

Empirically-Informed Modal Rationalism

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In this chapter, it is suggested that our epistemic access to metaphysical modality generally involves rationalist, *a priori* elements. However, these *a priori* elements are much more subtle than ‘traditional’ modal rationalism assumes. In fact, some might even question the ‘*apriority*’ of these elements, but I should stress that I consider *a priori* and *a posteriori* elements especially in our modal inquiry to be so deeply intertwined that it is not easy to tell them apart. Supposed metaphysically necessary identity statements involving natural kind terms are a good example: the fact that empirical input is crucial in establishing their necessity has clouded the role and content of the *a priori* input, as I have previously argued (Tahko forthcoming). For instance, the supposed metaphysically necessary identity statement involving water and its microstructure can only be established with the help of a controversial *a priori* principle concerning the determination of chemical properties by microstructure. The Kripke-Putnam framework of modal epistemology fails precisely because it is unclear whether the required *a priori* element is present.

My positive proposal builds on E. J. Lowe’s work. Lowe holds that our knowledge of metaphysical modality is based on our knowledge of essence. Lowe’s account strives to offer a uniform picture of modal epistemology: essence is the basis of all our modal knowledge. This is the basis of Lowe’s modal rationalism. I believe that Lowe’s proposal is on the right lines in the case of abstract objects, but I doubt that it can be successfully applied to the case of natural kinds. Accordingly, the case of natural kinds will be my main focus and I will suggest that modal rationalism, at least as it is traditionally understood, falls short of explaining modal knowledge concerning natural kinds. Yet, I think that Lowe has identified something of crucial importance for modal epistemology, namely the essentialist, *a priori* elements present in our modal inquiry. The upshot is that rather than moving all the way from modal rationalism to modal empiricism, a type of hybrid approach, ‘empirically-informed modal rationalism’, can be developed.

1. After rationalism, but before empiricism

Modal epistemology has spurred a lot of interest in recent years, but it has been clear for some time that modal rationalism of the traditional type is going out of fashion. Modal rationalism encompasses intuition- and conceivability-based approaches of the type defended, e.g., by David Chalmers (2002). However, this is *not* the type of modal rationalism that I will discuss, not even a moderate version of it. Instead, I take my cue from the work of Lowe, who defends modal rationalism of a rather different sort. Lowe first developed his modal epistemology many years ago, but his recent work in a handful of papers remains – and sadly will remain – the most detailed presentation of the theory. I will present two challenges for Lowe’s modal epistemology and suggest an improvement to the theory, proposing a type of hybrid approach between modal rationalism and modal empiricism.

Lowe’s view, at least at first glance, appears to be unified: he holds that our access to modal knowledge is purely *a priori* – hence the label ‘modal rationalism’. However, it should be noted that Lowe himself, to my knowledge, never used this label. In fact, Lowe is very critical of intuition- and conceivability-based approaches. He argues that a view taking intuitions as evidential in metaphysics, quite generally, is ‘fundamentally misguided and leads inexorably to an anti-realist conception of metaphysical claims’ (Lowe 2014: 256). I am inclined to agree with this claim. One

might think that such hostility towards intuitions would lead to a more empirically tractable view. With regard to modality, the natural choice would be ‘modal empiricism’, according to which modal knowledge is purely experiential. This label has not been used much so far – the present volume notwithstanding – but relevant work includes, e.g., Hanrahan (2009) and Jenkins (2010). In addition, there are what might be called hybrid approaches. Timothy Williamson’s (2007) counterfactual account is perhaps one good example of a hybrid approach between modal rationalism and modal empiricism – Williamson reduces our capacity for modal knowledge to our capacity for assessing counterfactual conditionals, which he claims to have an evolutionary basis. Yet, Lowe himself is critical of all of these approaches. Lowe’s (2012) critique of Williamson is especially forceful and to the point, adding to several others (e.g., Roca-Royes 2011, Tahko 2012), but his own positive proposal has received somewhat less critical attention.

As we will see, Lowe attempts to remain firmly in the camp of modal rationalism. But instead of relying on intuitions or conceivability, he relies on our ability to ‘grasp’ essences. Despite having written on the topic extensively, Lowe has struggled to gain a broad following on this point. The reason, I suspect, is because the notion of essence and the epistemology thereof are still riddled with an air of mystery. I will attempt to demonstrate that this is quite unwarranted. However, sympathetic as I am to Lowe’s view, I do think that there is an important grain of truth in the emerging modal empiricist approach. In particular, there are certain modal truths that inevitably require empirical input. I have in mind modal truths concerning natural kinds in the first place – and I will focus on these – but there may very well be other cases as well. In any case, here I will not take a strong stand on whether the epistemology of essence (and hence modal epistemology) is uniform or non-uniform. In other words, it is no my aim to settle whether we might need different forms of inquiry for different kinds of modal truths. Rather, I will simply attempt to provide an account of modal truths concerning natural kinds. Having said that, it seems likely that the case of abstract objects and the case of natural kinds will ultimately require a different treatment, which points towards non-uniformity. I have labelled the resulting view ‘empirically-informed modal rationalism’, but as others have pointed out to me, the label could just as well be ‘rationally constrained modal empiricism’.¹ I will return to this issue in the concluding section.

2. Neo-Aristotelian modal epistemology

The starting point of the Lowe-inspired modal epistemology is controversial: it is based on what might be called ‘neo-Aristotelian’ presuppositions. But there is an important strand of the literature which starts from these very presuppositions. They are expressed most lucidly in a recent paper by Lowe (2012), where he presents a theory of modal epistemology which he purports to be an improvement over recent suggestions. According to Lowe (2012, p. 919), metaphysical necessity is *absolute* – necessity of the strongest possible kind. Contrary to some (e.g., Hale 1996), Lowe considers even logical necessities to be a proper sub-class of the class of metaphysically necessary truths.

The neo-Aristotelian framework of essence popularised especially by Kit Fine (1994) is central to Lowe’s modal epistemology. On Fine’s view metaphysical modality reduces to essence and Lowe considers essence to be prior to existence both ontologically and epistemically (Lowe 2008, p. 40). In Lowe’s own words: ‘instead of trying to explicate the notion of essence in terms of that of modality, as on the Kripkean account of essence, the very reverse needs to be done’ (2014, p. 264). Therefore, the putative answer to Lowe’s (2012) question, ‘What is the source of our knowledge of modal truths?’, is, in its simplest form, ‘essence’. Of course, this answer is hardly informative unless supplemented with an account of the epistemology of essence. This is exactly

¹ I owe this insight to Robin Hendry and Jani Hakkarainen.

what Lowe has attempted to do in his recent work (see especially Lowe 2012, pp. 934 ff.) and what I wish to focus on.

Lowe's understanding of essence follows a familiar neo-Aristotelian line, whereby the essence of an entity is its *real definition*. This idea is rarely elaborated on, but Lowe makes a commendable effort. Specifically, Lowe understands real definitions as propositions which tell us what a given entity *is* or *would be* – we can also state the real definitions of things that are non-existent (Lowe 2012: 935). Lowe holds that essences are not further entities, on pain of infinite regress. For if every entity has an essence (as Lowe also holds) and essences were entities, then essences themselves would have to have essences as well, and so on *ad infinitum*.

How do we come to know the propositions that express essences – the real definitions – according to Lowe? In previous work, Lowe has suggested that to grasp an entity's essence is simply to *understand* what the entity is:

To know something's essence is not to be acquainted with some further thing of a special kind, but simply to understand what exactly that thing is. This, indeed, is why knowledge of essence is possible, for it is a product simply of understanding—not of empirical observation, much less of some mysterious kind of quasiperceptual acquaintance with esoteric entities of any sort. And, on pain of incoherence, we cannot deny that we understand what at least some things are, and thereby know their essences. (Lowe 2008: 39.)

Even though this passage may not convince everyone about the possibility of our knowledge of essence, it does at least make clear what Lowe's take on the issue is, namely, the epistemology of essence is a simple *a priori* process of understanding what an entity is (or would be). On Lowe's view, this is the basis of all modal knowledge, including *a posteriori* necessities. In the paper that I have been mostly discussing (Lowe 2012), Lowe does not use the term '*a priori*'. But from his other work it is evident that his view requires something else than the typical story about a combination of an *a priori* element and a *a posteriori* inquiry as the basis of *a posteriori* necessities, since he does hold that: 'metaphysical knowledge—modal knowledge of mind-independent reality—must, if it exists at all, have another basis altogether [rather than conceivability or empirical knowledge], being grounded neither in experience nor in logic and concepts.' (Lowe 2008: 33). Furthermore, Lowe does explicitly state that 'modal truths [...] can be established only by a priori means' (Lowe 2014: 257). The core of Lowe's modal rationalism is the process of *understanding*, the ability to grasp essence, and it is this process that we must explicate in order to assess Lowe's theory. This is best done via a detailed study of the examples that Lowe presents.²

There is an important caveat, however, regarding Lowe's conception of *apriority*. He holds that *a priori* knowledge should not be considered completely independent of experience, but rather as proceeding in a 'cyclical manner, by alternating stages of a priori and a posteriori inquiry' (2014: 257). On this point, I am very sympathetic to Lowe's suggestion – I have called this 'cyclical' process a 'bootstrapping relationship' between *a priori* and *a posteriori* elements (Tahko 2011) and from my many discussions with Lowe it is quite clear to me that we are in agreement about how this process works: we should be fallibilists about the *a priori* just as about empirical knowledge and deny the existence of 'pure' *a priori* or *a posteriori* knowledge. Hence, if any work at all is left for the notion of *apriority*, we must qualify our conception of it and move beyond the naïve Cartesian account of infallible *a priori* knowledge. However, this is not the place to discuss

² But see also Vaidya 2010, where a more systematic theory about understanding and essence is developed. Vaidya's account, however, may not be compatible with the type of (realist) essentialism that Lowe hopes to defend, so it represents a somewhat different approach to the topic.

the notion of *apriority* in detail, as the point I wish to make is quite independent of what one may think about it. Regardless of this important point of agreement between Lowe and myself, it seems to me that Lowe did not develop this view to its natural conclusion. Here I hope to make a start with just that.

3. Real definitions and essence-generating principles

Lowe provides several intriguing examples of how we may arrive at real definitions, but it is worth noting that the vast majority of them concern abstract objects, geometrical objects in particular. This may prove problematic for his overall theory, as I will proceed to suggest in the next section. But let us first consider a few examples. Lowe's most detailed examples concern the real definitions of a circle and an ellipse:

(C1) A circle is the locus of a point moving continuously in a plane at a fixed distance from a given point. (Lowe 2012: 935.)

The 'given point' in (C1) is the circle's centre. Lowe suggests that principles such as (C1) are *generating principles*, which reveal to us what it takes for, say, a circle, to come into being. Such generating principles express at least a part of the real definition, and hence essence, of entities. Lowe does however add that a generating principle may not be always required.

To understand the relationship between essence and metaphysical modality, consider the difference between two further geometrical examples that Lowe provides:

(E1) An ellipse is the locus of a point moving continuously in a plane in such a fashion that the sum of the distances between it and two other fixed points remains constant

[...]

(E2) An ellipse is the closed curve of intersection between a cone and a plane cutting it at an oblique angle to its axis greater than that of the cone's side. (Lowe 2012: 936.)

Lowe suggests that (E1) gives us the generating principle of ellipses – and hence their real definition – whereas (E2) states merely a necessary property of ellipses. We can understand properties such as (E2) once we know the generating principle of ellipses, but Lowe insists that (E1) is not derivable from (E2). This is how essence and metaphysical necessity can be distinguished: we may state numerous necessary properties that ellipses have, but only something like (E1) will give us their essence. It would be tempting to conclude that all metaphysically necessary truths are true in virtue of the essence of something or other, but Lowe suggests instead that 'any *essential* truth is *ipso facto* a *metaphysically necessary* truth, although not vice versa: there can be metaphysically necessary truths that are not essential truths' (Lowe 2012: 938). However, this needs to be qualified further, as Lowe does not mean to suggest that (E2) as well wouldn't hold in virtue of the essence of *something* – it just doesn't hold strictly in virtue of the essence of ellipses. Lowe thinks that (E2) holds in virtue of the essences of ellipses and cones together. So following the line of thought familiar from Fine (1994), Lowe (2012: 939) concludes that all metaphysical necessities are grounded in essence, even though a given metaphysically necessary truth may not be an essential truth (i.e., a real definition) about any one thing.

In sum, the structure of Lowe's account is as follows:

- (1) We know that the essence of x is expressed by proposition p (which states the real definition of x).
- (2) If we know that p expresses the essence of x , then p is metaphysically necessary.
- (3) We know that p is metaphysically necessary.

In this connection, it should be noted that while Lowe himself focuses on defending (1), he simply relies on the Finean account of essence and modality to support (2). Yet, one might think that (2) requires an explicit argument and it is not obvious that Fine (in his 1994 or elsewhere) has given one. In a recent paper, Horvath (2014) takes up just this point. Horvath (2014: 210) challenges Lowe's account on the basis that there is a gap between (C1) and the knowledge that (C1) is metaphysically necessary, i.e., a gap between essential knowledge and modal knowledge. To fill this gap, a bridge principle according to which any essential truth is *ipso facto* a metaphysically necessary truth is needed (p. 212). Horvath speculates (p. 211) whether Lowe might get to modal knowledge from (C1) by adopting the idea that metaphysical modality reduces to essence, but thinks that this is far from obvious (since even though Lowe says that modality is grounded in essence, this does not necessarily entail reducibility).

However, I don't think that this challenge hits the mark, especially since Horvath grants 'Lowe's Finean account of the relation between essence and modality' (p. 210). As we have seen, on the Finean account this type of bridge principle is already assumed – and Horvath is willing to grant the Finean account – so Lowe makes no illicit assumptions about the connection between essence and modality on top of those already present in Fine (1994). Compare this with Correia's construal of Fine's account: 'On Fine's reductive account, for a proposition to be metaphysically necessary is for it to be true in virtue of the nature of all objects' (Correia 2011: 640). So here we have an explicit reduction of metaphysical necessity to essence (i.e., the natures of objects). Of course, there might be other reasons to deny the relevant connection between essence and modality, but this would require a different argument and should be aimed directly at Fine's account. Once the Finean account is granted, it's trivial that essentiality entails metaphysical necessity (even though not vice versa), and this result seems to be widely accepted. Indeed, given that it was commonplace to reduce essence to modality before Fine's counterexamples, it seems clear that there is an intimate connection between essence and modality whether or not the Finean account is accepted.

In any case, here I will leave aside this issue regarding (2), as I am willing to accept it. Instead, I will focus on two challenges for Lowe's defence of (1).

4. Two challenges for Lowe's view

The two challenges that Lowe's view regarding our knowledge of essence faces concern the applicability of his analysis to material objects and his acknowledgement (Lowe 2008a: 36) that we only need to know a *part* of a thing's essence to be able to talk or think about it comprehendingly –

to understand it.³ The first issue was mentioned above, but we will start from the second, as it has already been noticed in the literature, by Alexander Bird (2007, 2008). Bird in fact targets one of Lowe's relatively few examples of coming to know the essence of material objects, namely, coming to know the essence of *Tom*, a particular cat.⁴ Lowe's suggestion in this regard is simple: to talk or think comprehendingly about Tom, one must at the very least know that Tom is an *animal*. In other words, it is part of the essence of Tom that he is an animal and already this may be sufficient to gain an understanding of Tom. So it is crucial for Lowe's view that we need not know *everything* about a given object to understand what that object is. It is often enough if we can gain, *a priori*, a partial account of an object's real definition. However, as Bird argues, this leaves Lowe's epistemology of essence open to the possibility of *a posteriori* elements, since it could be that we come to know some or even most of an object's essence by *a posteriori* means. Indeed, it is plausible that to be able to distinguish different kinds of things, and especially things like natural kinds, a considerable amount of empirical information is needed in addition to knowledge of general essentialist facts. This seems especially plausible in the case of classic examples of *a posteriori* necessities concerning natural kinds, such as chemical substances having their actual molecular composition essentially. For Bird, this constitutes evidence in favour of *a posteriori essentialism* of the type familiar from Kripke and Putnam: we can derive knowledge of metaphysical necessities from general essentialist (*a priori*) facts with the help of particular empirical facts.

Given the problems regarding partial essences, it is not surprising that Lowe chooses to focus on abstract entities when laying out the details of his theory. It seems that abstract entities will not suffer from the same problem, since our epistemic access to each and every part of their essence is likely to be *a priori*. On Lowe's view, to determine what the real definition of an entity is, it will be necessary to specify what the entity depends on *essentially* for its existence and identity. Accordingly, *essential dependence* has a key role in specifying real definitions:⁵

Consider the following thing, for instance: the set of planets whose orbits lie within that of Jupiter. What kind of thing is that? Well, of course, it is a set, and as such an abstract entity that depends essentially for its existence and identity on the things that are its members—namely, Mercury, Venus, Earth, and Mars. Part of what it is to be a set is to be something that depends in these ways upon certain other things—the things that are its members. Someone who did not grasp that fact would not understand what a set is. (Lowe 2008: 37.)

So Lowe thinks that in many cases knowing how a thing is related to other things is central to our knowledge of *what* a thing is. But even in the case of sets Lowe is careful to add that for the set to depend essentially for its existence and identity on its members is only a *part* of what it is to be a set. In general, he seems to think that knowing the *complete* essence of a thing is not a very simple affair – perhaps almost impossible – but knowing a part of a thing's essence is often sufficient for talking or thinking about it comprehendingly, and for being able to distinguish it from other things.

³ Note that Lowe himself does not distinguish understanding and knowledge. This may introduce further problems, some of which are discussed in Vaidya 2010.

⁴ We should leave aside here the problems concerning the essences of biological species, or indeed individual members of biological species. The point of the example for our current purposes is simply to get a grip on Lowe's toolbox regarding the epistemology to essence.

⁵ See Correia 2008 for an analysis of different kinds of ontological dependence, including essential dependence. Lowe himself defines essential dependence as follows: 'To say that X depends essentially on Y for its existence and identity is just to say that it is part of the essence of X that X exists only if Y exists and part of the essence of X that X stands in some unique relation to Y' (Lowe 2008: 38).

We may grant to Lowe that abstract objects do not suffer from the problem of partial essences, at least not as seriously as material objects. But Lowe does need to extend his account to material objects as well. He is quite aware of this, of course: ‘A concern that might be raised here is that our example of ellipses and cones concerns geometrical objects, rather than material ones—for it might be suspected that our account cannot easily be extended to cover the latter’ (Lowe 2012: 939). Lowe’s reply to this concern resorts to the familiar case of a bronze statue and a lump of bronze. He holds that although a bronze statue and the lump of bronze it consists of coincide at all times, they are nevertheless numerically distinct – these are things that hold in virtue of the essences of bronze statues and lumps of bronze. Moreover, Lowe suggests that it is possible in virtue of the essences of bronze statues and lumps of bronze that the same statue could coincide with a different lump of bronze at different times. These are essential truths that we can grasp, according to Lowe, if we simply understand what bronze statues and lumps of bronze *are*. While I am sympathetic to this line of thought, it is obviously a controversial one. Lowe attempts to put the onus on those who would deny that such essentialist truths can be grasped, but the problem may be simply that the statue/lump example comes with too heavy baggage regarding competing views about composition as well as three-dimensionalism vs. four-dimensionalism. Lowe himself regards the latter debate a mere ‘storm in a teacup’ (Lowe and McCall 2006), but even if we were to grant that, the case of composition is something to worry about. Suppose, for instance, that the (now re-emerging) view of composition as identity is true, in one of its forms (cf. van Inwagen 1994). Then it would seem that to understand what a bronze statue is, all that would be required is to understand what a lump of bronze is, as the statue and the lump depend essentially for their existence and identity on the very same things. Now, Lowe would presumably consider this to show how absurd the ‘composition as identity’ view is, but we better be able to present a more neutral case of our epistemic access to essence if we are to apply the theory quite generally.

The case of natural kinds, one might think, is the perfect example. After all, essences of natural kinds are typically taken to be some of the least controversial cases of the applications of the term ‘essence’ in the first place, owing to the work of Kripke and Putnam. The idea, as it is usually put, is that it is metaphysically necessary, in virtue of the essence of a natural kind such as water, that it is composed of the very molecules that science has discovered it to be composed of, namely H₂O. Lowe takes the cue, albeit very briefly:

[M]y own view is that it is only naturally, not metaphysically, necessary that all and only water is (chiefly) composed of H₂O molecules, because the natural laws governing the chemical behaviour of hydrogen and oxygen atoms could have been significantly different, with the consequence that atoms of those types in chemical combination might not have composed a substance with any of the typical chemical properties of water. (Lowe 2012: 941.)

We need not go into the natural/metaphysical necessity issue here – the question regarding the epistemology of essence is distinct from that of the modal status of laws. Regardless of whether laws are naturally or metaphysically necessary, on Lowe’s picture their modal status is to be explained with reference to essence. But what is of interest to us now is Lowe’s conviction that the essence of water, and hence presumably the essences of many other chemical substances, is *not* its molecular structure. What is it, then? Lowe presents his positive story elsewhere (Lowe 2011), but we can summarise it as follows: instead of the *microscopic* features of water, the essence of water is exhausted by its *macroscopic*, observable features. Being *water-like* is more important for understanding what water is than being composed of H₂O. This suggestion is of course in tension with the usual view about the essences of natural kinds such as water, but it is apparently not entirely unheard of – at least Paul Needham (2011) has recently defended a similar view in more

detail. There are, however, some difficult questions to settle before we make sense of the view. The key question regarding the essences of natural kinds such as water is whether their microstructure may be considered to determine their chemical properties. This turns out to be a thorny issue, much debated in the philosophy of chemistry, but we cannot go into it here. Let us instead consider the significance of all this towards Lowe's general view about the epistemology of essence.

To maintain that we have *a priori* access to essence even in the case of material objects such as natural kinds, Lowe must adopt the view that the essential features of material objects are, by and large, accessible to us via a simple reflective process. This does not compel Lowe to claim that the *full essence* is to be so easily reached, but we ought to be able to access enough of the essence to be able to separate one object from another. Hence, it would *not* be enough to say that water is a transparent liquid (in 'normal' conditions, i.e., in room temperature etc.) because there are several other chemical substances, such as hydrogen peroxide, that have the same (essential) features. The obvious solution here would be to look for a generating principle similar to the one we saw Lowe to propose for a circle. But what could this generating principle be? It cannot rely on laws of nature, since Lowe holds that the natural laws governing the chemical behaviour of hydrogen and oxygen atoms could have been significantly different (and we could still have water). It seems that Lowe's theory is wanting in this regard; perhaps his most informative input on the matter is the following:

[O]ur natural classifications do not need to be, and in fact should not be, forced into a single, all-embracing taxonomic scheme. Real divisions in nature are reflected by our natural classificatory schemes, but they are often divisions at different levels, allowing for a good deal of cross-classification. So, to revert to an earlier example, there is nothing wrong in saying that, for some purposes, diamond, graphite and charcoal may be regarded as different kinds of substance[.] (Lowe 2011: 16–17.)

So diamond, graphite and charcoal may be regarded as different kinds of substance, *for some purposes*, even though they can be regarded as the same substance, namely carbon, from the microstructural point of view. On the face of it, the passage above may even seem to invite conventionalism, but this is surely not what Lowe has in mind. Nevertheless, it does leave his view open to a conventionalist challenge, for who is to say *which* of our classificatory schemes is supposed to reflect the real divisions in nature, if any? Moreover, there is no salvation forthcoming in the form of a generating principle. On the contrary, Lowe (2012: 942) acknowledges that there are cases where it is not plausible to talk of generating principles at all. He mentions colour-universals as an example, but it appears that he would have to say the same in the case of many if not all kind universals, carbon being a case in point.

5. Improving on Lowe's modal rationalism

The two challenges that Lowe's view faces may not be fatal, but they are serious. In part, Lowe relies on somewhat controversial examples, so the success of his theory is overly dependent on whether his opponent accepts the ancillary assumptions underlying those examples, such as those concerning composition in the example about a lump of bronze and the bronze statue. Moreover, Lowe focuses on abstract objects, geometrical objects in particular, and in that regard his examples are quite convincing, but extending his theory to material objects and natural kinds is not entirely straightforward. In what follows I will attempt to improve on these aspects of Lowe's theory, although it may be that the upshot would not be acceptable to Lowe himself.

The improvement that I wish to propose builds on Lowe's 'generating principles', which we saw him to identify in the cases of circles and ellipses. Lowe is willing to admit that there are many essences which are not subject to generating principles. In fact, he thinks that generating principles only apply 'in the case of entities that are in a suitable sense capable of "generation"' (Lowe 2012: 935–6). But I think that Lowe is being overly cautious about extending the idea of 'generation' to different kinds of entities, beyond the geometric examples he discusses. In particular, the idea of generation seems to be quite natural in the case of natural kinds, contrary to what Lowe's analysis of carbon suggests. So let's take the case of carbon: how is a suitable generating principle explicating the essence of carbon to be found?

Being one of the most versatile elements, carbon might seem to be an especially difficult case. Indeed, diamond and graphite, which Lowe mentions, are two of the several *allotropes* of carbon – pure forms of the same element that differ in structure. But there is of course a reason behind the fact that we typically classify different allotropes as members of the same kind, despite the significant differences in their chemical properties.⁶ The reason has its source in the fact that despite their many differences, the allotropes of carbon can be subjected to the same type of chemical reaction with the same type of result. I have in mind oxidation: if one burns diamond, graphite or charcoal, the result is always the same, namely pure carbon dioxide. If any of these allotropes were compounds of different elements instead, the burning would result in some impurities. As it happens, this is exactly how Antoine Lavoisier, the famous 18th century chemist, discovered that diamond is indeed an allotrope of carbon. Lavoisier heated a diamond in a glass jar until it disappeared and observed that the weight of the jar had not changed, hence concluding that the diamond must have been made of carbon to produce the carbon dioxide gas present in the jar after heating (Krebs 2006: 192).

The story about the allotropes of carbon does not yet give us the generating principle of carbon, or of any other element for that matter. But it does give us an important clue: the generating principles of elements ought to take into account at least two things. The first is the ability of elements to form allotropes and their ability to form compounds with other elements (which can also take several forms, that is, *polymorphism* in general must be taken into account). The second is the *survival* of something essential to the element in all of the different forms that it can take. The upshot here is not unlike the one that Lowe proposes in the case of a lump of bronze and a bronze statue, but the example is much less controversial, since it relies only on familiar empirical knowledge of the behaviour of elements and compounds. More precisely, it is in virtue of the essence of carbon that carbon atoms are capable of forming allotropes with varying crystalline structures, and it is also in virtue of the essence of carbon that the vast range of forms that carbon can take in a variety of allotropes and compounds still share some aspect of the elemental form of carbon. What these aspects are is a question of chemistry and we cannot go into a lot of detail here (but see Tahko forthcoming). In brief, we could understand the chemical properties of compounds to be a result of the interaction of the elements present in those compounds, which points towards microstructural essentialism. If this is correct, it must be the case that something *survives* in the causal processes that elements undergo when forming compounds – and also allotropes. In the philosophy of chemistry literature, this may be closest to what Robin F. Hendry calls the 'core conception' (e.g., Hendry 2006), according to which it is the *nuclear charge* of elements that is most central to their chemical properties and hence – we might infer – their essence. So this line of thought would suggest that the nuclear charge of elements is what survives when elements form compounds and allotropes. Interestingly, Hendry identifies this type of idea in Lavoisier's work, which was already mentioned. As a final appeal to authority, consider Eric Scerri's analysis of elements, which also happens to take carbon as the example:

⁶ For further details on allotropy, see Addison 1964.

Consider first the fact that the modern periodic table is based on the principle of one element occupying one space. This being the case, there is no separate place in the periodic table for the various allotropes of an ‘element’ like carbon. All three currently recognized allotropes which are diamond, graphite and buckminsterfullerene, must all be accommodated into a single space. So what is the carbon that is indicated when one points to the symbol C occupying the sixth place in the periodic table? The simple answer is that it is none of these separate allotropes but in fact the abstract essence of carbon that underlies all three allotropes and perhaps even new as yet undiscovered allotropes.

Similarly one can consider the question of isotopes of an element. Let us remain with carbon. The three most abundant isotopes of this ‘element’ are ^{12}C , ^{13}C and ^{14}C . But again the periodic table is based on “one element one place” and so any contemporary chemist has to concede that when he or she points to the sixth place in the periodic system they are not pointing to any physically existing isotope but to an abstract entity which somehow embodies all the isotopes of carbon. (Scerri 2012: 70–1.)

Scerri is perhaps exaggerating when he suggests that contemporary chemists, quite generally, consider themselves to be pointing to an *abstract* entity when considering the element occupying the sixth place in the periodic system, but for those willing to accept kind universals as abstract entities (as Lowe certainly would), this upshot would probably be welcome. Either way, the quote from Scerri underlines the problem of unification when it comes to defining elements, and this must be taken into account if we hope to find a generating principle for them. Incidentally, as Scerri makes clear in the same paper, it is not straightforward to come up with an analysis of elements from the point of view of quantum mechanics either – I will leave this issue aside here. Given this, we already have all the central requirements regarding the generating principle for elements in place. For the sake of illustration, I will rely on Hendry’s ‘core conception’ in constructing the principle, which is an extrapolation of the idea of something surviving when elements form allotropes and compounds:

(ELE1) An element is a (stable) collection of subatomic particles, potentially capable of forming compounds and/or allotropes in such a way that its nuclear charge survives.

(ELE1) is obviously not a scientific definition of elements, even if it does contain scientific terminology. Moreover, the principle assumes that Hendry is correct in taking nuclear charge to be a definitive property of elements, but here our main interest is the form of the principle rather than its scientific content. The stability of elements varies dramatically, but here I have in mind a very minimal constraint: it must be possible for a collection of subatomic particles to hold together at least for some brief period of time before they can be considered an element – this could be as little as 10^{-24} seconds, as is the case, e.g., with some isotopes of hydrogen and lithium. Note also the qualification ‘potentially’. We should not assume that every element must be capable of forming compounds and/or allotropes, especially given how short-lived some of them are. Despite these complications, the main strength of (ELE1) is that it can accommodate all the problematic aspects regarding the unification of elements that Scerri mentions, allotropes and isotopes in particular. In addition, the survival of the nuclear charge of participating elements in compounds, also noted in (ELE1), takes care of the tricky question concerning the status of elements in compounds where they end up “sharing” electrons, like in the case of covalent bonds in water molecules. The case of water is of course notorious, because electrons are shared unequally by the hydrogen and oxygen atoms of water, resulting in polarity. But since the survival of nuclear charge is all that is required

by (ELE1), such complications do not pose a problem. Accordingly, allotropes, isotopes, and various compounds all respect the constraint stated in (ELE1), so it is at least a promising starting point in our search for a generating principle.

Importantly, the analysis of elements in terms of (ELE1) is not subject to the conventionalist critique that Lowe's analysis of carbon seemed to be. For even though we could still talk about the macrophysical features of carbon and other elements in some contexts, the idea here is that something like (ELE1) is what gives us the real definition of elements and this must be done at the microphysical level – any macrophysical features of elements are determined by the microstructural features. Admittedly, I have hardly given any account of *how* this happens. Moreover, one might think that there is an element of convention in the qualifications concerning stability and the potentiality of forming compounds and allotropes. There is indeed some vagueness involved, at least with the stability requirement, but I would suggest that this is merely linguistic vagueness concerning the folk usage of the notion of 'stability'. Clearly, if a collection of subatomic particles holds together for only 10^{-24} seconds, the folk requirement for 'stability' is hardly satisfied. But the chemical notion of 'stability' is defined as a relative thermodynamic property. Therefore, we can use 'stability' relative to some assumed standard, which is most naturally set by empirical limitations. In any case, the notion of 'stability' at work here should not be confused with the folk usage, nor with the (more or less) scientific usage of the notion referring to isotopes that have half-lives too long to be measured. Accordingly, (ELE1) is certainly not subject to the radical conventionalist variation that Lowe allows for the different allotropes of carbon – they always come out as members of the same substance on this analysis.

One might question in what sense (ELE1) is a *generating* principle rather than a descriptive one. My reply here is simply that we should not put too much weight on the requirement that a principle capturing a real definition of an entity should be 'generative' in anything more than the sense that it expresses an essence in a repeatable manner and quite generally. In fact, I am even willing to admit that there is a distinctive flavour in the present usage of 'generative' which is not present in Lowe's usage. Lowe himself illustrates the idea also by saying that a real definition 'provides a *recipe* or *formula* for a certain thing or kind of thing' (Lowe 2014: 266). The latter notion, i.e., 'formula', might be closest to the idea at hand: whenever a collection of subatomic particles is stable and has a determinable nuclear charge as well as the dispositional profile that goes with it, the formula for elements is fulfilled. Part of that dispositional profile is that if the element forms compounds or allotropes, the nuclear charge of the original element survives the process. As we saw, the lack of any obvious principle of this type in the case of water led Lowe to abandon the possibility of a microstructural characterisation altogether, but this seems too drastic a move, since it leaves his view open to a conventionalist challenge. In fact, Lowe has previously entertained examples that would benefit from an analysis of the type proposed here. A particular example I have in mind concerns transuranic elements – elements with an atomic number higher than 92, i.e., that of uranium. Transuranic elements are notoriously short-lived (and radioactive). But what is important is that many of the transuranic elements were only synthesized after their existence was predicted. With the help of the principles underlying the periodic table of elements, chemists have been able to predict the existence of a number of yet to be discovered elements and to give highly accurate estimates of their chemical properties. In Lowe's own words:

Prior to the actual synthesis of various transuranic elements—prior, indeed, to the actual existence, anywhere in the universe, of certain of these elements—chemists knew *what they would be*. That is to say, they grasped the real definitions of certain as yet non-existent transuranic elements. (Lowe 2014: 267.)

The story about transuranic elements fits Lowe's picture of 'essence precedes existence' quite nicely (Lowe 2008: 41), but it's not clear how a macroscopic characterisation of elements could account for our ability to predict the existence and chemical properties of transuranic elements prior to their synthesis. Lowe says that chemists grasped the real definitions of these elements before they had been synthesised, but this could only amount to something along the lines of (ELE1) rather than the macroscopic characteristics of transuranic elements. In fact, given how unstable most of these elements are, they don't tend to be present in the sort of quantities that could even be appropriately *called* macroscopic. So chemists could have known what these elements would be—what their chemical properties would be like—because they had some idea about what kind of chemical properties a given microphysical structure is likely to produce. This, it would appear, gives direct support for a microphysical rather than a macrophysical characterisation of elements.

Does the present account respect Lowe's idea of 'essence precedes existence'? Yes, but only in part. Recall that, for Lowe, essence precedes existence *both* ontologically and epistemically. The present account is perfectly compatible with the idea that essence is ontologically prior to modality, since it was just suggested that it is something about the essence of elements – the survival of nuclear charge – that underlies (ELE1) and gives rise to the dispositional profile of elements. Regarding the epistemic side, things are trickier, as the process of inquiry will be cyclical, proceeding via a bootstrapping relationship of *a priori* and *a posteriori* elements (see Tahko 2011 for more details on the idea of bootstrapping). We will return to nature of the *a priori* elements in a moment, but note that Lowe himself does not seem to have considered the cyclicity of this process of inquiry to violate the idea of essence preceding existence. I myself am less certain that the epistemic priority of essence can be upheld in the case of natural kinds, but it seems far less controversial in the case of abstract objects. All this points towards non-uniformity – the need for a different epistemic story for abstract objects and concrete objects, but I do believe that there is a role for the notion of 'generation' in both of these stories, at least if it is understood liberally.

(ELE1) is of course just one example of how we could extend the idea of a generating principle beyond Lowe's geometric examples, but there is no space here to develop a larger battery of examples. It should however be clear just from this one example that any natural kind could, in theory, be subjected to a similar analysis.

6. Modal rationalism or modal empiricism?

In what sense is the view resulting from my suggested modification to Lowe's theory still modal rationalism? It is quite obvious from the previous example concerning the generating principle for elements that empirical information will have to play a key role in this view – much more so than in Lowe's original theory. I consider this an advantage, since it serves to demystify the essentialist approach to modal epistemology, which has traditionally suffered from criticisms concerning the epistemic dimension (e.g., Hale 1996: 114). However, the suggested addendum to Lowe's theory does not, it seems to me, automatically lead to 'modal empiricism' instead of modal rationalism. Here's why: although generative principles such as (ELE1) need to be supplemented – or better, *specified* – with empirical information, their primary content would still appear to be *a priori*.

What is this *a priori* content? In the case of (ELE1), it is the categorical constraint on entities such as elements that are capable of forming complexes and surviving decomposition. As we have seen, this idea was grasped already by Lavoisier, who realised that diamond must be a form of carbon since it is possible to decompose it into carbon by means of heating. To be precise, the product of this procedure is of course carbon dioxide, but it is possible for CO₂ to undergo further high-temperature thermal reactions that yield carbon monoxide, hydrogen and oxygen from

CO₂ and water. (Such a reaction would have to be driven by some other form of energy than a carbon-based fuel if we do not want to produce more CO₂ in the process.) Chemical details aside, the important lesson of the story concerns the already emphasized *survival* of the element through all these chemical processes. A scientific analysis of this survival may be found, e.g., in Hendry's (2006) account of the 'core conception', but the very idea that there is something that persists in chemical reactions does not itself seem of empirical origin. Hence the suggested label: 'empirically-informed modal rationalism'. However, as I observed already in the beginning of this paper, the resulting view could perhaps just as well be called 'rationally constrained modal empiricism', as it is clear that empirical elements play a key role in the view – we are dealing with a cyclical process.

This small improvement on Lowe's theory of modal epistemology is, I believe, in the spirit of Lowe's original theory. It might not be acceptable to him as it stands, but it is clear that Lowe's account needs to be supplemented with some kind of an analysis of how we come to know the essences of natural kinds, since much of his work relies on such knowledge. Despite touching on the issue many times in his published work, Lowe does not provide a fully satisfactory answer to the question of how his modal rationalism enables epistemic access to natural kind essences. This may be partly because he seems to have changed his view on the topic over the years (compare for instance Lowe 2012 and Lowe 1998). So perhaps he would have been willing to do so again, at least to the extent that his modal rationalism could be converted into what I have here labelled 'empirically-informed modal rationalism'. At any rate, Lowe makes it quite clear that his view is not 'pure' modal rationalism. In fact, I suspect that he would shun away from the labels of modal rationalism and modal empiricism altogether, given that his own view does have some 'hybrid' elements as well. But at the same time I have no doubt that Lowe would strongly emphasize the *a priori* element of the view, because his conviction has always been that the Kripkean analysis of *a posteriori* necessities undermined and misconstrued the role of *a priori* reasoning—and indeed essentialism—in modal epistemology. On this point, I am in full agreement with Lowe, although much more work remains to be done in order to clarify how rational and empirical elements are intertwined in modal epistemology.⁷

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