Composition as pattern*

Steve Petersen

January 28, 2018

Abstract I argue for *patternism*, a new answer to the question of when some objects compose a whole. None of the standard principles of composition comfortably capture our natural judgments, such as that my cat exists and my table exists, but there is nothing wholly composed of them. Patternism holds, very roughly, that some things compose a whole whenever together they form a "real pattern". Plausibly we are inclined to acknowledge the existence of my cat and my table but not of their fusion, because the first two have a kind of internal organizational coherence that their putative fusion lacks. Kolmogorov complexity theory supplies the needed rigorous sense of "internal organizational coherence".

Keywords composition, ontology, ordinary objects, pattern, compression, organicism

Peter van Inwagen's Special Composition Question asks when a bunch of things, together, compose a new thing. That is, given a plurality *xx*, he asks "when is it true that there is a y such that the *xx* compose y?" A mereological *nihilist* notoriously answers that no non-trivial

*This is a *draft*, and should not be circulated or cited without permission. Thanks to Karen Bennett, Daniel Dennett, Maureen Donnelly, John Keller, Dan Korman, David Kovacs, Kris McDaniel, Catherine Nolan, James Overton, Lewis Powell, Ken Regan, Barry Smith, Terrance Tomkow, Peter van Inwagen, Dean Zimmerman, the anonymous referees, and others.

pluralities compose; nothing exists with proper parts. Thus the nihilist will say, for example, that there are no tables—at least, strictly speaking. A mereological *universalist* notoriously answers that all pluralities compose; for any *xx*, there is a *y* that they compose. Thus the universalist will say that there is a table, and also a table-Robin, the thing composed of both the table and Robin. Between nihilism and universalism are "moderate" answers, according to which some pluralities compose a new thing, and some don't. An *organicist*, for example, follows van Inwagen's own notorious answer that composition only takes place when "the activity of the *xx* constitutes a life."[1] Thus an organicist will say that there is no table, but there is a Robin. None of these proposals comfortably capture our natural judgments; we would like, all else being equal, to find a principle according to which there is a table and there is a Robin, but there is no table-Robin.

Plausibly we are inclined to acknowledge the existence of the table and of Robin, but *not* of a table-Robin, because the first two have some internal organizational coherence that a table-Robin lacks. The problem of course is in specifying this right kind of "internal organizational coherence". I propose an answer to this problem, and so to the Special Composition Question, inspired by Daniel Dennett's "Real Patterns" (1991). According to *patternism*, very roughly, a plurality *xx* compose a *y* just in case there is a real pattern to the *xx*.[2] The notion of *pattern* here is from Kolmogorov complexity theory: basically, data are patterned if they are *compressible*, and data are compressible if a reference universal Turing machine (UTM) can produce the data as output given a shorter string as input.[3] (A simple counting argument shows that most strings are *not* compressible in this sense.)

[1] van Inwagen (1990) p. 82.

[2] Though Dennett himself has foresworn developing this proposal as a full-blown ontology, there has been other such work on his behalf, most notably Ross (2000) and the subsequently developed Ladyman and Ross (2007). Haugeland (1993) is a critical response to Dennett's paper. Independent philosophical work on patterns and ontology is in Johansson (1998) and Johansson (2004).

[3] The standard Kolmogorov text is Li and Vitányi (2008). Incidentally, for what it's worth: after working on this Kolmogorov approach to patterns independently, I was surprised on going back to Dennett's paper to find he had just the same notion in mind.

Metaontological prelude

Patternism is, I think, a promising theory—but before we examine its details, experience teaches me that I must first address a problem: different data will be compressible, and so patterned, for different UTMs. Worse, *any* finite data are compressible relative to *some* UTM.[4] So, even supposing that patternism succeeds in providing a rigorous account of the internal organizational coherence that we are inclined to think unifies some pluralities into genuine objects, whether the data have such coherence will depend on the choice of UTM. This relativity does not sound like traditional, analytic, realist metaphysics, so the ambitions of the view may be unclear. Is it some more modest metaphysics, doing traditional ontology with some acceptable relativity? Or is it ambitious epistemology, seeking to put our ordinary and scientific judgments about objects on a more objective—but still mind-relative—footing?

Dennett's pragmatism

Dennett's own answer to this question—at least when it comes to his specific question of whether *beliefs* exist—is that his "Real Patterns" account is meant

> to convince philosophers that a mild and intermediate sort of realism is a positively attractive position, and not just the desperate dodge of ontological responsibility it has sometimes been taken to be. (p. 29)

In other words, I take it, Dennett holds that patterns (and so beliefs) are *real enough.* As for whether his view is best seen as an "instrumentalism" or "a sort of realism", Dennett says "the view itself is clearer than either of the labels, so I shall leave that question to anyone who stills find illumination in them" (p. 51). Unofficially, I must confess that I am sympathetic

[4]"Proof": given any finite data string x (longer than one bit of course), pick some UTM and prefix it with a program that has x stored as a hardcoded value, and outputs that value on any input that begins with `1`—including just `1`. On any input that starts with `0`, strip the initial `0` and pass the rest to the unmodified UTM. The result is a new UTM that compresses x to one bit.

Dennett either did not notice, or chose not to address this problem.

not only to Dennett's patternist proposal, but also to this metaontological stance. I too am inclined to a mild, Quinean pragmatism that blurs the border between epistemology and metaphysics; roughly speaking, I see little room between the pluralities we *should* track and the pluralities that *are*.[5] I recognize, though, that I am in a minority here, and that many consider such insouciance more frustrating than enlightening.

Patternism as metaphysics

Officially, then, I present patternism as realist metaphysics. Though I've disclosed my ultimately pragmatic and epistemic aims, I think it's good practice even for those ends to seek "objective" and "realist" answers as best as we are able. Where some pragmatists and naturalists see mere semantic games in metaphysical debates about the existence of heaps or clouds or fists, I see "edge cases"—cases for which science or ethics may not have any immediate need, but that metaphysics can fruitfully address in case they come up, much as mathematicians have paved the way for techniques that physicists didn't even know they need yet.

There are plenty of ways patternism can be understood to address van Inwagen's standard metaphysical project directly. First, just as a realist metaphysician might insist that *green* is a fundamentally more natural property than *grue*,[6] so I am tempted to insist that a small UTM is fundamentally more natural than a UTM hardwired with a long data string specifically for the purpose of outputting that string on a short input. The standard text on Kolmogorov complexity theory, for example, simply recommends we fix as a reference "any small universal machine ... with state-symbol product less than 30," and leaves it at that.[7] The idea,

[5]This is how I would gloss what Dennett calls the "scientific path to realism" in his "Real Patterns", according to which for example "centers of gravity are real because they are (somehow) *good* abstract objects. They deserve to be taken seriously, learned about, used" (p. 29).

[6]Goodman (1954). Of course this particular example of a "natural" property is complicated by the fact that in order to explain what the green surface spectral reflectances have in common, it seems we need to refer to our own cognitive architecture.

[7]Li and Vitányi (2008) p. 112.

presumably, is that a minimal UTM will have no bias or preconceptions—a move closely analogous with the objective Bayesians' insistence on uninformative priors. With a fixed such "natural" reference UTM, we have a resulting account of which data are *really* patterned.

Second, even a UTM-relative patternism sits well with renewed interest in metaontology that David Chalmers calls "lightweight realist". For example, I think patternism could be a friendly addition or even a welcome tool for several of the metaontological views surveyed in the Chalmers, Manley, and Wasserman (2009) anthology: Chalmers' own neo-Carnapianism, Bob Hale and Crispin Wright's abstractionism, Eli Hirsch's quantifier variance, Kris McDaniel's ontological pluralism, and Amie Thomasson's deflationism.[8] And if McDaniel (2013) is right that recent metaphysical talk of groundedness and fundamentality is tantamount to ontological pluralism, then this work too supports a lighter kind of realism.[9] Patternism might also go some way toward providing the metaphysical "building relation" that Karen Bennett (2011) seeks.

Meanwhile, I do sympathize with those metaphysicians who have loftier, more "heavyweight" aspirations. True, that sympathy comes mixed with some pity—because they seem doomed to mereological nihilism, mereological universalism, or perhaps organicism with vague existence. It's worth noting that ontologists of various stripes still find the need to refer at least hypothetically to the apparently natural objects; for example, van Inwagen (1990) writes of "virtual objects", Dean Zimmerman (1996) of "naturally demarcated parts", Peter Simons (1987) of "complexes", and Achille Varzi (2014) of "components". These ontologists may still find some interest in the epistemology at which my metaphysics is ultimately aimed.

[8] Chalmers (2009), Hale and Wright (2009), Hirsch (2009), McDaniel (2009), Thomasson (2009).

[9] See Correia and Schnieder (2014) for an overview of issues in grounding.

Epistemic consolation prizes

I think the epistemic questions related to composition come down to these two: first, are there pluralities that are epistemically just *more natural* than others? Second, if there are more natural pluralities, what makes them so? Why, for example, do scientists treat some pluralities as independent objects of study, but not others? When *should* they do so? This goes even for the everyday proto-scientific inference we all do. Why are we naturally inclined to attribute existence to the "ordinary objects"—to tables and to Robin, but not to a table-Robin? Korman (2011) tells us that

> Very roughly, ordinary objects are objects belonging to kinds that we are naturally inclined to regard as having instances on the basis of our perceptual experiences: *dog*, *tree*, *table*, and so forth.

Sure—but why, and how, do our perceptual experiences so incline us to carve up the world that way? And when *should* they? Here is a very short version of a plausible answer to all three questions: epistemic agents are built to get by in the world,[10] which involves keeping tabs on as many potentially important environmental features as possible, for the purposes of prediction. We cannot store and induct over every sense-datum (at least, not in time to act intelligently), so we summarize where possible by cogitating on the patterns instead of the particulars so patterned. This means picking out bigger-picture regularities from the overwhelming minutiae of information available to even the most rudimentary perceptual mechanisms. This, in turn, means seeking patterns.

My own particular interest is to bridge ontology with computationally respectable inference—in particular, to computational implementations of inference to the best explanation and Ockham's razor. There are notoriously many possible explanations compatible with our sense-data, including the theory that each datum is generated completely independently of the other.

[10]In fact I would argue that being built to get by in the world is *necessary* for being an epistemic agent—which, if true, would help explain pragmatism's prevalence among philosophers of cognitive science.

Inferring to patterns, when understood as the least Kolmogorov-complex explanation, looks like inferring to the *simplest* explanation. If the "objects" are the compressible pluralities, we would ideally so infer to them, and thus it seems Ockham's razor is a guide to truth.

I think it is no coincidence that much recent work in cognitive science—especially the parts aimed toward artificial general intelligence—focus on pattern extraction. On the computational neurobiology side, Clark (2015) summarizes "predictive processing" theories of intelligence, building on the hierarchical Bayesian work in *e.g.* Friston and Stephan (2007). Seeking to minimize Bayesian surprise on higher-order parameters is basically just pattern extraction.[11] On the computer science side, pattern extraction features in both traditional and connectionist approaches. The "universal AI" model in Hutter (2005) is rooted in Solomonoff induction, while others pursue its more tractable cousin, minimum description length inference. These are explicitly taken to be algorithmic information theoretic versions of Ockham's razor.[12] Meanwhile the current darling of AI—the "deep learning" neural networks—plausibly have their success best explained by Naftali Tishby's "information bottleneck" theory, according to which

> a network rids noisy input data of extraneous details as if by squeezing the information through a bottleneck, retaining only the features most relevant to general concepts.[13]

That artificial neural networks engage in pattern extraction is unlikely to surprise old fans like Churchland (1995). (As with predictive processing and minimum description length, the focus here is on good *lossy* compression; like the `mp3` codec, such compressions keep just the relevant patterns, and throw out the irrelevant noise.)

[11]This is from the probabilistic rather than algorithmic information theory perspective, of course, but see P. Grünwald and Vitányi (2004) for an overview of the close ties between Shannon information theory and Kolmogorov complexity.

Incidentally, Friston et al. (2015) further argue that any agent worthy of the name must be seeking to minimize such surprisal (p. 5).

[12]See for example Solomonoff (1960) and P. D. Grünwald (2007). Baum (2004), like Hutter, insists that cognition is essentially a form of information compression.

[13]See https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/.

It's also important to note that patternism, even in its most epistemic and relativistic guise, would only be relative to a subject's computational architecture, and not to that subject's thoughts—that is, the subject can still be mistaken about what is compressible, even for that subject. Though our brains may be designed to pick out compressions, doing so *successfully* is an iffy business that takes work and luck. For one thing, our brains might be wrong about the best compression available simply because our perceptions give us imperfect access to the raw data. For another thing, even given perfect access to relevant data, finding a compression of those data is computationally intractable; there is no guarantee that a good (let alone best) compression can be found in close to a reasonable amount of time.

As for worries about the relativity to computational architecture, remember first that conspecifics (at least) share very similar architectures, and so their natural ontologies will be very similar. There will probably be *some* data one creature can compress and another cannot, but assuming ordinary objects are hugely compressible, conspecifics (at least) will agree on them. More generally, practical constraints of negotiating the world will probably ensure that the architecture employed by *any* evolved agent will be relatively "natural". The UTM approximation that a successful agent must instantiate in a harsh environment will almost surely be generally able to compress the pluralities that actually do have trackable causal powers—at least ones relevant to the agent.[14] Perhaps objects, ultimately, should be defined in terms of how intelligent agents negotiate the world. "Object" might be a description like "visible"—objective, but only relative to the type of subject.[15]

Second, even if we did encounter epistemic agents with architectures that look unnaturally biased from our perspective, remember that *translation* between any two UTMs is always possible in principle. Thus the difference between two standard UTMs' complexity measures will always be bounded by some constant[16]—namely, the bit-length of the shortest program

[14]For reasons like evolutionary pressure I am open also to "logical depth" versions of complexity, which consider time constraints; see C. H. Bennett (1988).

[15]Compare Bas van Fraassen (1980) on "observable", p. 17.

[16]By a "standard" UTM I mean what Li and Vitányi (2008) p. 103 call "additively optimal"; contrast the perverse UTM in Example 2.1.2 on p. 107.

required for one to emulate the other. And through emulation, one UTM can in principle always verify that an object exists-for the other UTM. Thus patternism's relative measure of naturalness is something like the relative measure of velocity: first, because it is always in principle possible to state the reference frame, and second, because a standard reference frame can normally be left implicit.[17] Just as we are typically interested in velocities relative to the earth, so we can typically take human hardware for granted.

For these reasons, I think patternism is a worthwhile philosophical project, however we might best categorize it. From here I will suppose the reference UTM has been fixed for one good reason or another, and address the metaphysical Special Composition Question.

Patternism

So now, with a clearer picture of the background aims, let us turn to the view itself, and its answer to the Special Composition Question.

Formal preliminaries

The Special Composition Question presupposes that we can make sense of some pluralities *xx* as potential candidates for composition. These might be truly fundamental individuals, such as fermions and bosons, or strings, or spacetime points, or something undiscovered. Or there might be no true foundation—some members of the candidate plurality might include atomless gunk, for example, or the composing plurality might always be relative, with composition all the way down.[18] Let's call any such candidate plurality a composition

[17] Thanks to Terrance Tomkow for this comparison.

[18] For issues with gunk see Sider (1993) or Zimmerman (1996); see Ladyman and Ross (2007) for composition all the way down. Ladyman and Ross reject the atomic-gunky dichotomy—see for example p. 20 and p. 44—but whether their own view is best summarized as "composition all the way down" is contentious.

"base", remembering this might be a relative term.[19] We will suppose the base pluralities also have base properties, again in this ecumenical sense that does not assume being absolutely foundational.

In what follows I have in mind an especially convenient composition base for my purposes: namely, a finite space, pixelated down to some informational limit, and such that each pixel has some mix of a finite number of basic properties. We can encode each pixel's mix of possessing and lacking basic properties as a vector of ones and zeroes. In what follows we will assume seven basic properties, making $2^7 = 128$ possible combinations per pixel—easily represented by 128 different shades of grey. I think my proposal works (with modification) also for bases that are infinite, or continuous, or where the basic individuals are discrete and *located* substances rather than spatial *locations*—but I mention it because I am not sure this is so. I am even less sure this proposal works for pluralities that are neither locations nor located (but I'm also less sure I care).

Finally, because it is already plenty ambitious, I consider here only purely *synchronic* cases of composition. Thus for now I put aside many "ordinary" composites—most notably artifacts—because they probably have essential diachronic features, such as a history or a function. "Scattered" objects that can occupy disconnected regions of space also, I assume, require such diachronic features to gain any plausibility as a unified whole. So in this synchronic case I will consider only pluralities over a connected region, and will often leave the "connected" part implicit.[20]

In the long term, I hope to parlay the patternist account of synchronic composition into diachronic composites such as artifacts, scattered objects, and living beings. The rough plan is to extend the two-dimensional toy case into a third dimension of time, and treat the whole as a spatiotemporal distribution of intrinsic qualities. Applying the same patternist technique

[19] This usage is meant to echo, but not be the same as, that of Simons (1987), pp. 44–45, where for the Fs to serve as a "base" in an atomless mereology means $\forall x \exists y(Fy \wedge y < x)$ and $\forall z((Fz \supset (z < x \equiv z < y)) \supset x = y)$.

[20] For scattered objects, see Cartwright (1975). "Connected" should be read as the topologists' "path connected", but not as their "simply connected"—that is, I allow for regions with holes.

should then be able to recover persistence, causation, function, and intentionality.

For now, though, we tackle a specific case of the Special Composition Question: pick a particular time and a connected region of space. Do the base plurality in this region, at this moment, given their base properties, compose an object?[21]

Patterns

Let us call the complete specification of the base plurality and its base properties in a connected region at a time its "configuration."[22] Patternism starts with this apparent truth, surely basic to any moderate ontology: if the configuration of the plurality in a region is utterly *random*, then that plurality do not compose a new *y*. As Simons (1987) would put it, a composite must possess "a certain degree of integrity or internal connectedness."[23] Naturally we need to make this informal notion of "integrity" and its complementary "randomness" more precise. As suggested above, Kolmogorov complexity theory serves as an especially enlightening characterization of randomness: some data are random basically just in case there is no way to summarize them more concisely. More formally, data are random if a reference universal Turing machine requires at least as many bits of input in order to produce the data as output. If on the other hand we can *compress* the data by specifying them completely in fewer bits, the data are not random. Compression requires exploiting the data's interdependence—the ability to predict some of the data based on the rest of them. The more bits required to reproduce the data, the more (Kolmogorov) complex the data are.

So if the configuration of the *xx* is *not* random in the Kolmogorov sense, then there must be some more concise way to convey it; the information inherent in the states must be compressible due to some regularity. Such compressibility is all that's meant by a *pattern* in

[21] I try to treat the word 'plurality' as a plural collective noun. (What better candidate for one?)

[22] As with "base", this usage is meant to echo, but not be the same as, that of Simons (1987), p. 357.

[23] See p. 290. I like to think of patterns as unifying and generalizing Simons' subsequently developed notion of "integrity".

the sense at play here. So any plurality whose configuration is not Kolmogorov-random is therefore patterned. (In the grip of this picture, I will use "patterned" and "compressible" interchangeably.) Given that the configuration of a composing plurality cannot be random, we see that a pattern is at least a necessary condition for composition.

Consider figure 1 as a heuristic. All pixels in this image take one of 128 shades of grey, which means that it would take at most seven bits of information per pixel to reproduce the image exactly.[24] The pixels in the areas we see as the "background" had their shades determined randomly; if the image were comprised entirely of the noisy background, it would be incompressible, requiring the full seven bits per pixel to store. But there are also some easily visible areas where the pixels were *not* shaded randomly. The triangle has one uniform shade, and that shade need be specified only once over the whole region. The subtler circle repeats one very small randomly-composed area many times, and that small random chunk need only be specified once and then called as a kind of subroutine. The blob shape has the shades of all its pixels determined randomly, but over a range of only 32 shades, thus requiring at most 5 bits per pixel. Finally, the square is composed of eight possible small solid chunks, arranged randomly. To specify its pixels requires specifying the possible eight solid chunks, and then the random ordering in which those chunks come.

(This image illustrates the patternist answer to our epistemic questions above. That we can so easily isolate the triangle in figure 1 from its background, or a table from its surroundings, is *prima facie* evidence that the triangle and table have enough of a summarizing pattern for our heuristic-hungry little brains to grasp.)

So far I have only argued that the presence of a pattern in this sense is a necessary condition for composition. But other interesting necessary conditions, which together may be sufficient, all follow from one rough guiding principle, which I call the Patternist Ontological Principle:

[24]Each "bit" of information is basically a yes-no answer—in this case, one for each of the seven independent base properties assumed earlier. There would also be some computational overhead for header information like image size and such.

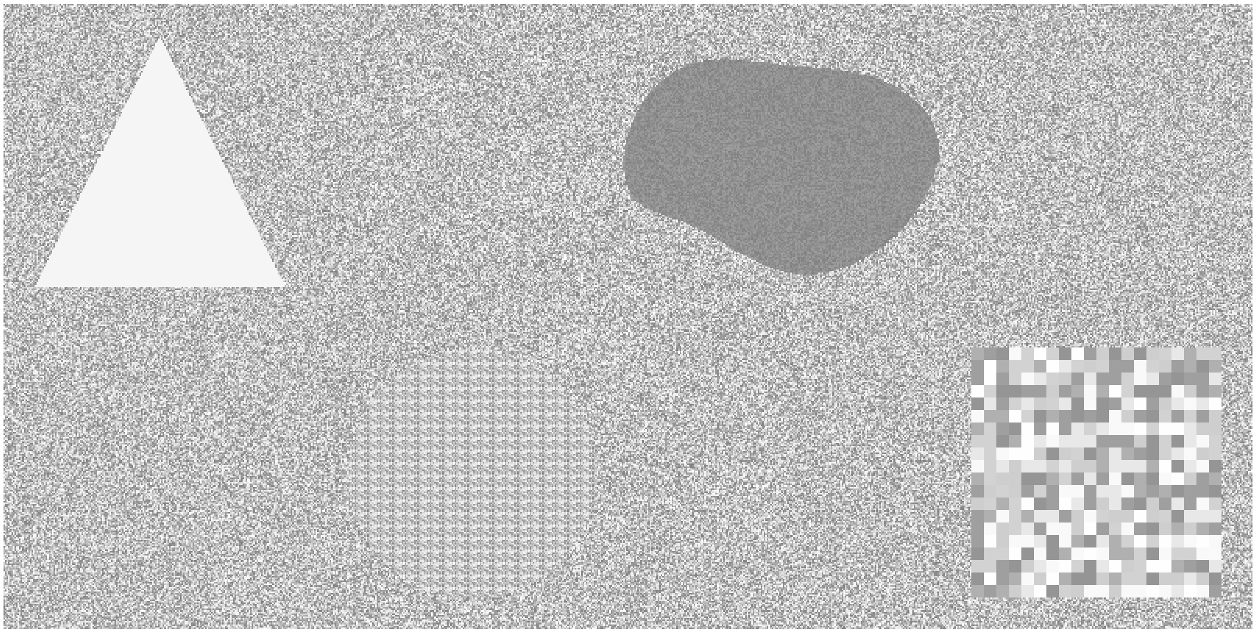

Figure 1: Some compressible regions against a random background.

(POP) There is only ontological *gain* where there is gain in pattern.

More formally: to compose, a compressible region must be referenced by the best compression of the totality in which the region resides.

To the extent that this notion of pattern coincides with simplicity, we have the corollary that there is only ontological gain where there is gain in simplicity.

This principle may now seem too vague in the informal version, and too abstruse in the more formal version. It will make more sense as we look at its key applications. I'll first give the more ambitious ontological view, and then return briefly to the epistemic questions.

Undetached parts, arbitrary differences, and maximality

Suppose that on our (putative) table, and near our (putative) Robin, there is also a (putative) lump of clay, well-kneaded by much philosophical work. The clay plausibly has a certain kind of internal structure—enough of a regularity to make it different from wood or bone, and to allow compressing its configuration. If so, the plurality in the region containing the lump of clay are eligible for composing an object by patternism's lights.

Robin removes some chunk of this clay, setting it aside, and now we would normally say we have two lumps of clay where we used to have one. But nothing relevant changed about the internal patterned structure of that separated lump—it was just transported some distance away. So it seems we should say it was a clay lump all along, even while attached to a bigger one. In general, if a region has a uniform pattern over it, it will also have that pattern over (sufficiently large) sub-regions, and so from what's been said so far it seems patternism should countenance each such sub-region as another thing. Patternism thus seems to endorse too many arbitrary undetached parts.[25] Figure 2 illustrates the situation in our abstract pixel world: in the circle on the left, the plurality in the subregion outlined with dashes are also compressible, and so patterned in our sense.

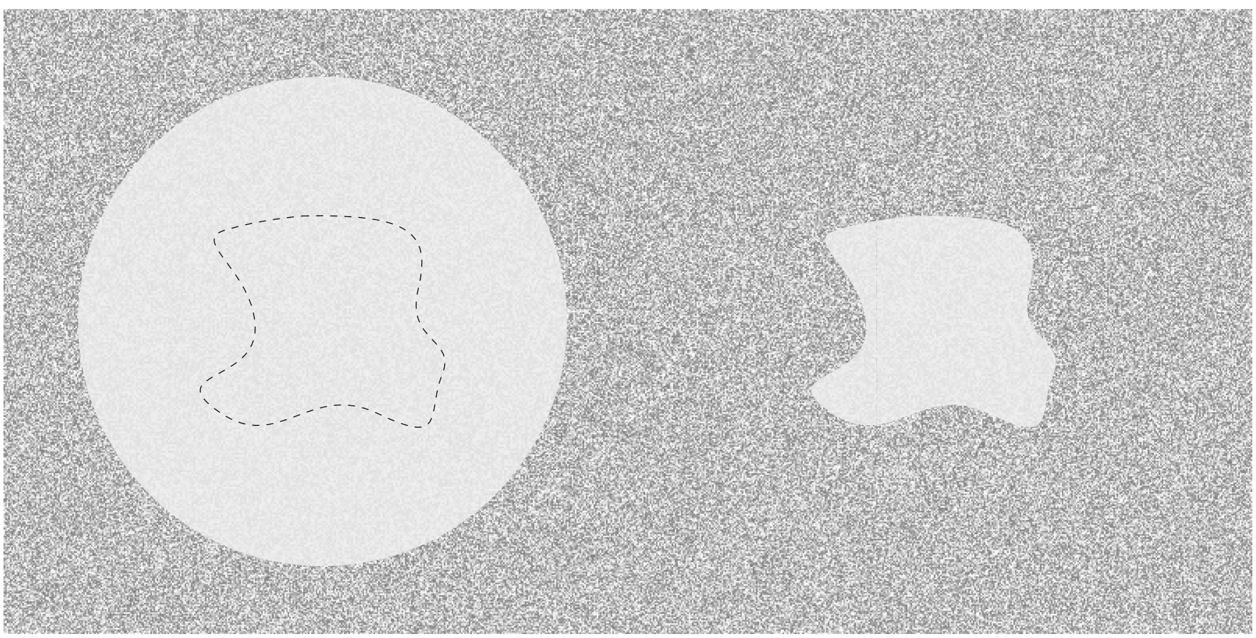

Figure 2: An undetached part?

Of course no good compression algorithm of the image in figure 2 would compress the dashed subregion separately from the rest of the circle; that would involve unnecessary computational overhead in specifying the shape of the subregion and such, when the entire circular region

[25]Though it would not endorse the full "Doctrine of Arbitrary Undetached Parts" from van Inwagen (1981), since small enough subregions will not have enough of the pattern to be compressible.

could be compressed by the same pattern wholesale. The formal version of POP says that "to compose, a compressible region must be referenced by the best compression of the totality," and since the best compression of the whole image would not reference the outlined subregion, the outlined subregion does not compose something. Put less formally: since there is no total compression gain in treating the lumpy subregion separately, there is no ontological gain there either. Thus composing is what Sider (2001) would call a *maximal* property of a plurality, because large subpluralities of a composite do not themselves make up composites. Put another way, POP seems to imply this maximality principle:

> **(POP-Max)** If the same pattern over a region R can be extended to a larger region S (that contains R), then the plurality in R do not compose anything. (The more formal details are best saved for a long footnote.[26])

This application of POP effectively legislates against arbitrary mereological differences.

Such a maximality clause can provide the needed "selection principle" to solve Peter Unger's Problem of the Many.[27] Unger worries that there will always be too many candidates for "the" clay lump, since there will be many surface particles that could plausibly be considered either part of the lump or tiny foreign debris. But according to POP-Max, a clay lump minus a few surface base particles that could count as part of the lump is not also a clay lump,

[26] Let rr be the base plurality over region R, and let $K(rr)$ be the Kolmogorov complexity of the configuration of plurality rr—that is, the length of the shortest input to a reference universal Turing machine U required to output that configuration. U is normally understood to take inputs encoding the Turing machine (or "program") to emulate, and the input to that emulated machine, as (p, n). Let $P(rr)$ be the shortest p such that $U(p, n)$ returns the configuration of R, where the length of (p, n) is minimal (that is, $K(rr) = |(p, n)|$). This shortest such TM that most compresses the rr is thought by Kolmogorov complexity theorists to represent what I am calling the "pattern"; the n represents the noise. So as a first pass, we want to say that if for some region S containing R, $P(ss) = P(rr)$, then the rr do not compose anything.

There is a complication here, though, because one part of the regularity of a region can be its *shape*. Thus a perfectly spherical region embedded in an irregular clay lump will have not just the clay pattern, but also the comparatively regular sphere pattern. This added regularity will show up in the "pattern" part of the encoding for its configuration, and so the "same pattern" will not extend to the totality. The fix for this is to factor out the region specifications by looking at the *conditional* Kolmogorov complexity. Thus let $K(R)$ be the Kolmogorov complexity of specifying just the region R, without its plurality and their properties. Then $K(rr|R)$ is the complexity of the configuration conditional on its region specification, and the proper statement is this: if for some region S containing R, $P(ss|S) = P(rr|R)$, then the rr do not compose anything.

[27] Unger (1980).

because it is not maximal. Contrast van Inwagen's answer to this problem, which relies on vagueness in which pluralities form a life, and commits him to accept both that "for any *xx*, those *xx* are not the simples that compose me" *and* that "the simples that compose me collectively weigh about 68 kilograms."[28]

This is good progress toward our target notion of composition. You may have noticed, though, that this application of POP has an odd consequence: whether the plurality over a region form a composite does not depend entirely on just that plurality. Figure 2 illustrates the idea that a plurality of clay particles embedded in a bigger clay lump do not compose, but the same clay plurality *not* so embedded do. As Sider points out, border-sensitive properties are not intrinsic; whether some plurality count as a composite depends on what else is nearby. Thus being a composite—an "object"—is not an intrinsic matter according to patternism, and this may be some theoretical cost.

Still, such maximality only makes sense if we wish to deny the Doctrine of Arbitrary Undetached Parts while at the same time allowing for uniform composites (like the lump of clay). And it is further consolation that though being a composite is not an intrinsic property, it is what we might call a *local* property: whether the *xx* compose an object cannot depend on any regions that do not contain the *xx*.

Contact, arbitrary sums, and minimality

Remember that the clay lump is sitting on a table—meaning there is one connected region that encompasses them both. Assuming that the table region's configuration is also compressible, then the configuration of the region encompassing *both* the table and clay will be compressible, and the whole region is patterned in our sense. That same table-or-clay pattern won't extend to any larger region, so it is also maximal. Thus it seems patternism must countenance a table-lump in addition to the table and the lump. Figure 3 illustrates the situation in our

[28] van Inwagen (1990) pp. 216–219.

abstract pixel world: one pattern in contact with a *different* pattern.

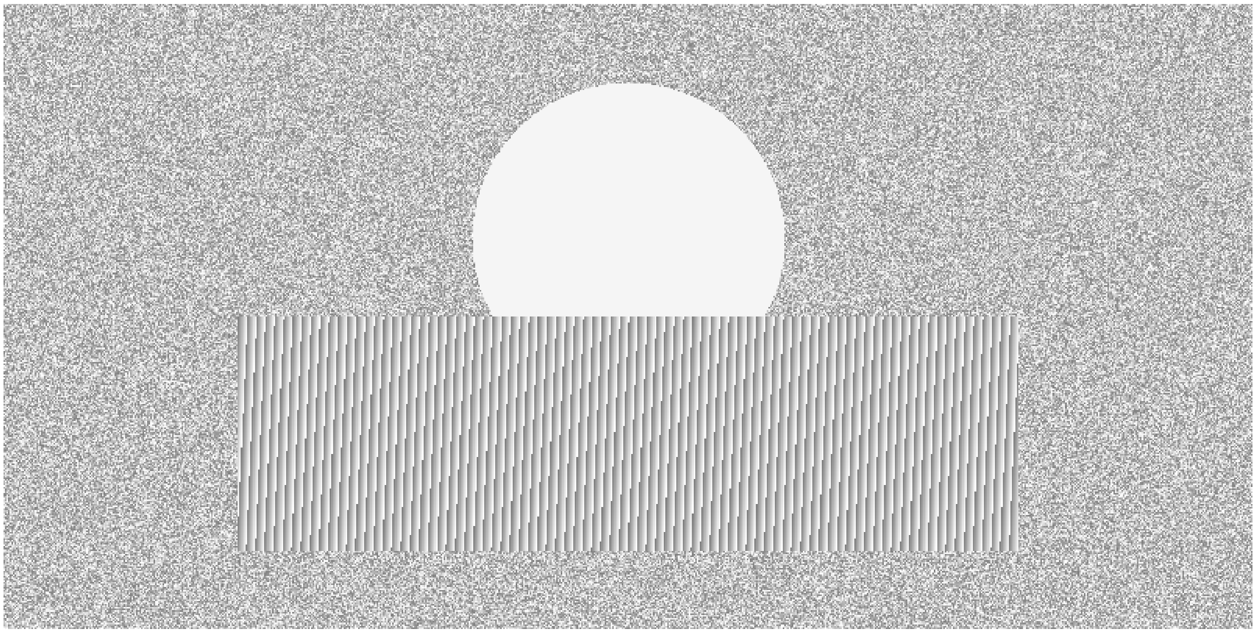

Figure 3: An arbitrary sum.

Yet the plurality occupying the table-lump region do not have enough in common with each other to make one unified, ordinary object. And POP bears this out, since presumably the best compression of the configuration over the totality involves compressing the configuration of the table region separately from that of the clay lump region. To treat them as one region would add overhead; it would be like writing a subroutine for a computer program that just called two other subroutines. In such a case it is shorter just to call each of the sub-subroutines separately from the main program.[29] Thus since the total compression would compress the configuration of the two regions separately, according to the formal version of POP the plurality of the combined region do not compose. Put less formally: since there is no total compression gain in treating the two regions together, there is no ontological gain there either.

This application of POP effectively legislates against arbitrary mereological summation of composites in contact. For composites to sum into a further composite, each must contribute

[29]Shorter, *unless* the two subroutines are frequently paired over a larger region, in which case you would gain savings. But in this case we plausibly have what I later call super-composition.

to greater compressibility of the whole. So POP implies that to form a composite, a plurality over a region must be in a certain sense *minimal*:

> **(POP-Min)** If R has a subregion that does not contribute to the compressibility of the remainder, then the plurality in R do not compose anything. (Again, formal details are best saved for a footnote.[30])

For the table-lump region, we see that the compression of the subregion that encompasses just the clay lump will not help compress the remaining table region.[31]

Non-arbitrary sums and composite parts

Though POP-Min thus rules out arbitrary summation, it does allow *non*-arbitrary summation. For example, also on the table are many wooden blocks. Tiring of the clay, Robin arranges the blocks into a neat pyramid (*à la* van Inwagen (1990) p. 43). Here it seems the pyramid is composed of the blocks, which are themselves composites. For simplicity, suppose the blocks are exactly similar cubes—so that the same pattern will describe any one of them, and only indexical details distinguish one block from another. The compressing algorithm for the pyramid's configuration can in effect call the "block" subroutine several times, passing it different arguments for the particulars of location and such. And as any programmer knows, such subroutines offer big savings in total lines of code. Figure 4 illustrates the situation in our abstract pixel world.

Each block of the pyramid is still both maximal and minimal in the senses above. Each block is minimal because any subregion of the block large enough to have a compressible

[30]Suppose S is a subregion of R. Let $R \setminus S$ be the region difference of R minus S (note this resulting region might be disconnected!), let $rr \setminus ss$ be the resulting plurality, and let $K(rr \setminus ss)$ represent the Kolmogorov complexity of that plurality's configuration. Then for the plurality of R to compose something, it must be the case that $K(rr \setminus ss) + K(ss) > K(rr)$. In other words, including the information in S must make it easier to compress the *rest* of R.

[31]More formally, if rr is the plurality over the table-lump region, tt is the plurality over the table region, and cc the plurality over the clay region, it seems $K(rr) = K(tt) + K(cc) + c$, where c is needed to perform the conjunction. Thus $K(rr) > K(rr \setminus cc) + K(cc)$, in violation of the more formal version of POP-Min. In general POP-Min implies that no composite can be partitioned into subregions $\{S_i\}$ such that $\sum_i K(ss_i) + c = K(rr)$.

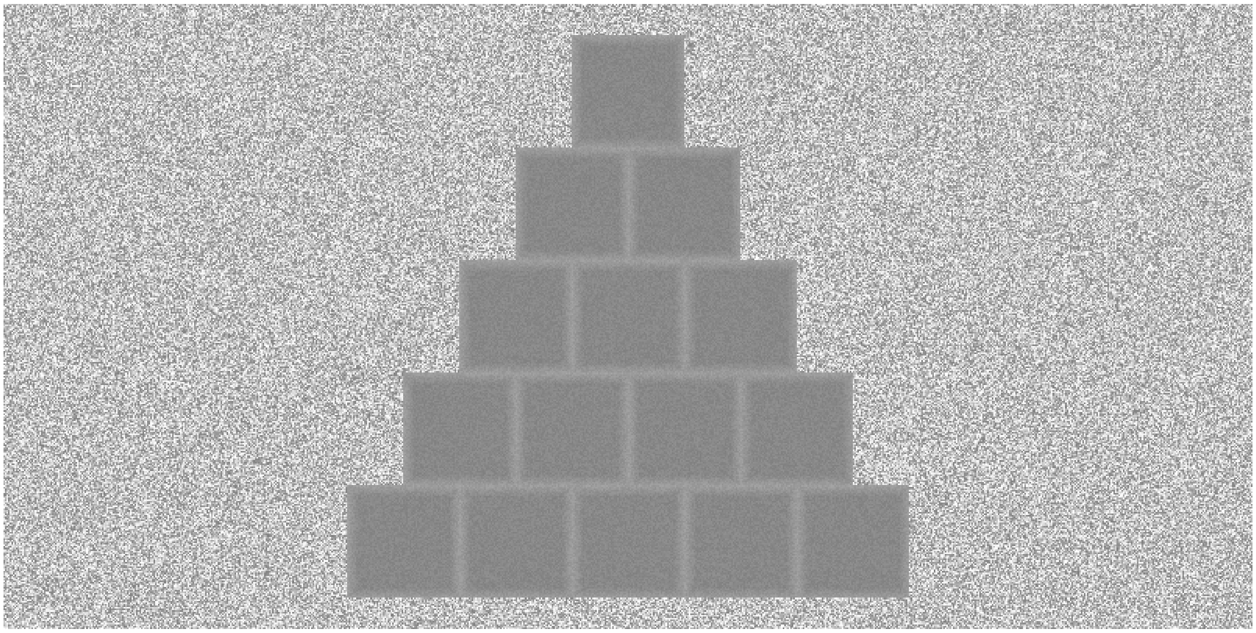

Figure 4: A composite of composites.

configuration will contain the wood pattern that can help compress the whole. It may be harder to see why each individual block is maximal, since the same wood pattern seems to extend beyond it. Basically, each block's maximality relies crucially on the *anomalous boundaries* between them. For example, we know that putting two ordinary cubical wooden blocks next to each other is not the same thing, over their combined 2x1x1 region, as one rectangular block that fills exactly that region. The configurations for the two cases will be different because of the difference along the face between the two cubes. The situation would of course be different for substances that do not form such boundaries; putting two cubes of water (not ice—water!) in contact along a face *would*, I suppose, be the same as one 1x1x2 rectangular area of water.[32]

Supposing that the block boundary is integrated enough into the block pattern to have each block counted as maximal and minimal on its own (as opposed to a case where one uniform substance is wrapped in something else), the best compression will therefore not be

[32] Note that this notion of "anomalous boundary" does not appeal to internal *cohesion*—a diachronic notion, presumably, and a problematic one for composition anyway, as van Inwagen (1990) argued. Something like cohesion may *explain* why boundaries are anomalous—or vice-versa—but I do not assume so.

"this wood pattern over this pyramid-shaped region" but rather "blocks like this, in these pyramid-forming places".

The upshot is that the blocks are non-trivial and non-basic *parts* of the pyramid; the composite blocks themselves compose something further. Furthermore, assuming that compressibility is a mark of simplicity, POP gives us this natural principle:

> **(POP-Parts)** Parts must each be simpler than wholes, but wholes must be simpler than all their parts taken separately. (A more formal argument from POP is again saved for a footnote.[33])

You may have noticed that even a jumbled pile of blocks in contact would pass the requirements for composition. Despite the disordered relative locations of the blocks in a pile, there will still be savings in calling the block algorithm multiple times. In the pyramid case, the regularity of the blocks' locations means even these details can be compressed, and thus the pattern score is still higher. If the blocks in contact are disparate enough, though, they will not qualify for composing a new thing. (They might have to be so disparate that they wouldn't all easily count as "blocks".) Then, like the table and clay (and the air and floor they touch), we simply have different things in contact. On the other hand, if the blocks in contact are fairly disparate, but their arrangement is quite regular, the savings from the arrangement may compensate enough to qualify, and so on.

In my experience some will happily say a pile of similar blocks is a composite—I suppose because it is internally similar in a way that a more sundry pile would not be. Others understandably resist the idea that such a pile might be a composite. A still less intuitive implication of patternism is that just *two* similar blocks in contact can still qualify to compose a new thing (with the individual blocks as composite parts). We specify one block by its compression, and then simply say "do that again, here instead" for the other; a program that

[33] Parts must be simpler than wholes as a simple consequence of POP: the best compression of the totality would get more for less by doing the putative whole without detailing the putative part separately. And wholes must be simpler than the sum of their parts or else we will have a non-trivial partition that violates the POP-Min formal inequality.

calls a subroutine only twice still typically saves many lines of code.[34] Van Inwagen considers this a serious objection to my view; when I proposed an early version of patternism to him, he pushed two quarters together on the table and asked me if he had just made a new thing. To answer "yes" seemed to him incredible.

I have two main responses to this concern. First, I can explain away some of the hesitation to call block piles and block pairs composites. A block pyramid probably strikes more people as a composite than a block pile does because pyramids, unlike piles, typically result from someone's deliberate intentions—and Rose and Schaffer (2015) provide good empirical evidence that just a whiff of teleology will incline us (or, at least, "the folk") toward attributing composition. But here we are considering only synchronic cases, to which the pyramid's history and future—whether intentional or accidental, functional or fruitless—is completely irrelevant. A block pyramid formed accidentally and a block pile formed accidentally both compose, on this account; the pattern score is just higher for the former, despite its equally unplanned origin.[35] I think something similar misleads the judgement about two blocks (or quarters) in contact: we may unfairly expect the resulting composite to share the rich diachronic features of its component parts.

My second response to the "two quarters" problem addresses the wider dialectic. It was only some time after hearing van Inwagen's objection that it struck me: *this from a guy who thinks there are no quarters.* Even controlling for the teleological distractions, I grant it is some cost to patternism to say that just two very similar blocks (or quarters) in contact make a new thing.[36] Though patternism rescues a good deal of commonsense, it might not

[34] As part of a *pyramid*, though, the pattern of "this block here, then that one here" extends further than any two, so when embedded within a pyramid two adjoining blocks are not maximal, and therefore do not themselves compose anything further. All blocks in *one layer* of a pyramid are likely to be maximal, though, since their best compression probably employs the more specific "blocks placed according to this *square* of locations" algorithm; the regularity of the square shape makes a more concise pattern that does not extend over the pyramid, and the best compression of the latter probably employs the former. If so, we have blocks composing layers, which in turn compose a pyramid.

[35] Whether an otherwise completely disordered pile built by careful deliberation counts as a composite will depend on the role intentions play in the diachronic account of patterns. (I suspect it will be a significant role.)

[36] In some moods, perhaps too beholden to my view, I confess I am not even willing to grant this:

perfectly capture *all* of our natural judgments about what exists. It is ultimately a *revisionary* proposal, and like most revisionary proposals in science or philosophy, we should adopt it if its theoretical virtues are worth the cost of the revision.[37] But the cost at issue here is, I think, quite cheap—especially compared to the revisionary cost of its rivals. Remember that what we're buying with this cost is a *principled* way to countenance quarters and tables, without countenancing quarter-tables. No other view will offer such a bargain.

Underview

Implicit in our original POP we now have three necessary conditions for *xx* to compose a *y*.[38] Informally summarized, they are:

1. The *xx* must be patterned (its configuration must be compressible).
2. The pattern of the *xx* must not extend to the plurality of a containing region.
3. Each patterned plurality in a subregion must contribute to the pattern of the *xx*.

Taken together, we see there are three possible results when composites come into contact:

Adjacency The composites in contact each continue to compose something, but together they compose nothing; they are merely adjacent objects. (The resulting plurality are not minimal or not maximal.) Examples: a lump of clay on a table (not minimal), or three touching blocks of a large block pyramid (not maximal).

Super-composition Each original plurality compose something, and together they compose something further. (The resulting plurality are maximal and minimal, and so are those

controlling for teleology, I want to insist that two similar-enough things in contact just *do* compose, even "pre-theoretically". It reminds me of the case Hart (1991) makes that four grains are minimally sufficient for a heap—a case Williamson (1994) calls "astonishingly plausible" (p. 213).

[37] I am taking something like wide reflective equilibrium for granted as the methodology; see for example Daniels (1979).

[38] Four, if we count the requirement for synchronic composition that it must be over a connected region of space.

of each original composite.) Examples: a pyramid of blocks, or two quarters brought together.

Merging The original pluralities no longer compose anything, but the entire plurality do compose something. (The resulting plurality's configuration is maximal and minimal, but the original composites are not.) Examples: two lumps of clay squashed together with no remaining boundary, or two piles of blocks brought into contact.

The bigger picture

Having seen its trees—if not its branches and twigs—let us now consider some forest-level issues for patternism.

Comparison to organicism

As a principled, moderate ontology, patternism's main rival is van Inwagen's organicism. We have already seen that patternism has a considerably less revisionary ontology, and that it has a more elegant solution to the Problem of the Many. Another important advantage is its handling of *vagueness*—a problem that threatens any moderate ontology. When exactly, for example, do two clay lumps merge to become one? Or, for a synchronic example, where is the boundary of the circle in figure 5, which gets progressively more random in distance from the center? Van Inwagen's costly solution to such problems is to embrace vague composition, and thus to accept that existence itself is vague. Patternism, on the other hand, provides principled sharp cutoffs to composition, and thus to existence. Either the configuration of a plurality over a region meets the compression criteria or it doesn't. Of course, we can't always be in a position to *know* when composition has taken place, and so there is still room for "epistemic" vagueness in the style of Williamson (1994).

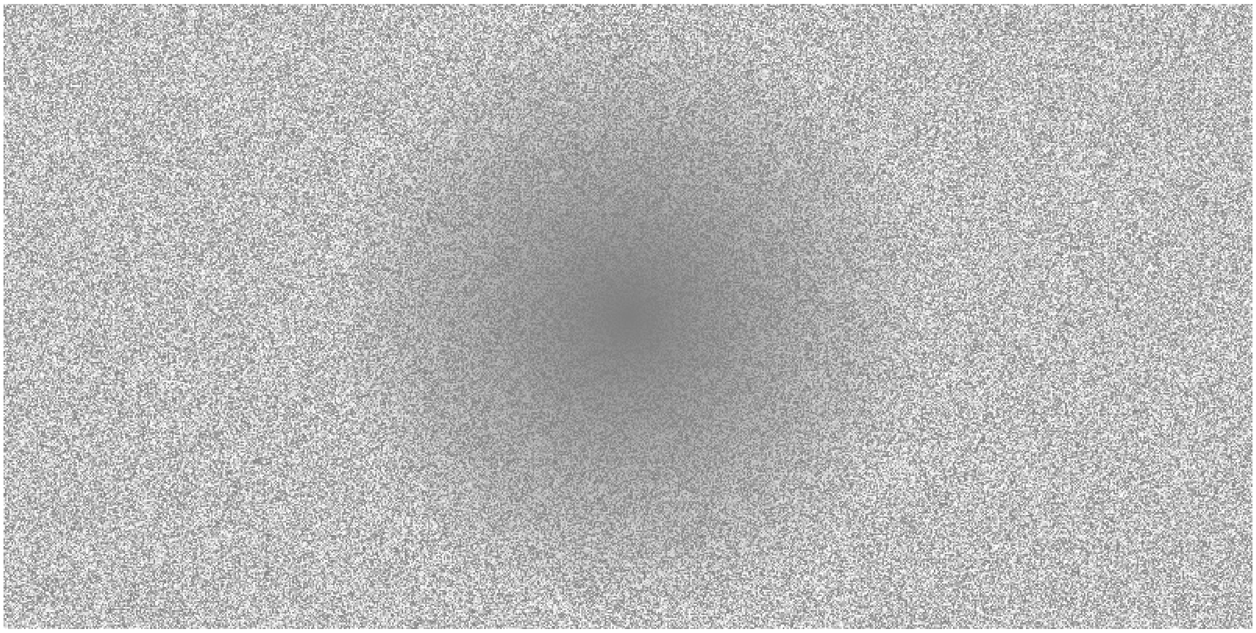

Figure 5: A vague circle?

But the conceptual distance moved from organicism to gain these advantages is not so far. As van Inwagen is well aware, it is difficult to give necessary and sufficient conditions for 'life'—but surely life involves some kind of self-*organization*, and thus patterning. If we push the principles that led van Inwagen to life as the key criterion, it begins to look like patterns in my sense would do better to fit van Inwagen's bill. Consider, as one indicative point on a slippery slope, the simple self-maintaining robots to which van Inwagen seems committed.[39] The spectrum of life-like self-organization seems to be along a certain kind of resistance to thermodynamic entropy—"negentropy", as Schrödinger put it in his definition of life.[40] From there it is a short conceptual hop to the synchronic state of negative *information-theoretic* entropy over a region, which basically just is compressibility, and so pattern.

[39] van Inwagen (1990) p. 138.
[40] Schrödinger (1945).

Coincidence neutrality

Next I must confess to some deliberate ambiguity in the patternist criteria for composition. As it stands, the criteria could apply to a plurality, or to a plurality *plus* a candidate pattern. This matters because it is possible for more than one pattern to satisfy the criteria for the same plurality and region—such as a statue pattern and a clay lump pattern. We would like to know whether there can be coincident objects, and patternism is neutral on this question.

It seems to me that from here we could choose whether to say the *xx* in a connected region compose an object *for each* pattern meeting the criteria, or if there is *at least one* such pattern. In the first option, we commit to allowing two things in one place, and roughly speaking what results is a kind of Aristotelian hylomorphism—an object is a form as realized in prime matter. In the synchronic case, consider a clay sphere; it could be compressed adequately like any clay lump, or it could be compressed better with the more specific pattern of being spherical. Since the *xx* have both the lumpy and spherical "forms", they compose two things. On the other option, a plurality can compose at most one object, and different compressing patterns provide two compatible and relatively central *properties* of the ordered plurality: the "lump" property and the "spherical" property. Both options have well-known advantages and disadvantages.

New work for a theory of patterns

I have argued that an algorithmic theory of patterns can provide a natural criterion for when pluralities are organized in the right way to compose an object. This criterion promises to capture and even explain much of our everyday ontological judgments, give principled answers to puzzles such as the Problem of the Many and vagueness in composition, and supply an account of how wholes can be more than the sum of their parts.

I suspect an algorithmic theory of patterns has potential for many other, related problems;

here I'll mention two. First, as above, it plausibly formalizes inference to the best explanation and Ockham's razor; indeed it is already used this way in some AI work. Second, it could underwrite a unificationist theory of what explanation *is*, because we can take data unification roughly to be data compression.[41] Related philosophical fruits hang tantalizingly close to these. Given how often philosophical views appeal—explicitly or implicitly—to patterns, it is worth exploring whether a precise theory of them can serve to make those views more precise as well.

References

Baum, Eric B. 2004. *What Is Thought?* MIT Press.

Bennett, Charles H. 1988. "Logical Depth and Physical Complexity." In *The Universal Turing Machine: A Half-Century Survey*, edited by Rolf Herken, 1995 edition, 207–36. Oxford University Press.

Bennett, Karen. 2011. "Construction Area (No Hard Hat Required)." *Philosophical Studies* 154 (1): 79–104.

Cartwright, Richard. 1975. "Scattered Objects." In *Analysis and Metaphysics*, edited by Keith Lehrer, 153–71. Dordrecht-Holland: D. Reidel Publishing Company.

Chalmers, David J. 2009. "Ontological Anti-Realism." In *Metametaphysics: New Essays on the Foundations of Ontology*, edited by David J. Chalmers, David Manley, and Ryan Wasserman, 77–129. Oxford University Press.

Chalmers, David J., David Manley, and Ryan Wasserman, eds. 2009. *Metametaphysics: New Essays on the Foundations of Ontology.* Oxford University Press.

Churchland, Paul M. 1995. *The Engine of Reason, the Seat of the Soul.* 1996 edition. MIT

[41] See Kitcher (1989) for unificationist explanation.

Press.

Clark, Andy. 2015. *Surfing Uncertainty: Prediction, Action, and the Embodied Mind.* Oxford University Press.

Correia, Fabrice, and Benjamin Schnieder, eds. 2014. *Metaphysical Grounding: Understanding the Structure of Reality.* Cambridge University Press.

Daniels, Norman. 1979. "Wide Reflective Equilibrium and Theory Acceptance in Ethics." *Journal of Philosophy* 76 (5): 256–82.

Dennett, Daniel C. 1991. "Real Patterns." *The Journal of Philosophy* 88 (1): 27–51.

Friston, Karl, and Klaas E. Stephan. 2007. "Free-Energy and the Brain." *Synthese* 159: 417–58.

Friston, Karl, Francesco Rigoli, Dimitri Ognibene, Christoph Mathys, Thomas Fitzgerald, and Giovanni Pezzulo. 2015. "Active Inference and Epistemic Value." *Cognitive Neuroscience* 6 (4). Routledge: 187–214.

Goodman, Nelson. 1954. *Fact, Fiction, and Forecast.* Fourth edition (1983). Harvard University Press.

Grünwald, Peter D. 2007. *The Minimum Description Length Principle.* MIT Press.

Grünwald, Peter, and Paul Vitányi. 2004. "Shannon Information and Kolmogorov Complexity." Online; last accessed 7 June, 2010 from http://de.arxiv.org/abs/cs.IT/0410002.

Hale, Bob, and Crispin Wright. 2009. "The Metaontology of Abstraction." In *Metametaphysics: New Essays on the Foundations of Ontology*, edited by David J. Chalmers, David Manley, and Ryan Wasserman, 178–212. Oxford University Press.

Hart, W. D. 1991. "Hat-Tricks and Heaps." *Philosophical Studies* 33: 1–24.

Haugeland, John. 1993. "Pattern and Being." In *Dennett and His Critics*, edited by Bo

Dahlbom, 53–69. Cambridge: Wiley-Blackwell.

Hirsch, Eli. 2009. “Ontology and Alternative Languages.” In *Metametaphysics: New Essays on the Foundations of Ontology*, edited by David J. Chalmers, David Manley, and Ryan Wasserman, 231–59. Oxford University Press.

Hutter, Marcus. 2005. *Universal Artificial Intelligence*. Springer.

Johansson, Ingvar. 1998. “Pattern as an Ontological Category.” In *Formal Ontology in Information Systems*, edited by Nicola Guarino, 86–94. IOS Press.

———. 2004. *Ontological Investigations*. ontos verlag.

Kitcher, Philip. 1989. “Explanatory Unification and the Causal Structure of the World.” In *Scientific Explanation*, edited by Philip Kitcher and Wesley C. Salmon, XIII:410–505. Minnesota Studies in the Philosophy of Science. Minneapolis: University of Minnesota Press.

Korman, Daniel Z. 2011. “Ordinary Objects.” In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Winter 2011. http://plato.stanford.edu/archives/win2011/entries/ordinary-objects/.

Ladyman, James, and Don Ross. 2007. *Everything Must Go: Metaphysics Naturalized*. 2009 edition. Oxford: Oxford University Press.

Li, Ming, and Paul Vitányi. 2008. *An Introduction to Kolmogorov Complexity and Its Applications*. Third. New York: Springer.

McDaniel, Kris. 2009. “Ways of Being.” In *Metametaphysics: New Essays on the Foundations of Ontology*, edited by David J. Chalmers, David Manley, and Ryan Wasserman, 290–319. Oxford University Press.

———. 2013. “Degrees of Being.” *Philosophers’ Imprint* 13 (19): 1–18.

Rose, David, and Jonathan Schaffer. 2015. “Folk Mereology Is Teleological.” *Noûs* 49 (3).

http://dx.doi.org/10.1111/nous.12123.

Ross, Don. 2000. "Rainforest Realism: A Dennettian Theory of Existence." In *Dennett's Philosophy: A Comprehensive Assessment*, edited by Don Ross, Andrew Brook, and David Thompson, 147–68. MIT Press.

Schrödinger, Erwin. 1945. *What Is Life?: The Physical Aspect of the Living Cell.* Cambridge University Press.

Sider, Theodore. 1993. "Van Inwagen and the Possibility of Gunk." *Analysis* 53 (4): 285–89.

———. 2001. "Maximality and Intrinsic Properties." *Philosophy and Phenomenological Research* 63 (2): 357–64.

Simons, Peter. 1987. *Parts: A Study in Ontology.* 2003 edition. Oxford University Press.

Solomonoff, R.J. 1960. "A Preliminary Report on a General Theory of Inductive Inference." V-131. Cambridge, Mass.: Zator Co.; Air Force Office of Scientific Research.

Thomasson, Amie L. 2009. "Answerable and Unanswerable Questions." In *Metametaphysics: New Essays on the Foundations of Ontology*, edited by David J. Chalmers, David Manley, and Ryan Wasserman, 444–71. Oxford University Press.

Unger, Peter. 1980. "The Problem of the Many." *Midwest Studies in Philosophy* 5 (1): 411–68.

van Fraassen, Bas C. 1980. *The Scientific Image.* Kindle edition. Oxford University Press.

van Inwagen, Peter. 1981. "The Doctrine of Arbitrary Undetached Parts." *Pacific Philosophical Quarterly* 62: 123–37.

———. 1990. *Material Beings.* 1995 edition. Ithaca NY: Cornell University Press.

Varzi, Achille. 2014. "Mereology." In *The Stanford Encyclopedia of Philosophy*, edited by

Edward N. Zalta, Fall 2014. http://plato.stanford.edu/archives/fall2014/entries/mereology/.

Williamson, Timothy. 1994. *Vagueness*. 1996 edition. Routledge.

Zimmerman, Dean W. 1996. “Could Extended Objects Be Made Out of Simple Parts? An Argument for ‘Atomless Gunk’.” *Philosophy and Phenomenological Research* 56 (1): 1–29.