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## Epistemological Perspectives on Simulation III

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- 1.1 Simulation in the social sciences is a diverse and multidisciplinary field that has been growing impressively since the 1990s. While simulation is opening new horizons for investigating systems that traditional scientific approaches were not able to address, a whole set of epistemological puzzles is emerging in the area, which brings the philosophy of simulation to a higher level of attention. The recognition that progress in simulation must go hand-in-hand with the analysis of its epistemological status has been an important motive for the series of EPOS workshops that have been taking place since 2004 (see Frank and Troitzsch 2005; Squazzoni 2009).
- 1.2 There are currently two different visions on the state of simulation in the social sciences. While recent surveys suggest a reasonable level of maturity and consolidation of key research questions in the field (see Meyer, Lorscheid and Troitzsch 2009), some conjecture that simulation is still in its infancy, lacking standards of good practice and validation of models. At the same time, a large community of researchers with an interest in investigating the conditions for the successful use of simulation is using a large set of sophisticated tools as well as frameworks and methods in an intense cross-disciplinary atmosphere. While on the practical side there seems to be an increase in the thematic character of the discipline as well as on the level of detail in the models and on the size and duration of projects, two main issues seem to be of concern to researchers on the epistemological side.
- 1.3 One tendency, which we call the methodological trend, includes (i) formulating methods; (ii) inquiring into methodological and epistemic conditions that determine the credibility of methods used; and (iii) analysing the role of prediction and explanation in simulation. Important issues in this trend include the description of policies and good practices, rules, protocols or even tests, in order to ensure that the practice of simulation results in good models of social complex phenomena; that models are comparable among each other, and that the simulation behaviour is appropriately understood by the researcher.
- 1.4 Another tendency, which we call the epistemological trend, goes deeper into the epistemological status of simulation and the analysis of the knowledge that it provides. This includes the relation

between theory, models and reality; how simulation produces knowledge, and its relationship with experimentation; and what kinds of empiricity are obtained through simulation. Included in this tendency is also the analysis of the concept of emergence.

- 1.5 Both of these trends are found in the papers included in this special section, originally presented at the "Third Edition of Epistemological Perspectives on Simulation: a Cross Disciplinary Workshop" (EPOS 2008), which was held in Lisbon, at ISCTE-Lisbon University Institute, October 2-3, 2008.
- 1.6 What is the epistemic status of different types of models and simulations and what kinds of empiricity are obtained through simulation? The extent to which models can be seen as a kind of experiment, simulations can be seen as experiments on models, and simulations can be seen as experiments by itself is questioned by Phan and Varenne (2010). Their analysis leads to the conclusion that the denotational power of the different levels of symbols at stake in simulation has to be taken into account if one wants to characterize the type of empiricity that a given simulation possesses, and hence characterize its proper epistemic status and credibility.
- 1.7 Interestingly, the approach taken by Baker (2010) in an attempt to clarify the recalcitrant notion of emergence in simulation lies in examining the precise boundaries of simulation-based and non-simulation-based techniques. Should a property be said to be emergent if and only if its presence can be derived only by simulation? While the core notion of simulation is well-understood, if such a definition of emergence is sustainable then placing bounds on the definition of simulation itself is, according to Baker, surprisingly difficult to do. This clarification remains open, while having close implications to the epistemological role of emergent properties in prediction and explanation.
- 1.8 On the methodological trend, however, the ways in which one can explain emergent interaction patterns in agent-based simulations can be quite distinct. In the case of simulations involving agents with goal-directed behaviour, such as BDI agents, the behaviour of agents is more variable, more difficult to predict, and harder to explain. In this context Harbers *et al.* (2010) present a concrete agent model that is able to generate goal-directed behaviour and explanations about that behaviour, thereby contributing to the explanation of a simulation as a whole.
- 1.9 On the bridge between methodological and epistemological trends, evaluation and comparison of simulation models is a crucial topic in agent-based modelling. Too often models are deficient in specifying rigorously the full set of elements relevant for the intended simulation domain. As Livet *et al.* (2010) stress, there is no reason to assume that the ontologies underlying the empirical, the conceptual and the implemented model domains are coherent with one another. They propose a conceptual framework, based on the crossing of the philosophy and the computer science insights, intended to reflect upon the role that a well-defined ontology plays to help model-building processes and to help with the comparison among models. In this context an *ontological test* for every simulation is proposed in order to assess the ontological compatibility among theories, models, and phenomenological facts in a simulation.
- 1.10 The methodological focus of Cioffi-Revilla (2010) is focused on how to build complex social simulations in inter- and multi-disciplinary contexts. These are increasingly based on building and publishing a succession of models, starting from a first simple model—which defines the initial basic ontology—to a final complex model, which should be sufficiently rich for answering the intended research questions. Inspired by Lakatos' notion of a research program, Cioffi-Revilla proposes methodological guidelines for dealing with present-day, complex, social simulation

projects, which are characterized by including numerous collaborators and many institutions.

- 1.11 In a long-term view on the future of social simulation and the difficulties encountered by its researchers for modelling social phenomena, Edmonds (2010) views science, and social simulation in particular, as an evolutionary process, in which the development of knowledge proceeds as a process of selection of models that are relevant for advancing further investigation. In this context, for Edmonds, the question of the quality of models in social simulation then lies in identifying the kinds of modeling approaches that are conducive to a strongest selective process, which would support a better understanding of observed social phenomena. He puts forward a set of modelling perspectives and activities that should be appropriately directed to obtain evidence, in order to gradually promote increasingly accurate models in the field.
- 1.12 Notably, one of the methodological difficulties in social simulation is the availability of empirical data with which to compare simulation results. Nevertheless, some technical fields do have a reasonable amount of data available and can arguably provide models that can serve as testbeds for relating real-world processes with empirical data. This is the case presented in Shuttle (2010), in the domain of air traffic movement, in which the author introduces a method for narrowing the gap between theoretical assumptions and empirical data.
- 1.13 Rather than comparing real-world data with model data, the methodological goal of Cecconi *et al.* (2010) is comparing and integrating different kinds of modelling approaches, namely agent-based modelling (ABM) and equation-based modeling (EBM). The goal is exploring theoretically the emergence of social conventions in simple traffic-like interactions. To what extent is ABM relevant to do EBM and vice-versa? In this regard, the authors find that the availability of analytical models for this problem is essential for comparing the results of ABM and EBM, suggesting that these two classes of models are not alternative but complementary in ways that go beyond the well-known considerations on the benefits of each modeling approach.
- 1.14 Overall, the set of papers presented at EPOS 2008 provided an excellent forum for debating the epistemological status of simulation, with contributions from researchers spanning a number of nationalities and scientific fields, including computer scientists, social scientists, and philosophers of science. The increasing interest in epistemological perspectives shows that simulation is becoming a discipline spanning a number of fields, with its own dilemmas, methods and techniques, its own influence on society, and its own contribution to knowledge and critical thinking. The co-editors hope that these papers contribute to a deeper understanding of the relevant issues, certainly in the scope of an exciting non-ending discussion, which will have its next episode in the EPOS workshop in 2010, in Hamburg, Germany, organized by Klaus Troitzsch and Mathias Meyer.



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