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The morals of model-making ☆

S.G. Sterrett [a,b]

[a] Department of Philosophy, 135 Baker Hall, Carnegie Mellon University, Pittsburgh, PA 15217, USA
[b] Department of Philosophy, Wichita State University, 1845 North Fairmount, Campus Box 74, Wichita, KS 67260-0074, USA

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ABSTRACT

I address questions about values in model-making in engineering, specifically: Might the role of values be attributable solely to interests involved in specifying and using the model? Selected examples illustrate the surprisingly wide variety of things one must take into account in the model-making itself. The notions of *system* (as used in engineering thermodynamics), and *physically similar systems* (as used in the physical sciences) are important and powerful in determining what is relevant to an engineering model. Another example (windfarms) illustrates how an idea to completely re-characterize, or reframe, an engineering problem arose during model-making.

I employ a qualitative analogue of the notion of physically similar systems. Historical cases can thus be drawn upon; I illustrate with a comparison between a geoengineering proposal to inject, or spray, sulfate aerosols, and two different historical cases involving the spraying of DDT (fire ant eradication; malaria eradication). The current geoengineering proposal is seen to be like the disastrous and counterproductive case, and unlike the successful case, of the spraying of DDT. I conclude by explaining my view that *model-making in science* is analogous to *moral perception in action*, drawing on a view in moral theory that has come to be called moral particularism.

1. Introduction

That the practice of science involves values and norms is no longer in question. At least, my starting point here is that that question is already settled. The question can be pushed farther down, though, to the level of specific activities involved in scientific practice. The question concerning the role of values and norms then arises for one of the most ubiquitous activities in the practice of science: *model-making*. Does it make sense to ask questions about the role of values and norms for such technical aspects of the practice of science? Assuming that it does, we can go on to ask: Are there some such activities for which values and/or norms are *especially* or more intimately involved? At the other end of the spectrum, are there any such activities that do not involve values at all?

For this symposium, I thought through these questions for model-making,[1] and, as a result, came to see model-making as, in some cases, akin to moral perception; to put it more precisely, I came to see *model-making in science* as analogous to *moral perception in action* on the account of it given by the philosophical view known as moral or ethical particularism.[2] In this paper, I will try to explain how I came to this view.

2. Model-making: impact and nature

There are reasons to suspect at the outset that model-making might involve values and norms. For, model-making is employed in *describing* and *conceiving* and, consequently, might be expected to have an impact on actions taken. Common sense and critical examination of life experiences are probably sufficient to indicate that this is indeed the case, but there is also some experimental research in the behavioral sciences that illustrates the existence of what have become known as *framing effects*: the phenomenon that

E-mail address: susangsterrett@gmail.com

[1] For this invited talk, I was asked to specifically address the topic of models in engineering science.
[2] An introduction and overview of moral particularism is given in Dancy (2009).

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people choose differently depending upon the descriptions used to present the choices available to them. Experiments designed to exhibit such effects have been carried out for groups reaching a group decision, as well as for individuals making a choice. Instructed to indicate their choice, which option people say they prefer is sensitive to *how the options presented* to them are parsed and described; it is sensitive to *how situations are characterized* in the experiment, it is sensitive to *the consequences that are identified* in presenting the issue in the experiment, and, even, to *the perspective (individual, group) from which the consequences are described*.[3] How things are conceived of, evidently, makes a difference to what people would choose, at least within the constraints of, and when confined within, the laboratory.[4] Of course, how individuals act outside the laboratory may well differ in some ways from the behavior they exhibit in the laboratory situation set up in order to make predictions, so caution is in order when predicting actual behavior based on such experiments. Nevertheless, these experiments are informative on more general points. The general point I take from this experimental work is that they confirm that *how an agent responds to a situation can depend upon how the agent conceives of that situation*. As models are means of conceiving things (entities, situations, processes, etc.) model-making can, accordingly, have an impact on what agents do. That models have such consequences indicates that it is unlikely that model-making can be decoupled from values.

Other hints that model-making might involve values or norms come from the practical experience of those who have made models. It is part and parcel of model-making, whatever the field, and for almost every kind of model, that one must make choices about what the model is to include. There is generally going to be more than one way to model a given thing, situation, or process. This simple fact raises the question of what kinds of constraints or norms, if any, are employed to winnow down or rank the different ways one could make the model.

Yet, one could ask, even if values and norms are involved in the *use* of models, does this fact alone really determine the answer to the question as to whether model-making necessarily involves values and/or norms? On reflection: no, it doesn't. We might try distinguishing between what's involved in the model-making from what's involved in using the model. Once we do, we see that the fact that values and norms are involved in the *use* of models alone doesn't rule out the possibility that the model-making activity itself could be decoupled from specifications about what the model is to accomplish. Specifications for the model could be developed with the use to which the model is to be put in mind. So, decoupling looks possible. In fact, some might find it quite natural to wonder if it is not the case that *all* values and norms associated with the use of models are due to interests or values that can be identified either *before* the model-making occurs (i.e., in the specification of the problem that the model is made to help deal with) or *after* the model-making is complete (i.e., in using the model as a guide to what actions one will take).

To help gain some clarity on this, let us look more carefully at just what is involved in model-making. I'll begin by first examining models of some relatively circumscribed targets: models of machines. Then, I'll look at examples of models constructed for use in engineering the environment. Finally, I'll look at some proposals for engineering the planet.

3. An engineering model of a machine is never a model of *just* a machine

Since we are interested in examining the objection that the activity of model-making might be separable from interests, and that the source of values and norms that show up in the course of model-making are all attributable to the interests involved in either the specification or use of the model, let us begin by looking at cases towards the end of the spectrum where model-making is most circumscribed.

Consider the following example: making a full-scale reproduction, i.e., replica, of the original 1903 Wright Flyer.[5] This is a model-making task in which the target is relatively well defined and the goal of the model is defined sufficiently clearly that choices about how the model is to be made are relatively constrained by the problem definition. To draw out the point I want to make here about *engineering models* (versus *physical replicas*), let's clearly distinguish two different problem definitions.

> **Problem R (Make a Physical Replica of a Machine)**: Produce a physical object that is as close as possible to being exactly like the physical object that existed in 1903 now known as "The 1903 Wright Flyer" in terms of the physical properties it had when it was built and flown in 1903.
>
> **Problem E (Make an Engineering Model of a Machine)**: Produce a physical setup that allows one to determine the dynamic behavior (e.g., the forces, deflections, and motions) of the 1903 Wright Flyer during the flights that were made in it in 1903.

Neither problem is unusual, and each involves modeling with historical accuracy (i.e., one of them is to model a physical object that actually existed at one time; the other is to model behavior (position, momentum, forces) during an event that actually took place).

Different interests sometimes call for different problem characterizations, even for the same event or topic under investigation: Problem R is the appropriate problem statement, were someone to commission a work for a museum aimed at exhibiting a certain machine that once existed, with historical accuracy. Problem E is appropriate were someone to want to recreate selected scientifically-relevant aspects of the events in the historical record that the original researchers would have experienced when carrying out the experiments their notebooks indicated they carried out with that same physical machine. It is easy to conflate Problem R and Problem E.

Are these *necessarily* different model-making problems? Couldn't one model satisfy both of the problems set? The answer is that even if the same physical object that constitutes a solution to Problem R can be *used in* a solution to Problem E, the problems are really quite different and the models meeting those problem specifications are not comparable. So the answer is that they are in fact different model-making problems.

Perhaps some explanation is in order here. Since an engineering model is concerned with behavior, anything relevant to behavior is part of the model specification. The behavior of interest in Problem E (the engineering model) is similarity of processes, in that the model is to produce, possibly after rescaling, the same forces, deflections, and motions as the historical event. The behavior of interest in Problem R (the reproduction, or replica model) is to make a working replica. Now, one might think that making a working replica just is making a model that behaves the same way, but

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[3] There is a large literature on framing effects; a recent review is Stalans (2012). Paese, Bieser, & Tubbs (1993) discuss the relation between individual and group framing effects. Druckman (2001) proposes a method of evaluating the strength of framing effects due to a particular frame.

[4] The design and interpretation of many of the experimental studies meant to present particular instances of framing effects and establish claims about the mechanisms at work have sometimes been rightly criticized. However, I think the fact that framing effects exist and are frequently operative is well established. That is all I am relying upon here.

[5] Also discussed in Sterrett (2006).

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