**WHAT IS A THEORY OF SCIENTIFIC REPRESENTATION?**

**Abstract:** I address the question of precisely what recent debates about scientific representation have been about. I respond to a recent paper by Callender & Cohen (2006), who argue that such debates have largely been concerned with non-issues, because (i) they have primarily addressed the question of what *constitutes* something's being a scientific representation, and (ii) this constitution question receives a trivial answer, for what constitutes something's being a scientific representation is the fact that it is *stipulated* to be a scientific representation. I argue that the stipulation proposal doesn't account well for the apparently non-arbitrary nature of much scientific representation, and that the constitution question presupposes problematic metaphysical and semantic theses. Contra Callender & Cohen, I propose that recent debates about scientific representation are best understood as provisional attempts to explain a certain empirical phenomenon: the use of representational artifacts for predictive and explanatory purposes.

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**1.0 Introduction**

The philosophy of science has in recent years seen a flowering of interest in the nature of scientific representation. Philosophers have been particularly interested in precisely how scientific representations represent. Some philosophers have argued that the relation between a scientific representation and the entity or process that it represents (the 'target' of the representation) is to be explicated partly in terms of similarity (Giere, 2004). Others have argued that the relation is best understood as a particular kind of structural similarity, such as isomorphism or partial isomorphism (French 2002). Others have argued instead that the representation relation obtains in virtue of the fact that scientific representations facilitate inferences about their targets, and that this does not require there to be a special relation of similarity between the representation and its target (Suárez, 2004).
In this paper I attempt to clarify precisely what an account of scientific representation is, or ought to be. Note that I am not addressing the first-order question of what scientific representation is. Nor am I addressing the purely descriptive second-order question of what an account of scientific representation is. Instead, I am attempting to provide a charitable reconstruction of the project that philosophers have been engaged in when they have offered accounts of scientific representation, even if they have not explicitly acknowledged this as their project. My enquiry is motivated by a recent paper by Craig Callender and Jonathan Cohen (2006), who argue that there is no special problem of scientific representation. Callender & Cohen claim that the issue that recent accounts of scientific representation have been addressing is, on closer inspection, not a single issue but a congeries of distinct issues. Moreover, they claim that the issue that best answers to the problem of scientific representation is in fact an instance of a more general question about representation, which receives a rather trivial answer: scientific representations, like all representational artifacts, represent in virtue of being stipulated to do so. Thus, Callender & Cohen conclude, "some of the (hotly contested) debates in the literature are concerned with non-issues" (2006, p.7).

In what follows, I argue against this conclusion, and in the course of doing so develop my own proposal about what the scope, aims, and methodology of an account of scientific representation are. I argue that although Callender & Cohen perform a useful service in distinguishing between different questions that one might have about scientific representation, they privilege one of these questions as being the central question about scientific representation. But to assume without argument that participants in recent debates about scientific representation have been primarily interested in that question, which receives a trivial answer, is apparently a failure of interpretative charity, especially given that there are other interesting questions in the vicinity that don't receive trivial answers.

Moreover, the question that Callender & Cohen privilege appears to make questionable metaphysical and semantic assumptions. If these assumptions are rejected, as I think they should be,
then what Callender & Cohen take to be the question about scientific representation becomes much harder to address in isolation from the various other questions that they identify. Thus, on the emerging view, although the questions that philosophers have been asking about scientific representation are a congeries of distinct questions, they are nevertheless intimately related questions about different aspects of a single empirical phenomenon: the use of external representational artifacts to predict, explain and control features of reality. The problem of scientific representation is understood on this view as the broadly empirical problem of explaining how scientific representation works. This problem plausibly encompasses a wide range of questions, and implicates explanatory perspectives from a wide range of disciplines -- much as (say) the problem of explaining heredity encompasses a range of questions and explanatory perspectives.

In the next section, I outline the various questions about scientific representation that Callender & Cohen distinguish, and describe their proposed deflationary solution to what they take to be the central question of scientific representation. In the subsequent section, I argue against their deflationary solution on the basis that it makes implausible assumptions about the nature of representation, and that it doesn't do interpretative justice to the positions of those who have recently advocated accounts of scientific representation. Finally, I flesh out how I think the problem of scientific representation ought to be construed. I conclude that recent philosophical accounts of scientific representation are best understood as tentative first steps toward an empirical explanation of the phenomenon of scientific representation.

2.0 Deflating the Problem of Scientific Representation

Callender & Cohen (2006) argue that participants in recent debates about the nature of scientific representation have been engaged in debates about "non-issues" because they have failed to adequately distinguish between different questions concerning scientific representation. Callender & Cohen suggest that the central question that most recent accounts of scientific representation have addressed, either implicitly or explicitly, is the constitution question: "what constitutes the
representational relation between a model and the world?" (Callender & Cohen 2006, p.8). For example, French (2003) is best read as addressing the constitution question when he argues that the existence of an isomorphism between systems A and B is a necessary and sufficient condition for A to be a scientific representation of B.

Of recent participants in debates about scientific representation, the philosopher who has perhaps been most explicit about addressing the constitution question is Suárez (2003). According to Suárez, a *substantive* theory of scientific representation ought to provide a reductive definition of the following form:

\[ A \text{ is a scientific representation of } B \text{ iff } \delta \]

where \( \delta \) is a set of conditions that are individually necessary and collectively sufficient for A to represent B\(^1\). That is, \( \delta \) constitutes what it is for something to be a scientific representation.

Like Callender & Cohen, Suárez proposes that the project of developing an answer to the constitution question ought to be distinguished from, and pursued independently of, other questions one might have about scientific representations. For example, both Suárez and Callender & Cohen distinguish the constitution question, concerning what makes something a scientific representation, from *normative* questions concerning what makes something a good, accurate, or explanatory representation.

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1. Confusingly, just a year later Suárez (2004) wrote that "representation is not the kind of notion that requires, or admits, [necessary and sufficient] conditions. We can at best aim to describe its most general features". It is unclear whether or not this expresses a change in his views. The earlier paper (Suárez 2003) was a critique of similarity-based accounts of scientific representation, so it is conceivable that he was there appealing to necessary and sufficient conditions *conditionally*, to make the point that no similarity-based account can provide a substantive account (in his sense) of scientific representation.
Suárez (2003) also argues that we should carefully distinguish the constitution question from questions about what he calls the *means* of scientific representation, namely the features of a scientific representation that scientists actively make use of when they make inferences or predictions about the target of the representation. For example, it seems plausible that scientists rely on certain similarities between the structure of the ball-and-rod model of the helical structure of DNA to make inferences about the properties of DNA. However, it is not immediately obvious that these similarities are what *constitute* the fact that the model represents the structure of DNA. Indeed, Suárez argues, questions about the means of representation are *prima facie* distinct from questions about what constitutes representation, so to avoid begging any questions, we ought to carefully distinguish the two -- at least at the outset of inquiry. Callender & Cohen echo this sentiment when they distinguish the utility of scientific representations for making certain inferences from the status of scientific representations *qua* representations:

> [Q]uestions about the utility of... representational vehicles are questions about the pragmatics of things that are representational vehicles, not questions about their representational status per se.

(Callender & Cohen 2006, p.15)

A fourth question that Callender & Cohen argue should be distinguished from the constitution question concerns the differences between scientific representations and other kinds of representations. There seems to be something characteristic about the kind of representation that is employed in science. What, if anything, is distinctive of scientific representation -- as opposed to, say, artistic or culinary representation? Callender & Cohen argue that this question is best understood as an instance of the traditional demarcation problem in the philosophy of science, which

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2. This seems to be precisely what is going on when Watson & Crick (1953) point out that their model "immediately suggests a possible copying mechanism for the genetic material" (p.737).
concerns what makes scientific enquiry distinct from other fields of enquiry, and ought to be kept distinct from the constitution problem *per se*.

To summarize, Callender and Cohen (2006) argue that there are at least four distinct questions concerning the nature of scientific representation that many participants in recent debates have failed to explicitly distinguish. These are:

1. The constitution question.
2. The normative question.
3. The means of representation question.
4. The demarcation question.

Callender & Cohen argue that recent debates about scientific representation have primarily concerned the constitution question, but because that question has not been adequately distinguished from the other questions, the debates have seemed much more interesting and important than they in fact are. Once the constitution question is distinguished from the others and addressed on its own terms, it is revealed that, given certain uncontroversial assumptions in the philosophy of mind about the nature of representation, the question has a rather trivial answer: what constitutes A's being a scientific representation of B is that A is *stipulated* to represent B.

The uncontroversial assumptions that Callender & Cohen think support this conclusion derive from a generalization of Grice's (1989) account of representation, according to which "non-natural" representational artifacts, such as language, paintings, street-signs, computer code, and so-on derive their representational content, and hence their status as representations, by being related in a certain way to a more fundamental class of "natural" representations, which have their content intrinsically.
According to Grice and others in the Gricean tradition, the bearers of intrinsic representational content are mental representations. Without wanting to commit themselves to any particular conception of the relationship between between natural (or 'intrinsic') and non-natural (or 'derived') representations, Callender & Cohen appeal to a 'generalized' Gricean picture according to which there is some distinction to be made between natural representations and non-natural representations, such that the latter derive their representational content from the former. Callender & Cohen rightly point out that this generalized Gricean picture is widely endorsed among philosophers of mind and cognitive scientists; and apparently for good reason, for it appears to afford a certain explanatory economy: While it says little about how natural representations obtain their content, it at least explains how non-natural representations obtain their content, thereby replacing two puzzling questions with one.

Moreover, Callender & Cohen argue, it helps to resolve, or perhaps dissolve, the constitution question for scientific representation. For it seems plausible to count scientific representations alongside language, paintings, road-signs, and so-on as instances of non-natural representations, which obtain their representational content by being related in a certain way to natural representations. But if this is right, scientific representation is just another species of non-natural, derivative representation to which the General Gricean account is straightforwardly applicable, hence there is no special problem about what constitutes scientific representations qua representations; what constitutes scientific representations qua representations is the same as what constitutes any other kind of non-natural representation qua representation.

Not only is there no special answer to the question of what constitutes scientific representation, there is no particularly interesting answer either. For according to Callender & Cohen, the relation between natural representations and non-natural representations in virtue of which the latter obtain their content (the 'interpretation relation') is one of arbitrary stipulation. As a result, there are "almost no substantive constraints on the sorts of things that can be representational relata" (2006, p.13) because
virtually anything can be stipulated to be a representational vehicle for the representation of virtually anything... the representational powers of mental states are so wide-ranging that they can bring about other representational relations between arbitrary relata by dint of mere stipulation.

(Callender & Cohen 2006, p.14)

Callender & Cohen describe the upshot of their view as follows:

the varied representational vehicles used in scientific settings... represent their targets... by virtue of the mental states of their makers/users. For example, the drawing represents the bridge because the maker of the drawing stipulates that it does, and intends to activate in his audience... the belief that it does.

(Callender & Cohen 2006, p.15)

As they point out, this proposal has the apparently counterintuitive consequence that virtually anything can serve as a vehicle of scientific representation. But if representation is so easy to come by, it is unclear why scientific representations are so useful and interesting. What is the use of constructing, say, an elaborate model of the helical structure of DNA, if one could represent DNA just as well using, say, a teapot?

Callender & Cohen argue that this reaction derives from conflating the constitution question with questions about the means of scientific representation. They insist that a teapot might, for some scientific purpose, be stipulated to represent DNA. In all likelihood it won't, for reasoning about teapots doesn't allow one to infer much about DNA. But this is a point about the pragmatics of scientific representation, not a point about what constitutes something's being a scientific representation. The difference between the Watson & Crick (1953) model of DNA and a teapot is not that the former can be used to represent DNA and the latter cannot, it is that the former happens to be better at licensing inferences about DNA than the latter. While Callendar & Cohen allow
that there might be interesting generalizations to be made about why certain artifacts provide better means of scientific representation than others, they insist that such concerns are, strictly speaking, orthogonal to the question of what constitutes something's being a scientific representation.

3.0 Inflating the Problem of Scientific Representation

Although Callender & Cohen claim to endorse only a minimal, uncontroversial version of the Gricean picture of representation, they in fact adopt a far more controversial version than they appear to realize. To see why, consider again the conclusion that their adopted version of Griceanism is intended to support: that the question of what constitutes the representational relation between a scientific representation and its target receives a trivial or deflationary answer. This is supposed to follow from a version of Griceanism according to which the interpretation relation between natural and non-natural representations obtains arbitrarily, in virtue of stipulation. For if the representational relation between a scientific representation and its target obtains merely in virtue of stipulation, then that relation is presumably not very interesting. Conversely, if that relation is interesting, then there are presumably more constraints on the relation than mere stipulation.

So the deflationary account of the constitution question that Callender & Cohen provide presupposes a particular version of Griceanism according to which the interpretation relation obtains merely in virtue of stipulation. But not only does this assumption go unmotivated, it also runs contrary to Callender & Cohen's claim to be endorsing only a minimal, uncontroversial version of Griceanism. For the notion that the interpretation relation is merely one of stipulation seems to imply that all (non-natural) representation is intrinsically arbitrary, and this seems to unduly restrict what is counted as representation. For there certainly seem to be representations that are not purely arbitrary. At least since Pierce (1932), philosophers have distinguished between symbolic and iconic representations. Symbolic representation is said to involve a purely arbitrary re-
lation between the symbol and its target. For example, the representational relation between the name 'Mr. Ed' and its referent is arbitrary, and obtains for contingent socio-historical reasons. On the other hand, the relation between iconic representations and their targets is not purely arbitrary, and is thought to obtain in part because of certain resemblances between the icon and its target. The representational relation between a photograph of Mr. Ed and what it depicts is, arguably, not purely arbitrary.

While it is perhaps best to think of symbolic and iconic representations as occupying opposite ends of a continuum, there nevertheless seem to be some interesting differences between these kinds of representation. One such difference is that symbolic representations seem conducive to expressing specific propositional contents, whereas iconic representations do not, at least not in the same way that symbolic representations do. For example, consider the (canonically symbolic) English sentence 'the cat is on the mat'. To a first approximation, this sentence expresses no more and no less than the proposition that the cat is on the mat. Consider instead an image of a cat on a mat. Does this express a proposition? Not obviously, and if it does, it presumably expresses indefinitely many propositions. For an image conveys a richness of content that a sentence does not. An image of a cat on a mat conveys multiple aspects of the cat's being on the mat: it represents the cat as having a certain color, as being a certain shape, as being closer to the fireplace than to the table, and so on. Conversely, a sentence conveys a specificity of content that an image does not. The sentence mentioned above states precisely that the cat is on the mat; no more, no less.

An intimately related difference between symbolic and iconic representation concerns the normative dimensions along which the veracity of a representation is evaluated. The primary evaluative dimension of symbolic representation seems to be truth or falsity; this of course follows from the supposition that symbolic representations express specific propositional contents. On the other hand, the primary evaluative dimension of iconic representation seems not to be truth or falsity, but rather accuracy. Again, this seems to follow from the supposition that icons convey a
rich, multifaceted content. There are indefinitely many aspects of an image that might be evaluated for veracity.

These are differences that any explanation of non-natural representation ought to account for. But a version of Griceanism that restricts the interpretation relation to stipulation alone cannot easily account for these differences. For it's surely not plausible that the relation between an icon and its target obtains solely in virtue of arbitrary stipulation; that relation is supposed to be non-arbitrary. Prima facie then, a fully general Gricean account of the interpretation relation between natural and non-natural representations ought to allow that relation to obtain in virtue of something other than, or in addition to, stipulation. Such an account would still be a version of Griceanism, for it would still explain the content of even iconic representations in terms of their relations to natural representations. Of course, the relation between an icon and its target cannot obtain solely in virtue of there being a similarity relation between the two; at least since Goodman (1976) it has been a truism in philosophy that anything is similar to anything else in some respect, yet it is surely false that anything represents anything else. Instead, a fully general Griceanism should hold, roughly, that the relation between an icon and its target holds partly in virtue of certain recognized similarities between the two.

Callender & Cohen might insist that the interpretation relation is determined solely through stipulation, and that any intuitive force to the idea that icons achieve representational status in virtue of something other than stipulation accrues, as described earlier, from a conflation of the constitution question with the means of representation question. But while Callender & Cohen claim to endorse only the most austere and least committal version of Griceanism, they don't provide any positive reason to suppose that such a minimal Griceanism should restrict the interpretation

3. Note that I'm not proposing that the recognition of similarity between X and Y is a sufficient condition for X to be a (non-natural) iconic representation of Y. The point is merely that what makes X an iconic representation of Y will have something to do with an agent's interpretation of Y.
relation to mere stipulation in the way that they suppose. In fact, we've seen *prima facie* reasons to think that a minimal Griceanism should *not* restrict the interpretation relation in this way. To insist that it does, in the face of these reasons, is just to beg the question.

Not only is the claim that the interpretation relation is restricted to stipulation unmotivated, it also seems straightforwardly false. It seems false, for example, that images represent their targets in virtue of being stipulated to do so. Are we to suppose that whenever a tourist takes a photograph of the Statue of Liberty, say, she *stipulates* that the photograph represents the Statue of Liberty? It seems overwhelmingly implausible that photographers generally stipulate *explicitly* that the photographs they take represent their targets. But then are we to suppose that photographers somehow *implicitly* make such stipulations -- *sotto voce*, as it were? What are we to make of this notion of implicit stipulation?

A related problem is that, as I discussed earlier, a characteristic feature of iconic representations seems to be that they convey a richness of content that symbolic representations do not. Insofar as a photograph can be understood to convey propositional content at all, a photograph of, say, the Statue of Liberty conveys indefinitely many propositions: that the statue has two eyes, that there is a helicopter in the distance, and so-on. Are we to suppose that the photographer *stipulates* that the photograph conveys each and every one of these propositions? If not, are we to suppose that the photograph does *not* represent that the Statue has two eyes, that there is a helicopter in the distance, and so-on? These are all serious questions that demand serious answers, and until they're addressed, Callender & Cohen's version of Griceanism appears to be a non-starter.

Perhaps Callender & Cohen might concede that the constitution question for certain kinds of non-natural representations cannot be deflated by cashing out the interpretation relation solely in terms of stipulation, while attempting to preserve their position by insisting that the constitution question for specifically *scientific* representations *can* be deflated by cashing out the interpreta-
tion in terms of mere stipulation. That is, perhaps Callender & Cohen might argue that while many non-natural representations are iconic, scientific representations are purely symbolic.

This seems not only *ad hoc*, but simply false. For many scientific representations seem to occupy the iconic end of the continuum of representation. Recall some of the examples mentioned at the outset of the paper: a model airplane in a wind tunnel, the double-helix model of the structure of DNA, the billiard-ball model of a gas. Moreover, recall that a characteristic feature of icons is that they are primarily evaluable in terms of accuracy rather than in terms of truth and falsity. There seems to be a relative consensus among philosophers of science that the same is true of many or most scientific representations. Indeed, as Callender & Cohen themselves put it,

> Just as there seems to be something wrong with claiming that a toy model airplane is true or false, there seems something wrong with claiming that the Ising model, Bloch model, or a logistic map is true or false.

(Callender & Cohen 2006, p.8)

The idea that scientific representations are symbolic rather than iconic is perhaps most plausible in the case of mathematical models. Equations seem to be the epitome of symbolic representation. However, even this case is not clear-cut, for similarities can obtain not just in virtue of shared first-order properties, but also in virtue of shared higher-order properties (Gentner & Markman 1997). Two systems might be similar in virtue of having the same abstract, relational structure, and one might argue that this structure is precisely what mathematical models represent.

4.0 Is there a (Unique) Problem of Scientific Representation?
Putting aside concerns about the particular version of Griceanism that Callender & Cohen adopt, I have deeper concerns about the way that Callender & Cohen construe the issues underlying recent philosophical debates about scientific representation. Callender & Cohen claim that there is an issue that deserves to be privileged as the problem of scientific representation, and that this is to be identified with the constitution question. I think there are two related problems with this claim. First, it seems to involve a dramatic failure of interpretative charity. Callender & Cohen provide little explicit textual evidence to support their claim that recent debates have been primarily concerned with the constitution question; their claim is an interpretative gloss. But given that Callender & Cohen think that the constitution question receives a trivial, deflationary answer, and hence think that recent debates about scientific representation have largely been concerned with "non-issues" (p.1), it seems uncharitable to interpret those debates as being primarily concerned with the constitution question -- particularly given that there are other, apparently non-trivial, questions in the immediate vicinity.

Second, it seems to me that the constitution question is enmeshed in a web of questionable metaphysical and semantic assumptions. To ask which facts constitute something's being a scientific representation presupposes that there are facts that constitute something's being a scientific representation, i.e. that there are essential properties that are individually necessary and collectively sufficient for something's being a scientific representation. The essentialism presupposed by the constitution question is made explicit by Suárez (2003), who claims that "a substantive theory of scientific representation ought to provide us with necessary and sufficient conditions for a source to represent a target" (p.226).

The constitution question thus appears to presuppose both metaphysical essentialism and the classical view of concepts (according to which concepts consist of necessary and sufficient application conditions). These theses are intimately associated with a particular construal of philosophical methodology, namely conceptual analysis. Now, I take it if that philosophy made any progress at all in the 20th century, it was in the realization that the project of conceptual analysis,
and the theses that it presupposed, is profoundly flawed. Like many contemporary philosophers, I think that attempts to provide conceptual analyses of interesting philosophical concepts have heretofore been resoundingly unsuccessful. Invariably, such analyses have either been subject to counterexamples, or have been uninformative because they've presupposed an understanding of the concepts that they purported to analyze. Further, I think it's fair to say that the classical theory of concepts is almost universally rejected by cognitive psychologists (Margolis & Laurence, 1999). While much more can be said about the shortcomings of the triad of essentialism, the classical view of concepts, and conceptual analysis, I think enough has been said to warrant the following point: it is highly problematic for Callender & Cohen to hang the albatross of the constitution question around the necks of participants in recent debates about scientific representation without considerable justification.

If recent debates about scientific representation haven't primarily been about the constitution question, what have they been about? I propose that participants in these debates are best understood as making tentative steps towards an explanation of a characteristic kind of empirical phenomenon, namely the use of representational artifacts to predict, understand and explain patterns in experience. Let me elaborate. Perhaps the most striking difference between humans and other animals is the extent to which we construct and rely on artifacts. Early humans probably used artifacts primarily to manipulate their material environments, but following the purported 'revolution' of the Upper Paleolithic, modern humans increasingly used artifacts to manipulate their cognitive environments. Representational artifacts were used to measure, record, process, and transmit information for a wide range of purposes, including agriculture, construction, navigation, trade, social affiliation, and so-on. One such purpose stands out in the present context: the explanation and prediction of natural phenomena. The use of representational artifacts for the purpose of explanation and prediction has a long history in most human cultures, but arguably achieved unprecedented social significance in Europe during the 16th & 17th centuries.
Precisely how we use representational artifacts for explanatory and predictive purposes (how we use scientific artifacts, for short) seems to be an interesting empirical question, one that could potentially shed light on long-standing epistemological questions about not only how we obtain knowledge, but also how we ought to obtain knowledge. However, the question isn't one that admits of a simple answer in the form of a classical definition -- just as, for example, the question of how heritable traits are transmitted from generation to generation isn't to be answered by providing a classical definition. Both questions require answers in the form of something far broader and more amorphous: a substantive empirical explanation. Moreover, both questions plausibly delineate research projects that encompass multiple disciplinary perspectives. It seems likely that the project of explaining how we use scientific artifacts will require the efforts of psychologists, anthropologists, historians, philosophers, and others. An example of a particularly promising line of enquiry being pursued by developmental psychologists involves research into the development of explanation, functional understanding, and the mechanisms of cultural learning (Csibra & Gergely, 2006; Keil, 2006).

I agree with Callender & Cohen that participants in recent philosophical debates about scientific representation haven't always been entirely explicit about the nature of their project, and I think that Callender & Cohen have performed a useful service in clarifying what's at issue in these debates. However, I think that their interpretation of what's at issue is not well motivated. Contra Callender & Cohen, I propose that moves in these recent debates are best understood as initial attempts to provide a schema for an explanation of scientific representation (Darden, 2002). I have two reasons, each corresponding to the criticisms of Callender & Cohen I presented earlier. First, my proposal about how debates about of scientific representation are to be construed is more charitable in that it doesn't imply that participants in those debates are largely concerned with "non-issues". And second, my construal is not tied to the questionable metaphysical and semantic theses of essentialism and the classical view of concepts. Whatever one's theoretical proclivities, it is presumably hard to deny that the project of explaining how we use representational artifacts for explanatory and predictive purposes is a worthwhile endeavor.
So we should reject the constitution question and instead interpret the problem of scientific representation in the way that I've suggested. This is not to claim that an explanation of scientific representation can ignore the general issue motivating the constitution question, namely the issue of what a scientific representation is. It's presumably a requirement on any adequate explanation of scientific representation that it provide a characterization of what a scientific representation is. But (1) there is no requirement that such a characterization take the form of a classical definition, and (2) such a characterization is surely not all there is to an explanation of scientific representation. Moreover, once the metaphysical and semantic assumptions of the constitution question are rejected, it seems likely that the question of what a scientific representation is can no longer be cleanly distinguished from the various other questions about scientific representation that Callender & Cohen identify, i.e. the demarcation question, the normative question, and the means of representation question. I now argue that these questions are indeed inextricably linked.

First, consider the relationship between the constitution question and the demarcation question. Callender & Cohen are surely right when they argue for the generalized Gricean position that scientific representations, like all non-natural representations, derive their representational content by being interpreted -- that is, by being related in a certain way to mental representations. However, as I argued earlier, the position that the interpretation relation between scientific representations and mental representation is purely arbitrary goes beyond a minimal version of Griceanism, and does not account well for the fact that in many cases, the relationship between scientific representations and their targets seems not to be arbitrary. Callender & Cohen might reply that whatever the relation between scientific representations and their targets, whether arbitrary or not, that relation is determined by interpretation. Thus, the reply goes, what determines the target of a scientific representation is no different from what determines the target of any other kind of non-natural representation. Hence the question of what makes X a scientific representation is distinct from the question of what makes X a representation simpliciter.
However, nothing here provides reason to doubt that there are interesting generalizations to be made about what distinguishes scientific representations from the more inclusive class of non-natural representations. There is every reason to suppose that scientific representations represent their targets in a characteristic kind of way, and that this is what makes scientific representations conducive to performing specifically scientific purposes, such as explanation and prediction. In fact, Callender & Cohen themselves allow that there are certain characteristic pragmatic constraints on the kinds of vehicles that are used as representations in scientific contexts. While they claim that such constraints are 'merely pragmatic', I think that once one rejects the metaphysical and semantic framework presupposed by the constitution question, a robust distinction between conditions that are constitutive of scientific representation and conditions that are 'merely' pragmatic disappears. The upshot is that what makes something a scientific representation, as opposed to a non-natural representation simpliciter, has to do with the specifically scientific uses to which that representation is put. In this way, the demarcation question and the question of what a scientific representation is are intimately related.

Note that in suggesting that there are interesting generalizations to be made that distinguish scientific from non-scientific representations, one needn't provide a definition of what a scientific representation is, nor does one need to claim that there is a bright line between scientific representations and non-scientific representations. It is a mistake to think that empirical explanation proceeds by providing a strict definition of the explanans at the outset of inquiry. As Churchland (1988) nicely put it in a slightly different context,

The idea that if only we could get the words correctly defined then we would understand the phenomenon is seductive but misguided. The words will come to have a more precise meaning as they are more deeply embedded within the framework of an empirical theory.

(Churchland 1988, p.284).

We have a rough idea of what scientific representations are, and can identify some canonical examples. From this we can begin the project of explaining scientific representation, and this
can in turn provide us with a better grasp of that which we're explaining. Moreover, we can allow that an explanation of scientific representation will reconfigure some of our intuitions about what a scientific representation is. For example, as I suggested earlier, many artifacts were plausibly used for identifiably 'scientific' purposes before the scientific revolution of the 16th & 17th century. Similarly, many artifacts used in engineering disciplines seem to have similar functions to representations that we would consider canonically scientific. So it might well turn out that 'scientific representation' is something of a misnomer for that which we're interested in. In any case, if we were to obtain a full explanation of the various phenomena that we pre-theoretically think of scientific representation, how we'd choose to apply the honorific 'scientific' in that case would be a merely semantic, rather than epistemic, matter. And there's no reason to think that such an explanation is unavailable.

A second distinction that loses focus when one rejects the constitution question is that between the constitution question and the normative question, i.e. the question of what makes a scientific representation accurate or explanatory. To see why, it is important to distinguish between two different ways of understanding the notion of representation. We need to distinguish between locutions of the form 'A is a representation (of B)', and locutions of the form 'A represents B'. To say that A is a representation of B apparently implies that A has a certain kind of function; namely, to represent B. However, it need not imply that A veridically or accurately represents B, nor even that B exists. After all, not everything successfully performs its characteristic function. A heart that fails to pump blood is no less a heart. On the other hand, to say that A represents B does seem to imply that there is a B such that A successfully or accurately represents it. Thus whether something is a representation seems to depend on its function, which presumably depends on how it is used by intentional agents⁴. But whether something represents seems to depend in addition in whether that thing successfully performs its representational function;

⁴ Note that when I mention 'representation' hereafter, I am talking specifically about non-natural representation, unless I explicitly indicate otherwise.
whether in fact it successfully represents its target or not. To put the point somewhat more con-
cisely: we need to distinguish the noun 'representation' from the factive verb 'to represent'.

How does this point pertain to the relationship between the constitution question and the norma-
tivity question? It poses the following dilemma for Callender & Cohen. On one way of reading it, the constitution question concerns the conditions in virtue of which A is a scientific representation. That is, it concerns the particular kind of representational function that A has, *qua* scientific representation. But, as I argued earlier, it seems plausible that scientific representations have a characteristic kind of representational function that is distinct from other kinds of repre-
sentations, such as artistic and culinary representations. In that case, the constitution question seems inextricably linked with the demarcation question.

On another way of reading it, the constitution question concerns the conditions in virtue of which A veridically represents B. This question seems much closer to what recent philosophers have had in mind when they have argued, for example, that scientific representations represent in virtue of being similar or isomorphic to their targets. But in this case, the constitution question seems inextricably linked with the normativity question.

One might further suppose that the constitution question, demarcation question, and normativity question are all intimately related in the following way: one might think that one of the charac-
teristic features of scientific representations, as opposed to representations more generally, is that they are intended, in the long run, to accurately represent their targets. That is, one might think that in contrast to (say) artistic representations, which have the function of (say) eliciting emo-
tions or an aesthetic attitude\(^5\), the primary function of scientific representations is to accurately represent features of the world. Of course, not everything fulfills its function, and it is a deep

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5. Of course, I am not endorsing the claim that this is in fact the function of artistic representation. The example is merely illustrative.
and long-standing question in the philosophy of science whether scientific representations do in
general veridically represent the world, but it seems plausible that in many cases this is at least
what they are intended to do. Much more can, and should, be said about this issue, but for
present purposes the point should be clear: contra Callender & Cohen, it is plausible that there
are intimate links between what a scientific representation is, the characteristically scientific uses
to which scientific representations are put, and the accuracy of scientific representations.

Finally, it is worth pointing out that there also likely to be intimate links between the three ques-
tions just addressed, and questions about the means of scientific representation. It seems plausi-
ble that a central (though arguably not constitutive) characteristic of scientific representations is
that they have the function of veridically representing and explaining certain features of the
world, and that the means of scientific representations, i.e. the 'pragmatic' features that scientific
representations have in virtue of which they facilitate reasoning about their representational tar-
gets, are features in virtue of which scientific representations are able to fulfill those representa-
tional and explanatory functions. Thus, from this perspective, the 'merely pragmatic' features of
scientific representations are part of what makes representations characteristically scientific.

Moreover, if we put aside the question of what a representation is, and focus on the question of
how a scientific representation (veridically) represents, it seems plausible that the utility of a rep-
resentation in licensing inferences and predictions about a certain feature of the world is part of
an explanation of how the representation manages to (veridically) represent that feature of the
world. This seems particularly plausible in the case of non-ostensible features of the world, for
which our only epistemic contact is via the 'pragmatic' characteristics of the representations we
have of them (Enç, 1976). Indeed, a close relationship between the pragmatic utility of scientific
representations and the accuracy of those representations is presupposed by standard arguments
for scientific realism, according to which the practical success of scientific theories provides rea-
son to think that those theories are accurate. In sum, it seems plausible that questions about the
means of representation are intimately related to questions about the what scientific representa-
tions are, and how they veridically represent.
To conclude, once one rejects the metaphysical and semantic picture presupposed by the constitution question, an alternative construal of the problem of scientific representation emerges: the problem amounts to providing an explanation of the empirical phenomenon of scientific representation. This not only seems like an independently worthwhile project, but it also seems like the most charitable interpretation of the project that proponents of recent accounts of scientific representation have in fact been engaged in -- primarily because this interpretation does not trivialize such accounts. In any case, Callender & Cohen have performed a useful service in making the following point clear: insofar as philosophical accounts of scientific representation are intended to be substantive, they should be divested of any commitment to essentialism, the classical theory of concepts, and conceptual analysis. Instead, they should be understood as tentative steps toward an explanation of a fascinating empirical phenomenon: scientific representation.
References:


