Maps and Scientific Representation

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"What is the single correct conceptualization of scientific representation?" This query dominates philosophical discussions about scientific representation. Callender and Cohen (2006) "dissolves" and "reframes" the philosophical discourse in at least three ways: (i) the various accounts of scientific representation on offer need not conflict, (ii) these accounts are more about pragmatics than about epistemology, and (iii) we must turn to fields besides philosophy of science to understand representation. I concur with this analysis and turn to cartographic practices (Winther 2014a "Mapping Kinds in GIS and Cartography," and *When Maps Become the World*, under contract University of Chicago Press http://ihr.ucsc.edu/when-maps-become-the-world/).

In cartography, maps have been defined as "graphic representations of the milieu" (*The Nature of Maps*, 1976, Robinson and Petchenik) and have been characterized as containing "propositions" and as simultaneously denotative and performative (*Rethinking the Power of Maps*, 2010, Wood). Some maps are *examples* of scientific representations – e.g., geological or astronomical maps. More generally, according to the map analogy—viz., "a scientific theory is a map of the world"—literal and figurative maps (e.g., geological maps, brain maps, rational choice theory as a map of human behavior) are *models* or *analogues* of scientific representation. Philosophers of science as diverse as Rudolf Carnap, Ronald Giere, Helen Longino, Philip Kitcher, and Thomas Kuhn have drawn extensively on the map analogy. Turning to scientific representation, in this paper I shall show how different parts and types of maps suggest that extant accounts of scientific representation in terms of *isomorphism* (e.g., Bas van Fraassen), *similarity* (e.g., Ron Giere, Michael Weisberg), and *fictionalism* (e.g., Roman Frigg, Adam Toon) are all valid. (Inferentialism, e.g., Mauricio Suárez, is also valid, but beyond the scope of this presentation.)

1. *Isomorphism and map scale.* Isomorphism is a one-to-one bijective mapping between two formal structures or sets. For Van Fraassen (1980, 1989, 2008), the relation of scientific representation—or at least the success criteria of representation—is isomorphism between course-grained structures of observable phenomena (Suppes' "data models," van Fraassen 2008, 167-8) and fine-grained "surface model" empirical substructures, and/or between empirical substructures and theoretical models (cf. Winther 2014b "The Structure of Scientific Theories," *Stanford Encyclopedia of Philosophy*).

   In cartography, map scale (Fig. 1) is defined as "the relationship between distances on the map and their corresponding ground distances" (*Map Use*, 2009, Kimerling et al. 23), and should be thought of as a relation between two idealizations, visual map space and abstracted Earth space (e.g., the Earth is not perfectly elliptical; *Elements of Cartography*, 1995 6th edition, Robinson et al., 61-63). Map scale is best understood as a relation of isomorphism, constructed and evaluated by satisfying this relation.

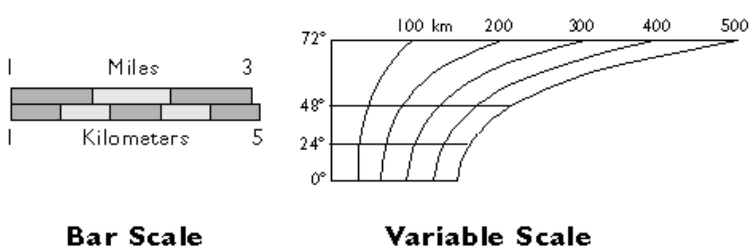

Figure 1. Map Scale
https://www.e-education.psu.edu/geog482fall2/c2_p6.html

2. *Similarity and symbolization*. Similarity is an intuitive and purposeful relation of resemblance between a target phenomenon and a model or other representational vehicle. According to Giere, the scientific representation relation takes this form: "*S* uses *X* to represent *W* for purposes *P*," where *S* is a scientist, research group or community, *W* is a part of the world, and *X* is, broadly speaking, any model (Giere 2004, 743). Relatedly, Weisberg (2013) develops a similarity metric for model interpretation (equation 8.10, 148).

    In cartography, visual "map generalization" practices involve "elements" (Robinson et al. 1995, 451-57) and "algorithms" (*Generalization in Digital Cartography*, Shea and McMaster, 1992) such as simplification, smoothing, symbolization, aggregation, typification, displacement, and classification. Map symbolization (Fig. 2) in cartography is "the process of graphically coding information and placing it into a map context" (Robinson et al., 451). Map symbolization, whether iconic or symbolic is best understood as involving similarity relations of various kinds, built and justified according to intentional, purposeful, and contextual similarities.

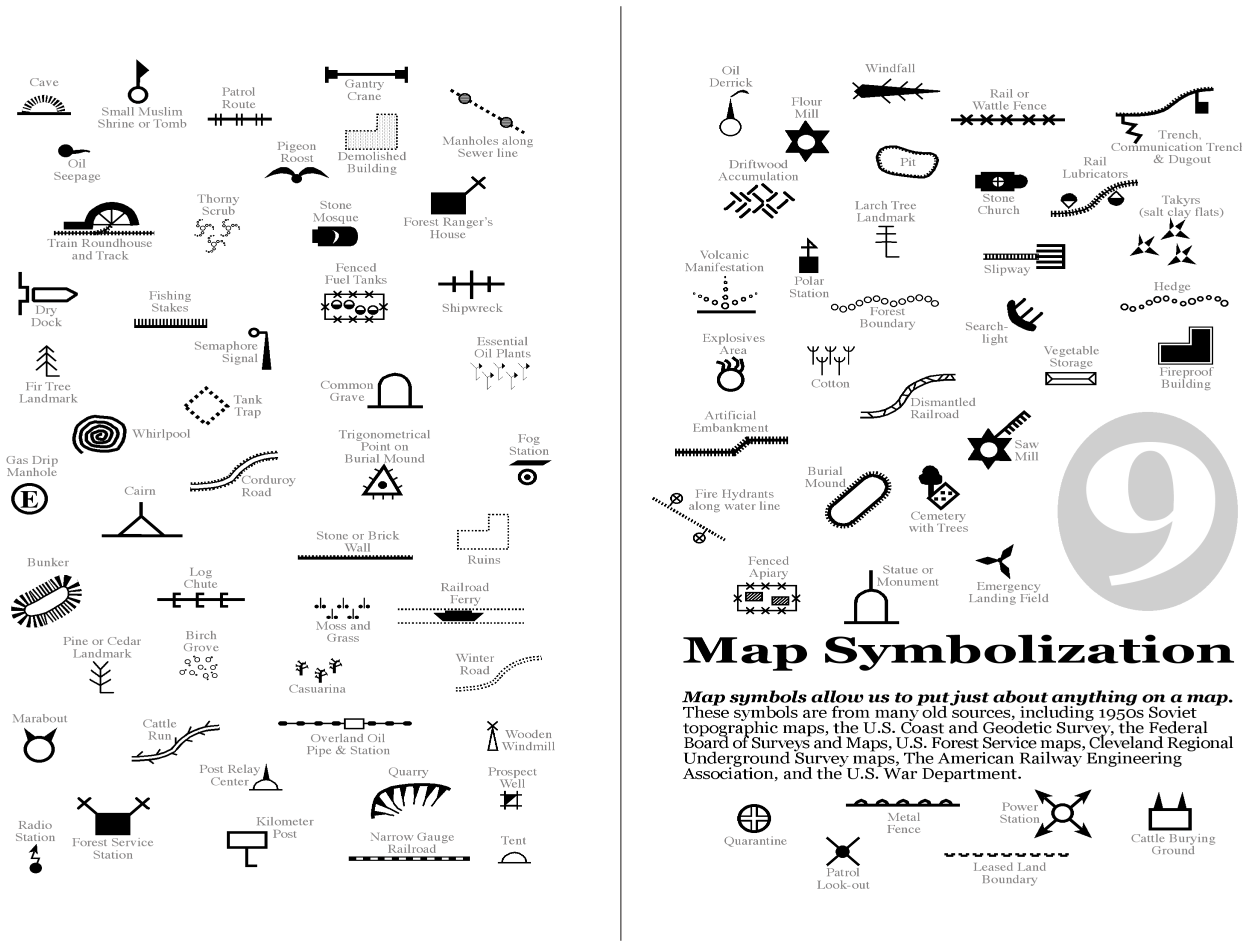

Figure 2. Map symbolization, from *Making Maps*, Krygier and Wood 2011, 170-71; cf. Bertin (1983/1967).

3. *Fictionalism and military maps*. Fictionalism holds that representational vehicles postulate and represent non-existent entities and processes, although some of their properties may correspond to real ones and some possibilities may be actualities. According to Frigg, proposing a scientific model involves "introduc[ing] a hypothetical system as the object of study" and "claim[ing] that this system is a representation of a target-system of interest" (2010, 98; cf. Toon 2010; Weisberg 2013, Chapter 4).

   In cartography, some map types are literal depictions of the actual, e.g., topographic maps (*Cartographic Relief Presentation*, Imhof, 2007/1965; cf. Wood 2010, 124-5 on topographic vs. thematic maps). Other map types should be understood as fictional and as exploring counterfactual possibilities. For instance, military maps spread on tables or walls and studied by military personnel (e.g., Winston Churchill's Map Room, Figure 3) are intended to be accurate. Even so, because of their role in experimenting with possible strategies and outcomes, they are best seen as fictions. Military maps are resources in representing possible worlds, or at least different fictional worlds that may become actual.

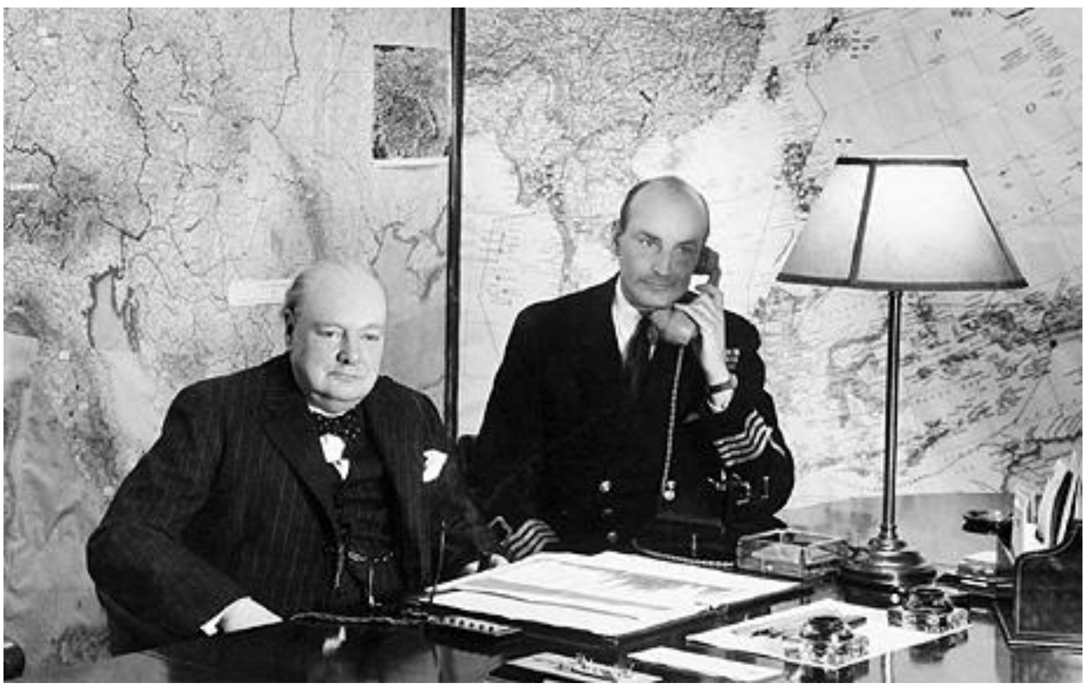

Figure 3. Winston Churchill with Captain Richard Prim, RNVR in the Map Room of his bunker near Westminster. http://www.telegraph.co.uk/education/6857064/Churchills-staff-reveal-their-hidden-stories.html

Rather than engage in "armchair cartography," as is common in contemporary philosophical discussions of scientific representation appealing to merely intuitive characterizations of maps, we would do well to explore actual practices of map making (e.g., surveying and data modeling; map generalization; map visualization) and the lessons these have for understanding scientific representation. Different map parts (e.g., map scale, map symbols) and map types (e.g., military maps) provide evidence for a plurality of ways for understanding the ontology, the justification, and the practices of scientific representation. Different scientific model parts and types can also be understood according to these three extant analyses, as indicated by a Pragmatic View of Theories (Winther 2014b, under contract).