Chapter 6
An Epistemological Gap in Simulation Technologies and the Science of Society

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ABSTRACT

This chapter addresses methodological issues in relation to simulation technologies, using the example of archaeological modeling. While the top-down architecture of system dynamics became popular in the 1970s, the bottom-up approach of agent-based modeling actually predominates in social simulation. This paper demonstrates that the gap in sociological theory between interactionalist and structuralist theories can be discerned in the methodological framework. The theoretical implications associated with the choice of a simulation methodology are examined by contrasting agent-based and equation-based models in detail. This example makes evident how intimately issues of methodology are interwoven with epistemological and ontological questions. However, agent-based modeling aims precisely to overcome this dichotomy with the notion of emergence. The chapter therefore concludes with an overview of requirements for a technology of emergence.

INTRODUCTION

The past decades have witnessed an expanding number of computer simulations in the social sciences. For this reason, an investigation of those theoretical assumptions discerned in simulation approaches to social sciences becomes essential to comprehending the contribution of simulation technology to social theory, as well as taking

into account their positioning within the web of social sciences. While far from being adequately understood, there is a growing awareness of the specific contribution of technology to theory. Less discussed than the pros- and cons of the general methodology of simulation, however, are the theoretical implications that can already be discerned at the level of specific simulation tools. This purview forms the material of this chapter. Closer examination reveals that modeling tools are far from theoretically innocent. To this purpose,

the chapter will draw on the example of so-called equation- and agent-based modeling. It will be shown that these different approaches reflect a fundamental discrepancy within social theory. Broadly speaking, these methodological tools can be related to structuralist and interactionalist social theories. However, it is precisely the promise of agent-based modeling to provide a means of overcoming this dichotomy through showing how actors produce, and are simultaneously the product of social reality (Deffuant et al., 2006). It aims to bridge the gap between structuralist and interactionalist theories. Nevertheless, it will be argued that to date a lacuna remains.

To this purpose, a specific example is investigated in more detail: *archaeological modeling*. The specific explanatory strength and weakness of an agent-based model of hierarchy formation is compared with a corresponding analysis of an equation-based model for the emergence of the state. The choice of these specific examples is informed, indeed, by the circumstance that humans are ecologically special with regard to the emergence of complexity in their social organization. It is, in particular, remarkable that social differentiation is a process that took place in space and time. Many (so-called) primitive societies survive without bureaucratic structures. Hence, it is exactly the emergence of the gap between structure and agency that forms the subject of archaeology. For this reason, archaeological modeling is a particular interesting case: *methodological* issues (of the modeling framework), *epistemological* issues (of sociological theories) and *ontological* issues (of the emergence of social structures), are intractably interwoven. The conditions that have to be formulated in order to arrive at a methodology to bridge the gap between structure and agency might therefore be expected to be especially vivid in this example.

The chapter is organized as follows. First, a broad overview of the background is provided, consisting of two parts: a brief sketch of the background of developments in modeling technology and the theoretical problem of the micro-macro link in the social sciences. The next section is also divided into two parts, the first arguing for an evolutionary perspective on the problem, the second relating findings from archaeological modeling to the problem thus-specified. Finally, a possible solution for bridging the gap will be outlined that is commonly related to the notion of emergence. Those conditions that need to be formulated for future trends in order to study social emergence using simulation models will be investigated.

BACKGROUND

From System Dynamics to Agent-Based Modeling

The history of social simulation goes back to the early 1960s. Even though a number of different simulation technologies exist (comp. Troitzsch, 2003), for the purposes of evaluating the relation of theory to technology, a more detailed examination of two examples will be provided in what follows: namely, system dynamics and agent-based modeling. These have been most important in the history of social simulation, and represent the most powerful contrast within theoretical background assumptions.

Broadly speaking, simulation technologies first received attention in the social sciences with the rise of system dynamics, developed in the 1960s. The 'Limits to growth' were widely discussed both in the public sphere and social sciences in the 1970s. The System Dynamics approach is based on differential equations. It allows for the study of the non-linear interaction of systems of many connected equations, which soon exceeds the capacity of analytical mathematics. The body of all the equations is denoted the *structure* of the system. This modeling technology is characterized by two main features (Troitzsch, 2003). First, it describes the dynamic properties of a whole

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