Do Kind Terms Denote Kinds?

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Abstract

According to the causal theory of reference, the references of (some) natural kind terms are fixed in baptisms. To wit, a so-baptized kind term refers to those things that share a certain inner constitution with the sample used in the baptism. I argue that this is incompatible with the claim that natural kind terms are *open textured*, i.e. that semantics can underdetermine reference. The two views, fixed reference and open textured reference, entail competing claims about the course of science. By examining an episode from the history of science, the discovery of isotopes, I conclude in favor of open texture for natural kind terms.

Keywords: reference, meaning, causal theory, open texture, kind terms

1 The causal theory

The causal theory of reference, first outlined by Kripke (1972) as a replacement for the descriptivist theory, has it that the references of proper names and certain common nouns are not *determined by descriptions* but *fixed in baptisms*.[1] Speakers successfully refer by using such a term in virtue of their use bearing a causal

[1]Supposedly, *baptism* is a broader metaphor for whatever linguistic development leads to a word coming into a particular use. Perhaps the claim is most charitably rendered as follows: whatever happened, the outcome of a literal baptism would be the same.

connection to the initial moment of baptism. A version of the causal theory thus comes in two parts (Devitt, 1996): an account of *grounding* that explains the moment of baptism, and an account of *borrowing* that explains how speakers who were not present for the baptism can 'borrow' the referential use of the term from other speakers (who might in turn have borrowed it from others, and so on).

My focus will be on the moment of baptism. When a child is named (or a pet, building, *etc*), the reference of the newly assigned name is a concrete object that can be picked out by ostension or description. All that is required to get the causal chain going is that the newly named object is uniquely designated; *how* it was designated can then be forgotten. But when one baptises a kind, there is an extra step. Kripke suggests that the baptiser of a kind picks out a sample of the kind and, roughly, names the kind by identifying the sample and fixing the designation of the common noun as *its kind*.

> The original concept ... is: *that kind of thing*, where the kind can be identified by paradigmatic instances. (Kripke, 1972, 122)

The sample of paradigmatic instances, being a concrete collection of particular objects, can again be picked out by ostension or by description. But what is so picked out is not the reference of the kind term. Rather, the reference is something else that is somehow determined by what one just picked out: its kind.

There is a well-known difficulty here: any given sample can belong to many kinds. The *qua-problem* challenges the causal theorist to explain how speakers can fix reference to a *single* kind from a sample (Devitt & Sterelny, 1999). Causal theorists are divided on what is the best response here. Devitt & Sterelny propose a *hybrid theory* that re-introduces some amount of description. The hybrid view has been developed further by Stanford & Kitcher (2000) who arrive at the following statement.

> A natural kind term is associated with (a) a range of samples, (b) a range of foils, (c) an open sentence $\varphi[x]$ in conjunctive form $\varphi_1 x \& \varphi_2 x \& \ldots \varphi_n x$, such that each sample satisfies $\varphi[x]$ and each foil fails to satisfy at least one of the φs. Each of the φs can be used by members of the community into which the natural kind term is being introduced. The term refers to the set of those things having the inner constitution that is a common constituent in the total causes of the presence of each of the so-properties in each of the samples, and that is absent from all of the foils. (Stanford & Kitcher, 2000, 114)

According to a hybrid theory, the initial baptism does not merely refer to a kind as *that kind of thing* but adds some further description (the 'φs' in Stanford &

Kitcher's version) in order to identify an inner constitution that isolates a unique kind; the initial baptism is not of *that kind of thing* but perhaps of *that kind of soft, ductile metal*. For the term 'gold', the story goes, this inner constitution is *atomic number 79* (or this is so according to our current best science). That some substance has atomic number 79 is a constituent in all the total causes of the relevant features of gold (the 'φs'), e.g. it's malleability and ductility (Stanford & Kitcher, 2000, 113). However, it is not a given that there is such an inner constitution in each (attempted) baptism. Stanford & Kitcher conclude that speakers perform baptising acts under the assumption that there is such a shared inner constitution. Sometimes this assumption is in error and then the term fails to refer (although it might be used for a while under the false assumption that it does refer).

Other causal theorists defend the adequacy of the *pure* causal theory (i.e. that a grounded referring term is not associated with any descriptive content), arguing that the '*qua* is built into the causal power' (Miller, 1992, 429; also see Deutsch, 2023).[2] Reinikainen (2024) defends a pure causal theory by construing the relevant inner constitution as a *super-explanatory property*.

> A super-explanatory property of a natural kind is its property which explains a lot of other properties of the kind as well as why these properties are instantiated together in tokens of the kind. For example, in the case of the natural kind water, the super-explanatory property is its molecular structure; this is what explains (perhaps conditionally on laws of nature) many of water's typical features like its boiling point, freezing point, why it is a powerful solvent, and arguably even why it is necessary for carbon-based life forms. (Reinikainen, 2024, 131)

To see that there is no *qua*-problem, Reinikainen argues, one must

> see the grounding act (speaker pointing at the cat and saying 'That is a cat') as an effect, the cause of which are the perceived properties of the cat, such as having whiskers, being a predator and being cute. The properties in turn are causally structured so that their mutual coexistence in the cat is explained by the property of being a cat, which in important part consists of having a certain genomic material and a certain phylogenetic and ontogenetic history. In this relation, being a feline, a mammal, a vertebrate or an animal do not play a super-explanatory causal role. (Reinikainen, 2024, 131)

[2] *Reference magnetism* is another solution to related worries (Lewis, 1983, 1984; Merrill, 1980), but is itself a strained notion (Warren, 2023).

That is, the speaker performing the grounding act (the baptism) need not have a description in mind, but there are still some properties of the relevant sample that are perceived by the speaker. What is named by 'that kind of thing' is everything that has the—unique, Reinikainen argues—super-explanatory property for these perceptions. For chemical substances, this property is their molecular structure (Reinikainen, 2024, 131). So, supposedly, the super-explanatory property of gold is again *atomic number 79*. Again, the baptism can fail if there is no such super-explanatory property in the sample used in the baptism.

Both hybrid and pure theorists tie the success of a baptism (i.e. whether the act introduces a referring expression that does in fact refer) to whether some inner constitution is present in the sample used in the baptism.[3] If there is no inner constitution, the baptism fails and the term does not refer (although the term might be used as if it were referring). The exact conditions for failure are difficult to determine. For one, the baptism might succeed even if the sample is impure; Kripke (1972, 136) notes that the sample used to baptize *gold* could contain some small amount of fool's gold, for example. How *precisely* an account of baptism deals with impurities is something I set to the side here, but I return briefly to impurities in Section 5.

Regardless of how a baptism might *fail*, I take the following claim about the *success* of a baptism to be part of the consensus among causal theorists: If the baptism of some natural kind term succeeds, then the term refers to the things that have the same relevant inner constitution as the sample used in the initial baptism.[4] I will call this assumption Baptism.[5]

Baptism. If a natural kind term was successfully baptized, it refers to the collection of things that have the inner constitution fixed in the moment of

[3]There is substantial debate on the shape of these inner constitutions (e.g. Van Brakel 1986; Needham 2000, 2011; Tahko 2015; Häggqvist & Wikforss 2018) that I set to the side here. I will phrase my arguments assuming that the inner constitution of an element is its atomic number, but nothing crucial hinges on on this choice.

[4]A version of (something like) the causal theory that may not entail Baptism is due to Field (1973). I discuss it separately in Section 5.

[5]Baptism says that having the inner constitution of the initial sample is necessary and sufficient for being in the extension of the baptized term. A referee rightly notes that Kripke's focus was on the necessary direction. However, Kripke (1972, 138) does make claims of necessity and sufficiency; and the subsequent causal theorists likewise seem to regard it has necessary and sufficient to have the relevant inner constitution. My argument against Baptism will involve a counterexample to the sufficient direction, i.e. something that shares the relevant inner constitution but is not determinately referred to by the kind term. But this is just a feature of the particular example and I suspect that a similar counterexample to the necessary direction can be found, i.e. something that does not share the relevant inner constitution but is not determinately *not* referred to by the kind. The example of 'mother' at the beginning of Section 2, for instance, works in both ways.

baptism.

Whether *the things* are a plural denotation, a set, or some otherwise structured entity is of no consequence here. I use 'collection' as a neutral term. Also, I do not claim that Baptism exhaustively characterizes the meanings that a causal theorist assigns to natural kind terms. But since reference is either a part or a consequence of meaning, it follows from Baptism that if a natural kind term was successfully baptized, then using it to refer to something that does (or does not) have the relevant inner constitution will be correct (or incorrect) in virtue of the meaning of the term.

Now, a striking consequence of Baptism is that (for all we know according to our best science) gold is necessarily that which has atomic number 79.

> [A] material object is (pure) gold if and only if the only element contained therein is that with atomic number 79 … such theoretical identifications … are *necessary*, though not *a priori*. (Kripke, 1972, 138)

Thus, when we have some substance in front of us, there is a determinate fact of the matter whether it is gold, given that there is a determinate fact of the matter whether its atomic number is 79. Kripke (1972, 136) also notes that there could be vagueness about the notion *same kind*. It is not quite clear what such vagueness could look like. Given the clarifications offered by later causal theorists, such as reviewed above, one possibility is that vagueness about *same kind* occurs when there are vague inner constitutions.[6] If *having atomic number 79* is vague, then *being gold* is vague too. But atomic number is not vague in this sense (it is a discrete property). I set vagueness to the side for now, but return to it Section 5.

Barring vagueness, then, causal theorists maintain that questions such as *This sample has atomic number 79—is it, therefore, gold?* always have a definite answer (if 'gold' was successfully baptized). On the account of Reinikainen (2024), *having atomic number 79* is the super-explanatory property of the initial sample of gold; and for Stanford & Kitcher (2000) it is the 'inner constitution that is a common constituent in the total causes of the presence of each of the so-proprties' of the initial sample. On either theory, if something has the property, it is gold (barring vagueness).

[6] Gómez-Torrente (2019, 179) claims that "the things exemplifying a substance will be the things which are not too different, in a suitably vague sense, from the paradigms as regards the necessary properties of the latter" which may be another way in which *same kind* could be vague. Since Gómez-Torrente does mention inner constitutions, his theory might avoid my arguments against Baptism. However, as I argue in Section 5, vagueness does not strike at the heart of the open texture phenomenon.

But this is a problem. Waismann (1945) claimed that meanings, including those of kind terms, are *open textured*, which means that such questions do not always have a definite answer. Even if there is a determinate fact of the matter whether some stuff has atomic number 79, Waismann claims, it may be indeterminate whether it is gold. If Waismann is right, this is a problem for Baptism and, thus, for the causal theory. I will argue that Waismann is in fact right and that the problem is significant.

I now go on to elaborate on the different predictions made by the causal theory and by Waismann. I argue that the dispute can be understood as being about the course of science. I then examine the actual course of science by discussing an episode from its history, the discovery of isotopes, where there appears to be a case of open texture. LaPorte (2003) made similar observations about the open texture of terms for biological taxa.[7] But while LaPorte agrees that these observations undermine the causal theorist's claims about the course of science, he claims that they do not undermine the causal theory itself. I argue that this is a mistake, likely stemming from LaPorte's misconstrual of open texture as 'hidden vagueness' (LaPorte, 2003, 97). LaPorte is right to conclude that an alternative account of how theory change begets reference change is needed, but wrong that such an account could *supplement* the causal theory. The causal theory's posits about *how reference is determined*—the posits that engender Baptism—are incompatible with open texture, so any such effort would be futile.

2 Open texture

Waismann (1945, 122) observed that "most of our empirical concepts are not delimited in all possible directions". One might (at least conceivably) find oneself in a situation where the application of a particular common noun N is undetermined by its meaning. That is, the pre-established meaning of N does not determine whether it would be correct or incorrect to say of a certain x that it is N. Waismann called this the *open texture* of meaning. Blackburn (1994) usefully describes it as follows.

> **open texture**: The term, due to Waismann, for the fact that however tightly we think we define an expression, there always remains a set of (possibly remote) possibilities under which there would be no right answer to the question of whether it applies. This … is not

[7] For biological terms it might be disputed whether these are natural kind terms at all (but see Devitt, 2023 for a rejoinder). It might hence be disputed whether observations about such terms challenge the causal theory. A further upshot of my observations is that they are about the names of chemical elements, the supposed paradigm cases of natural kind terms.

> the same as vagueness, since in actual situations the application of the term may be quite definite. For example, the term "mother" is not vague, but its open texture is revealed if through technological advance differences open up between the mother that produces the ovum [and] the mother that carries the foetus to term … It will then be fruitless to pursue the question of which is the 'real' mother

The example of 'mother' is apt. The practices that once conferred meaning onto the term, supposedly, were not sensitive to the possibility of distinguishing between the person who produced the ovum and the person who carried the fetus, as the possibility of such a distinction has only recently been recognised (and then actualised in medical practice). If Waismann's analysis is correct, then among the available choices—producer of the ovum, carrier of the fetus, both, neither—there is no right or wrong answer insofar as the meaning of 'mother' is concerned. To be clear, 'right' and 'wrong' here mean right and wrong *in virtue of prior meaning*. There may be other reasons to regard some choices as right or wrong.

One can see in this example how the argument against Baptism is going to work. Suppose that the term 'mother' was introduced by a successful baptism. Then, a determinate kind was fixed to be its reference. It follows that there are right and wrong answers (in virtue of meaning) to the question of who the real mother is. The mother is whoever has the inner constitution of the sample used in the baptism (the relevant constitutions being something like the *gave birth to* and *genetic ancestry* relations). One might object that the initial sample (likely) exhibited *both* relevant inner constitutions and, thus, that the inner constitution that was fixed in the baptism is a combination of both inner constitutions. But this does not help. If the combination is conjunctive, then this means that 'neither' is the correct answer; and if it is disjunctive, then 'both' is the correct answer.[8] Regardless, Baptism entails a contradiction to Waismann's point that there is no right or wrong answer.

The issue is not merely whether the meaning of 'mother' changed through the discovery of in-vitro fertilization and embryo transfer. The causal theory can straightforwardly accommodate the fact that meanings change, i.e. that sometimes an old term is re-baptized to have a new reference. Rather, the issue is whether the prior meaning sets a standard of correctness for the newly recognised options. If 'mother' was introduced by a successful baptism, then Baptism entails that the extension of 'mother' is constrained by the inner constitution fixed in the moment of baptism. It is then determinate whether the person who provided the ovum, the person who carried the fetus, both, or neither share this

[8] In Section 5 I further discuss Field's (1973) theory of partial reference as a version of a conjunctive account.

structure. That is a prior standard of correctness, contravening the open texture of 'mother'. That we can go against this standard and re-baptize a term to something else—that we are not beholden to semantics and can do with our words what we will—is besides the point.

However, it may not be the case that 'mother' was introduced by a successful baptism. As Lewis (1984) and Deutsch (2023) point out, it may be that only a few terms are introduced by baptism and that other terms are introduced by descriptions grounded in the baptized terms. So perhaps the reference of 'mother' was not fixed by baptism like, according to causal theorists, the reference of 'gold' was.

So, can paradigmatic natural kind terms like 'gold' be open textured? Baptism entails that they cannot be, since it entails that their extensions are constrained by whatever inner constitution was fixed in the initial baptism. However, Waismann claims that even natural kind terms are open-textured.

> The notion of gold seems to be defined with absolute precision … Now what would you say if a substance was discovered that looked like gold, satisfied all the chemical tests for gold, whilst it emitted a new sort of radiation? 'But such things do not happen.' Quite so; but they might happen, and that is enough to show that we can never exclude altogether the possibility of some unforeseen situation arising in which we shall have to modify our definition. (Waismann, 1945, 122-3)

Today, we call 'gold' the element with atomic number 79. Causal theorists contend that this is a *discovery* of science (e.g. Kripke, 1972, 124; Devitt & Sterelny, 1999, 88), i.e. that we have determined *element 79* to be the inner constitution of the sample used in the (metaphorical) baptism of gold. Thus, whatever has this atomic number is gold.

Causal theorists, one assumes, would initially be unperturbed by Waismann's claims. Of course there is 'the possibility of some unforeseen situation arising in which we shall have to modify our definition'. One such possibility is that the theory of atomic numbers could be falsified. Should this happen, then *necessarily, gold is element 79* is revealed to be a falsehood about gold that we mistakenly believed. We then have to reject that gold is element 79. But none of this rules out that there is some inner constitution K such that *necessarily, gold is* K is a truth to be found by science. The fact that we cannot be sure that we have the right answer does not mean that there is no definite answer. Indeed, for the causal theorist, the possibility of such mistakes proves the causal theory (see Lewis, 1984; Miller, 1992; Weatherson, 2003). Intuition says that science may be mistaken about gold, so there must be something definite that gold *is* that it can

be mistaken *about*. The causal theory ensures that there is a fixed fact of the matter that science can go investigate (more on this in Section 4).

This short-changes Waismann. He argues for the possibility that science is not falsified but *stumped* by the discovery of a substance that satisfies all tests for gold yet is palpably different from anything we have hitherto called 'gold'. (For comparison, recall the case of 'mother': we may find a person who bore a child, thereby passing all hitherto imagined tests for motherhood, but is palpably different in virtue of not having produced the ovum.) This does not mean that any theory is overturned. The theory of atomic numbers may remain in place as the proper theory of chemical properties if this newly discovered difference is not a difference in chemical properties. Waismann now asks, do we go forward calling such a substance that passes all tests yet is palpably different 'gold'? It follows from Baptism that there are right and wrong answers here *qua* meaning. For Waismann, it is a choice that is left open by meaning.

Such possibilities as claimed by Waismann may arise, for instance, when an advance in technology allows us to make hitherto impossible observations that fall outside the *remit* of existing theory. We need not strain our imagination here. Such things actually happen.

3 Open texture in science

Before the discovery of neutrons, the periodic table was understood to sort substances that each could not be separated further ('elements') into groups with certain shared properties. Soddy (1913b) observed that some elements could be further separated by weight, hence

> ten occupied places [in the periodic table] contain over forty distinct elements, whereas if chemical analysis alone had been available for their separate recognition, only ten elements could have been distinguished. … [These places] thus represent, not single homogeneous elements as has hitherto been supposed, but groups of elements identical in chemical character.

That is, some substances—decay products of radioactive elements—were determined to be *chemically* indistinguishable (i.e. in terms of reactive properties), but not *physically* indistinguishable, as they could be separated by nuclear weight. Whether these substances were, therefore, *of a single element* or *of different, chemically indistinguishable elements* was, at this point, open. Both options appear to have been live at the time. Although above Soddy speaks of different elements, he also (in a paper published the same year) claims that chemically inseparable substances are the same element.

> [I]t may be predicted that all the end-products [of certain radio series]… should be non-separable from lead; that is, should be "lead" (Soddy, 1913a)

He then cites the opposing view, that there may be different—*qua* differing in weight—elements occupying the same place.

> [Lead] appears in the International List with the nuclear weight 207.1. I should mention that Mr. [Alexander S.] Russell a year ago told me that he believed that the discrepancy between this value and that calculated (206.0) … was due to the end-product of radium [Lead-206; then known as Radium G] not being lead, but an element non-separable from it (Soddy, 1913a)

A third option would have been to reject the term 'lead' as incoherent or unsuitable for naming an element, on the grounds that it has now been revealed to denote not a kind, but a mixture. Our question is whether these options were merely epistemically open and some options are wrong *qua* meaning (as Baptism says), or were left indeterminate by meaning (as Waismann would have it).

Soddy and Russell found themselves in the kind of situation that Waismann described for 'gold'. It had hitherto not made sense to consider a difference between *identical nuclear weight* and *identical chemical properties*, just like before the advent of modern reproductive medicine it had not made sense to consider a difference between *producer of the ovum* and *carrier of the fetus*. In either case, the fact that these two categories can come apart is a new insight, but this insight outstrips the received semantic practice.

Today, one speaks of different isotopes of one element, rather than of multiple isotopic elements. In the publication record of the time, one finds no trace of a debate on whether elements "really" are chemically inseparable substances or "really" are physically inseparable substances.[9] Rather, the two ways of speak-

[9] A referee suggests that the terminological difference between Soddy and Russell primarily concerns the technical term 'element' and only derivatively the term 'lead'. The causal theory is primarily concerned with the ordinary, vernacular use of terms like 'lead'. Thus, perhaps, a decision about the scientific term 'element' (that was not introduced by baptism) led to the scientific use of 'lead' diverging from the vernacular use of 'lead'. For the vernacular use, the causal theory tells the correct story. Or the vernacular use has become indeterminate between the historical use (fixed by baptism) and the scientific use (fixed by description), roughly akin to how vernacular talk of 'fruit' is indeterminate as to whether tomatoes are included. I am skeptical about how useful this option could be to the causal theorist. This would require jettisoning all the claims about how scientific inquiry can tell us more about the inner constitution of the referents of our ordinary vernacular. Alternatively, the referee suggests, one could say that scientific inquiry only tells us more about the inner constitution of the *ordinary* referents of our ordinary vernacular (so that, say, tomatoes are non-ordinary fruits or Radium G is non-ordinary lead). But whether Radium G is *ordinary* lead seems itself to be left open by the prior meaning of 'lead'.

ing (of 'isotopes of (single) elements' and of '(multiple) isotopic elements') were used in parallel and, for all intents and purposes, interchangeably until 'isotopes of elements' becomes dominant around a decade after Soddy's discovery.[10] As seen, even Soddy himself goes back and forth. In fact, his remark about his colleague Russell reads not so much as noting a disagreement than as giving credit for anticipating his conclusions. To put it bluntly, everybody was excited about the newly discovered distinction, and nobody appeared concerned about what elements "really" are or what 'element' or 'lead' means.

Absent any discussion of the semantic matter, it seems plausible to conclude that the choice was not seen as significant and made largely arbitrarily. If anything, chemists apparently found it more convenient to continue talking of elements as occupying a single position in the periodic table. All this is as one expects it to be if Waismann is right. The received meaning of 'lead' (or indeed of 'element') was indeterminate as to whether nuclear weight makes a difference. Thus, we may conclude with Waismann, it was neither correct-*qua*-meaning nor incorrect-*qua*-meaning to say that Radium G is lead. This explains why the semantic debate did not happen and why the choice was made by convenience, rather than by appealing to pre-established meaning.

LaPorte (2003) discusses a series of similar observations about biological kinds. One of his examples involves the biological category *rodents*. At the time of LaPorte's writing, some biologists claimed that paradigm rodents such as mice and rats do not share a common ancestor with guinea pigs that is not also an ancestor of paradigm-non rodents such as primates (D'Erchia *et al.*, 1996). Thus, it was declared, guinea pigs are more distantly related to paradigm rodents than previously thought, hence not actually rodents.[11] LaPorte claims that

> "the guinea pig is not a rodent" was not discovered to be true, and scientists would not have been mistaken to have concluded otherwise. More precisely, neither the conclusion that guinea pigs are "rodents" nor that they are not "rodents" is quite right or quite wrong on the earlier use of 'rodent'. … Scientists [also] could have concluded that the "rodents" are just the animals traditionally called "rodents," including guinea pigs but not primates, by saying that … the "rodents" are *not a historical group* worthy of taxonomic recognition. (LaPorte, 2003, 67, his emphasis)

The choices for 'rodent' are similar to the choices for 'lead'. Guinea pigs could have been declared non-rodents; guinea pigs (and all intermediately related species,

[10] Today, scientists use 'isotopic element' or 'multi-isotopic element' to denote an element with multiple stable isotopes, which is a different use of the term.

[11] As far as I can tell, current taxonomies have returned to classify guinea pigs as rodents.

including primates) could have been declared rodents; or 'rodents' could have been rejected as a term unsuitable for taxonomy. Again, there is no indication of the *semantic* matter—what 'rodent' "really means"—being taken into account for this choice.

To be sure, the matter of isotopes—of why 'gold' names the element rather than its only stable isotope—is already discussed by Stanford & Kitcher (2000). However, their discussion is on the *qua*-problem (see Section 1), so confined to the matter of how atomic number (identifying an element rather than an isotope) was fixed to be the inner constitution of the initial sample. I raise a different issue: regardless of how reference was fixed and regardless of whether it was fixed to the element or some isotope, the causal theory cannot explain the scientific discourse after Soddy.

4 The causal theory revisited

My claim is that upon the discovery of isotopes it was an open question whether Radium G is lead. My evidence for this claim is that the scientific discourse of the time appears to have treated this question as open.

A causal theorist might however respond as follows. Just from it being the case that semantics *was not* considered, it does not follow that there were no semantic standards of correctness that *could* have been considered. It might just be that more significant considerations determined the choice. In the case of 'mother', there might be sufficient overriding considerations about who gets to be a mother, with all the moral, legal, and political consequences this entails, to render any prior semantic constraint so irrelevant as to escape notice. Likewise, chemists after Soddy might have had overriding concerns (perhaps related to the perspicuity of the periodic table) that rendered any prior semantic constraint irrelevant. Biologists might have found that among their choices—excluding guinea pigs from the rodents, including primates in the rodents, denying that rodents are a taxon—the first is most conducive to their craft. Thus, the mere absence of any appeals to semantics does not mean that no such appeals could have been legitimately made.

But this response is unsuccessful. The causal theorist's story about lead, supposedly, goes roughly as follows. A certain sample was once designated and the meaning of 'lead' was defined as *things of this kind* (or this is an apt metaphor for whatever actually happened). Science now determined that this kind is individuated by the inner constitution we call *atomic number 82* and that two substances share atomic number if and only if they are chemically indistinguishable. It follows that, necessarily, lead is everything that is chemically indistinguishable from the original sample. Science had not advanced this far when Soddy discov-

ered the isotopes. But epistemic shortcomings aside, the matter is determinate and will be recognised as such once science has caught up (as it did).

However, it seems straightforwardly possible that the matter of isotopes could have been resolved differently, so that today we would say that Russell's phrasing was right. We would then credit Soddy with the discovery that the places in the periodic table are not in fact occupied by single kinds, but by groupings of multiple distinct kinds. In this situation, 'lead' names only one of the substances with 82 protons and 'Radium G' possibly names another. But if the causal theorist's story about 'lead' is right, then this is mistaken *qua* the prior meaning of 'lead'. So, had science, for overriding concerns, gone with Russell, the term 'lead' would have undergone a meaning change *that it would not have otherwise undergone*. But this, in turn, means that *facts* changed that would not have otherwise changed. If, after the initial baptism, the reference of 'lead' was so that it refers to anything with 82 protons, then it was true that Radium G is lead. We expect science to care about such facts. Had we gone with Russell, the meaning of 'lead' would have changed so that it would be false that Radium G is lead. Supposedly, the decision to change the meaning was made for overriding concerns, such as the desire to preserve the elegance of periodic table. This means that the scientists changed certain facts due to an aesthetic concern. But re-defining meanings to get rid of *inconvenient facts* is, supposedly, bad science.

That is, if the causal theory is right, prior meaning fixes a particular reference that, in turn, fixes a particular fact. Any choice that changes the meaning, thus, would be a choice that disregards the facts. So the causal theory predicts that science *should* respond to prior meaning *in virtue of* caring about the facts. The causal theory entails that among the choices presented to Soddy, one was distinguished not merely due to conforming to prior semantics, but due to conforming to *truth*. Thus, the semantic matter, if it exists, *ought* to have been taken into account. But just like we find no evidence that it *has* been taken into account, we also find no evidence that it *should* have been taken into account.

This is not to say that scientists ought to be semanticists. My point is rather that the causal theory seems to put extraordinary demands on scientists who seek the truth—demands for which we find no evidence in scientific practice. Indeed, it seems hard to say what the scientists could have done or what kind of data they could have used to adjudicate whether lead ("really") includes Radium G or does not include it. The only and obvious move is to reject that there are such truths, that is, to say that the question of whether Radium G is lead was open. So 'Radium G is lead' and 'Radium G is not lead' were equally appropriate conclusions as far as the facts were concerned. But this can only be the case if the reference of 'lead' is not fixed as the causal theory says it is, as Baptism entails that there are such truths.

Ghiselin (1987), for analogous reasons, moves to reject the causal theory,

claiming that

> we scientists do not attach a name to a class, then discover the defining properties which are its essence, but rather redefine our terms as knowledge advances. Therefore the view of Kripke … should be dismissed as nugatory, and with it the accompanying essentialism. (Ghiselin, 1987, 135)

LaPorte gives much the same analysis of his 'rodent' example:

> To make one conclusion standard or correct, the meaning of 'rodent' had to be altered. Scientists would have been entitled to alter language either way, so neither possible conclusion seems to represent a discovery about what have all along been called "rodents." It is not as if one conclusion gets the facts right and the other gets them wrong. (LaPorte, 2003, 67)

However, he rebukes Ghiselin's claim. Although LaPorte also concludes that the facts leave open either choice to change the meaning, he claims that this leaves the causal theory *as a theory of reference* (but not its predictions about science) untouched. Ghiselin, LaPorte (2003, 48) claims, has equivocated two distinct claims. The following are my renderings of these claims (Baptism is repeated from above).[12]

Fixed Reference. Science proceeds by discovering what a term refers to without changing what the term refers to.

Baptism. If a natural kind term was successfully baptized, it refers to the collection of things that have the inner constitution fixed in the moment of baptism.

To be sure, causal theorists seem to broadly endorse Fixed Reference. LaPorte claims that this is (in part) to ward off certain doubts raised by the likes of Kuhn (1970, 1990) and Feyerabend (1981). In brief: a common view is that science has made *progress* towards determining the true nature of, say, gold. That is, earlier scientists were wrong about the true nature of gold and we, now, are either right or closer to being right. But if science can proceed by changing meanings, then different scientific theories may be incommensurable. One theory might say true things in a language in which 'gold' means one thing, and another theory might say other true things another language in which 'gold' means something else.

[12]LaPorte also includes claims about rigidity in the part of the causal theory he seeks to preserve. This does not matter here.

Such theories might be impossible to objectively compare. Fixed Reference solves this, as it entails that modern and earlier scientists were talking about the same substance when they talked about 'gold'.

Alas, Fixed Reference is untenable, as we have seen that science *does* (and it seems, *must*) sometimes proceed by deciding between two equally valid choices for a new meaning, with each choice resulting in a different state of background facts. LaPorte agrees with all this, but contends that Baptism remains unimpeached. Terms get re-baptized as science proceeds but, he insists, Baptism is compatible with meaning changes. One reason to think so is that, my discussion notwithstanding, Soddy and Russell might have found themselves in a type of situation that Kripke describes as follows.[13]

> If ... the supposition that there is one uniform substance or kind in the initial sample proves more radically in error, reactions can vary: sometimes we may *declare* that there are two kinds of gold, sometimes we may drop the term 'gold'. (These possibilities are not supposed to be exhaustive.) (Kripke, 1972, 136, my emphasis).

It seems that Kripke leaves some space here to make *decisions* (expressed as declarations) about meaning within the causal theory. But the mere possibility to re-baptize or otherwise change the reference of some term is insufficient to address the problem of open texture. The problem was that prior meaning does not privilege any of the choices engendered by open texture, whereas Baptism entails that some choices are privileged. It is of no consequence that it is *possible* to declare a dis-privileged choice to be the correct one. The choice to re-baptize a term is always open. The challenge from open texture concerns the prior meaning of a term and whether this meaning privileges any choice.

Moreover, note that Kripke allows such declarations in situations where the supposition that there was one substance in the initial sample was mistaken. Indeed, Baptism is compatible with the failure of Fixed Refernce *only* for terms that were not successfully baptized. More technically, the following argument shows that if the relevant term was successfully baptized, then Baptism entails Fixed Reference.

1. If it is a fact whether Radium G is lead, then science ought to discover rather than decide this fact. (P1)

2. Science did proceed as it ought. (P2)

3. If 'lead' refers to the collection of all things that share a particular inner constitution, it is a fact whether Radium G is lead. (P3)

[13] I thank a referee for discussion on this passage.

4. 'Lead' refers to the collection of all things that share a particular inner constitution (Assumption)

5. It is a fact whether Radium G is lead. (From 3, 4)

6. Science ought to discover rather than decide whether Radium G is lead. (From 1, 5)

7. It was a discovery rather than a decision that Radium G is lead. (From 2, 6)

Premiss 1 is that science follows the facts;[14] Premiss 2 is that the scientists after Soddy did not act improperly *qua* scientists; Premiss 3 is a fact about extensional meanings. The Assumption is the instance of Baptism for 'lead' given that it was successfully baptized, and the final conclusion is the instance of Fixed Reference for 'lead'. By generalization, Baptism entails Fixed Reference whenever a term is successfully baptized.

So there is nothing to be gained by holding on to Baptism while rejecting Fixed Reference. One can only do so for terms that are not successfully baptized. But for such terms, Baptism is vacuous and there is no point to holding on to it.

5 Vagueness and open texture

LaPorte's plan to retain Baptism likely stems from his misconstrual of open texture as 'hidden vagueness' (LaPorte, 2003, 97). For instance, LaPorte claims that the choice about the meaning of 'rodent' is open, because 'the earlier use is vague about the matter' (67). Supposedly, this means that according to the prior meaning, guinea pigs are borderline cases of rodents, so no fact as to whether guinea pigs are rodents is settled. That is, assuming that kinds themselves are vague allows LaPorte to reject Premiss 3 in the above argument.

If the prior meaning of 'rodent' is reference to a vague kind, science can then proceed by precisifying this meaning to a more specific (but possibly still vague) kind. The reference of 'rodent' could be the things that share the same *vague* inner constitution. Once a borderline case is encountered, the term can be re-baptized to a precisification of that constitution.

[14] A referee suggests that a causal theorist who rejects Fixed Reference but keeps with Baptism might reject P1 on the grounds that scientists are free to define their terms as they see fit. I agree in principle, but my point is that this freedom tells us something about meaning that is incompatible with Baptism. Surely we expect science to follow the facts in *some sense*. So this move to reject P1 would require that a true sentence of the form 'x is P' is not itself indicative of a fact that science is to follow. If Baptism requires us to drive such a wedge between meaning and fact, then, in Ghiselin's phrase, it is nugatory indeed.

> When speakers recognize that their use of a term is vague, they tend to offer further specification for its use. That further specification amounts to a stipulation that changes the term's meaning. (LaPorte, 2003, 118)

The vagueness account appears to work, as far as it goes, for LaPorte because most of his examples involve biological clades, which are defined to be all descendants of a common ancestor. Some clades might be vague because it is vague what the common ancestor is.

> [If] the appearance of feathers [is] selected to mark the beginning of the birds, there may be vagueness as to when the clade begins on account of there being vagueness as to when this character arises: Modern feathers arrived after a series of more primitive structures that speakers might or might not count as feathers. (LaPorte, 2003, 85)

Perhaps such cases also support Kripke's (1972, 136) claim that the notion *same kind* could be vague. But even if such observations vindicate intrinsically vague kinds, they do not explain open texture. In the 'rodent' case, the transition from paradigm rodents to guinea pigs supposedly goes through paradigm non-rodents like primates. But to be a borderline case, the guinea pigs should lie *in between* the paradigm rodents and paradigm non-rodents. Perhaps LaPorte means to say that the primates have always been borderline rodents, but that would be odd as well.

Generally, open texture is not vagueness, and open texture is not always resolved by precisification. As Blackburn (1994) points out, the term 'mother' is open textured but not vague (also see Shapiro & Roberts, 2019). There might be, after the advent of modern reproductive medicine, cases where the prior meaning of 'mother' does not settle whether it should be applied. But there still are no smooth transitions from mothers to non-mothers. Likewise, there are no borderline cases of pure lead. To be sure, there are impure samples of lead and impurity is vague. But the case of the radioactive decay products is not related to impurity. We may treat 'pure lead' as an absolute, so that a sample is not pure lead if it contains even a single stray atom. If Soddy had had at his disposal a machine that can determine, down to single atoms, whether some sample is entirely and absolutely chemically inseparable from lead, he would still have faced the same conundrum. The open texture of 'lead' does not turn on impurity or other sources of vagueness. Thus, as it is for 'mother', the open texture of 'absolutely pure lead' not resolved by precisifying a prior meaning, as this meaning is not vague, hence not of the type of meanings that can be precisified.

Perhaps one would now move to apply a kind of three-valued logic whereby a non-vague but partially indeterminate kind has an extension, an anti-extension, and a neither-extension. The neither-extension contains the indeterminate cases. But this still draws sharp boundaries! The problem with the causal theory was that it entails that there are facts like *Radium G is lead* (or its negation). If we assign a tri-partite division as the reference of 'lead' and consider Radium G to be in the neither-extension, then perhaps it can be made out that neither *Radium G is lead* nor *Radium G is not lead* is counted among the facts that science ought to respond to. But then, this indeterminacy itself is a fact that science ought to respond to. If science proceeds by moving some items from a neither-extension into an extension (or anti-extension), a new fact is still created, and so the facts have been changed. This means that the tri-partite division still privileges one of the choices for resolving open texture, namely the choice to reject the term 'lead' as a term for a taxon (assuming that indeterminacy renders something so unsuitable). But the requirement is to have meanings that leave all choices equally open.

The same goes for attempts to avoid the problem of open texture by replacing Baptism with a weaker principle stating that, after a successful baptism, some term can *partially refer* to things of possibly different inner constitutions. Such an account has been developed by Field (1973), in response to a different (but similar) episode from the history of science. He observes that the term 'mass' admits of two distinct meanings that we may call *proper mass* and *relativistic mass*. This distinction was not known to Newton, but Newton said some true things about mass (things that are true for both proper mass and relativistic mass). Field considers and rejects the options that (i) Newton's use of 'mass' did not refer at all; (ii) it referred to proper mass; and (iii) it referred to relativistic mass. Instead, he concludes that Newton's use *partially referred* to both proper mass and relativistic mass.

In order to vindicate the truth of some of Newton's assertions, Field then gives a supervaluational truth definition. A sentence like x *is* P where P denotes some extension E and x partially refers to a and partially refers to b is true if and only if both a and b are in E. (Field extends this definition to more complex sentences.) Field's account of partial reference is friendly to the causal theory, but does not include Baptism. Nonetheless, it does not explain open texture. If, say, 'lead' partially refers to all isotopes of lead, then *Radium G is lead* is neither true nor false. Then we are in the tri-partite situation above. If 'lead' partially refers to only a few isotopes, then *Radium G is lead* is either false or neither true nor false. If 'lead' partially refers to different subsets of the element lead, we are in the same situation again. In each case, too many facts are fixed.

The problem is this: to explain open texture, the meaning of a term must not settle certain facts about the application of the term. But the attempt to introduce

indeterminacy in the referential use or in the kind itself *still settles too many things*. Thus, adding a neither-extension or partial reference changes nothing. Adding further divisions changes nothing further.[15]

6 Conclusion

It follows from Baptism that, if 'gold' and 'lead' were successfully baptised as the causal theory would have it, it is a scientific discovery that the inner constitutions of gold and lead are atomic numbers. According to Waismann, this is the outcome of a decision. I argued that the actual course of science—as exemplified by the discovery of isotopes—supports Waismann. Open texture explains why there was a choice and why it was resolved the way that it was, whereas the causal theory entails that the scientists must have disregarded certain facts, or that the baptisms of the relevant terms were not successful.

Thus, the causal theory fails to explain the actual course of science, as it mistakes *decisions* for *discoveries*. Hence, it does not explain the meet of science and language. Proceeding from similar observations, LaPorte (2003) similarly concluded that the causal theory fails to explain the actual course of science. However, he claimed that the core of the theory, that reference to a collection of things with a shared inner constitution is established in successful baptisms, remains intact. But the thesis about baptisms is not properly separable from the thesis about science. The successful baptism of a term determines certain facts that science ought to be responsive to.

A further attempt to save the causal theory is to allow the references of kind terms to be themselves vague. Then, once science concludes that a term denotes a vague kind, the term can be re-baptized to a precisification of the kind. This avoids the previous problem, but the appeal to vagueness cannot amount to a full solution to the problem of open texture since open texture is not (always) vagueness. To otherwise introduce indeterminacy in the references of open textured kind terms is futile, as this will still entail that certain facts are fixed that actually are not fixed.

Thus, Baptism fails. Kind terms do not denote kinds.[16]

[15]Genuinely *vague* (i.e. admitting of smooth transitions) kinds might escape this argument, since when a kind is vague, then it may be indeterminate whether something is an indeterminate case, indeterminate whether it is indeterminately indeterminate, and so on. That is, something might be a borderline case in all orders of higher-order vagueness. For such cases, it might be said that there is no settled fact of any matter. But, as said, vagueness is not the right response to open texture.

[16]I am grateful to two referees for *Erkenntnis*, Chris Rahlwes, Stewart Shapiro and the audiences of the Lisbon *Functions and functional roles of concept* workshop for comments on this work.

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