may be bothersome enough. Thus, Floridi's *modus ponens* will be our (and most ontologists') *modus tollens*.

Keywords Mereology · Mereological composition · Digital ontology · Atomism · Analogue versus discrete

1 Introduction

In recent important works Floridi (2009, 2011a) has raised an ingenious challenge for the proposition expressed by our title. The argument is at the core of Floridi's two-stage project in informational ontology: a *pars destruens* highlighting the shortcomings of *digital ontology*, and a *pars construens* putting forth a new informational picture of reality, called "Informational Structural Realism" (ISR).

Digital ontology is based on the claim that (DO) "The ultimate nature of reality is digital" (Floridi 2009, p. 151).[1] For Floridi, DO is not entailed by information-inspired ontology as such: by showing that the former is "not a promising line of research" (Ibid, p. 176), we can set the stage for the development of the latter, as per Floridi's ISR.

DO as such may not imply *pan-computationalism*: the claim that the universe is a big Turing machine-like device (see Piccinini 2010, § 3.1). In practice, digital ontologists generally conflate the two views, as in Ed Fredkin's much-quoted Finite Nature Hypothesis:

> Finite Nature is a hypothesis that ultimately every quantity of physics, including space and time, will turn out to be discrete and finite; that the amount of information in any small volume of space–time will be finite and equal to one of a small number of possibilities. […] We take the position that Finite Nature implies that the basic substrate of physics operates in a manner similar to the workings of certain specialized computers called cellular automata. (Fredkin 1993, p. 116)

Floridi's strategy is notable: he does not aim at showing that reality is *not* a cellular automaton; nor does he claim that we cannot address the issue effectively, due to cognitive limitations. He attacks the very meaningfulness, or truth-aptitude, of the proposition that the world is either digital or analogue (henceforth: "D v A"). We should therefore clarify, to begin with, exactly what that proposition means.

2 What "D v A" means

Firstly, "either… or…", "… v …", is taken by us (as by Floridi: see 2009, p. 160 and n. 16) as expressing ordinary disjunction. Secondly, the predicates "is digital" and "is analogue" are, just as for Floridi, a more fashionable way of expressing the same

[1] Our approach to DO is described in Berto et al. (2010).

properties expressed by the traditional philosophical predicates "is *discrete*" and "is continuous" in "the age-old question about the *discrete* versus *continuous* nature of reality" (Ibid, p. 152).

Thirdly, "the world" just means the totality of things (Floridi himself mostly, though not always, uses the world "reality"). Perhaps the world is a big physical object. But perhaps "some parts of it are entelechies or spirits of auras or deities or other things unknown to physics", as a philosopher once said.[2] Or, only slightly less controversially, maybe the world comprises also irreducibly abstract sets and set-like entities, such as recursive functions and groupoids. Perhaps it comprises also the abstract objects dear to many philosophers, like concepts, properties and relations; and maybe the latter kind of abstract object is reducible to the former. We take a dim view on this and allow ourselves plain talk of sets, properties, and relations, just as structural ontologists, as we shall see, generally do, and Floridi as well does in the aforementioned works.

So let's say that "the world" is to stand for the totality of the things or objects Floridi refers to when he talks of "reality", however this is further characterized.[3] What do "thing" or "object" mean here, then? The reply to this question is the absolutely crucial step in the current enquiry: most of the claims to follow in *this* work depend on it.

We take a modest view on this as well—one, we submit, which any structuralist ontology currently on the market, including Floridi's, is to accept. An object, at the very least, has properties and stands in relations. Because of this it may, as philosophers often say, satisfy certain predicates that express the properties or relations at issue or, equivalently, make true the corresponding sentences. This is what its *objecthood* consists in:

> An object is anything that can be the value of a variable, that is, anything we can talk about using pronouns, that is, *anything*. (Inwagen 2002, p. 180)

So taken, "object" or "thing" are just unrestricted, maximally general terms (they stand for what Wittgenstein called a *formal concept*): "Every x is such that, if x is an object, then x is P" means nothing more and nothing less than "Every x is such that x is P". And "Some x is such that x is an object and $x$is P" means nothing more and nothing less than "Some x is such that x is P".

That things are whatever bears properties and stands in relations, then, does not count as a full-fledged definition. Nor can one do much better when such fundamental notions come into play. For now, what is a property or a relation? Well, it is something things can bear or stand in. Then properties and relations count as things in their turn. They are things, in that they are bearers of (further) properties: *as tall as* has the property of partitioning the set of men into equivalence classes; *divides* has the

[2] Lewis (1986, p. 1).

[3] Some postmodern metaphysician, some philosopher of science of Kuhnian sympathies, or some advocate of the disunity of science such as Dupré (1993), may take such extremely different theories as Aristotle's *tà physikà*, Newtonian mechanics, general relativity or quantum mechanics, as speaking of different worlds altogether and, perhaps because of this, as incommensurable. We set this issue aside, for it appears to be irrelevant to assess Floridi's point. His structural realism is not a postmodern ontology: it is committed to the existence of a mind-independent reality populated by objects, as we are about to see. Several structuralists in the philosophy of science, in fact, invoke structuralism precisely as a vindication of realism in the face of radical theory change (see Worrall 1989; Saunders 2003; Ladyman 1998).

property of being a partial ordering on N^+. Once being a thing is glossed just as being a property-bearer, one cannot think of anything which is not something, or some *thing*.

May structural ontologies like ISR resist this minimal claim? In fact there are no self-subsistent individuals, a structural ontologist may say: individuals are just placeholders for stating things about structural relations and worldly patterns.

But this doesn't count as a rejection of our characterization. Even Ladyman and Ross' *Every Thing Must Go* (2007), aside from the rhetorical force of its title, does not deny that there are things.[4] What structural ontologists like Ladyman, Ross, or Floridi (seriously) deny is a *specific*, albeit (allegedly) pervasive, metaphysical conception of objects as bottom-level, self-subsistent individual substances with intrinsic natures independent from the relational structures they are embedded in. It may well be that the identity of things is nothing over and above the patterns or structural relations they enter into (so that Putnam's paradox is dissolved: we can just individuate things up to isomorphism). This wouldn't change that patterns or structural relations are, of course, things. They are objects of reference, property-bearers, standing in relations, subjects of true claims. We have it from the structuralists' own mouths:

> There are objects in our metaphysics, but they have been purged of their intrinsic natures, identity, and individuality. […] Real patterns are the objects of genuine existential quantification. (Ladyman and Ross 2007, pp. 131, 239)

> As a form of realism, ISR is committed to the existence of a mind-independent reality addressed by, and constraining, our knowledge. It supports […] a minimal ontological commitment in favour of the structural properties of reality and a reflective, equally minimal, ontological commitment in favour of structural objects. Unlike other versions of structural realism, ISR supports an informational interpretation of these structural objects. (Floridi 2009, p. 176)

So structuralism, and in particular Floridi's ISR, accepts ontological commitment to "structural objects" constituting reality in itself. We can even endorse the Kantian perspective proposed by Floridi,[5] to be explored in greater detail below, that our theories or modes of presentation of reality can develop into better and better views insofar as they are

> increasingly informative about the relations that obtain between these (possibly sub-observable) informational objects that constitute the system under investigation (through the observable phenomena). (Ibid)

These objects may be "noumenal" in some Kantian sense ("sub-observable", says Floridi). But these are the things the relevant modes of presentation of reality are *about* ("informative *about* the relations that obtain… system under investigation *through* the

[4] Well, *sometimes* it looks like it does: "we go on to deny that, strictly speaking, there are 'things"' (Ladyman and Ross 2007, p. 121); "there are no entities in the material mode according to us" (p. 186). But if one took take these claims at face value, one would have to consider their book plainly inconsistent, as we are about to see.

[5] Thanks to our anonymous referee #2 for pressing us on the importance of taking Floridi's Kantian view seriously. This view, as based on a constructivist epistemology, is explained in a detailed way in Floridi (2011b), in the context of a general methodology for philosophical enquiry.

observable phenomena"). Floridi, as we just heard from him, quantifies on such sub-observable objects, and goes a long way towards *characterizing* them, speaking *of* them at length: they are "cohering clusters of data", they are "mind-independent, concrete, relational points of lack of uniformity" (Ibid), etc.

3 The thought experiment against DO

"Either the world is discrete or continuous", or "Reality is either digital or analogue", according to Floridi are what Ryle (1949, p. 16) would have called a "category mistake". The world or reality is not of the right *kind* for those predicates to truly or falsely apply to it:

> Both digital and analogue are only "modes of presentation of Being" (to paraphrase Kant), that is, ways in which reality is experienced or conceptualised by an epistemic agent, at a given *level of abstraction* (LoA). They do not pick up some knowledge- or LoA-independent properties, intrinsic to the external world. […] It is not so much that reality in itself is not digital, but rather that, in a metaphysical context, the digital versus analogue dichotomy is not applicable. (Floridi 2009, pp. 152, 159)

"The world is either digital or analogue", thus, should be like "The set Q of rationals is either transparent or opaque"; or "The idea of beauty is either left- or right-handed"; or "This cobblestone is either odd or even". Each of these grammatically well-formed claims is semantically deviant: a *satzklang*, as a neo-Positivist would have said. Each is plain false or, more likely, devoid of truth-value on the ground of its failing to express a proposition.

The argument for this runs as follows. If DO holds, that is, "If the ultimate nature of reality in itself is digital, this implies that it is either digital or analogue" (Floridi 2009, p. 160). So once we show that the entailed disjunction is flawed, DO is refuted by *reductio*. To pursue this, two Floridi-steps are made:

(F1) He provisionally grants D v A, but shows that an agent can never know that DO is true.

(F2) He claims that the result in (F1) is not just an epistemic limitation: it is due to the nature of the concepts at hand. *Digital* and *analogue* are features of modes of presentation of reality, not of reality, and the initial concession in (F1) must be withdrawn. (see Floridi 2009, p. 160)

"'*x* is *P*' is a category mistake" arguably entails "An agent cannot know that *x* is *P*". A category mistake is either plainly false or, more probably, truth-valueless. But one can only know true things. Therefore, (F2) alone would suffice for the desired conclusion. That Floridi puts forward (F1) is important, though: we will come to this in Sect. 6.

The full-fledged argument is an ornate 11-page long thought experiment involving four angels, Michael, Gabriel, Raphael, and Uriel, who actually are idealized Turing machine-like cognitive agents standing in various relations. The idea is that a cognitive agent, presented with an analogue model of reality, cannot possibly tell from this whether reality *is* analogue. For convenience, we rephrase the experiment in less elaborate but still theologically inspired terms:

(1) God chooses to create U, a universe which is in itself either digital, or analogue (as it pleases the Lord).
(2) Whether U is in itself digital or analogue, it gets translated into an "analogue world of experience", A_U, trough a digital-to-analogue reality converter.
(3) The analogue translation A_U of U is presented to an observer, the relevant cognitive agent, deemed incapable of detecting the intrinsic (digital or non-digital) nature of U as imposed in (1).

We are asked to imagine a universe which prima facie looks analogue (as ours does), and to consider if an answer to the following question is, in principle, possible: "Is our universe *intrinsically* analogue?".

Floridi supports (3) by relying on the idea of "Levels of Abstractions", a tool borrowed from computer science (see Roever and Engelhardt 1998; Hoare and He 1998; Floridi 2011a, pp. 46–79). Any observer trying to make sense of an analogue system, such as A_U, may produce infinitely many models or representations of varying ontological granularity (i.e., abstractness in the predicates they use to characterize the system):

> *Analogue systems are closed under modelling at levels of abstraction*, or, which is the same thing, there is no finite number of levels of abstractions that can provide all possible models of an analogue system. (Floridi 2009, p. 167)

A potential problem with the argument so far: when in (2) U is translated into an analogue version, a new ontological layer L is produced starting from UL is analogue and is presented to the observer in (3) (see Fig. 2 in Floridi 2009). According to Floridi, if U is analogue an observer will never halt the production of models, never knowing the true nature of reality—but what if U is digital (which cannot be denied beforehand to the supporter of DO, on pain of begging the question against him)?

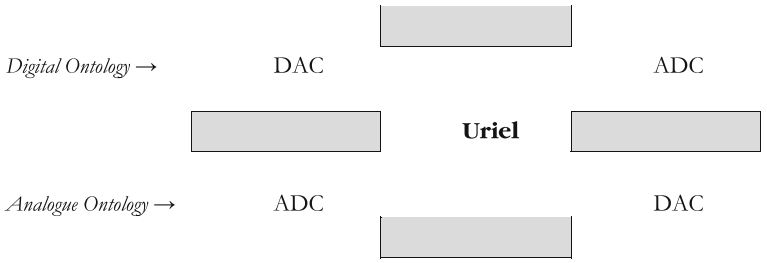
If our world *is* digital, what we experience cannot be a truly analogue L, just a *seemingly* analogue L. If our world is digital there is no way to store continuous information *within* it. Therefore, the models that can be produced are not infinite since the target system is not analogue: we may know, after all, that we live in a digital world. This is a collateral issue anyway; for (F1) does indeed little, if anything, to establish (F2), as Floridi acknowledges:

> Once Raphael (the epistemic agent) is shown to be unable to establish the digital (or analogue) nature of reality in itself, one still needs to answer the objection according to which this conclusion, even if granted, shows nothing about the actual nature of reality in itself. (Floridi 2009, p. 161)

But the scenario in (F1) is supposed to be useful to better understand why (F2) holds, once we add the final step in the argument:

(4) It is possible to use digital-to-analogue and analogue-to-digital converters to switch the nature of the layer presented to the observer, disregarding the question whether U itself was digital or analogue in the first place.

To vindicate (4), Floridi asks us to imagine his final angel Uriel building a "wheel" (Ibid, p. 169–170) with four nodes made by digital-to-analogue and analogue-to-digital converters:



The system generated by the wheel will be perceived by the observer as either digital or analogue depending on the observer's position with respect to the wheel: "It is now obvious that it makes no sense to ask whether the system is digital or analogue in itself" (Ibid, p. 169).

Given (4), Floridi can round up the argument with the Kantian conclusion:

> At this point, the doubt that naturally comes to one's mind is whether the analogue/continuous versus digital/discrete dichotomy may be sound at all, or at least whether its application to the description of the intrinsic nature of reality may not be misguided. Kant thought it was. And I agree that it is. Analogue/continuous and digital/discrete are modes of presentation of Being, i.e. ways in which a system is modelled (experienced or conceptualised) by an observer (an epistemic agent) at a given level of abstraction. (Ibid, p. 168)

From now on, we focus on the consequences of the conclusion: how must the world be like, if "D v A" is a category mistake? We show, via three objections, that the world ends up in bad shape.

4 Intuitions?

Out first objection is ad hominem (thus weaker than the ones to follow it, which are not). As we are about to see, Floridi occasionally resorts to the practice and shared beliefs of scientists to explain his point. However, it is doubtful that they would follow him down his path. To be sure: we are *not* relying on shared beliefs or intuitions in defence of DO, or of the claim expressed by the title of our paper. For we do not believe that intuitions or beliefs matter much in issues of fundamental ontology.[6] Rather, we argue that the very intuitions referred to by Floridi in his paper and book don't lend support to his claim that "D v A" makes for a category mistake.

There is a prima facie big difference between such claims as "Q is either transparent or opaque", or "This cobblestone is either odd or even", and "Reality is either discrete or continuous". The semantic deviancy of the former claims is patent; not so for the latter. Debating whether our world is *Life*-like or not[7] and debating whether this cobblestone is odd or even seem to be quite different things: the latter is patent nonsense; the

6 Thanks to our anonymous referee #1 for pressing us to clarify this point.

7 See Berto and Tagliabue (2012) for a philosophically oriented introduction to *Life*, probably the most popular cellular automaton; the *locus classicus* is Berlekamp et al. (1982).

former apparently targets a real, substantive, structural (in the sense of Sider 2012)[8] difference concerning reality. It is so taken by the vast majority of theoretical physicists and scientists. But even if one resorted to the scientists' intuitions as having some value, these would not deliver a clear verdict in addressing the D v A-issue. Some infer from the digital nature of their favourite models of the physical world to the digital nature of the physical world itself, while others refrain from such a conclusion. In the former party, there are authors like Zuse (1982) and the Nobel prize winner 't Hooft (1997). Approaches based on causal set theory (see Sorkin 1995; Dowker 2003; Malament 2006) take the geometry of real-world space–time as such that at the Planck length (10^{-33} cm) it is discrete. Cognate strategies take space–time as made of polysimplexes, usually polydimensional counterparts of tetrahedra (see Ambjorn et al. 2004).

Other researchers, probably the majority of them, as *Floridi* stresses (see Floridi 2009, p. 159), are just against the idea of a digital world—for instance, another Nobel laureate, Steven Weinberg. Deutsch (2005) and Hardy (2005) reject the view that quantum probabilities and quantum computing vindicate a discrete structure of space–time, and claim that quantum mechanics complies with the idea that the world is continuous even more than classical physics.

An inference from our best discrete or analogue models or theories or representations of reality to the discrete or analogue nature of reality itself may just be an inference to the best explanation. The scientists who refrain from performing such inference (Floridi lists Toffoli (2003), on the basis of quoting Toffoli's "a non frivolous aspect of this Digital Perspective is its heuristic capacity", p. 147) are, of course, logically allowed to: for it is not deductively, at most abductively, warranted. One may take our best physical theory to be an analogue (digital) one, and refrain from declaring that the world is analogue (digital), taking the theory only as a "useful model" of reality—in whatever sense of that frustrating phrase, so often used as a *deus ex machina* to avoid further bothersome questions.

Which does not change that theorists generally take the question, "D v A?", "Is the physical world discrete or analogue?", as perfectly meaningful. When they resist the abductive inference, they typically do so on methodological grounds. They may even do so on the basis of a philosophically much more committing scepticism on the possibility of knowing the ultimate nature of reality. But they rarely, if ever, resist the inference on the ground that it would commit one to a category mistake: to the misapplication of such concepts as *discrete* or *continuous* to something of the wrong kind. They do not take, that is, "is discrete" or "is continuous" as standing for properties that meaningfully (truly or falsely) apply only to theories, models, or modes of presentation of reality. In general, neither the digital-friendly, nor the digital-unfriendly, nor the neutrals quoted by Floridi, seem to vindicate his view. This, in our opinion, holds also for Turing, quoted by *Floridi* again (2009, p. 168) as somehow supporting his view:

[8] Sider uses the term in the context of an extension of David Lewis' theory of natural properties: substantive ontological questions are those about structural features of reality, questions "to be cast in perfectly joint-carving terms" (Sider 2012, p. 46).

> The digital computers […] may be classified amongst the "discrete state machines", these are the machines which move by sudden jumps or clicks from one quite definite state to another. These states are sufficiently different for the possibility of confusion between them to be ignored. *Strictly speaking there are no such machines. Everything really moves continuously* [Floridi's emphasis]. But there are many kinds of machine, which can profitably be thought of as being discrete state machines. (Turing 1950, p. 439)

Machines, says Turing, can often be usefully *modelled as* discrete. They can, that is, be represented as digital, and these theories, or representations, are profitable. But the world in itself is analogue ("Strictly speaking […] everything really moves continuously"). Turing is asserting that reality itself *is* analogue, that is, not digital, though it can be profitably represented as digital.

5 The parts of the world

The argument from scientists' beliefs works only ad hominem: its is not independently appealing to us. Who cares about scientists' intuitions in this case? The D v A-issue is head-on philosophical. We don't expect the solution, or dissolution, of such a fundamental metaphysical problem as the labyrinth of the continuum to take care of the intuitions of possibly philosophically naïve scientists. Scientists developing physical theories have no special authority on their metaphysical interpretation.

Our second argument addressing Floridi's view, then, leaves aside the ad hominem move of turning his appeal to Turing and others against him. It stresses, instead, that such view is incompatible with the world's having parts, which is hard to swallow. The objection, therefore, calls mereology into play. Specialists take mereology as a most general and, in this sense, "formal" ontological theory (contrast "material ontology", in Husserl's sense). Mereology spells out the principles governing the notion of parthood for stuff of *any* kind. It has been developed as a nominalistic alternative to set theory and, according to philosophers like Lewis (1991), mereology can be used in place of ZF(C) for the foundation of mathematics. But its application is largely independent from issues concerning realism and nominalism (in the philosophy of mathematics, and elsewhere). Combined with standard topology into mereotopology, it can be readily applied to spatiotemporal representation to yield a neat, rigorous formal treatment (see e.g. Casati and Varzi 1999).

Let parthood be expressed by a dyadic predicate, P. Some mereological axioms are uncontroversial,[9] for they fix the mere lexical meaning of P. Parthood should be a nonstrict partial ordering:

(A1) $\forall x\, Pxx$
(A2) $\forall x \forall y (Pxy \wedge Pyx \rightarrow x = y)$
(A3) $\forall x \forall y \forall z (Pxy \wedge Pyz \rightarrow Pxz)$

[9] Or *almost* so: see e.g. Cotnoir and Bacon (2012) for a perspective rejecting antisymmetry, yielding a non-wellfounded mereology. We leave this option aside, for it doesn't threaten our argument.

Any thing x is part of itself, any part of any part of x is part of x, etc. Other principles governing composition (the existence of wholes given the parts) and decomposition (the existence of parts given the wholes) are more controversial—to mention a famous one, unrestricted fusion: is it so that for any x and y there's a z whose parts are exactly whatever is part of x or part of y? Some say yes, others are firmly opposed.[10]

Now here's another controversial issue in this area. Start with the definition of *atom*:

$(\mathrm{A}_{\mathrm{def}})\ Ax =_{\mathrm{df}} \sim \exists y\, PPyx$

(Where "$PPxy$" stands for proper parthood, the strict ordering defined from parthood, the usual way: $PPxy =_{\mathrm{df}}\ Pxy \wedge \sim Pyx$). An atom is a mereological simple: it has no proper parts.

Are there any? Perhaps there are no atoms, that is, everything is divisible *in infinitum* ("gunky", as Lewis said). Or perhaps everything is in the end made of atoms. In the former case, we accept the following as true:

(Gunk) $\forall x \exists y\, PPyx$

In the latter case, we accept the following as true:

(Atom) $\forall x \exists y (Ay \wedge Pyx)$

(Gunk) and (Atom) are contraries: they cannot be true together, but they leave room for intermediate positions. Perhaps space–time is continuous but the mereology of material objects is discrete:

(GunkSpace) $\forall x (\sigma x \rightarrow \exists y\, PPyx)$
(AtoMatter) $\forall x (\mu x \rightarrow \exists y (Ay \wedge Pyx))$

…Where only space–time regions and material beings satisfy σ and μ, respectively (this may happen, if mereological simplicity is not tied to lack of spatial extension: see Simons 2004; Braddon-Mitchell and Miller 2006).

Now principles such as these (modulo the expressive limitations on cardinality of standard mereology's first order language) are enough to express how *Life*-like, Finite Nature-like, or Newton-like universes substantially differ in many ways. For instance:

- (Atom) is a natural way to phrase the key claim of DO, that "reality can be decomposed into ultimate, discrete *indivisibilia*" (Floridi 2009, p. 153).
- Any finite world is atomistic, so if (Atom) fails, then Fredkin's Finite Nature hypothesis is false.
- *A fortiori*, an atomless world where (Gunk) holds has infinitely many things.

Shaffer (2003) has argued that science offers no evidence that (Atom) is true of the physical world. Nolan (2004) has discussed the issue in a general setting. Now for the key question (of interest to us): What do the variables in (Atom), (Gunk), (GunkSpace), (AtoMatter), *range over*? It is to say the least implausible to claim that:

(a) In (A1)–(A3), our variables range on worldly things, that is, bits of reality in itself; whereas,

[10] See for example Lewis (1986), Sider (2001), Casati and Varzi (1999) for the yes-side, and Inwagen (1990), Simons (1987), Koslicki (2008) for the no-side.

(b) When we discuss more controversial principles, like (Atom), (Gunk), etc., we have an unspotted category switch (a *metábasis eis állo génos*, in Aristotelian terms), and we end up talking of modes of presentation of reality, or features of levels of abstraction; so that if we believe we are still talking of—quantifying over bits of—reality in itself, we are victims of a category mistake.

Thus, we should reject (a): we were talking of features of modes of presentation of reality from the start. The lexical axioms for parthood (A1)–(A3) are *about* modes of presentation of being, not about reality in itself. Such modes of presentation are what actually is in the range of the relevant quantifiers. This amounts to denying that parthood relations are objective features of the world: out there in reality, *parthood* does not apply.

To reject the worldly meaningfulness of the D v A-issue, one needs *parthood relations not to be features of reality* (and *not* even in the minimal sense of Rosen and Dorr's 2002 mereological nihilism: if there are only atoms, DO is vindicated by default already). We find this rather implausible.

Perhaps the implausibility may be tempered on the following grounds. In a structural world, the structural ontologist may retort, there is no *unique* notion of parthood that applies unrestrictedly to the whole of reality. Relational structures making for reality in itself can obviously admit various form of composition (take coalesced sum for lattices, for instance). They can also admit various forms of decomposition, that is, they also have substructures (take e.g. endomorphisms). Just like Aristotle's being, however, in a structural world mereological (de)composition is spoken of in many ways.

Of course, structures and patterns enter into lots of relations that are uncontroversially partial orderings. But being a partial order, the structuralist may retort, is far too lax a requirement for a relation to qualify as parthood.

On the other hand, of the many partial orderings around that enjoy further parthood-like features (e.g., satisfying formal principles that correspond to mereological weak supplementation, or strong supplementation, etc.), there is none of which we can say that *it* is the one qualifying as *the* parthood relation, grounding a single notion of decomposition for reality, which may either digitally come to an end, or serially go on forever.[11]

We doubt, however, that the worldly meaningfulness of the D v A-issue presupposes even this. For assume that in reality there are only patterns or relational structures, that is, as we heard structuralists themselves claim, that "real patterns are the objects of genuine existential quantification". *Some* notion of structural analysis of patterns or structures into subpatterns or substructures is just enough for the D v A-issue to be perfectly meaningful of the world. For one can ask: Is such analysis a serial relation? That is, do relations go all the way down? If yes, the world is analogue; if not, not.

And structural realists *do* need such a notion of structural analysis.

[11] "Why suppose that there is any such thing [as a unique parthood relation]? It is supposed to be the relation that obtains between parts of any whole, but the wholes mentioned above are hugely disparate and the composition relations studied by the special sciences are *sui generis*. We have no reason to believe that an abstract composition relation is anything other than an entrenched philosophical fetish" (Ladyman and Ross 2007, p. 21).

It is a common remark on structuralism that structural relations simply make no sense unless there are relata standing in such relations: see e.g. Dorato (2000), Psillos (2001), Esfeld (2004), Morganti (2004)—and many others. Floridi (2003) himself argues against a radically eliminativist version of structural realism, which simply denies that there are relata. As we have seen, according to Floridi *there are* indeed (structural) mind-independent objects constituting reality in itself: (structural) property-bearers, standing in various relations.

Serious structuralism, then, does not deny the existence of the things that are the relata. But there is an analysis relation on patterns, a (multigrade?) relation that works serially. We have it, again, from the structuralists' mouth—let us listen to Ladyman and Ross:

> While there are *relata*, they can be analysed into further relational structure themselves. […] The *relata* of a given relation always turn out to be relational structures themselves on further analysis. (Ladyman and Ross 2007, pp. 152, 155)

So given a thing x (an "object of genuine existential quantification", that is, a real pattern or structural object), there always are relational structures into which x is analysed. Then the analysis relation works serially: indeed "it's relations all the way down" (Ibid, p. 152).

Then there is no *complete* analytic decomposition for patterns. This is certainly gunky, that is, "non-atomistic metaphysics." (p. 190):

> Life differs greatly from the universe with respect to the kinds of reductionism sustainable in it. Life admits of complete decomposition: the universe does not. (Ibid, p. 201)[12]

6 The number of things

For our third objection, we resort to Floridi's own understanding of how the issue whether the world is digital or analogue should be understood. This is where step (F1) of his argument, where he provisionally concedes that the world might be either digital or analogue, comes handy.

Once "world", "thing" or "object", "digital" and "analogue" have been understood as per Sect. 2, the D v A-issue may boil down to a question about the number of things. As such Floridi, very correctly, presents it. In his step (F1) (see Floridi 2009, § 3.1), he describes Michael's (his first angel's) epistemic position, which is like the one of

[12] And many other typical mereological issues make perfect sense in a structural world. Take again the problem of unrestricted mereological composition: given any two objects $x$and y, is their mereological fusion automatically given? Some say yes, other say no, as we have seen. Now given any two real patterns $x$and y, is there a real pattern automatically obtained by conjoining them? (Some) structural ontologists deny this, on the basis of their conditions for pattern existence: "The object named by 'my left nostril and the capital of Namibia and Miles Davis' last trumpet solo' is not a real pattern, because identification of it supports no generalizations not supported by identification of the three conjuncts considered separately" (Ibid, p. 231).

God in our rephrasing of his thought experiment in Sect. 3: Michael "enjoys a God's eye view of reality in itself" (Ibid, p. 162).

Michael shapes the stuff constituting reality by applying a total ordering on it, so that the result can be represented as a line. Then Michael uses his maximally sharp sword to Dedekind-cut the line, i.e., to figuratively map reality via Dedekind cuts to the real number line:

> When it cuts (i.e., intersects) the line, it divides it into two disjoint, non-empty parts, left and right. If the point at which the sword cuts the line belongs to either the left or the right half, then that point corresponds to a rational number. If the point belongs to neither (if neither subset of the rationals contains it), then it corresponds to an irrational number. (Ibid, p. 162)

Emblematic representation aside, Michael is *counting*: working towards establishing the number of things. Take the totality of things in the world. If such a totality is in one-to-one correspondence with R, then the world is analogue, A: reality is dense and continuous.[13] If not, that is, if some points in the line are missing, then the world is digital, D: either it's not dense, or it is but still it's enumerable, that is, equinumerous with Q.

Now the D v A-issue boils down to this: either there are finitely-or-denumerably-many things, or not. Thus, "D v A" can be a category mistake, only if it makes no sense to speak of the total number of things. Take reality, or the world: the collection of all the (relevant, structural, etc.) objects. How many of them are there (countably many, uncountably many)?

How can this question originate a *satzklang*? This is *not* for us a rhetorical issue: we conjecture in the next section that the question *may* be ultimately nonsensical, as Floridi wants. The purpose of this section is to set up the conditions under which that question may fail to make sense.[14]

The question, notice, does not depend for its making sense on worldly stuff's making for a linear order. One could reject a well-ordering principle for worldly stuff, and request a weakening the assumption in step (F1), on the basis of considerations from contemporary physics.[15] For instance, it might be that worldly stuff cannot even be partially, thus *a fortiori* linearly, ordered: for Saunders (2003, 2006), fermions are only weakly discernible as standing in irreflexive relations, and they may not be enumerated. They can, however, be counted: Krause (1992), Dalla et al. (1998) have developed set-theoretic frameworks in which quanta can be gathered into sets with no ordinal, but with cardinal.

How can it be nonsensical to ask the question of how many things there are, "thing" or "object" being, recall, just blanket terms for any property-bearer, anything that can be the value of a variable, that is, *anything*? To rephrase the point with the help of van

[13] Floridi leaves aside the issue whether such a totality may have a larger cardinality for this is irrelevant: if it reaches the continuum, that's enough as far as his point is concerned.

[14] Thanks to our anonymous referee #1 for suggesting that we make this point explicit.

[15] We mention this only *en passant*, for Floridi (2003) speaks against letting quantum-theoretic considerations, e.g., from the phenomenon of entanglement, teach us lessons in general ontology; so he may be resilient to remarks of this kind anyway.

Inwagen: once "thing" is understood in the minimal sense outlined in Sect. 2, given that we have the amount of space and time Floridi's angels have as idealized cognitive agents, we can write down "a sentence that expresses any of the propositions in the following infinite sequence" (Inwagen 2002, p. 186):

> There is nothing;
> There is exactly one thing;
> There are exactly two things;
> There are exactly three things;
> …

At most one of the claims in the sequence will be true, and that one true sentence gives the number of things.

Or, none of them is true, for there are infinitely many things. In the latter case, given the bits of transfinite arithmetic in Floridi's Michael example, we can claim of any number K that K is the number of things. We say: "There is a set of things, U, such that $|U| = K$, and no number larger than K is the cardinal of any set of things".

Or, if we don't even accept those bits of transfinite arithmetic, we cannot say what the number of things is, but we *can* say they are innumerable: "For any number K, there are at least K + 1 things."

At which point of this reasoning by cases do we hit a meaningless *satzklang* or dead end? We can only think of two ways in which this may happen—two ways in which Floridi may be right. As we shall see in the next section, however, neither makes for a promising world view.

7 Ways out for ISR?

The first way in which the D v A-question may now be ill-posed is in the presence of what are usually called vague identity relations: for some things a and b, it is *de re* indeterminate whether $a = b$ or not. If so, there is no answer to the question of what the number of things is, for it is *de re* indeterminate whether, when we take a and b into account, we have to count one thing or two. If there are vague identity relations, there are vague objects, namely those that stand in such vague relations.

There being *de re* vague objects can, in fact, pose difficulties also for the mereological framework rehearsed by us above, since arguably many supposedly vague entities are vague precisely because of their vague parts—clouds, forests, heaps of sand, mountains:

> What are the mereological boundaries of a desert, a river, a mountain? Some stuff is positively part of Mount Everest and some stuff is positively not part of it, but there is borderline stuff whose mereological relationship to Everest seems indeterminate. (Varzi 2009, §5)

Other philosophers (Sainsbury 1989; Tye 2000) have challenged this thread of thought. Vague objects can be "mereologically elusive", but they still have as precise identity conditions as any other object. For suppose that *parthood* is fuzzy—it comes in degrees. Still one can say that $a = b$ iff they have the same parts to the same degree.

And these are perfectly crisp identity conditions, as Williamson (1994) already stressed in his book on vagueness. Moreover, on most plausible ways of spelling out this ontic indeterminacy at the formal level, the core of our mereological argument using (Atom), (Gunk), etc., in order to spell out the D v A-issue would still be intact (see Varzi 2009, § 5, for a discussion of the main alternatives).

The second way in which the D v A-question may be ill-posed is in case identity is sortal-relative and not Leibnizian, i.e., it defies Leibniz's Law or the Indiscernibility of Identicals. In this case, "$a = b$" does not express a complete, truth-evaluable proposition, unless we take it as implicitly including some sortal restriction. It makes no sense to wonder if a and b are one or two, *simpliciter.* What does make sense is to wonder whether a and b are the same F, where "F" stands for some sortal predicate. But their being the same F does not entail congruence with respect to all features, in particular their being the same G, where "G" stands for some different sortal predicate (see Geach 1967; Deutsch 1998).

We take both of these views, namely that there are objects which are vague because of their standing in vague identity relations, and that identity is sortal-relative and not Leibnizian, as problematic on logical and metaphysical grounds. We will not spell out our motivations here, for the following reason: even if such doctrines were true, it is not (yet) clear to us how Floridi's ISR may appeal to them to vindicate the view that the D v A-issue is ill-posed because "D v A" is a *satzklang*. Are some of Floridi's structural objects, with their properties and structural relations, vague and such that they stand in vague identity relations? Perhaps this can be motivated via considerations from (the philosophy of) quantum physics, to the effect that quantum field theories defy the idea that there always is a determinate number of things at least for things of some kind (say bosons, if not fermions; but again, Floridi (2003) seems to speak against taking this route).

Or is perhaps the identity of such objects, as supervening to the net of structural relations they are involved in, sortal-relative and non-Leibnizian? Whether Floridi's structural objects *could* be vague or sortal-relative is an issue to be addressed in another paper, after a more thorough examination of the *pars construens* of Floridi's ambitious project. It is enough for us to notice that, if this were the way to go for him to declare that the world is neither digital nor analogue, it would involve tampering with the logical features of identity as the smallest reflexive relation entailing congruence with respect to all properties. It may involve challenging Leibniz's Law or the Indiscernibility of Identicals itself—the Law of which Kripke notoriously claimed that it is as self-evident as the Law of Non-Contradiction: a route which will look discouraging to most logicians and ontologists, and certainly to us.

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