Models of Interactive Effects

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In my talk, I examine the use of models to investigate unexpected experimental results. I examine experimental demonstrations of previously unknown interactions between phenomena in a system. For instance, if a patient is the first to take two drugs together, the drugs may interact with each other in a way not explained by the conjunction of the effect of each drug on its own. I call such phenomena "interactive effects." Models of interactive effects contribute to scientific progress, since experiments that confirm interactive effects stimulate new models and more extensive explanations.

I focus on the use of models to construct new experiments that probethese "interactive effects,"which do not fit into any linear composition of the known capacities or properties of known objects. In such cases, I argue the role of these models is to narrowdown the options for what could be causing such effects. Models of interactive effects need notbe internally coherent or even consistent. Instead, they serve a heuristic role: composite models relate known capacities of typesof phenomena to mathematical equations that predict the behavior of these phenomena. These models are useful because they allow experimenters to conduct tests that determine whether a given effect is caused by a phenomenon that is analogous to, or in the ballpark of, some known phenomenon.

My main example of this kind of modeling is Heinrich Hertz's experimental model of electromagnetic waves. I show that Hertz was able to demonstrate radio waves (a kind of EM wave) because he constructed an experimental model that incorporated (1) a mathematical prediction about the buildup and discharge of potential energy in an electrical circuit, independently of the physical nature of that energy, and (2) a substantive experimental model based on the hypothesis that the phenomenon tested for is a kind of "wave," but that treats the phenomenon on analogy with two different types of waves, waves of sound and waves of fluid, at two different points in the experiment.

After examining Hertz's experiment, I make the following claims: (1) Experiment often reveals well-defined interactive effects, phenomena we cannot trace to any linear composition of the known capacities of causal agents, and (2) To avoid presuppositionsabout what kind of causal agents are at work one can construct a model that mediates between: mathematical equations agnostic about the character of the phenomena described; composite, often analogical descriptions of the phenomena that can be tested to narrow down the causes; and experimental data.

This view of the role of models in experimental testing accounts for one of the most fascinating aspects of Hertz's demonstration: Hertz provided one of the key experimental supports for Maxwell's wave theory, which led to two great achievements of the 19thcentury(the field theory and the unification of electromagnetism and optics),although Hertz had only a very loose conception of what the waves he was testing were. I arguethat this example, among others, supports the use of intermediate models of the kind I've described, to establish the limits of current theories and to test new phenomena that are not captured by known explanations.