

There *Is* a Special Problem of Scientific Representation

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Abstract: Callender and Cohen (2006) argue that there is no need for a special account of the constitution of scientific representation. I argue that scientific representation is communal and therefore deeply tied to the practice in which it is embedded. The communal nature is accounted for by *licensing*, the activities of scientific practice by which scientists establish a representation. A case study of the Lotka-Volterra model reveals how the licensure is a constitutive element of the representational relationship. Thus, any account of the constitution of scientific representation must account for licensing, meaning that there *is* a special problem of scientific representation.

1. Introduction

According to many philosophers of science, representation in scientific practice is different from representation in other disciplines, like art and language. This claim is denied by Craig Callender and Jonathan Cohen (2006), who argue that representation is the same across disciplines. In this paper, I will argue that their view leaves the communal nature of scientific representation unexplained. To explain why scientific representation is dependent upon practice, I will introduce the concept of licensing, in which the targets of representational vehicles are determined through various activities performed by scientists in accord with broader scientific practice. I will argue that licensure is a constitutive feature of representation in science, indicating that there *is* a special problem of scientific representation.

2. Callender and Cohen's View

On Callender and Cohen's evaluation, much of the literature on scientific representation has been "concerned with non-issues" (2006, 67). Specifically, they think there is no reason for philosophers of science to give a special account of the "constitution question:" "What constitutes the representational relation between a model and the world?" (2006, 68). In response to this question, they make a few observations. One is that it is "economical and natural to explain some types of representation in terms of other, more basic types of representation" (2006, 70). They also identify a general desire to have a consistent account of how "entities other than models—language, pictures, mental states, and so on—...represent the very same targets that models represent" (2006, 71). For these reasons, they suggest that

“scientific representation is just one more special case of derivative representation” (2006, 75). That is to say that the representational nature of scientific vehicles is explained in the same way that the representational nature of linguistic entities, artwork, etc. is explained. In each case, and in every practice, the representational nature in question will be reduced to a more fundamental representational entity. So, e.g., the representational nature of a word, a painting, and a scientific model will each be explained in terms of the representational nature of mental states.

On Callender and Cohen’s view, representation is purely stipulative: “virtually anything can be stipulated to be a representational vehicle for the representation of virtually anything...” (2006, 74). Of course, it is not the case that *any* stipulated representation will actually be useful for scientific aims. Thus, they identify pragmatic constraints which delimit scientific representation. However, they make it quite clear that these constraints are delimiting *already-existing* representations. As such, the pragmatic constraints are not a part of an account of the constitution of representation itself: “the questions about the utility of these representational vehicles are questions about the pragmatics of things that are representational vehicles, not questions about their representational status per se” (2006, 75).

If Callender and Cohen are correct, then we are left rethinking a rather extensive literature on scientific representation which typically begins with the assumption that there *is*

something special about representation in science.¹ As one example among many, Mauricio Suárez (2004) defends an inferential conception of scientific representation. His account takes careful notice of the aims of scientific practice, noting that mere stipulation (what he calls “representational force”) is insufficient for representation in science. To be a *scientific* representation, a vehicle must also permit surrogate reasoning which “allows competent and informed agents to draw specific inferences regarding [a target]” (2004, 773). If we accept Callender and Cohen’s view, then Suárez’s account and the many others like it do nothing more than identify some of the typical pragmatic strategies employed in delimiting representations for scientific uses (Callender and Cohen 2006, 78).

3. Private Reminiscence and Communal Representation

In order to show that the extensive literature on scientific representation has not been addressing a non-issue, I will need to show that there is a special problem of scientific representation, a feature unexplained by Callender and Cohen’s account. I submit that the relevant feature in need of special explanation is the communal nature of scientific representation, that it inherently involves reference to the practice. To see why Callender and

¹ For more accounts which answer the constitution question in a distinct way, see the work of Ronald Giere (1988, 2004), Bas van Fraassen (1980, 2008), RIG Hughes (1997), Steven French, James Ladyman, and Otávio Bueno (French and Ladyman 1999; Bueno and French 2011), and Gabriele Contessa (2007). For an overview of these accounts of scientific representation among others, see Brandon Boesch (2015) and Mauricio Suárez (2015).

Cohen's view is unable to account for the communal nature of scientific representation, consider what I call 'reminiscence', a representational relationship which lacks the same communal feature. It is defined schematically as the following:²

Some X is reminiscent of some Y for some agent A provided that when A thinks about or experiences X, she thinks about or experiences Y and attributes some connection between X and Y.

So, for example, a drawing can be reminiscent of my nephew, the smell of honeysuckle can be reminiscent of golfing, etc.

There are three noteworthy features of reminiscence. First, the representational nature of reminiscence can be reduced to the representational nature of more fundamental entities. For example, I can explain the drawing's reminiscence of my nephew in virtue of the mental state produced by the drawing (which is about my nephew, who created it). Second, stipulation is sufficient to create an instance of reminiscence. For example, I could draw a symbol on my hand which I create for the sake of reminding me to buy bread from the store. The reminiscent relationship exists because of my stipulative act. Finally, any limitations of reminiscent relationships will be made for pragmatic reasons. For example, it would be for pragmatic reasons that I make the symbol on my hand look like a loaf of bread.

² I should note that the account of reminiscence here is not meant as a detailed explanation of this concept, but only as an analogy to draw a point about representation.

These three features of reminiscence are noteworthy because they are shared by Callender and Cohen's view of scientific representation. In fact, from Callender and Cohen's perspective, the only major difference between the two concepts would be the particular aims for which each relationship is utilized. While important, these different aims alone are insufficient to explain a key dissimilarity between scientific representation and reminiscence: while reminiscence can be private, scientific representation is necessarily communal. That reminiscence can be private can be seen from the fact that discussions of reminiscence can terminate in disagreement. For example, no one is ultimately 'correct' about whether or not someone is reminiscent of someone else. This is because reminiscence is agent-relative and so depends only upon some particular agent and her mental states.

Scientific representation relies on much more. As Suárez has argued, "representation is not at all 'in the mind' of any particular agent. It is rather 'in the world', and more particularly in the social world – as a prominent activity or set of activities carried out by those communities of inquirers involved in the practice of scientific modelling" (2010, 99). Scientific representation is not isolated from the practice in which it is embedded. It is necessarily communal.³ The communal nature is demonstrated from the fact that representational vehicles demonstrate autonomy from individual scientists and their mental

³ The view of representation argued for in this paper echoes many of the points made by Ludwig Wittgenstein's in his 'Private Language Argument' where he argues that meaning is necessarily communal (1953/2009, 95^e-111^e).

states.⁴ For example, a scientist's rogue stipulation that the Lotka-Volterra model (which represents predator-prey relations) represents population change due to genetic drift does not count as an instance of scientific representation. This is not only because it does not (pragmatically) allow for meaningful insights, but also because it ignores and discounts the autonomous elements of the model as understood by the broader scientific community.⁵ The autonomous elements are seen in the materiality or historicity of the representational vehicle; in its development, reception, and contemporary use. Understanding how and why the scientific object represents its target requires paying attention to these communal features. That is to say that the communal nature is partially *constitutive* of the representational relationship. Callender and Cohen's account of scientific representation does not sufficiently account for these constitutive communal elements, as will be shown more explicitly below.

4. Licensing

Explaining the communal nature of scientific representation requires that attention be given to the material, autonomous dimensions of the representational vehicle in terms of its

⁴ This point has already been made specifically with regard to models by Morrison and Morgan (1999). Here, I am extending a similar point to other representational vehicles, including things like diagrams and figures.

⁵ Of course, there may be disagreements and developments internal to the practice about how to use some representation, but these disagreements and developments are *part of the practice*.

development, reception, and use. All of these features partially establish a scientific representation, through an activity I call *licensing*. Licensing is the set of activities of scientific practice by which scientists establish the representational relationship between a vehicle and its target. It is itself a constitutive element of the representational relationship: it is a critical part in explaining how and why some vehicle represents its target. Seeing the sorts of activities involved in licensing and how they partially constitute the representational relationship will require that we pay close attention to the historical development, reception, and use of actual instances of scientific representation.

4.1 Licensing in Artistic Representation

A similar sort of licensing is present in representation in art, and so an initial pass on the concept as it applies to artistic practice will be helpful to draw an analogy to licensing in science.⁶ To see the role of licensing in artistic representation, consider an example. The mere stipulation that Pablo Picasso's *Guernica* should represent the pain of cyberbullying is clearly insufficient to make it represent this target. Understanding how *Guernica* is representational involves an awareness of communal features: Picasso's intentions within the environment in which he created the painting, how the painting was received by viewers in the years following its creation, and how it is understood today. With these features in mind,

⁶ It is somewhat contentious to draw conclusions about the nature of representation in science by appeal to art; see e.g. Bueno and French (2011). Nonetheless, it is a common technique in discussions of scientific representation; see e.g. Suárez (2004).

it is clear that *Guernica* represents the pain and suffering of the people of Guernica who had been bombed by axis forces at the request of Francisco Franco and the Spanish Nationalists. The licensing here is a constitutive element of *Guernica*'s representational nature: without these features, it is not clear whether or how the painting would manage to represent anything at all.

Licensing also occurs outside of the scope of authorial intent, when the artistic community comes to accept that a piece of art is representational in a way that was not intended by the author. A good example can be taken from an anecdote related by the author Flannery O'Connor:

[A] student asked me...: "Miss O'Connor, what is the significance of the Misfit's hat?" Of course, I had no idea the Misfit's hat was significant, but finally I managed to say, "Its significance is to cover his head." (1988, 853)

The Misfit is a key character in O'Connor's famous short story, "A Good Man is Hard to Find," and, as such, it would not be surprising for his wardrobe to be importantly representational. Her answer indicates that while she did not intend any representational target for the hat, there may yet be one. If the hat is representational, it will not be due to her authorial intent, but rather due to the views of the broader artistic community.

Let me make it very clear that the licensure so far described is not already accounted for by elements of Callender and Cohen's account. First, notice that none of these means of licensing is a mere pragmatic limitation of already existing representations. It is not as if *Guernica* represents anything and everything, but is then *limited* by the contexts of Picasso,

audiences, and art historians. These contexts are a crucial part of understanding why it represents at all. Nor is the licensing mere stipulation. O'Connor leaves it open that there may be a representational target for the Misfit's hat, even though she did not stipulate one. A single reader's stipulation alone is insufficient to make it a representation, since the target must also fit well with the Misfit's characteristics, with O'Connor's general themes as understood by literary critics and audiences alike, and so on. Once again, these contexts are a critical part of establishing the representational nature of the hat.

4.2 Licensing in Scientific Representation: A Case Study

The unique aims of science indicate that the licensing of scientific representation is of a different kind than the licensing in art. All the same, licensing similarly plays a critical role in establishing scientific representation. According to Tarja Knuuttila, case studies of scientific representation have revealed that it is "a complicated phenomenon" and "a laborious art" (2014, 304). Understanding the nature of licensing and its role in the complexities of scientific representation will be best accomplished by examining the complicated features seen in the context of a case study. Examples could be made of any type of representational vehicle, like the masterful case study of a scientific figure made by Bruno Latour (1999). I will take as my example the Lotka-Volterra model, since its development exhibits interesting features, many of which have already been widely discussed by other philosophers (e.g. Knuuttila and Loettgers 2011, forthcoming).

As mentioned above, the Lotka-Volterra model is used by ecologists to represent predator-prey relations. It had its beginnings in the independent work of two different

scientists, Vito Volterra and Alfred Lotka. In understanding the representational nature of this model, it is important to pay attention to the licensing through its historical development. This attention includes noticing things like the way that the construction of the model by Lotka, Volterra, and others has been responsive to certain theoretical and empirical aims. These historical and practice-centered features of the model's development reveal the partial autonomy of its representational nature. These features constitute the licensing which is itself partially constitutive of the representational nature of the model since understanding how and why the model represents its targets requires attending to these features. Let us now turn to examine these features in more detail.

Consider first the development of the model by Volterra, who was “motivated by the goal of reproducing the kind of oscillating behavior that was observed empirically in fishery statistics” (Knuutila and Loettgers forthcoming, 19). His aim to address a theoretical question with an empirically useful model is central not only to understanding how the model historically came about, but in understanding how it represents its targets. Consider how Volterra described his project and the aims which permeate his description:

Let us seek to express in words the way the phenomenon proceeds roughly: afterwards let us translate these words into mathematical language. This leads to the formulation of differential equations. If then we allow ourselves to be guided by the methods of analysis we are led much farther than the language and ordinary reasoning would be able to carry us and can formulate precise mathematical laws. These do not contradict the results of observation. Rather

the most important of these seems in perfect accord with the statistical results.

(1928, 5)

Volterra's actual process of moving from words, to equation, to application of results (for both theoretical and empirical purposes) first involved creating an equation to account for the population change of a single species. He then added additional species and modelled interactions under different conditions, including, notably, contending for the same food and the predation of one species upon the other. Using these models, he demonstrated "three fundamental laws of the fluctuations of the two species living together" (1928, 20). He then applied these theoretical laws of predator-prey relations to the empirical case which had prompted his analysis, the peculiar rise in predator populations during the decrease of fishing of prey populations in the Adriatic Sea during World War I (1928, 21).

Why does Volterra's model represent these theoretical features of predator-prey relations? Why does it represent the populations of fish in the Adriatic during World War I? It represents these targets because, through a series of steps of analysis, revision, and development, each of which was responsive to certain theoretical and empirical aims understood and described in his account, Volterra *established* this representational nature. Indeed, as explained by Knuuttila and Loettgers (forthcoming), the historical development of this model has a much more extended history than the one Volterra described in the two papers where he first introduced it (1926, 1928). The model is a representation of its target not by mere stipulation and pragmatic constraint, but through careful and attentive construction of equations which ensure that the model functions in the wider theoretical

contexts and can explain the relevant empirical aims. In short, the model represents its targets because Volterra so *licensed* it by building into the model these external, autonomous representational features. Without these features, how or what would it represent?

Consider another instance of licensing in the development of the Lotka-Volterra model, this time by Lotka. His development proceeded with a different aim than Volterra: “instead of starting from the different simple cases and generalizing from them, he developed a highly abstract and general model template that could be applied in modelling various kinds of systems” (Knuuttila and Loettgers forthcoming, 13). He began by creating a very general equation which described “evolution as a process of redistribution of matter among the several components...of the system” (Knuuttila and Loettgers forthcoming, 15). In two papers (1920a, 1920b), Lotka applied this general equation to particular cases in biology and chemistry, in each case coming to theoretical conclusions about the systems in question. For example, in applying the equation to a predator-prey system, he concluded that there would be “undamped oscillation continuing indefinitely” among the two populations (1920a, 414). Lotka did not specifically apply the results to any empirical data, but instead used his results to come to theoretical conclusions about these relationships which he then connected to theoretical ecological principles drawn from Herbert Spencer’s *First Principles* (1920a, 414).

Why does Lotka’s model represent its theoretical target? What constitutes this representational relationship? Any attempt to explain the representational relationship must reference the way in which Lotka derived his general equation and the way in which he applies it to the specific cases. That is to say, the representational nature of the model is

constructed through the scientific activities performed by Lotka during the development of the model. Lotka does not merely stipulate that his model targets predator-prey relationships. Instead, he builds this ability into the model during the development of the general equation and further constructs this ability in his application of the question to specific targets. In so doing, he partially constructs the representational nature of the model—he licenses it as a representation through activities in accord with the broader practice.

The Lotka-Volterra model's history since its initial development is long and complex. As described by Alan Berryman (1992), one development was a shift in the 1940s to the use of a logistic formulation which allowed for attention to be placed on predator-prey ratios rather than products. Another development, which occurred around the same time, was the use of a predator functional response which introduced a nonlinear rate of death for the prey. These developments license new representational targets by expanding and altering the model to make it responsive to different theoretical or empirical aims, by removing idealizations, or otherwise by allowing for different theoretical conclusions. Many other variations of the Lotka-Volterra model exist, licensed by similar developments. Additionally, the original formulation of the model is still used in introductory textbooks on ecology (see, e.g. Cain, Bowman, and Hacker 2008). The representational nature of the model in each of these cases is partially established by these features of the model which stand independent of any mental states of scientists and students alike. In short, the constitution of the representational nature of the Lotka-Volterra model relies deeply upon these historical features of licensing as understood by the broader scientific community.

Let me briefly underscore the importance of these activities of licensing to the representational nature of the Lotka-Volterra model by imagining a scenario in which these features are absent. Suppose that Volterra and Lotka had proceeded differently. Suppose that they began, for no particular reason, by drawing a five-pointed star and stipulated that it represented predator-prey relations. What is the status of this star, qua representation? It is not as if the star *really* is a scientific representation of predator-prey relations albeit a bad representation (because it does a poor job of meeting certain pragmatic constraints). Rather, the star plainly fails to be a scientific representation at all. Scientific representations are constructed to assist in answering certain questions, explaining certain phenomena, understanding certain target systems. It is through licensing that scientists build into the vehicle the features capable of achieving these aims. A vehicle without licensing does not have this ability and so it is not just a bad representation. It is not a representation *at all*. Indeed, a discussion of the representational nature of vehicles which lack these features is either infelicitous or involves an equivocation of the word ‘representation.’ A view of scientific representation which equally counts both the star and the Lotka-Volterra model as full scientific representations, even if it specifies one as good and one as bad, underestimates the role of these historical features of the model. They are not external to the representational nature of the vehicle, but are themselves an essential constitutive feature of this representational nature: without these features, the vehicle is not a scientific representation at all.

5. The Special Problem of Scientific Representation

If I am right that licensing is a necessary constitutive feature of scientific representation which explains its communal nature, then contrary to Callender and Cohen's suggestion, we cannot pull the question of the constitution of representation away from questions of practice. A scientific object represents its target not (only) because there is some stipulation and pragmatic constraint, but also in virtue of licensing: the context in which it was created, the application of theoretical and empirical constraints, the awareness of and management of idealizations, and the history of its reception and use. Accounting for whether and how a scientific object represents its target will always require reference to these features which partially establish the representational nature. Thus, there *is* a special problem of scientific representation.

I should note that I am not here arguing for a stronger counter claim to Callender and Cohen which says that accounts of the representational nature of mental states are without *any* value to the constitution question of scientific representation. But my argument does indicate that an account of the representational nature of mental states *alone* is insufficient to account for scientific representation. Even if tomorrow we had a solid, universally accepted account of the representational nature of mental states, we would not yet have a complete account of scientific representation. We would still need an account of the deep reliance that it has upon the practice in which it is embedded. Thus, while our discussion of the constitution of scientific representation might include reference to the representational nature of mental states, it must also include reference to what I have described here as the licensing by the practice.

A different concern is that the use of the word ‘special’ is a bit deceptive. What I have identified here as the ‘special’ problem of scientific representation turns out to be a common feature of representation across disciplines, since, for example, I have suggested that it holds of artistic representation as well. While it is true that, according to my argument, an account of artistic representation will likely take account of licensing as well, it does not indicate that it is the *same type* of licensing in both practices. Indeed, given the unique aims that mark off scientific practice, its licensing can reasonably be expected to be correspondingly unique. That is to say that understanding, knowing, or explaining the empirical world are special aims, and therefore subject to special sorts of licensing. Scientific representation remains special because these features merit special attention.

We might also wonder whether it is right to continue to discuss scientific representation as a whole. If understanding representation in science requires in part that we understand the way in which scientists of a practice develop, utilize, and adapt these representational devices, then it is at least possible that these activities will be different within different domains. For example, the licensure of representations in physics might be rather different from that of economics. My suspicion is that, given the common broad scale aims of the various domains, we can still say some general things about representation in science as a whole. Nonetheless, we would do well to pay attention to representation as it occurs in these more localized contexts. Moving forward from this conclusion to develop further insights about the nature of scientific representation will involve analyzing specific representational objects or strategies as they occur in scientific practice, perhaps taking hints and clues from

in-the-field investigations like those conducted by sociologists of science, e.g. those in Lynch and Woolgar (1990), Latour (1999), and Coopmans et al. (2014).

6. Conclusion

Though Callender and Cohen's view remains a formidable approach to the constitution question of scientific representation, I have endeavored in this paper to show why their account is insufficient, and thus why this question merits continued attention by philosophers of science. Representation in science is deeply tied up with the practice in which it is embedded. The communal nature of scientific representation can be seen in the way that science, as a practice, partially constructs its representations through the activities of licensing. The licensing is not the pragmatic limitation of some already existing representations, but is itself a constitutive element of the representational relationship. Any account of what it is for a scientific object to represent its target will necessarily involve reference to licensing. Thus, there *is* a special problem of scientific representation.

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