# Chapter I
# The Need for Systematic Replication and Tests of Validity in Simulation[1]

**Michael Townsley**
*University College London, UK*

**Shane Johnson**
*University College London, UK*

## ABSTRACT

*This chapter outlines how simulation methods might be used to make valid causal inferences in the social sciences, specifically the study of crime. We argue that significant threats to validity exist for simulation studies and that, if researchers do not actively take measures to minimize these, much of the promise of simulation will not come to pass. Further, we nominate replication as a general method to facilitate the generation of valid findings. It is anticipated, with the burgeoning interest in simulation methods in criminology, that simulation studies will be published in sufficient detail that allows researcher scrutiny and replication, with a view to developing a cumulative body of scientific knowledge.*

## INTRODUCTION

Scientific approaches to understanding phenomena are distinguished from other methods by an obsession with validation. In academia this usually amounts to peers attempting to replicate or falsify results to examine the validity of published findings. For successful replications, modifications may be introduced to test the limits of context and to identify exceptions. Once sufficient replications have been conducted (and disseminated) the observation becomes "established lore" in the field,

or where replication is not forthcoming, or further research challenges the established convention, theories are revised (and sometimes reinvented) and the cycle begins again.

While the scientific method relies on an iterative cycle of hypothesis generation, testing and modification, academic disciplines advance under two conditions: (a) when its theories are falsifiable; and (b) when research findings are replicable. These are arguably easier to achieve when true experiments are possible. That is, where the effect of X on Y can be tested by manipulating X while observing the effect on Y, and those who do and do not receive the manipulation can be randomly selected.

In general, the social sciences have suffered, in some ways, due to an inability to conduct experiments in an absolutely controlled environment. Putative causal variables are not easily manipulable; "natural" experiments are rare; and field experiments expensive or ethically dubious. Ethnographic research is valuable but open to problems of memory distortion and impression management. However, recent technological advances have made simulation techniques[2] (i.e., *in silico*), particularly agent based methods for which interacting actors (pseudo victims, offenders, or guardians) with heterogeneous characteristics or propensities can be observed across a variety of settings, a viable social science analogue to traditional experimental designs. This presents previously unimagined opportunities for social scientists, but also introduces a number of complications.

As exciting as the potential for simulation-as-method is, serious methodological issues will arise as the popularity of simulation grows. The chief concern of this chapter is to explore the ways in which simulation studies and their findings could be described as valid. If we truly believe in the benefits of *in silico* experimentation, just like any other well established research method, effort must be committed to ensuring the approach is valid, or at least to establish its strengths and weaknesses. In setting out our position, we treat simulations as *in silico* experiments. It follows, we argue, that establishing the validity of *in silico* experiments will be very similar to the means through which this is achieved for experimental and quasi-experimental studies.

The rest of this chapter is organized around the validity typology conceived by Donald Campbell (1957), which has been built upon by others (Campbell & Stanley, 1963; Cook & Campbell, 1979; Shadish, Cook, & Campbell, 2002) and on which at least two generations of social scientists have cut their methodological teeth. There exist criticisms of definition and completeness of this typology, nevertheless we are satisfied that it covers the most germane and prevalent validation issues related to causal inference in social science.

## ARE COMPUTER SIMULATION TECHNIQUES JUST A FAD?

Underpinning this chapter is a provocative contention: computer simulation, as a methodology, has the potential to be no more than a fad. As evidence, consider the characteristics of fads. Aguirre, Quarantelli, and Mendoza (1998) distil their attributes by claiming that fads are *novel*, in that the practice is a new behavior or has no history; and are *perceived as odd* with respect to extant cultural norms[3]. Computer simulation techniques certainly share these traits. It is only due to Moore's Law[4] and the declining cost of computer processing that these simulation approaches are now possible. The concept of creating an artificial world as detailed and nuanced as imaginable in which entities interact according to defined rules and produce patterns that are often unanticipated *is* odd.

Further, Richiardi, Leombruni, Sonnessa, and Saam (2006) lament that despite the increase in agent-based research over the last 15 years there has not been a corresponding penetration on social