THE LIMITS OF COMPUTER SIMULATIONS AS EPISTEMIC TOOLS

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Over the past few decades the use of computers for scientific purposes has been extended to virtually every branch of science. Such widespread acceptance is clear: their provide powerful means for solving complex models, as well as speed and memory for analyzing and storing data, visualizing results, etc.

A less broad, yet still important, use of computers in laboratory practice is by means of implementing computer simulations. Lately, scientists have turned their interest to the design, validation, and execution of computer simulations instead of setting up, controlling and calibrating a whole material experiment. Whether for budgetary reasons, time-consuming delays, or complexity, today scientific practice is carried out in a way that strongly relies (if not fully depends) on computers. Here we face a philosophical problem that now has become widely discussed.

Current philosophical literature deals with the question whether the epistemological value of a traditional experiment has greater (or less) confidence than a computer simulation. The most used trick for answering this question is by addressing the so-called "materiality problem".

Its standard conceptualization is characterized by Parker in the following way: "in genuine experiments, the same 'material' causes are at work in the experimental and target systems, while in simulations there is merely formal correspondence between the simulating and target systems (...) inferences about target systems are more justified when experimental and target systems are made of the 'same stuff' than when they are made of different materials (as is the case in computer experiments)" (Parker, 282). In general terms, the materiality problem can be addressed either by emphasizing the lack of materiality in computer simulations as epistemically defective (for example, as in Guala, Morgan and Giere), or by claiming that the presence of materiality in experiments is rare and, ultimately, unimportant for epistemic purposes (Morrison, Parker and Winsberg).

Either solution leads to what I call the "dilemma of computer simulations" for it presupposes that once the ontology of computer simulations is sorted out, its epistemic power can be fully determined. Indeed it is required, as premise, to provide an ontology that resolves the epistemic value of computer simulations. However, the informative exercise of simply checking off ontological features of computer simulations begs the question whether it is legitimate to draw any epistemic conclusion at all. Paraphrasing Hacking, they disagree because they agree on basics.

A different approach consists of defending the epistemic reliability of computer simulations as philosophically detached from its ontological conceptualization. This does not suggest, though, that they are two unrelated issues, but instead that each can be analyzed in its own right. In fact, there exist a close relation between them insofar the ontology becomes, to certain extent, a limiting case for the epistemology of computer simulations.

Therefore, instead of asserting that "on grounds of inference, experiment remains the preferable mode of enquiry because ontological equivalence provides epistemological power" (Morgan, 326), I hold a twofold claim: firstly, that materiality only restricts computer simulation from "accessing" certain aspects of the world which require a causal story; in other words, materiality draws the boundaries from where experiments become a specific and irreplaceable method for knowing something about the world. Secondly, that computer simulations provide ways of inference that do not depend on its materiality but on its capacity for representing empirical as well as non-empirical systems.□□Keeping an eye on these two claims, I propose to proceed in to co-related steps: firstly, by analyzing and characterizing the nature of computer simulations and material experiments; naturally, this step is highly dependent on assumptions on computational models, computer programs and experiment, all of which will be briefly addressed. Secondly, by discussing the philosophical relevance of the limits imposed to computer simulations by materiality as well as drawing some preliminary conclusions on their epistemic power.

Case examples will be briefly discussed as well. In one sense, there are many aspects of scientific practice that cannot be substituted by computer simulations, but require interaction with the material world: measurement, for instance, is one case. In certain measurement instances (i.e. the so-called "derived measurement"), the causal interaction of an instrument with the world cannot be replaced by the calculus performed by a computer simulation. Another interesting case-study is the reproducibility of experiments (Cf. Franklin and Howson 1984): as it is well known, the variation of instruments and experimental set-up tends to increase its epistemic reliability; it is not clear, however, that a similar methodology may work for computer simulations. In addition, the detection of new real-world entities seems a complete chimera for computer simulations, although it is a key role of material experiments. On the other hand computer simulations have the capacity of dealing with incredible complex equations that represent real-world systems and from which it is possible to "crunch" large amounts of data. Most of our knowledge about the world also comes from manipulating and interpreting such data. Computer simulations can also be used for investigating "rational worlds", such as counterfactuals, thought experiments and mathematical worlds.

I then urge for a philosophical discussion of the epistemological value of computer simulations based on its capacities and limits, instead of the dependence on an ontological conceptualization.

References

Franklin A., and Howson, C. (1984), Why do scientists prefer to vary their experiments?, *Studies in History and Philosophy of Science Part A*, 15(1), 51 – 62.

Giere, R. (2009), Is computer simulation changing the face of experimentation? *Philosophical Studies*, 143, 59–62.

Guala, F. (2002), Models, simulations, and experiments. In: L. Magnani and N. J. Nersessian (Eds), *Model-Based Reasoning: Science, Technology, Values* (pp. 59-74). Kluwer.

Morgan, M. (2005), Experiments versus models: New phenomena, inference and surprise. *Journal of Economic Methodology*, 12(2), 317–329.

Morrison, M (2009), Models, measurement and computer simulation: the changing face of experimen- tation, *Philosophical Studies*, 143, 33–47.

Parker, W. (2009), Does matter really matter? computer simulations, experiments, and materiality, *Synthese*, 169(3), 483–496.

Winsberg, E. (2009), A tale of two methods, *Synthese*, 169(3), 575–592.