

DISCUSSION

MODELS, THEORIES, AND KANT*

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A large number of definitions of the concept “model” have been given by various authors in recent years. Thirty-seven definitions are listed by A. I. Uyemov in a recent monograph (see [9]). This list is somewhat one-sided since it contains a disproportionate number of references to the work of Soviet authors. However, most of the important definitions given by Western writers are included. I shall give three definitions, all of great generality, so that various types of models, replicas, maps, theories and, most importantly, cybernetic models, are included. The advantage of this high degree of generality, or all-inclusiveness, is that the task of the investigator of uses of models in science, is reduced to classifying the various types of models, their construction, function, and structure, thus avoiding indecisive arguments (historically important, of course) such as the Duhem–Campbell controversy, so perceptively discussed by Mary Hesse ([2], [3]).

I shall begin with a descriptive definition, found with many variations among a number of authors, which may be stated as follows:

Definition A. A model is a functional homomorphism of a portion of the external world, or even of the observer himself, on a system of concepts, which preserves functional relations between the elements of each. This is a mapping which is not one-to-one (that would have been an isomorphism which is usually unattainable). The fact that the functional relations are preserved makes such models not only descriptive, but also predictive.

Definition B. This definition is due to Minsky, [6]. It is “To an observer B, an object A^* is a model of an object A to the extent that B can use A^* to answer questions that interest him about A.”

A rather similar definition is due to Raphael, [8]. It reads:

Definition C. “A model for an entity x has the following properties:

- a. Certain features of the model correspond in some well-defined way to certain features of x .
- b. Changes in the model represent, in some well-defined way, corresponding changes in x .
- c. There is some distinct advantage to studying the model and effects of changes upon it in order to learn about x , rather than studying x directly. The term ‘ x ’ may refer to any of a wide class of entities, such as an object, a statement in English, or a mathematical concept.”

It will be seen that *Definition C* is, in a certain sense, intermediate between *Definitions A* and *B*.

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In particular, all three of the above definitions include, as a subclass, theories (whether mathematical, as the theory of relativity, or descriptive, such as Darwinian evolution). In physics at the present time it is common practice to use the terms ‘model’ and ‘theory’ interchangeably, as in ‘liquid drop theory or model of the nucleus’, the ‘Schwartzschild Model of the Universe’, etc.

The chief importance of *Definitions B* and *C* is that they are especially suitable to cybernetic models, i.e. information processing systems. Profound analogies have been recently discovered between neural networks of the central nervous systems and the electrical networks of highly sophisticated electronic computing machines. Accordingly, a very attractive working hypothesis (model?) is that what we call “thinking” is information processing by a highly complex cybernetic system, the human central nervous system. I shall accept this hypothesis, in a heuristic sense, ignoring the controversies on this subject (see [1], [5], and [10]).

But if we accept this view, then the nature of the model is determined not only by the input from the outside, but also by the nature of the information-processing device. One cannot obtain a colored image on a black-and-white television set. Some features of the information-processing device itself predetermine the nature of the model. But is this not Kant in modern terminology? We read in the second paragraph of the Introduction, Paragraph I, “On the Difference between Pure and Empirical Knowledge,” of the *Critique of Pure Reason*, the following:

But, though all our knowledge begins with experience, it by no means follows, that all arises out of experience. For, on the contrary, it is quite possible that our empirical knowledge is a compound of that which we receive through impressions, and that which the faculty of cognition supplies from itself (sensuous impressions giving merely the *occasion*), an addition which we cannot distinguish from the original element given by sense, till long practice has made us attentive to, and skilful in separating it. ([4], p. 41)

To make this completely equivalent to what was said above one need only substitute ‘information processing system’ for ‘faculty of cognition’.

An even more suggestive passage occurs in “General Remarks on Transcendental Aesthetic,” of Section II, of Time, of Transcendental Aesthetic, in the *Critique of Pure Reason*. It is:

What may be the nature of objects considered as things in themselves and without reference to the receptivity of our sensibility is quite unknown to us. We know nothing more than our own mode of perceiving them, which is peculiar to us, and which, though not of necessity pertaining to every animated being, is so to the whole human race. ([4], p. 35)

Does this not imply that another “animated being,” possessed of superior (or just different) information processing devices, could, for instance, produce models of the world in which the space-time ordering had no part? More interesting, perhaps, is the obvious possibility of supplementing our own nervous system with information processing devices (at present called “computers”—not a very descriptive term); together, these could produce cybernetic models of the external

(and internal) world which are at present beyond our own unaugmented powers. As one example, perhaps the present impasse in the theory of elementary particles awaits a system (nervous system plus computers of highly sophisticated type) which would have an enormously larger storage capacity (memory) and information processing methods of vastly superior quality.

Finally, I suggest that it might be very profitable to re-examine much of Kant's work in the light of the information-processing theory of "thinking."

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