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Successful visual epistemic representation

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ABSTRACT

In this paper, I characterize *visual epistemic representations* as concrete two- or three-dimensional tools for conveying information about aspects of their target systems or *phenomena of interest*. I outline two features of successful visual epistemic representation: that the vehicle of representation contain sufficiently accurate information about the phenomenon of interest for the user's purpose, and that it convey this information to the user in a manner that makes it readily available to her. I argue that actual epistemic representation may involve tradeoffs between these features and is successful to the extent that they are present.

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1. Introduction

How do scientists gain information about a physical system? The most straightforward way would be to examine the system using their unaided senses. But the senses often do not suffice for observation because the system is too small (like a molecule), too distant (like a star), too dispersed (like a population), or otherwise imperceptible. In such cases, scientists may use instruments to facilitate their investigation. But once they have exhausted all observational avenues—once they have done everything possible to gain information from the system itself—they usually have only completed the first phase of their investigation. For scientists are generally not interested in particular measurements, but in generalizations or patterns that can be inferred from them.[1] These patterns, which I will refer to as *phenomena of interest*, are rarely accessible through direct observation.[2] So the question is: once all available observational data has been acquired, how can scientists use a vehicle of representation—an entity physically separate from the system it represents—as a tool for gaining information about the phenomenon of interest?

The answer, I will argue, is by representing the system in a way that makes these patterns perspicuous to the user. I call vehicles of representation that are used as tools for gaining information about phenomena of interest *epistemic representations*.[3] As I will show, these include not only scientific representations, but also other representations that are used in similar ways outside of scientific practice. By bringing the features of interest to the fore, an epistemic representation unlocks for the user a dimension of access to the phenomenon of interest that she wouldn't otherwise have.

There are two sorts of contexts in which epistemic representations may be used: those in which little or nothing is known about the phenomenon of interest, and the representation functions as an *investigative* tool; and those in which the creator of the representation already understands the phenomenon of interest fairly well and uses it as a tool for *conveying* information about this phenomenon via testimony. In this paper, I focus on the latter sort of context and limit my attention to two- and three-dimensional visual representations. I investigate the features in virtue of which such representations convey information to their users about phenomena of interest that they wouldn't otherwise have. That is, I determine the features of *successful* representation for these kinds of cases.[4]

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[1] The point that scientists tend to be interested in patterns or regularities has been nicely articulated by Batterman (2009, pp. 429-30).

[2] Why this is so will become clear shortly through the consideration of examples (Section 2).

[3] I borrow the term 'epistemic representation' from Contessa (2007), but my usage of this term differs substantially from his. For a discussion of this terminological choice, see Bolinska (2013).

[4] Many authors (cf. Callender & Cohen, 2006; Contessa, 2007; Suárez, 2004) focus on understanding mere—that is, not necessarily true or accurate—representation. I think that understanding successful epistemic representation (which, as I will show, isn't just true or accurate representation) can also guide us in understanding 'mere' representation, but discussion of why this is so is beyond the scope of this paper.

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In order to understand what is required for successful visual epistemic representation, two questions must be addressed. First, what kind of information ought the vehicle of representation *contain*, and what is required for it to contain this information? Second, how is this information *effectively conveyed* to the user? I will argue that an epistemic representation is successful to the extent that it contains sufficiently accurate information about the phenomenon of interest for the user's purpose (Section 3) and is able to convey this information to the user in a manner that makes it readily available to her (Section 4). I will show that because visual epistemic representation often involves tradeoffs between these two features, the success of such representation is determined by how well they are balanced (Section 5). But I will begin (Section 2) by outlining three examples of successful visual epistemic representation and showing that they share two general features that inform the more specific features considered in Sections 3 and 4: they are user- and purpose-specific.

2. Examples and general features

User- and purpose-specificity are widely accepted features that comprise a central part of several accounts of scientific representation (cf. Bailer-Jones, 2003; Giere, 2004, 2009; Mäki, 2009; Teller, 2001). I highlight these features here to provide a foundation from which the remainder of my analysis may be developed. By taking the user- and purpose-specificity of epistemic representations as a starting point, we may then ask further questions about these features, thereby better coming to understand visual epistemic representation. In which ways, precisely, are such representations user- and purpose-specific? In virtue of what are they so?

In this section, I will present three examples of successful visual epistemic representation, in each case identifying the phenomenon of interest, indicating the sense in which it is inaccessible to its user(s) through direct examination of the physical system in question, and highlighting the ways in which the representation is successful only for certain users and for specific purposes.

The first example is adapted from Suárez (2004). Suppose we want to represent a system consisting of two ships travelling along the sea using two pens and a piece of paper. Let us further assume that the representation is used in the context of a conversation between the captain of one of the ships and her friend. To help recount the highlights of her last voyage, the captain might move the two pens along the paper to demonstrate, for instance, a manoeuvre she had to perform to avoid colliding with another ship that had strayed off course. In this example, the phenomenon of interest consists of the relative trajectories of the ships. It is inaccessible to the captain's friend because he was not present to witness her collision-avoiding manoeuvre. While the intended user of the pens-on-paper system is the captain's friend, it would be suitable for many other users as well, since little background knowledge is required to understand the relative motions of the ships. The purpose of the pens-on-paper system is to help the captain relay certain parts of her voyage to her friend.

A second example of a successful epistemic representation is the iconic map of the London Underground transit system.[5] Originally designed by draftsman Harry Beck in 1933 and modelled after a circuit diagram, the network of railway lines and stations that comprise the Underground is depicted as an orderly array of intertwined coloured lines, along which lie evenly-spaced marks labelled with station names, with white circles replacing these marks to designate interchange stations. Included with the map are keys that tell users how to interpret each of its features (Fig. 1). With the aid of this map, approximately three million daily users of the Underground are able to navigate this expansive system. The phenomenon of interest varies between users: for each, it is the set of the possible routes connecting the stations between which she wishes to travel. These routes are inaccessible to her, since while she could in principle ride the Underground in various directions to determine which one connects her to her destination station, this would be extremely impractical. Because the map of the London Underground is intended for use by a broad range of people with a variety of backgrounds and cognitive capacities, it is designed to cater universally to human users.[6] The purpose of the map is to determine the most efficient route from one station to another.

Finally, a third example of a successful epistemic representation is a three-dimensional model of a macromolecule like DNA or protein. The phenomenon of interest in this case is the structure of the molecule, *viz.* its three-dimensional shape, including bond types, lengths, and angles between constituent atoms. This structure is otherwise inaccessible to the user: it is not directly observable even using techniques like X-ray diffraction photography, since the images produced using such techniques must be interpreted to yield putative structures, and the process of interpretation can yield results that are often ambiguous or misleading.[7] Unlike the map of the London Underground, a molecular model's key is implicit, so users must be told which features of the model correspond to which features of a molecule, e.g. that white balls stand of hydrogen atoms, black for carbon, etc. While any user who understands this convention may grasp the structure as a whole, molecular models are most useful for one with training in molecular biology in the pursuit of further aims. For instance, such a user may rely on the knowledge of the structure she gains from the model to determine the function of the molecule or how it will interact with other molecules. Thus, the purpose for which the model is used often extends beyond simply learning about molecular structure.

3. Containing sufficiently accurate information

With these examples in hand, we may now turn to the more specific features of successful epistemic representation, each of which depends on the phenomenon of interest, the user, and the purpose for which the representation is used. The aim of employing epistemic representations is to learn about an aspect of the target system, the phenomenon of interest. But as I showed in the previous section, users often don't seek to learn about this phenomenon for its own sake, but rather to use what they learn for some further purpose. How accurate the information they gain need be depends on what this purpose is.

3.1. When is information sufficiently accurate?

In the pens-on-paper example the user is interested in the ships' relative trajectories as an aid to understanding the relevant parts of the captain's voyage. Thus, only very general information about the trajectories need be contained in the pens-on-paper representation. For instance, let us assume that one ship was on a head-on collision course with the other, and the other veered off to the

[5] This example is also discussed by Contessa (2007), Hoover (2012) and Bolinska (2013).

[6] This is not to say that no training whatsoever is required—users must be familiar with the conventions involved in reading maps—but that the level of training required is relatively low and fairly universally held in many parts of the world.

[7] The problem of determining molecular structure from X-ray diffraction photographs in the mid-twentieth century was notoriously difficult. See Olby (1974) and Judson (1996).