Formal Causes for Powers

Penultimate draft

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§1. Causation, Powers and Explanation

Here's a story about causation that will surely sound familiar:

> The Aristotelian teaching of causes lasted in the official Western culture until the Renaissance. When modern science was born, formal and final causes were left aside as standing beyond the reach of experiment; and material causes were taken for granted in connection with all natural happenings—though with a definitely non-Aristotelian meaning, since in the modern world view matter is essentially the subject of change, not 'that out of which a thing comes to be and persists'. Hence of the four Aristotelian causes only the efficient cause was regarded as worthy of scientific research. (Bunge 1959: 32).

This account is surely oversimplified, and most likely any historian of science will protest that it does not reflect the actual practice of modern science. However, it is a much more accurate depiction of what *philosophers,* both modern and contemporary, believed happened with the advent of modernity– normally equating efficient causation with mechanical causation, and causal explanation with mechanical explanations. That the equation of causation with efficient causation was widespread to the point of being commonsensical is nicely illustrated by Hume, who attacking efficient causes (billiard balls hitting each other, and so on) is confident to have dismantled causation *tout court*.

Unfortunately, it turns out that we do need other kinds of explanations in our scientific practice; in particular, traces of the much maligned final explanation appears in many of the special sciences, and the very way we speak of laws of nature betrays this fact. The only problem is that the metaphysics elaborated in the meanwhile – in particular, our current received neo-Humean metaphysics, *really* struggles to make sense of final explanations and final causes. Final causes are just hard to square with the view that the world is nothing but a mosaic of discrete, unrelated particular matters of fact.

On the other hand, a metaphysics admitting irreducibly dispositional properties (powers) seems well suited to ground teleological explanations because it can provide a metaphysical correlate to the *telos* in the explanation. Friends of powers often speak of powers being *directed towards* something – their manifestations, what the power are *for*. It is relatively easy, then, to provide a realist theory of final explanations within such metaphysics, because there are obvious candidates to play the role of final causes – the 'what for the sake of which' *just is* the manifestation of the relevant power(s). Efficient

causal explanations, on the other hand, would be grounded in the powers themselves: they are the 'whence the source of change'.

Insofar as i) final explanations are required by our best scientific theories, ii) power metaphysics does a better job in grounding them, and iii) we want to be realist about explanation, we have a good *naturalistic* argument in favour of this metaphysics over its Humean foil.[1] None of these points is beyond dispute. Since defending it is not the aim of the paper, we are happy to just assume that powers can rehabilitate and ground final explanations. What interest us here are these two rather natural follow-up questions:

1) Do we also need *other* kinds of causal explanation, beside efficient and final?
2) If yes, can we ground these in a metaphysics of powers just as naturally as we did for final causes? In short: are powers *better* grounds for other kinds of explanations, too?

Now, there are a number of ways to go about answering 1). The meticulous route would be to take a look at least at the current scientific practice, detect whether other kinds of explanations are employed, whether these explanations can be eliminated or would be redundant in a better or ideal scientific practice, and only then make a pronouncement. This would be a rigorous methodology, but also, crudely put, a lot of work. In this paper, we will try to take a heuristic shortcut.

The notion of final causation was prominent in the Aristotelian tradition. But, as Bunge noted, the Aristotelian theory of causal explanation is considerably richer, and is not limited to efficient and final causes: it also includes the 'out of which', normally referred to as 'material cause', and the 'what it was to be', later[2] called the 'formal cause'. Our plan is, therefore, to start from Aristotle's richer conception, examine these other ready-made kinds of explanation, and ask ourselves whether they are intelligible and useful – and, in such case, adopt them.

One needs to be careful when importing notions from a different philosophical system: they might not be an easy fit. This is the case also (perhaps, especially) when the import is from the Aristotelian doctrine onto a so-called 'Neo-Aristotelian' framework. Therefore, it is not obvious that we can just take Aristotle's notion of various kinds of *aitia*, translate them, and just plug them in. Nevertheless, we think that in this case the enterprise is legitimate, because we think that our project (answering questions 1. and 2.) is the same kind of operation that Aristotle's *aitia* were meant to perform. We take it that Aristotle used *aitia* to mean, first and foremost, what answers a determinate

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[1] Needless to say, the argument is not conclusive, nor the only reason for accepting a metaphysics of powers over a neo-Humean mosaic; it does not even need to be the main reason for believing in powers. One might be moved by metaphysical reasons (e.g. rejection of quidditism. Mumford 2004), or simply by the fact that powers allow us to better understand efficient causal explanations (Mumford & Anjum 2011), or certain scientific practices (e.g. the analytic method. Cartwright 1999, Cartwright & Pemberton 2013). Theory choice is always tricky, and especially so in metaphysics, and it is hard to come by master arguments for one theory over the other. That being said, it does seem that an argument along these lines carries some weight.

[2] Aristotle spoke of 'four modes into which cause falls' (*Phys.* II 3 195a15), rather than 'the X cause'.

kind of *why-question*: explanations. That's why his preferred expressions to refer to them are such as 'that for the sake of which', 'whence the source of change', etc.[3] However, Aristotle was a *realist* about causal explanation. So, there cannot be a causal explanation which is not grounded in some entity in the world – in a bit of the metaphysics. Why-questions are answered by pointing at things out there in the world: for Aristotle, not only events or states of affairs, but also substances, matter, ideas, etc. Thus, by 'formal cause' we mean what grounds a formal explanation: what we can point at when we give a formal explanation. And this is exactly what we aim to do, too. We first consider an answer to a determinate kind of why question (a formal explanation) and then ask ourselves whether a metaphysics of powers has what it takes to ground such explanation: whether it can be the thing we point at in giving the explanation.

This heuristic strategy is not in competition with the more rigorous one, and indeed if we end up admitting also material and formal explanations in our conceptual repertoire it does not mean that there cannot be *further* explanations that we need to take into consideration.[4] In particular, in this paper we will be interested in *formal explanations* and *formal causes*. It goes without saying that if we could show that i) we need formal explanations and ii) powers do a good job at providing a realist account of them, it would be a point for powers. If we could, furthermore, show that powers do a better job than a Humean metaphysics at it, we would thereby have provided another argument for adopting an overall metaphysics of irreducible dispositional properties. We will not be so ambitious here, though, and will be content to ascertain whether we need anything like formal explanations, and whether these can be grounded in powers. There is another preliminary question that we need to address before taking on the task. Even without a worked-out theory, or even from the point of view of the modern received view that ruled them out as nonsensical and misguided, it was quite obvious how final explanations were supposed to look – what Aristotelians used to say and moderns used to reject. We all can think of examples of both (supposedly) good and (surely) bad teleological explanations: 'mammals have lungs so that they can breath', or 'the sun rose today so that I could get a tan'. So, the job was just to rehabilitate them and ground them in a metaphysics of powers. We have to confess that we are much less clear about what formal explanations are supposed to be – what the canonical examples of good and bad formal explanations are. Understandably, this makes the rehabilitation rather hard. Therefore, we will devote the rest of the paper at answering the following three questions:

A. What is Formal Causation? That is, what is formal causal explanation?
B. Do we *need* Formal Causation?

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[3] τὸ τίνος ἕνεκα and ὅθεν ἡ ἀρχή τῆς κινήσεως, respectively.

[4] Take, for instance, the non-causal 'explanations by constraint' which Lange (2017) talks about. Evidently, these are not the kind of 'formal explanations' that we will be concerned with here – although there might be some overlap. Take, for instance, one of Aristotle's classic examples of formal causation: the octave. The formal cause of the octave is 'the ratio 2:1, and in general number' (*Meta.* V. 2 1013a24-9). In cases like this, perhaps there are points of contact between the Aristotelian 'formal causes' and Lange's 'non-causal explanations'. This would, admittedly, make it harder to ground Aristotelian formal explanations upon causal powers.

C. Does formal causation need powers? Can it be grounded in powers?

§2. What is a Formal Explanation?

The first step we need to make is to figure out what, exactly, formal causal explanations are supposed to be according to Aristotle. The most thorough treatment of the four causes can be found in the second book of the *Physics*. There he writes:

In another way, the form or the archetype, i.e. the definition of the essence, and its genera, are called causes (e.g. of the octave the relation of 2: 1, and generally number), and the parts in the definition. (*Phys*. II 3 194b26-29).

In *Metaphysics* 5, the definition given in *Physics* II re-occurs:[5]

[We call a cause] the form or pattern, i.e. the formula of the essence, and the classes which include this (e.g. the ratio 2:1 and number in general are causes of the octave) and the parts of the formula.
(*Meta.* V.2 1013a24-9)

Finally, more briefly, in the *Posterior Analytics*:

There are four types of explanation: one, what it is to be a thing; one, that if certain things hold it is necessary that this does; another, what initiated the change; and fourth, the aim. (*APo* II 1 94a21-23).

From these passages, we can draw some preliminary hypotheses about what formal explanations are supposed to be. Formal causal explanations are unique and differentiated from the others kinds of explanation according to Aristotle, because of the prominent role that is played in them by the *definition* or *formula* of what something is (its *logos*). By 'definition' or 'formula' here Aristotle means what nowadays we call 'real definition', as opposed to the mere 'nominal definition': the definition that captures and expresses not just the *meaning* of the word used to refer to it, but what something *is*. As Locke put it: the very being of any thing, whereby it is what it is'. (1975, III, III, §15). In short, the formal causal explanations involve accounts that express *what something is*. Aristotle uses the expression τὸ τί ἦν εἶναι, which we can translate as the 'what it was for something to be', or the 'what it is to be'; more commonly, however, it is just translated as the 'essence' – and since this is also the expression present in the contemporary debate, we will stick to 'essence'. So, formal explanations are characterised

[5] Differences in the two translations are due to two different translators: 'pattern' and 'archetype' both translate παράδειγμα, 'formula' and 'definition' both translate λόγος, and 'genera' and 'classes' both translate γένη.

by the fact in that essences are uniquely involved, or play a particularly key role lacking in other explanations. This will be our starting point.

There would be much more to be said from an Aristotelian point of view, of course. He had a complex account of the relationship between 'real definitions' and linguistic meaning, firmly embedded in his syllogistic and theory of demonstration (as can be glimpsed in the quotation from the *Posterior Analytics*).[6] We have also ignored the reference to natural kinds, and in particular to genus & species, that appear in his characterisation. These are connected to how Aristotle thought a real definition should look: mentioning genus & *infima species*; that is, the lowest species within the taxonomical tree to which the entity belongs. We would like to remain more neutral on how real definitions and statements of essences should be conceived. Finally, we have ignored the elephant in the definition: Aristotle's reference to *form* (*eidos*), which immediately evokes the hyleomorphic theory that can be found, for instance, in book *Z* of the *Metaphysics*. This is not accidental: we intended to pick up only on Aristotle's richer notion of causation and causal explanation, and see whether it can be plugged into a metaphysics of powers, and not rehabilitate or import other aspects of his thought. We'd prefer to remain neutral with regard to hyleomorphic theories of substance or composition (ancient or re-conditioned), and hope that formal causation does not stand and fall with *forms*. For the same reason, we will not adopt any particular theory of essence for the time being – so we will put in parenthesis whether essence is best understood as a primitive operator that selects a subset of truths (Fine 1994), as related to grounding (Fine 2015), as reducible to generalised identity (Correia & Skiles 2017), or something else. We will speak simply of some sentence being true in virtue of the essence (identity, nature) of something, or some entity having a certain property in virtue of the essence (identity, nature) of some entity. We want to formulate formal explanation first, and *then* take a look at what essence is, and how does it fit with a metaphysics of powers. So, for the time being, we will treat 'it is essential to...' to be a primitive operator of our language. We will return to this later.

So, what are formal explanations? We take it that a key point of Aristotle's theory of four causes is that different accounts of the very same *phenomenon* can be given, and that this means that the same *explanandum* has to occur in each different explanation. Typically, in asking and giving causal explanations we now take the occurrence of an event[7] as *explanandum*: why did *e* (rather than *e**) occur? It is not very easy to square talk of events with formal (and material) causes, though, so we will assume that the explanandum has the form of 'x is F because': when we ask a why question, after all, we want to know why some entity is the way it is.

The minimal hypothesis states that, in order to make it a formal explanation, *essence* must figure prominently in the *explanans*. This is not enough to give us a first schema, though. At least two points

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[6] See for instance Charles 2000 for an in-depth treatment of these issues.

[7] Or states of affairs, processes, etc.: whatever *goes on* in the world in the preferred ontology. Talk of events in what follows is a mere placeholder. We are not committed to an event ontology, nor should the friend of powers be.

are still unclear: first, the essence of what? Second: what is the relation between the F to be explained and essence?

As to the first question, Fabrice Correia (2006) distinguished between *objectual* and *generic* essence. Objectual essence is, perhaps, the more familiar one, and surely the one to which contemporary philosophers have devoted most of their attention: the concept of essence is traditionally associated with questions of the form "What is *a*?", where "*a"* is a singular term like "Socrates" or "the Moon"' (Correia 2006: 753). But this should not overshadow the fact that there is another important and common question that can be asked concerning essence: "'What is it to *F*?", where "*F"* is a predicate expression like "be a human being", "be wise", "think", or "be related as father to son"' (Correia 2006: 754). We can then individuate two kinds of essentialist statements: 'an objectual statement is one which states that a given object is by its very nature so and so, and a generic statement is one which states that to be thus and thus is essentially to be so and so' (*Ibid.*).[8]

This distinction allows us to formulate three schemata for formal explanation.

1. Objectual: 'x is F because it is essential to x to be F'.
2. Generic: 'x is F because i) x is G, and ii) it is essential to the Gs that they are Fs'.
3. Mixed: 'x is F because i) it is essential to x to be G, and ii) it is essential to the Gs that they are Fs'

We have construed the three schemata maintaining an identity between the subject of the explanandum and the subject of the explanans: this seems the most natural reading of an explanation that purports to involve the 'what it is to be' of the thing. Note, however, that nothing prevents us including also *other* entities in the explanans: for instance, the following seems a perfectly good mixed formal explanation: 'Sam is human' because i) Sam's father, John, is human, ii) It is essential to Sam that she was fathered by John, iii) it is essential to humans that they can only generate other humans ('man begets man', as Aristotle repeats over and over). It is less clear whether the explanans may fail to make reference to the subject of the explanandum. For simplicity's sake, we will stick only to cases where the same entity appears on both sides of the *because*.

If the first distinction concerned what kind of entities could be the argument of the essentiality operator – that is, what kind of thing could saturate the expression 'it is essential to ... that *p*' or 'it is true in virtue of the nature of ... that *p*', the second distinction concerns how the operator should be read: what is the relationship between the essence and the property or state of affairs in the explanandum. Kit Fine distinguished between *constitutive* and *consequential* essences: 'An essential property of an object is a constitutive part of the essence of that object if it is not had in virtue of being a consequence of some basic essential properties of the object; and otherwise it is a

[8] Correia (2013) introduced a third kind of essentialist statement, dubbed 'alethic' (or, in Correia & Skiles 2017, more aptly, 'factual'), which takes *facts* as arguments: examples would be 'it's essential to Socrates's being a human that he be a rational animal'. To keep things simple, in what follows we will ignore this further distinction.

consequential part of the essence' (Fine 1995b: 57). That constitutive essences are not closed under logical consequence was the lesson of *Essence and Modality*, after all.[9] For instance, it is true in virtue of the constitutive essence of Socrates that Socrates is human, but it is *not* true in virtue of the constitutive essence of Socrates that Socrates is either human or is not human, or that Socrates is human and everything is self-identical – these are cases of consequential essence only. Constitutive essence is thus the primitive term, and consequential essences are defined from it.[10]

Before crossing the two distinctions and generating a matrix of formal explanations, we should note that Fine identifies the distinction between constitutive and consequential essences with the Aristotelian and Scholastic one between essence and *propria* (or *idia*) – that is, the features that are not, properly speaking, parts of the essence of an entity, but that belong to it both uniquely and necessarily. To use the Aristotelian example, the essence of man is to be a rational animal. However, man is also the only animal capable of humour – a feature that *follows* from his essence as rational animal, but is not included in it, because real definitions are formulated along the lines of genus+*infima species*, and humorous animal is not a species. However, it is not obvious that Fine's distinction really maps the Aristotelian one. Consequential essence, defined as the logical closure of constitutive essence, includes logical truths: if *p* is part of Socrates' constitutive essence, so will *p* & ¬(q&¬q), etc. But it is hard to envision how humans having a sense of humour is a logical consequence of them being rational: it is surely not a logical truth. The only way in which it could follow logically from the essence of humans that they have a sense of humour is this: the constitutive essential truth of humans is a conjunction that has having a sense of humour as a conjunct. But *that*, it seems to us, would make having a sense of humour part of the *constitutive* essence of humans, rather than consequential essence – in the Aristotelian picture, it would not be an *idion* anymore, but *part* of the essence proper, just like being an animal is part of Socrates's essence in virtue of being a component of his being a rational animal.[11]

The Aristotelian distinction between essence proper and *idia* (or *propria*) seems, *prima facie,* a useful one. Given that it is not properly captured by the Finean constitutive/consequential distinction, we can supplement the two canonical ways to link properties with essences with a third one:

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[9] Details on the restriction on logical consequences for constitutive essence are given in Fine (1995a)

[10] Fine, alternatively, attempts to define constitutive essence from consequential as what cannot be 'generalised away'. See Koslicki 2012 for a critique of this latter method. For the time being, we are happy to take constitutive essence to be primitive.

[11] Oderberg (2012) argues that we should sharply distinguish between something's *essence* and its essential properties, because the essence is a single, unified (and unifying) principle, whereas the essential properties are many – thus, according to him, we should not conceive of *rational animal* as a conjunction of the properties of *being an animal* and *being rational* but rather a unified whole. This move is not available to Fine, for then it would not be clear how being capable of humour could be a logical consequence of being a rational animal so conceived – even if we admit that being rational is a complex conjunctive property, whose conjuncts include being humorous, we could not derive that from the *being a rational animal*. Oderberg's rejection of 'bundle of essential properties' view and his insistence on the unity of essence derives from the hyleomorphic emphasis that *form* (and hence essence) is what unifies aggregates, coupled with the problem of complex essences – that is, the problem of what unifies complex essences (Dumsday 2010). Since we wish to remain neutral on the question of hyleomorphism, we can continue holding the mainstream 'bundle of essential properties' view.

1. Constitutive: It is part of the constitutive essence of x that p
2. Consequential: It is a logical consequence of a part of the constitutive essence of x that p.
3. *Propria*: It follows (not as logical consequence) from the constitutive essence of x that p.

At this stage it is still quite mysterious in what sense *propria follow* from constitutive essences. Oderberg (2012) adopts the Lockean expression '*flows from the essence*' to refer to the link between (constitutive) essence and *propria*. To avoid having to specify when 'follows' is to be interpreted logically or not, we will adopt the expression, too, and say that 'F follows from E' in cases of consequential essence, and 'F flows form E' in case F is an *idion*.

We now can generate a matrix combining the distinctions. However, to keep things simple, we'll ignore some combinations. We will not consider any case of consequential essence, for a start: the grounds of logical truths, and their relationship with a metaphysics of powers, would require an independent and lengthy treatment which we cannot hope to provide here – consider those to be a subset of the non-causal formal explanations that we mentioned in footnote 4. We will also assume that objectual explanations can only appeal to constitutive essences, for schemata of the form: 'x is F because F is an idion of x' is just an instance of the mixed explanation: 'x is F because i) x is constitutively G, and ii) F flows from G'. Similarly, the mixed view that reads both essential operators as propria can be reduced to the mixed view.

This leaves us with the following seven schemata for formal explanations.

1) Objectual Constitutive: x is F because it is constitutively essential to x to be F.
2) Generic Constitutive: x is F because i) x is G, and ii) it is constitutively essential to the Gs that they are Fs.
3) Generic Propria: x is F because i) x is a G and ii) it flows from the essence of Gs that they are Fs.
4) Mixed Only Constitutive: x is F because i) it is constitutively essential to x to be G and ii) it is constitutively essential to the Gs that they are Fs.
5) Mixed Constitutive-Propria: x is F because i) it is constitutively essential to x to be G and ii) it flows from the essence of Gs that they are Fs.
6) Mixed Only Propria: x is F because i) it flows from the essence of x that it is G, ii) it flows from the essence of Gs that they are Fs.
7) Mixed Propria-Constitutive: x is F because i) it flows from the essence of x that it is G, and ii) it is constitutively essential to the Gs that they are Fs.

This should give us a clearer picture of what we talk about when we talk about formal explanation. We can then move on to the next question: do we need (any of) them?

§3. Do we need formal explanations?

We are not going to discuss each example of formal explanation in detail. We will assume that, if at least one of these schemata is useful or needed, then we have to admit formal explanations in general as genuine, and try to ground them in our metaphysics. It does not mean that we thereby would endorse *every* schema of formal causation as legitimate. We will discuss briefly some examples, starting from objectual constitutive explanations. We will consider examples of formal explanations in philosophy first, and then some in the natural sciences.

An example of objectual constitutive explanations would be 'Socrates is human because it is constitutively essential for Socrates to be human'. Prima facie, this seems an egregiously uninformative explanation.[12] The situation changes quite dramatically, though, if we add a modal qualification to the property attributed: 'Socrates is *necessarily* human because it is constitutively essential for Socrates to be human' is an interesting, informative, and controversial statement – at least, if we reject a modalist conception of constitutive essence. Explanations like these are prominent and hotly debated in metaphysics (see Fine 1994, Lowe 2006, Hale 2013). Importantly, they are employed also by those who ultimately think they are false or misguided. These philosophers do not dispute the form of the explanation, but rather its truth. They seem genuine cases of formal explanation.

A similar kind of formal explanation seems particularly important for friends of powers, and in particulars for those who accept an unrestricted version of the principle of Independence, stating that powers cannot necessitate the occurrence of their manifestations. For instance, Mumford & Anjum (2011:58) write that 'the possibility of prevention leaves no room for any kind of necessity in causal production', and that the 'acceptance of an irreducible and sui generis tendential modality ought to be the fundamental commitment of any genuine realism about dispositions or powers... powers have to be understood as disposing toward their manifestations, as opposed to necessitating them' (Mumford & Anjum 2018: viii). It is natural to think that the principle of Independence is, according to Mumford & Anjum, itself necessary.

IND: Necessarily, powers do not necessitate the occurrence of their manifestations.

What are the grounds for that necessity? Clearly, on pain of self-refutation, it cannot be the doing of some power. But of course it is because of the kind of things that powers are that IND holds. So it is tempting to offer the following formal generic constitutive explanation:

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[12] This feeling might be dispelled. Glazier (2016), for example, insists that essentialist explanations of this kind are *ultimate,* where 'The ultimacy of an essentialist explanation consists in there being no essentialist explanation of its explanans' (Glazier 2016: 2884), and later argues that such ultimacy makes these explanations uniquely satisfying.

Necessarily, powers do not necessitate the occurrence of their manifestations because it is constitutively essential to being a power that it does not necessitate its manifestations.

We can obviously build a mixed formal explanation to justify why any particular power has that property necessarily *de re*. A similar explanation can be given to what Bird (2016) considers the key feature of powers: the fact that they have a rigid modal profile: an irreducibly powerful property has the same causal/nomic profile in all possible worlds. It seems of the utmost importance for powers metaphysicians to be able to provide explanations of this kind – unsurprisingly, explanations involving essences are used in metaphysics.[13]

In the case of empirical sciences, it is much harder to find formal explanations involving constitutive essence – as noted above, these explanations seem quite uninformative, and so it is unsurprising that they are hard to come by. 'Electrons are negatively charged because it is constitutively essential to electrons to be negatively charged' is the kind of statement that *philosophers* utter, not scientists. On the other hand, formal explanations involving *propria* play a much more relevant role. Take, for example, water and its relatively high boiling point (100º C). Why does water have that property? It does not seem to be part of the constitutive essence of water – it is normally agreed that the essence of water is just being H_2O. But we can show that water's boiling point flows from its essence as H_2O: a molecule of water is formed by two covalent bonds between the two hydrogen atoms and the oxygen atom – they share one electron. The electrons that are not shared with the hydrogen atoms tend to stay closer to the oxygen atom than the shared atoms – resulting in the familiar topological arrangement of water molecules, and thus in an uneven distribution of electrical charge across the molecule: the "top" half is charged negatively (because the non-shared electrons tend to group there) while the "bottom" half is charged positively. And the uneven distribution of charge is what allows the formation of strong hydrogen bonds between water molecules – which explains water's high boiling temperature, its surface tension, etc. So, we can formulate the following formal explanation: water has the boiling point of 100º because the constitutive essence of water is to be H_2O, and it *flows* from the essence of H_2O (via a number of intermediate steps, involving the essence of other entities, such as electrons) that water boils at 100ºC. In short, water's boiling point is not a part of its essence, but *flows* from it – it is an *idion*. Finding similar examples is quite easy, so we can conclude that formal explanations involving *propria,* both mixed and generic, are at least present also in our scientific discourse. We can then conclude that formal explanations figure both in philosophical and scientific discourses: we need them. This leaves us with the last, and most important question: how are they related to powers?

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[13] In general, philosophical analyses directed at the phenomenon itself, rather than its concept or linguistic expression (Williamson 2007), seem to allow us to generate a number of formal explanations. 'Why do I have to believe everything I know? Because knowledge is true justified belief'.

§4. Three degrees of essential involvement

Can we ground formal explanations on powers? More ambitiously: is a metaphysics of powers better placed to ground formal explanations, as it is for final ones? Formal explanations are linked with essences, so the question becomes: what is the relation between powers and essences?

We can think of three ways in which powers *can* ground formal explanations, increasingly closely intertwined. It is less clear, however, whether the link is close enough, and whether there is a fourth, even stronger relationship between powers and essences.

4.1 First Degree: Subject-matter

The first, trivial way in which powers can interact with essences and be involved in formal explanations is simply being the subject-matter whose essence is relevant for the explanation: powers can be the arguments of the essence operator. The sort of metaphysical explanations concerning Independence or the rigidity of their modal profile given above are clear examples. This would obviously make them grounds for formal explanations, in some sense. The link is rather weak, though: virtually anything can be the argument of the essence-operator, and powers *qua powers* are not doing any serious work in providing the formal explanations: it is essences that are doing all the heavy lifting, and we have no reason to think that they rely on any feature of powers. Particulars or categorical properties could play that role just as well.

4.2 Second Degree: Dispositional Essentialism

A more interesting way in which powers can be linked to essences is if some of the essential properties of particulars, natural kinds, or other properties, are powers: if at least some essences are dispositional. Familiar examples would be: the essence of electrons is to have unit negative charge and mass 9.109×10^{-31} kilograms – where both electric charge and mass are irreducibly dispositional properties. We can make the involvement more intimate and the thesis more interesting by strengthening the thesis along two axes: extending the domain of quantification and adding an exclusivity clause to the effect that *only powers* can be given by essences. At a rough approximation:

	Non-Exclusive	**Exclusive**
Weak	The essence of some entity includes powers	The essence of some entity includes only powers
Moderate	The essence of all Ks includes powers	The essence of all Ks includes only powers
Strong	The essence of everything whatsoever includes powers	The essence of everything whatsoever includes only powers

We can easily map some positions in this table: Brian Ellis' (2001; 2002) Dispositional Essentialism seems to be an instance of a moderate non-exclusive thesis: the essence of a subset of the natural kinds of substances, events, processes, and properties are dispositional properties, but the essence of both properties and substances also include structural categorical properties. Bird (2007) on the other hand holds a moderate exclusive position: the essence of all fundamental entities is purely dispositional, non-fundamental entities do not have irreducible powers as their essences (Bird 2013; 2016). Pandispositionalism can be identified with strong+exclusive.

One might be tempted to think that a relatively strong position in the matrix above, especially one endorsing the exclusivity clause, represents the kind of link between essence and powers that we were looking for, allowing us to ground formal explanations on powers. We think that this would be a rushed conclusion. Assume that pandispositionalism is true at the actual world, so that every property whatsoever is dispositional. *A fortiori*, the essence of everything will only mention powers, and therefore every formal explanation will involve only powers. This is not enough to ground *formal explanations* in itself on powers: formal explanations involve powers only because*, as it happens*, there are only powers around. It does not mean that, at other possible worlds there are categorical properties alongside powers.[14] So, at those worlds, there are formal explanations that do not involve powers. It would seem that powers' involvement in formal explanations is somewhat *accidental*: formal explanations involve essences, and *as it happens* some essences (even of some highly significant set of entities, like the fundamental ones) are powers. But that does not show that formal explanations *qua formal explanations* are linked to powers – it merely indicates that they take place in a world populated by powers. The involvement of powers in these explanations seems just a consequence of our previous independent metaphysical assumptions. Powers can be formal causes, but not really *in virtue of* being powers. If we want to properly ground formal explanations onto powers we need to establish a closer relation between what essences are and powers.

4.3 Third Degree: Flow

So far, we have been rather vague and non-committal about what it means when something *flows* from a thing's essence. We have claimed that *propria* are to be distinguished from both constitutively essential properties and consequentially essential ones. But negative characterisations can get only this far – if we want to uphold the distinction, we need to say more. Given the role that *propria* play in the kind of formal explanations used in empirical contexts, this is of paramount importance.

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[14] Fine (2005) argued that it is part of the essence of a dispositional property like mass (grounding, say, Newton's law of universal gravitation) that it is not co-instantiated with a dispositional property that would ground competing laws for the same natural phenomena (e.g. the movement of planets) such as *schmass*. Even accepting the argument (which we do not find too convincing), it does not exclude the possibility that dispositional properties could not be contingently co-instantiated with categorical properties.

We want to suggest that a metaphysics of powers might allow us to provide an account of the difference between *propria* and the other kinds of essence – that a theory of 'flowing' can be given in terms of powers. Recall: *propria* are distinct from constitutively essential properties, and are not mere logical consequences of them either. They 'follow' from constitutively essential properties in some other way. Our initial hypothesis is that, if constitutively essential properties are powers, *propria* could just be their *manifestations.*[15]

Flow: a property F flows from an essence E iff E is a power such that F is a manifestation of E.

The hypothesis promises a number of advantages. *Pace* Marmodoro (2017), we take the manifestation of a power to be distinct from the power that points at it, thus assuring that *propria* are not identical to constitutively essential properties. On the other hand, directedness relations are not mere entailments: they are genuine (causal) relations! This would allow us to substantiate the idea that there is a significant distinction between the three notions of essence. Furthermore, the link between *propria* and essences would rely on a (relatively) well-understood relation such as directedness, rather than forcing us to invoke a primitive and mysterious 'flowing' relation. Furthermore, it sits well with the examples of formal explanations concerning propria that we examined. Water's boiling point was explained by appealing to the essence of water (H_2O), the essence of its components (oxygen and hydrogen's number of electrons, and *their* essence). But, most importantly, it was the causal behaviour of the electrically charged molecules that determined water's boiling point: the fact negatively charged entities have the power to attract positively charged and repel negatively charged ones determined that the unevenly charged water molecules could create hydrogen bonds. If we think that electrical charge is a power, then it becomes quite clear that the boiling point of water 'flows' from its essence really just means that it is the manifestation of the powers of water molecules.

Things are not so easy, though. There are two problems that we need to address, concerning the modal status of *propria* and their distinctness from consequential essence. The first problem is that we

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[15] Oderberg 2011 has a similar principle: he distinguishes between the unique essence (the substantial form) and the properties that flow from the essence, and formulates the principle thus: '(FLOW) the properties $P_1...P_n$ are properties of the objects of kind K with essence $E=_{def}$ $P_1,..., P_n$ are caused by and originate with the form of a K'. The two accounts, however, differ under some respects. For instance, he maintains that 'since FLOW is wholly general with respect to kinds of object, it cannot be causation essentially involving matter. The properties of a triangle are caused by its form just as much as the properties of a mammal are caused by its form'. If triangles are abstract objects outside of space and time, it is hard to attribute them causal powers of the kind that we are talking about. If, on the other hand, he is referring to mathematical properties of physical objects with a triangular shape, then a metaphysics of powers might account for it: our opinions differ on whether every mathematical property can be cashed out in terms of powers. We find the notion of causation invoked by Oderberg to be quite mysterious – he claims that it does not involve matter, but surely, given his example, he cannot be meaning mere energy-transfers, either; he also denies that it is a relation of *production.* On the other hand, Mumford & Anjum (2011) write that 'powers... are productive of their manifestations' – we also lean towards this conception, and so, despite the similarity of the general idea, are quite at odds with the details of Oderberg's account.

characterised *propria* as being necessary features: if F flows from the nature of x, E, then x has F necessarily. But, as we mentioned in §3, a number of philosophers (for instance Mumford & Anjum 2011; 2018) maintain that the principle of Independence, according to which powers cannot necessitate their effects, is constitutively essential to what it is to be a power. If *propria* are the manifestations of dispositional essences, then how could they be necessary features?

There are two ways to go about this. Either we scale back on Independence, and either deny it or restrict its domain, thus admitting necessary manifestations; or we scale back on the status of *propria* as necessary properties. Our opinions differ on the feasibility of the former option and the status of Independence as essential to powers, so we will focus on the second route, and question in which sense *propria* are necessary features. Are *propria* really necessary features? Consider water's boiling point. Water *does not* boil at 100ºC in every situation: increasing atmospheric pressure considerably raises its boiling point: at 220 atm it boils at 374ºC, for instance. *A fortiori*, it is not true that it necessarily boils at 100ºC: atmospheric pressure matters, among other things. And that is exactly the kind of interference that we would expect if causal powers are involved. We think that this is the case with all *propria*: they are not *really* metaphysically necessary properties of the object. They flow from something's essence in the sense that their essence *tends to* bring them about. What is necessary is the *tendency* to bring them about. It is not a sense of humour that is a necessary feature of humans (it would be all too easy to find counterexamples...) but rather the capacity to have a sense of humour – the tendency to develop one.[16]

The second issue is whether **Flow** really manages to distinguish between consequential essence and *propria*. Vetter (2015) defends the following principle:

CLOSURE1 Potentiality is closed under logical implication: If being Φ logically implies to being Ψ, then having a potentiality to be Φ logically implies to having a potentiality to be Ψ. (Vetter 2015: 171).

If Vetter's 'potentialities' just are our 'powers',[17] this means that every power directed to some M is also directed to all of its logical implications – including, for example, all tautologies. So, if it flows from the essence of x that it is F, it also flows from the essence of x that ¬(p∧¬p), or that Fx ∨¬Fx, etc. If this is the case, then the difference between *propria* and consequential essence simply collapses. This is, obviously, unacceptable, so we have to reject Vetter's CLOSURE1 if we hope to account for *propria* in terms of **Flow**. Arguing against the principle in sufficient detail would take us too far astray, so we will just state that the powers that we have in mind are quite different from Vetter's potentialities. We take powers to be *causal* powers; as such, their action has to be constrained by the light cone, if General Relativity is true. But such constraints are obviously incompatible with a logical principle such

[16] Oderberg 2011 has a prolonged discussion of non-necessary *propria* along these lines.

[17] This is not obvious, since in Vetter (forthcoming) she allows that there are potentialities with abstracta as manifestations.

as CLOSURE1. Furthermore, *causal* powers as we understand them are, as we stressed in fn. 13, *productive*: manifestations are productively dependent upon their powers. Obviously, such dependence does not obtain in the case of logical truths. As long as a notion of causal powers is viable, it can be kept separate from Vetter's potentialities, and there is no risk that anything like CLOSURE1 threatens **Flow** to collapse into consequential essence.

§5. Conclusion

It would seem that appealing to powers allow us to move past a purely negative characterisation of *propria* and elucidate their difference from consequential and constitutive essence. Insofar as an appeal to propria is a fundamental component of formal explanations, it seems that powers can suitably ground formal explanations. A metaphysics of powers provides us with the right kind of building blocks to reconstruct another of the four Aristotelian causes.

We have examined three degrees of involvement between powers and formal explanations involving essences. We have done this without taking a stance on the precise nature of the essence-operator, and therefore on what it is to be constitutively essential. This leaves an unsatisfactory gap in our treatment of the topic: those formal explanations appealing only to constitutive essences seem to have a much weaker link with powers. This leaves open the possibility of a *fourth* degree of essential involvement: that the essence-operator could be analysed or reduced to the basic ideology of powers metaphysics (be it Vetter's POT operator, or some primitive 'directedness' relation). In other words, that constitutive essence itself could be reduced to some feature of powers. This would establish the strongest possible link between formal explanations and powers. We are skeptical that this can be done. We will not, however, attempt to discuss it: taking on the debate about the best understanding of constitutive essence goes beyond the scope of the paper, and beyond our powers at the moment. So, in this paper, we settle for a modest conclusion: we are content to show that an important subset of formal explanations, those involving *propria,* can be grounded in a metaphysics of powers, without showing that all of them do, nor that powers are *uniquely* qualified to do so.

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