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14 Modeling the actual, simulating the possible¹

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1 Introduction

Pages hence I will have argued my way—our way, if you stay with me—to a point at which Elaine Scarry’s road-sign provides compelling direction. She writes:

Art, as though getting ready for an emergency, holds in steady readiness the intellectual equipment of creation in case (as seems now to be the case) there is a need to begin to look for and make recognizable the act of creating in the many other previously unacknowledged sites . . . Art is our starting place.
(1992, p. 245)

But not yet. We ourselves need to get ready for it by expanding our technological focus outward, step by step, into the surrounding disciplines.

Where else to begin but with a common word? Raymond Williams began with “culture” (1983/1976, 12), I begin with “model”—not just common but infamously polysemous. Trim the rampant growth of meanings back however much you wish, the idea in this age of digital representation is everywhere. It is not merely commonplace, it is fundamental to computing, in consequence ubiquitous, hence largely unnoticed, therefore a topic of considerable importance. The previous chapters of this book and the long essay on the subject in *Humanities Computing* (2014/2005) testify to Brian Cantwell Smith’s observation that nothing useful can be done with a computer otherwise. “In fact that’s really what computers are (and how they differ from other machines): they run by manipulating representations, and representations are always formulated in terms of models” (1985, p. 20).

But “model” is not adequate. As mere hardware, computers do nothing at all; as abstract formulations and their translations into code, neither do computational models. It is in the manipulating, in the enacting of the encoded model by hardware, that a model becomes a way of probing the known. Thus, there are deep reasons for centering not on “model,” but on the recursive *process* of exploring an idea of something by manipulating a digitally operationalized representation of it, changing that representation as results dictate, manipulating the altered representation, and so on. This process is what I mean by “modeling.”

In my earlier treatment, I noted that the word is commonly used for the process of designing and building a software model, but that sense emphasizes the engineering and suggests long-term stability of its result (McCarty, 2014/2005, p. 22). My emphasis is on what the scholar sees and does in the recursion of use, rethinking and re-engineering.

I also noted earlier that Clifford Geertz's two kinds, analytic "modeling of" an existing object and synthetic "modeling for" one to be made (1993/1973, pp. 93–4), blur into each other in practice (2014/2005, p. 24). But they differ and develop differently. As I will explain, the synthetic kind is, we might say, the logical precursor of simulation, which is my focus in this chapter.

Modeling *is* fundamental to everything we do with computing. But as we own up to the genuine complexity of that which we study, we face the stark limits of analysis and so need a different approach. My purpose here is twofold. First, it is to suggest how simulation might answer to the limitations of analysis in digital humanities by recalling what earliest users of digital computing did when they faced essentially the same problem, though in very different contexts. Second, by showing what simulation has done and is doing within the sciences, I want to come up with a means of identifying the most promising of futures for digital humanities.

But when we try to say what simulation is, in particular how it differs from modeling, difficulties spring up on every side. Disentangling the two sufficiently is no easy task. Usage in the sciences does suggest that they are quite different, that modeling is analytic, simulation synthetic. Nevertheless, coming to grips with specific differences, and so clearing a space for simulation in digital humanities, is difficult. I must struggle against the infamous polysemy of "model," against the protean nature of simulation in the various disciplines where it has developed over the last 70 years, and against widespread uncertainty of what simulation might signify for and do to the humanities, in which it has received scant critical attention until recently.

From the earliest days of digital humanities, simulation has been harnessed in much maligned experiments with automated writing and in pedagogical applications, though rarely by name or with awareness of its maturity elsewhere. My project here is to bring available knowledge to bear, triangulating on something like a common meaning or tendency detectable from its very different disciplinary forms. Then I will be able to return to the question of where and how simulation parts company with modeling—how it is *new*, at least for us, why it deserves to be called by its proper name. This is not to diminish "modeling," rather to be clearer about what we mean by it.

Clarity *will* prove elusive in the end, though not for want of effort. We, inheritors of Thomas Spratt's "plain style," working in the context of computing, tend to want clear-cut techniques to speed things up, get more done. But that is not what either simulation or modeling delivers. Simulation's mutagenic powers are ways of reasoning that evolve as they travel from discipline to discipline, altering the intellectual landscape wherever they find receptive ground, co-evolving with it.

2 Continuities of reasoning and practice

Definitions of “simulation” from the early period of digital computing frequently emphasize its dynamic, generative nature, sometimes explicitly contrasting it with the static model on which it is based—hence the popular term, “simulation model” to describe a basic design before it is put “in operation” (Lehman, 1977, p. 5). Furthermore, I have suggested that simulation co-evolves with the disciplines that take it up. Thus, its spread through the sciences has led to shifts in the meanings of basic terms, including “science,” in the latter half of the twentieth century, as part of greater cultural disturbances. I will argue that now the dust has settled, we can see in simulation a common ground for the sciences and the humanities where “fact” (*factum*, something made) and “fiction” (*factio*, the act of making) delimit a continuum rather than define an opposition.

The basic meaning of “simulation” is traceable from primeval ideas of similitude, analogy and figuration (Shepard, 1997; Foucault, 1989/1996, pp. 19–28), its technical history from devices in antiquity used or specifically contrived as analogies to physical objects, their functions, processes and later the equations describing them (Canguilhem, 1963, p. 510). Unfortunately, our common division of computing machinery into analogue (whose data varies continuously) and digital (which operates by discrete steps) has by a confusion of referents for “analogue” obscured the fact that both kinds of hardware implement analogical reasoning, though in different ways (Care, 2012, p. 98). As a result, the “continuity of practice” they share has been obscured (Care, 2010, p. vii), and so our view of simulation’s history blinkered.

The *Oxford English Dictionary*’s earliest entry for “simulation” in a positive sense does not help: it suggests that before the likely-seeming date of 1947 the word “invariably implied deceit” (Keller, 2003, p. 198), as it continued to do in other contexts. But a closer look reveals straightforward uses of the term in early twentieth-century descriptions of electrical circuits and of mechanics to simulate flight.² There can be no question that de facto simulations—Babbage notably describes one (Bullock, 2000)—go back as far as one cares to look, but positive use of the word to denote them would appear to originate near the beginning of the last century. This usage became dominant with the growth of digital computing.

Nevertheless, a redolence of deceit lingers, indeed is crucial to the total meaning of the word. Thus, RAND scientist David G. Hays remarked that “What goes on in a simulation . . . is a sham and a pretense: imaginative play” (1965/1962, p. 412). On one hand, the analogical, figurative nature of simulation makes it troublesome to believers in strict, objectivist realism, for whom it stands in much the same dubious position as figurative, poetic language. On the other hand, its technoscientific basis makes it equally disturbing to those for whom such belief is the enemy. Its dependence on skill and tacit knowledge moves it away from the theoretical to the practical, gives it the ambiguous status of an art or craft—for one ecologist “more akin to making wine than building a machine” (Peck, 2008, p. 394). Comparison to artistic practice is commonplace.

The telling point is simulation's defining moment: when it becomes the only way to know something or to form a coherent picture from fragmentary knowledge. But at that point we must ask, what kind of knowledge does the inferential bridge of simulation offer? How far can we go without it crumbling? I will return to these questions.

3 Continuity of intent

Simulation was intellectually compelling from the outset. Within the first decade of digital computing, publications grew rapidly in number and applications spread into widely diverse contexts. By the end of the 1960s, simulation had spread throughout the social sciences (Dutton and Starbuck, 1971, pp. 3–102). Today, hardly any corner of the sciences remains untouched (Gramelsberger, 2011; Winsberg, 2010; Keller, 2003).

Rapid uptake into such diverse contexts tempts us to look for a common aim or continuity of intent. I raise the question for a specific reason: if continuity could be found, it would give some indication of how those disciplines of the humanities that have not found a use for it might put simulation to innovative work. Evelyn Fox Keller cautions, however: no one taxonomy fits the variety of applications. The dilemma is this: while the “differences in aims, interests, and tradition” from discipline to discipline suggest distinct kinds of simulation, “the extensive cross-disciplinary traffic” that has characterized its history cannot be ignored (2003, p.199). She suggests following quasi-disciplinary lines of development while paying attention to the cross-talk. In the following, I heed her advice as much as limited space allows. But with an eye on the least likely humanities and the future of digital humanities in particular, I attempt two shortcuts: an argument for a continuity of simulation's effect on the sciences, at which I have already hinted, and the continuity of intent I am about to venture.

Consider to that end John von Neumann's “preoccupations with a question that might be regarded as the oldest and most fundamental of all questions about simulation, namely, how closely can a mechanical simulacrum be made to resemble an organism?” (Keller, 2003, p. 209). Among von Neumann's many distinctions, we know him as the father of Artificial Life. Since then A-Life has become an attempt to demonstrate via *in silico* simulation that “*life-as-we-know-it* [can be located] within the larger picture of *life-as-it-could be*” (Langton, 1989/1987, p. 1). But von Neumann's aim was different. In 1949, working on the cellular automata from which A-Life arose, he warned that, “By axiomatizing automata in this manner, one has thrown half of the problem out of the window, and it may be the more important half” (1966, p. 77). We know from his final set of lectures (1958) that his ultimate target was that other half, the problem of simulating the human organism in its physical totality. Elsewhere, I have argued that the implications for human self-understanding and the expressions of these in works of art and literature are central to the humanities (McCarty, 2014). So it begins to look like simulation belongs. But it is an indefatigable trouble-maker.

4 Cybernetics and nuclear weapons research

Between Turing's abstract *analogical* machine of 1936³ and von Neumann's 1945 translation of it into a design for hardware, World War II intervened. The war-effort resulted in two research programs important here: Norbert Wiener's cybernetics and nuclear weapons development.

Wiener named cybernetics after the Greek word for "steersman" (*kubernētēs*), whose intimate relationship with the tiller of a boat provides a telling metaphor of its aims (Wiener, 1961/1948). Cybernetics began in efforts to improve anti-aircraft artillery during World War II by integrating human with machine (Galison, 1994; Mindell, 2002). It succeeded, but it also resulted in a comprehensive theoretical vision, which for a time seemed to promise a universal science. Cybernetics did far more than is usually remembered: it had deep and long-lasting influence, bringing together common interests in the medical, social, psychological and physical sciences toward an integrative view of the human (Dupuy, 2009/1994; Heims, 1991). It provided a home for attention to kinaesthetic and cognitive human-machine integration, which surfaced later in the work of J.C.R. Licklider (who attended the Macy Conferences on cybernetics), Douglas Engelbart and others, in the fields of robotics, human-computer interaction and user-interface design. But I am getting ahead of myself.

Nuclear weapons development figures here for two reasons. First, digital simulation started there and proved itself to be a practical medium. The thermo-nuclear bomb would otherwise not have been possible. Second, in making the bomb, real simulation led directly to circumstances so unprecedented and otherwise unknowable in their outcome that military and civilian planners had to turn to simulation as the sole way of knowing how to plan for a probable, hauntingly immediate, terrifying future—and so to understand the world they and everyone else were in (Freedman, 2013, pp. 148–9). Simulation showed itself to be a means of realizing the imagined and imagining the real. With such traffic between the one and the other, can we be surprised that leading intellectuals of the time engaged in widespread questioning of what it meant to be rational (Erickson et al., 2013)?

During the research on the atomic bomb and then on the thermonuclear "Super," so much was unknown, yet by military and political imperatives had to be known that action could not be stalled for want of theory. The urgent need to make something that worked without knowing precisely how it might be done transformed the practical work of engineers and ordnance experts on the one side and the theoretical research of physical scientists and mathematicians on the other. Thus came about

a mode of inquiry to address problems too complex for theory and too remote from laboratory materials for experiment. Christened "Monte Carlo" after the gambling mecca, the method amounted to the use of random numbers (*à la roulette*) to simulate the stochastic processes too complex to calculate in full analytic glory.

(Galison, 1996, pp. 119f.)

Von Neumann was brought in to help with the practical, theoretically messy problems in continuum dynamics such as the behavior of shock-waves, flows of intense energy and other phenomena “too far from the course of ordinary terrestrial experience to be grasped immediately or easily” (Hawkins, 1946, p. 76; Aspray, 1990). Hence, the instrumental innovation required. Monte Carlo simulation thrived, first as a means of advancing the design and refinement of the atomic bomb in concert with laboratory experiments, then with the Super as the reality to be studied. Here we see a decisive shift: “bit by bit (byte by byte), computer designers deconstructed the notion of a tool itself as the computer came to stand not for a tool, but for nature” (Galison, 1996, p. 157; 1997, p. 777).

Let me underscore three things: that shift from tool to nature; the extension of the graspable by means of computationally imagined scenarios; and the Cold War culture of the Super, which simulation made possible. These three converge in a practical epistemology shared, for example, by military strategist Herman Kahn in *On Thermonuclear War* (2007/1960), by environmentalist Donella Meadows and others in *Limits to Growth: A Report for the Club of Rome’s Project on the Predicament of Mankind* (1972) and, bridging them in his involvements on both sides, by systems scientist Jay Forrester in *World Dynamics* (1973/1971). What united these very different people and their very different communities of belief was the conviction that global knowledge is simultaneously an absolute imperative and something acquired only by simulating an otherwise “unobtainable referent” (Ghamari-Tabrizi, 2000, p. 163). For Kahn, this referent was the future of warfare; for Meadows, the future of the world’s livelihood; for Forrester, the future of organizational systems; for everyone, simply the future.

Kahn argued likewise: all manner of fantasies had to be worked through *very* quickly (2007/1960, p. 125). A new language in which to conceive a practical response to an unprecedented military situation was needed. This the first postwar US defense planners seem to have found in Wiener’s *Cybernetics*. In the final report to the Scientific Advisory Committee of the Air Force in October 1950, the Air Defense Systems Engineering Committee (ADSEC) proposed *in these terms*, more than a decade before “cyborg” (Clynes and Kline, 1960, p. 27), a hybrid “organism” with coordinated animate and inanimate components: in effect, a great military anthropomorph comprised of men, mechanical “effectors” analogous to human sensory organs and the communications apparatus or artificial “nervous system” that would connect them (ADSEC, 1950, pp. 2ff.). (Anyone of television-watching age in the late 1980s within range of *Star Trek* will likely think immediately of the Borg.) ADSEC’s report was taken seriously, adopted immediately and acted on. From its imaginings evolved in time, the Semi-Automatic Ground Environment (SAGE), “an integrated information and control system on a continental scale” with which Forrester was intimately involved (Edwards, 2000, p. 230; Redmond and Smith, 2000). SAGE in turn led to various forms of “a world-encompassing surveillance, communication and control system” (Edwards, 2000, p. 230), including Ronald Reagan’s Strategic Defense Initiative, or “Star Wars.” “The President’s proposal did not seem bizarre to a public used to science fiction and conditioned by long exposure to Buck Rogers, Star Trek,

and Darth Vader to regard outer space as a natural environment for war and counterwar,” George Ball commented in the *New York Review of Books*. “The President had told us that the Soviet Union is an ‘evil empire’ and he was now warning America that the ‘empire’ might ‘strike back’” (Ball, 1985).

Thus, a real world and the simulated one blurred into each other.

5 Climatology

Paul Edwards asks a crucial question: “How did ‘the world’ become a system?” (2000, p. 221). He draws attention to the close parallel between SAGE and early climate modeling: both had to know the world globally and both to devise solutions for the problems of data-gathering and interpretation (2000, p. 230). Both turned to and developed large-scale computing equipment on which the necessary simulations could be run. Both were indebted to nuclear weapons research.

First efforts in climate modeling *c.* 1949–50 sprang from von Neumann’s insight that the nonlinear hydrodynamics of the climate would provide “a crucial test” of the digital machine’s potential for scientific research (Aspray, 1990, p. 121). Rapid progress followed: by the 1960s, circulation of the Earth’s atmosphere was being simulated, and by the end of that decade “global, three-dimensional climate models had emerged as the central tool of climate science” (Edwards, 2000, p. 234). But “as meteorologists sought to model the entire globe,” the lack of uniform, reliable data became the problem. Hence, the computer “now also became a tool for refining, correcting, and shaping data to fit the models’ needs” (Edwards, 2000, p. 229). Again, tool blurred into nature. Likewise, in current oceanographic, ecological, agricultural and other global sciences with ambitions beyond ordinary reach the debates quickly became to a large degree “*about* the model/data relationship” (Edwards, 1999, p. 439). Then, too, the models were and are themselves highly interpretative, employing differing techniques, influenced by differing scientific and political agendas, and aimed more at sensitivity to variable human activity and its consequences than non-human phenomena (Dalmedico, 2007). The emergence of the term “scenario” in climatology and other sciences affected by simulation tells the tale: of movement from the theory-like model that converges on and formalizes a singular, agreed-upon understanding of an objective world to narratives expressing the modelers’ assumptions, interests and agendas. In consequence, “a different conception of the nature of scientific work” is required (Edwards 1999, p. 439; Galison, 1997, p. 778).

How differently must we conceive the science? Ian Hacking’s argument about microscopy (1983, pp. 186–209) suggests to me that simulation does not so much provoke a new epistemological question as rewrite an old one: in what sense do we know when we look by means of a simulation? I will return to this question.

People turn to simulation when direct knowledge of something is blocked by matters of scale or accessibility: in the amount or complexity of the data to be considered, the size of the phenomenon to be known, its distance in time or space,

its unfamiliarity or its ethical prohibition. At one end of the realist's scale, a simulation is *of* something relatively near at hand and so at least comparable—for example, how people vote in an election; further away, it is *of* something the reality of which we are persuaded but cannot see, such as interactions at the core of the sun; at the far end it becomes a medium for imaginative projections and their exploration, or as Daniel Dennett has said of Artificial Life, “the creation of prosthetically controlled thought experiments of indefinite complexity” (1998, p. 261).

The idea of complexity, which I have postponed dealing with until now, is important here because it sharpens our grasp of what can be known through simulation. Complexity is a fundamental characteristic of a system in Robert Jervis's sense: an entity made up of interconnected parts that affect each other and that “exhibits properties and behaviors that are different from those of the parts.” No ghostly component is needed: a system, he emphasizes, is “*different from*, not *greater than*, the sum of the parts” (1997, pp. 6, 12–13). Examples are common enough—for example water (hydrogen plus oxygen, both gases) and table salt (sodium plus chloride, both toxic). As these suggest the properties and behaviors of a system are from the perspective of those parts *new* and *surprising*; they cannot be derived or inferred from the parts individually because these properties and behaviors are a result of the structural organization of the system. As the number of interconnections in the system increases, so does its complexity. Beyond a certain threshold (again, the matter of scale) a system is thus knowable only in performance. Hence a complex simulation, built from just such interoperable components of code, is necessarily a “black box.” How a complex simulation does what it does cannot be verified in detail, and so at its verisimilar best it parallels the object of study, arriving at resemblance (if that can be seen) by a different route that is unknowable move for move. As a modeling device, it invites experiment but weakens analogies between the artificial process and its target's processes, and so weakens the claim of the former to truthfulness, or requires a different conception of being truthful (Hacking, 2005).

6 Biology

What does the dominant science of the twenty-first century and quite possibly the most powerful disciplinary influence of all tell us about simulation? Biologists' uses of simulation to probe entities like us, not merely complex but also adaptive, self-organizing, self-replicating and *alive*, promise closer, or at least usefully different, analogies to simulation on a human scale than the sciences I have considered to this point. The refusal in experimental or field practices to identify theorizing with abstract laws (Keller, 1998, p. S76) makes biology a closer relation to a computationally experimental humanities. Furthermore biology raises the bar by focusing on entities that become “by a rather mysterious process of self-organization . . . more ordered and more informed” than physical law suggests that they should be (Cowan, Pines and Meltzer, 1994, p. 1).

From the nineteenth century to the present time, “the Riddle of the Universe” (as Benjamin Gruenberg called the phenomenon of life in 1911) has been pursued

in two directions: first, from the assumption that life could be explained by reduction to physics and chemistry, “to make live matter out of the non-living materials lying all about us,” that is, “an artificial system or ‘machine’ which behaves more or less like a living body;” and second, to create new life artificially from living tissue (1911a, p. 231; 1911b, p. 272). Simulation has been applied to both from the last quarter of the twentieth century and in both shows the same tendency to erode distinctions, formerly thought secure, between living and non-living.

Keller cites Sigmund Freud’s work on the uncanny to gloss the admiration and wonder elicited in Gruenberg’s time by biologist Stéphane Leduc, who attempted “synthetic biology” and “artificial life” (his terms) by fashioning inorganic materials so that they moved and seemed to grow (Keller 2002, pp. 11–49). Deceitful simulation, yes, but, she argues, “a positive virtue, not a negative one: it made possible that ‘willing suspension of disbelief’ that permits uncertainty to remain out of focus, that allows the ‘as if’ to do the remarkable work it has so often done in the past” (2002, p. 49). She quotes James Clerk Maxwell from the heartland of the factual on the usefulness of ideas known not to be true. Robotist Masahiro Mori, whom she quotes elsewhere, makes a different though related point with his now popular idea of the “uncanny valley”: that the uncertainty created by resemblance which does not quite replicate, though it frightens us and so is to be avoided in designing robots, nevertheless promises understanding of “what makes us human” (Mori, 2012/1970, p. 100; Kageki, 2012). But, I have argued elsewhere, this promise comes at a cost: the gap (or valley) between close resemblance and what as a result of it becomes an *inhuman* difference foregrounds uncertainty of a most disturbing kind (McCarty, 2014). Thus biology’s basic question—What is life?—becomes existentially fearful.

At the first workshop on A-Life at Los Alamos—the place of the Bomb—in 1987, Christopher Langton shifted the old question of how organic life arose out of inorganic elements to “how lifelike behaviors emerge out of low-level interactions within a population of logical primitives” (Langton, 1989/1987, p. 15). The persuasiveness of Langton’s efforts to answer that question, Keller notes, stems from the uncertainty they evoke about their authenticity: “Might not nature, at its most fundamental, really be constituted of cellular automata?” (2005, p. 209). Thus, slippage from hard but comfortable reality into soft but disturbing simulation, as before. However, Langton’s “life-as-it-could-be” also runs back to “life-as-we-know-it,” and stirs biologists to take up Gruenberg’s second direction of research, into creation of new life, then new kinds of life, from biological materials. Keller notes further slippage in the appeal of DIY life to those “who have themselves spent a significant proportion of their real lives inhabiting virtual worlds—as it were, coming of age in cyberspace” (2002, p. 276). The slippage continues in the blurring of analogies into realities—algorithm to genome, program code to body (Hayles, 1996)—and in Thomas Ray’s return back from *in silico* simulations to organic life as a model (Ray, 1998). “Life moves out of the domain of the given into the contingent, into quotation marks, appearing not as a thing-in-itself but as something in the making

in discourse and practice . . . a shadow of the biological and social theories meant to capture it” (Helmreich, 2011, p. 674).

“Without doubt,” Keller comments, “these entities are real. But another question immediately arises: are they ‘alive’? This is a question that worries many philosophers, but . . . it may well be a question that belongs more properly in the realm of history than in that of philosophy” (2003, p. 213). Thus, Helmreich’s “What was life?” (2011).

If we come to regard these things as alive, then we find ourselves alongside Dr. Frankenstein and so find ourselves with the question of the human. This is why the biological example is so important. We may contemplate with curious equanimity the blurring of many boundaries—it is the fashion now, is it not?—but the boundary between human and non-human is not one so easy to be calm about. And this brings simulation properly into the humanities. Simulation is “just a tool” if all it does is to produce more compelling representations or mechanical simulacra that generate objects of study from simple rules to a surprising degree of fidelity. It is of the humanities when it becomes a tool for raising the questions humans ask about human things and for bringing forth “the alternativeness of human possibility” (Bruner, 1986, p. 53).

7 The interpretative disciplines

Within the last half-dozen years, simulation has begun to receive widespread attention in the humanities, though it is hardly new to these disciplines. By the mid 1980s, when Robert Tannenbaum included it in his taxonomy of basic techniques for the humanities and social sciences (1987a, 1987b), work had been in progress in several fields for a quarter century (Lancashire and McCarty, 1988; Hymes, 1965). In history, the first applications were on the social scientific side of the discipline, in demographic, economic and geographical projects. In addition to yielding new knowledge of their subjects, these contributed methodologically by emphasizing the counterfactual qualities of simulation (Plakans, 1980, p. 140). The alternative-world, as-if status thus underscored made simulations attractive for the classroom (Oakman, 1987; Lancashire and McCarty, 1988), where counterfactual explorations could be enacted without fear of conservative scholarly disapproval.

Surprisingly, perhaps, the earliest simulations in the humanities themselves were of poetry-writing, not of phenomena studied for their law-like behavior, such as language—for example, by Kirby (2013), or Kretzschmar and Juuso (2013). Like the social sciences, the first efforts in poetry generation date to the late 1950s, followed by simulations of folktales and short fiction (Lancashire and McCarty, 1988, p. 2). From that time, experiments with poetry went on to chart an almost unbroken chronology, intermixed with experiments in the arts, into this century (Funkhouser, 2007 and 2012). In 1964, pioneer computational linguist and philosopher Margaret Masterman noted the serious purpose of such work, “to throw light both on the habits of language users and on the nature of conceptual thought itself” (1964, p. 690). But, like other seriously playful efforts in computing,

hers proved controversial. F.R. Leavis's outrage at the thought "That any cultivated person should *want* to believe that a computer can write a poem!" (1970, p. 442) and Howard Nemerov's gloomy warning of a mind "simplified (and brutalized) . . . in obeisance to its idol the [behavioristic] machine" (1967, p. 414), register the significance of such work (cf. Drucker, 2009, p. xix), though unraveling that significance is itself a major undertaking.

It may seem odd, then, that Tannenbaum's "Matrix of Applications and Disciplines" records a blank for simulation in literary studies (1987b, pp. 221–2). Simple oversight seems unlikely. I would like to read this blank as the response of someone who, noticing (as he must have) the stalemate repeatedly attested in literary computing from the early 1960s onward, found nothing much to report. In 1976, two years before Susan Wittig argued that text-analysis was theoretically bankrupt (Wittig, 1978), William Benzon and David Hays took up the question of what a theory adequate to the intersection of computing and literature might look like. "Man is self-aware," they wrote. "Consequently, it seems likely that any attempt to develop a computable model of literary texts will have to include a simulation of self-awareness if it aspires to deep results" (1976, p. 267). Are we, then, stuck waiting for adequate artificial intelligence? I will come back to this question.

It seems safe to infer—for example, from the release of *The Matrix* in 1999 and Jean Baudrillard's work on simulation (a must-read from the early 1980s), that by the beginning of this century scholars were familiar with the term, even if it was not widely understood in practice (Ryan, 2001). Since then, the relevant techniques and equipment have grown in speed, flexibility and intelligence, and dramatically shrunk in cost. Now they are within reach attractively for immersive enactment and study of whatever can be visualized.

The most popular simulations in the interpretative disciplines today are of groups or societies of people represented as autonomous agents populating a complex system—thus, "agent-based modeling" (Troitzsch, 2009). Unsurprisingly, these simulations avoid the unique, particular and inconsistent phenomena of human life so as to be able to reduce social behavior to the actions of algorithmic agents. Surprisingly, agent-based modeling from simple rules has proven quite effective at that level of generality, matching the regularities we observe in real societies—thus, Joshua Epstein's "generative social science" (1999). Such work dates from Thomas Schelling's classic papers on race-relations (1969–1978), in which he used a simple model to suggest that quite color-blind preferences could result in segregated neighborhoods (Epstein and Axtell, 1996, p. 3). The best known social generative simulation is of the Anasazi or Ancient Pueblo people, who simply vanished for no apparent reason from their ancestral homeland c. twelfth–thirteenth centuries CE (Axtell et al., 2002; Janssen, 2009). Based on all available evidence, the simulation closely matches the growth and partial decline of the Anasazi until their sudden disappearance, but suggests no reason why the civilization vanished: environmental evidence implies that they could have continued. Thus, explanation from purely environmental causes is ruled out. But a tantalizing puzzle remains: did failure occur precisely at the point at which

something other than such causes intervened—something, such as a shared crisis of the mind or spirit, that left no computationally tractable data behind?

Grüne-Yanoff convincingly argues that the problem with such work in the social sciences is that a simulation can only be said to explain something in the full sense if its model can be validated; his example is an automobile crash, for which the physical principles and equations are known (2009). In circumstances for which well-confirmed laws are unavailable, a simulation can at best aspire to “articulating the ways in which a phenomenon *could* possibly have been produced” (2009, p. 546, my emphasis). The less law-like a domain is taken to be, the more a simulation reveals not actualities but possibilities.

So far, simulation in the humanities has been a minority pursuit, despite affordances for imaginative exploration and play. There are likely several reasons for this, including mismatches of knowledge, skills and understanding on both sides of the technical divide. A crucial reason—indeed, the one that motivates this essay—is the misunderstanding of what simulation is for, or, more carefully stated, insufficient attention to how its protean capabilities and the disciplines that adopt it adapt to each other. I have argued that the history of simulation in the sciences and the subsequent effects it has had there demonstrate clearly enough a strong tendency away from the known toward the imagined unknown, even the otherwise unknowable. In the sciences, simulation has tended to start, as Elaine Scarry says, with the “made-up” but to finish with the “made-real” (1992). What happens, what could happen in the humanities?

The most likely places to look for plausible simulations are in the historical disciplines. In a recent study, Marten Düring draws on simulations of the Battle of Trafalgar, a Canadian influenza epidemic and the Anasazi to illustrate how the technique is being used in history (2014). His examples show simulation not deployed to explain, as in generative social science, but to test hypotheses and rule out competing explanations. The biggest challenge, he notes, is the degree to which (significantly not whether) historical events can be reduced to rule-based behavior. With Epstein, he observes that it is precisely the struggle with rules that tends to yield the most important insights, not subsequent work with the simulation. Could this amount to the difference between close engagement and distant observation? (Remember this possibility; I will return to it.)

The range and number of the historical simulations we have are also impeded by resistance within history to counterfactual research—a disciplinary problem but one that implicitly recognizes the fictive trajectory of simulation, away from history as usually conceived. It is difficult not to conclude that little has changed fundamentally since those early social-scientific applications in history. “The use of simulation modelling in history and archaeology is still regarded as something of a ‘dark art’ in many quarters,” Stuart Dunn comments in a recent review (2012).

Düring finds no current historical simulation that allows both collective and deviant individual behavior in its model. That fact, if it is one, leads to his most telling point (and recalls Benzon’s and Hays’s challenge from 1976), which he makes by quoting archaeologist Jim Doran’s observation of a “deep difficulty,”

which in turn suggests a very different response of the social sciences to simulation:

Distinctive human social structures and social processes emerge from distinctive human cognition. But we do not yet know how to model human cognition on a computer in other than relatively superficial and oversimplified ways. Thus we cannot yet experiment with the models that really matter: those that capture more than simple routine cognitive behavior. Archaeology faces this challenge as do all the social sciences.

(Düring, 2014, p. 133)

Again, the question of artificial intelligence. What is to be done?

8 From the actual to the possible

Before going further, from history into literary studies, let me sum up by returning to a question I raised at the beginning: what is the difference between modeling and simulation? I turn again to the words and to the meanings we make with them. “Modeling” literally insists on “model”—that is, on a representation which however unachievably true and inescapably false is always in mind. Anthony Giddens’s description of modernity—the condition of “going on being” in which moment by moment we *do* everyday life, selecting, revising and discarding as we go the lifestyles available to us (1991)—suggests that we find irresistible the pull of “modeling” toward thoughts of an ideal form. Thus, in grammatical terms “modeling” is indicative. Simulation, on the other hand, is subjunctive. It also proceeds from a model; it also can be and is used to approximate an unreachable truth, but (again literally) it insists at root on alternatives to the truth—true lies, if you will. Such alternatives, if they are to be true to simulation’s dual character, must preserve the “as-if”—the willing *suspension* of disbelief, not its dismissal. Modeling does not tend toward alternative worlds. It is a struggle with the model ever better to construe the modeled.

Virtual reconstructions of archaeological and historical sites are germane to the distinction I am making and help qualify it. Almost all of such reconstructions take simulation in a different direction than I have been describing, toward the visualized model. These unsurprisingly fit the interests of their disciplines: to make an absent part of the historical world digitally present—best not “as if that which returned were the same” but with conjectural elements marked and documented.⁴ These reconstructions move closer to simulation in my sense with the introduction of avatars displaying verisimilar behaviors and appearance, closer yet with the introduction of an avatar controllable by the participant-observer (Bogdanovych, Ijaz, and Simoff, 2012). I will return very briefly to simulations of this kind at the end.

For literary studies, Edward Versluis wrote thirty years ago, the problem is to describe “the dynamic structures we associate with literature,” expressing

them “in very explicit terms” (1984, p. 230). Simulation, we expect, would operationalize these structures. How? Sack, for example, has described a generative simulation of narrative (2011) in broadly the same vein as earlier experiments in poetry-generation. I want to focus, however, on participant-observer simulation of literature.

Versluis pointed to the “emotionally rich thinking experience” of game-playing (1984, p. 225) and to Joseph Weizenbaum’s psychoanalytic simulation *Eliza*, with its striking ability to induce “powerful delusional thinking,” as Weizenbaum wrote (1976, p. 7). Versluis rejected Weizenbaum’s worry, imagining instead an *Eliza* reconfigured in the service of teaching and research, delusion reconceived as imaginative fantasy exercised in order to elicit and make real Bruner’s alternativeness. But note: *Eliza*’s quite surprising power was not the result of sophisticated artificial intelligence, rather the product of a *non-autonomous, cooperative human-machine simulation*. It was a trick but also a clue to what could be done in much less constricted settings, were the artificial intelligence to be devised.

A similar set of ideas about computer-human cooperation underlies experiments like Jerome McGann’s *Ivanhoe Game*, in which human players make algorithmic changes to a shared text as a way of exploring the effects of those changes on the literary ecology of that text (McGann, 2014, pp. 100–1; Drucker, 2009, pp. 65–97). The game thus teasingly suggests what could be done cooperatively with a machine capable of adapting to other players’ moves. Note the term “player,” which suggests not merely connection with gaming, but also *Ivanhoe*’s strategy of “serious play.” In such play, the imaginative material on which it focuses—“fictional, counterfactual, hypothetical, heterocosmic”—functions with the force of as-if to keep players “very seriously” both unattached and committed to the game (Berger, 1988/1969, pp. 74–80; 1972, pp. 261–5; Wind, 1968/1958, pp. 222ff.). This is simulation achievable in every sense with the technology we have, though with better computer science it could go much further, as I will suggest.

There are other ways of thinking about these examples, other preliminary sketches with which to inspire our infant computer sciences—for example, as creative staging of improvisational performance (Laurel, 2014); as dynamically unfolding conversation (Soules, 2002; McCarty, 2013)—a common metaphor among jazz musicians; as ritual; and as resonance (Erlman, 2010). I must leave it at that for now: a clue, just as it is in Mori’s thoughts on the uncanny valley and Keller’s on Freud, pointing to the inescapable non-autonomous embodied (and so aesthetically present) other of simulation.

Where does this leave us? I will answer that question with a single project chosen for the clarity with which it poses the core dilemma of simulation: literary scholar John Wall’s *Virtual Paul’s Cross* (2016). This simulation digitally re-creates the poet and divine John Donne’s sermon at the Paul’s Cross preaching station in London on November 5, 1622, which celebrated the failure of a plot to blow up the British Parliament with James I inside it. As it stands, it is, like other

historical reconstructions, more a visual model than a simulation in my sense. But it points a way forward.

We begin with facts mixed uncertainly with uncertainties. The title-page of the printed edition is sole evidence, published years after Donne's death, that contrary to normal practice, the sermon took place inside the Cathedral because of rain. The simulation locates it outside where Donne would have planned it to happen and where the drama of improvisational performance for which he was noted would have been more in demand to hold listeners' attention against the distractions of an outdoor gathering—the freer social interactions, the dogs, horses and the many unsynchronized bells of nearby churches, not just St Paul's, ringing cumulatively on the quarter-hour. The text itself is a poor thing, without the drama. We know that Donne spoke from notes, writing out the text some time later. As for the solid stones, timbers, plaster, tiles, metal and glass, Paul's Cross and the Gothic Cathedral beside it perished in the Great Fire of 1666. Four centuries of social change and urban development far less reverent of the past than we are have intervened.

I said that *Paul's Cross* and other reconstructions are not quite simulations. But they become much more so once we understand that the kinds of conjectures that they offer us must be understood in the context of “simulation”: the kind of counterfactuality or misleadingness deployed here must be understood (in Keller's terms) as “a positive virtue, not a negative one,” as would be to an historical positivist. The hermeneutic of suspicion and critical awareness that such simulations call forth can also be understood from a different perspective as a kind of intellectual bravery.

In its current state, *Paul's Cross* is an experiential, *Eliza*-like simulation—cooperative, in resonance between scholar and tool—only for the maker, over whose shoulder the rest of us must look and listen. The next step is to bring us onlookers inside the modeler's head. Technically, that will take significant advances in immersive, participatory VR, but that alone is not enough. It will also take intimate collaboration between computer science and literary studies.

We are left, then, not just with big ideas but with big questions and projects, concerning the roles these two fundamental things you can do with a computer—modeling and simulating—play or are to play in our practices of enquiry, how we are to become self-aware practitioners of them and how they change these practices *and are changed by them*. “[T]he use of computers,” Fr Roberto Busa wrote in 1976, “is not aimed towards less human effort, or for doing things faster and with less labor, but for more human work, more mental effort” (1976, p. 3). The question is, to what is that effort directed? Not, as modeling and simulating both make clear, what the bereaved call “closure” but (once again) Bruner's “alternativeness of human possibility,” William Blake's “expanding eyes.” Simulation returns us to Aristotle's function of poetry (*Poetics*, 1451b), to describe not the thing that has happened (*genómena*) but a kind of thing that might happen (*génoito*), something more philosophical and worthy of serious attention, he thought, even than history.

Notes

- 1 I am deeply indebted to the editors, especially to Julia Flanders, for the immense patience, intelligent resistance, helpful suggestions and even, in two places, wording that said what I wanted to say but couldn't.
- 2 Early uses of "simulation" in circuitry are attested by journals in the IEEE Xplore Digital Library; in aeronautics by the US Patent and Trademark Office patent database. Available at: www.uspto.gov.
- 3 "Turing's 'Machines'". These are *humans* who calculate." Wittgenstein, 1980, p. 191e.
- 4 Derrida, 1996, p. 182. Note the recommendations of the London Charter, especially 4.6 and 4.10. Available at: www.londoncharter.org (June 3, 2018).

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