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On the Epistemology of Computer Simulation

Claus Pias

I DON'T KNOW if what follows can be termed »media philosophy«.[1] Probably not. And it cannot be termed such faute de mieux – that is, by dint of its *not* being »philosopher philosophy«.[2] For me, media studies (to avoid that confounded term »philosophy«) is not so much a discipline as a scholarly interrogation. It is concerned with the question as to how symbols, instruments, institutions and practices contribute to the constitution, circulation, processing and storage of knowledge. In this sense it investigates the media-historical conditions pertaining to knowledge and cognition and therefore is more a kind of historical epistemology. This interrogative approach may not only be found in various academic disciplines; in the sense of »media theory« (*Medientheorie*) it is already to be found in almost every imaginable field of knowledge – and this without being necessarily accompanied by any academic media studies (*Medienwissenschaft*). It is in this respect that media studies can be characterized as a field that provides the potential for a transdisciplinary dialogue because it unifies various disciplines or fields of knowledge through their preoccupation with the same question.[3] This sort of satellite status with regard to the classic scholarly disciplines must therefore be seized as both an opportunity and a challenge. On the one hand, media studies is an attempt to discover topics that enable the field to demonstrate its original ability and effectiveness, while on the other it is compelled to deliver itself up to the scientific and scholarly standards of those fields of knowledge on whose terrain it has encroached.

The terrain that I have for some time now been mapping out and where I have even broken new ground in certain select areas goes by the name of *Simulation*.[4]

1 Lambert Wiesing: Was ist Medienphilosophie?, in: Information Philosophie 3 (2008), pp. 30–38.

2 Lorenz Engell: Tasten, Wählen, Denken. Genese und Funktion einer philosophischen Apparatur, in: Stefan Münker and Alexander Roesler and Mike Sandbothe (eds.): Medienphilosophie. Beiträge zur Klärung eines Begriffs, Frankfurt/M. 2003, pp. 53–77.

3 Claus Pias (ed.): Was waren Medien?, Zürich/Berlin 2010.

4 The project »History and Epistemology of Computer Simulation« was started in 2008 at the *IKKM Weimar* and continued at the *Wissenschaftskolleg zu Berlin*. I should also like to thank Sebastian Vehlken, Thomas Brandstetter, Lorenz Engell, Frank Pasemann, Marie Farge und Ulrich Schollwöck for their stimulating input as well as Kevin McAleer for his translation of this piece.

It is at this point that I expect those in the humanities to wrinkle their brows and say, »Well, that's just sooo late-1980s, at best early 1990s, and as passé as Baudrillard or media art with data gloves!«. Yes, quite true, but it is for precisely this reason that we need to learn how to speak about it in new ways, for in view of the several thousand available books on the subject – and I am referring here exclusively to scientific simulations – the scholary and practical significance of computer simulation cannot be overestimated. But despite this fact, computer simulation has not yet been reviewed from the standpoint of media history or the history of science. There are no more than a dozen or so essays on the epistemic status of computer simulation and even fewer history-of-science studies that have done exemplary work in providing an account of how the complexion of a single discipline has been changed by computer simulation in the course of the last fifty years. Briefly put, I believe that in computer simulation we can observe an epistemic shift of considerable magnitude – and which in the 1960s Joseph Licklider compared with the invention of printing in its impact on the sciences.

In what follows I will be undertaking three things at once to suggest the potential of this research field. The first of these is a modest proposal as to what might be of possible interest for people from media studies and from the history and philosophy of science in terms of computer simulation *in general*; the second is to give you an *example* of just how simulations approach change and how they encroach on a certain discipline's store of knowledge; and the third is to comment on certain *theoretical and conceptual trends* within science studies – or more precisely put, why certain humanistic theories only emerge under certain technological conditions.

I.

In the late 1940s, mathematician and computer designer John von Neumann declared the end of the era of »analogy« and »representation« and the dawn of an era of »simulation«.[5] A decade later, in the preface to volume seven of his *Epoche Atom und Automation*, engineer and psychologist Abraham Moles predicted the transformation of contemporary science into a »science of modelling«.[6] These two

5 Claus Pias (ed.): Cybernetics – Kybernetik. The Macy Conferences 1946–1953, Zürich/Berlin 2003, vol. 1, pp. 171–202.

6 »The nineteenth century tried to describe the world as it actually is […]. Twentieth-century science will above all be a science based on models […]. Cybernetics will be able to answer the question [as to what something is] on that day when they can build a model [of it].« See Abraham A. Moles: Die Kybernetik, eine Revolution in der Stille, in: Epoche Atom und Automation: Enzyklopädie des technischen Zeitalters, Geneva 1959, vol. VII, p. 8.

references speak to the historical scope of an archeology of the present, within which numerous sciences implicitly or explicitly have undergone a transformation into computational science. Whether physics, chemistry, biology, electrical or mechanical engineering or space flight; whether it be military, genetic or climatic research, politics, economics, sociology, neurology or nano-technology – it is virtually impossible to name a single research area not essentially dependent on computer simulation (CS) processes and technologies. However, the definition of »simulation« in science and engineering remains somewhat vague. The German VDI-guideline 3633 states very simply: »Simulation is the imitation of a system and its dynamic processes in a model capable of experimental deployment in order to generate knowledge [...]. In particular, these processes are developed within a certain time frame.«

In short, for my purposes, the term »simulation« means the totality of various practices and widespread forms of knowledge that have been emerging since 1945 through the new medium of computers. But even if simulations in particle physics are to be distinguished from crash-tests or the agent-based simulations of epidemics, the term addresses a paradigmatic epistemological shift that has only recently been recognized by the history and philosophy of science. In a groundbreaking publication,[7] Peter Galison stated that CS indicates a transformation in the understanding of computers in science from mere »tools« to »nature«. While appropriate programming structures provide virtual environments for »computer experiments«,[8] CS establishes a »trading zone« between different scientific disciplines. These are no longer distinguished by their disparate »objects of inquiry« but coalesce through similar »strategies of practice«. The increasing power of computing and the perpetual refinement of numerical approximation routines have provided the basis for this transdisciplinary effectiveness, rendering the problems of a »messy« reality accessible – these being problems that analytical solutions fail to address. And it is precisely the accessibility of analytically intractable phenomena that serves to situate both CS (in its capacity of a temporalized imitation of system-behavior by computer media) and its »trading zone« in an epistemological dimension beyond or, if you like, between the traditional epistemological categories of theory and experiment. Whether one is speaking of the »digital laboratory«,[9] of

7 See Peter Galison: Computer Simulations and the Trading Zone, in: Peter Galison/David J. Stump (eds.): The Disunity of Science. Boundaries, Contexts, and Power, Stanford, CA 1996, pp. 118–157; Peter Galison: Image and Logic. A Material Culture of Microphysics, Chicago, IL 1997, pp. 689–780.

8 Evelyn F. Keller: Models, Simulation, and ›Computer Experiments‹, in: Hans Radder (ed.): The Philosophy of Scientific Experimentation, Pittsburgh, PA 2003, pp. 198–215.

9 Martina Merz: Multiplex and Unfolding. Computer Simulations in Particle Physics, in: Science in Context 12/2 (1999), pp. 293–316.

the »simulability« of contemporary theory development,[10] or of a »Möbius strip« that reconciles theory and experiment,[11] CS has incisively altered our understanding of the »exact« sciences.

In his book *The New Production of Knowledge*, Michael Gibbons emphasized the difference between »mode-1« and »mode-2« sciences.[12] In mode-1, the paradigmatic notion of scientific methods (in contrast to non-scientific methods) is limited to a form of the production of knowledge which is based on the system of experimental and mathematical mechanics proposed by Isaac Newton and on its institutionalized successors in physics and physical chemistry. Newton's mechanics not only abandoned substantial metaphysics but introduced the identification of mathematical theory with proofs and their consequent theories of truth. Imperatives such as »exactitude« and »provability« were thus transferred from mathematics to other sciences, and to this day the essence of the exact sciences is said to lie in their reliance on mathematics.

But when this concept of the exact sciences is thrown into question, mode-2 sciences come into play in two different ways. On the one hand, exact operations are inadequate in producing solutions to complex problems, and on the other, mathematical exactness is limited only to a small percentage of problems – namely to those with an analytical solution. However, the sheer *quantity* of the numerical operations executed by computer simulations of complex problems leads to a *qualitative* leap: the problem-solving methods of mode-2 sciences solely provide approximations of the exact solutions of mode-1 sciences, thus covering a much wider range of problems. Computer simulations are thereby not only characterized by hypothetical and heuristic aspects but by their general inexactitude; authors like Fritz Rohrlich, Paul Humphreys, Peter Galison and Eric Winsberg have stressed in which ways classical concepts of theory and experiment have been modified by CS, sketching out its role in the production of scientific knowledge.[13]

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10 Thomas Lippert: The Impact of Petacomputing on Theories and Models, in: The Societal and Cultural Influence of Computer Based Simulation, Blankensee-Colloquium 2007, Berlin 2007.

11 Gabriele Gramelsberger: Computerexperimente. Zum Wandel der Wissenschaft im Zeitalter des Computers, Bielefeld 2010.

12 Michael Gibbons et al.: The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies, London 1994.

13 See Fritz Rohrlich: Computer Simulations in the Physical Sciences, in: Proceedings of the Biennial Meeting of the Philosophy of Science Association, vol. 2, 1990, pp. 507–518; Paul Humphreys: Computer Simulations, in: ibid., pp. 497–506; id.: Extending Ourselves: Computational Science, Empiricism, and Scientific Method, Oxford 2004; Eric Winsberg: Sanctioning Models. The Epistemology of Simulation, in: Science in Context 12/2 (1999), pp. 275–292; and Eric Winsberg: Simulated Experiments: Methodology for a Virtual World, in: Philosophy of Science 70 (2003), pp. 105–125.

Based on the description of models as »mediating instruments« between theory and experiment – thus opening up a partly autonomous space with »elements of theories and empirical evidence, as well as stories and objects which could form the basis for modelling decisions«[14] – CS can be perceived as their dynamic and flexible realization.

Winsberg stresses the epistemological surplus of CS as opposed to a depiction of it as simple »number-crunching techniques«. He argues that CS »would be best addressed by a philosophy of science that places less emphasis on the representational capacity of theories (and ascribes that capacity instead to models) and more emphasis on the role of theory in guiding (rather than determining) the construction of models«.[15] In the process of modeling complex non-linear phenomena, Winsberg states that »theoretical« assumptions or a »theoretical framework« are worked down to a level of applicability and calculability involving numerous simplifying assumptions that are »creatively« modeled in an ad-hoc fashion. Thus, techniques of »modeling and simulation« blur the formerly distinct boundaries of »theory« and »experiment« in a dynamic reciprocal process. These techniques imply a partial autonomy in which »performance beats theoretical accuracy«,[16] an implication which is further substantiated by Thomas Lippert's notion of »simultability«. Lippert describes the direct impact of media technologies on the process of theorizing insofar as in particle physics, for example, only those theories are advanced which can be applied to a highly parallel computer structure. Effected by the advancements of computational calculating power (and not so much by the development of new algorithms), quantities are transformed into new qualities that are accompanied by technological standards and layouts which exclude certain theoretical approaches from the very beginning.

It is in this way that the widespread use of computer simulations causes science to become »postmodern« – if I may be permitted to use this term;[17] its new epistemological conditions are not detachable from their techno-historical roots in the computer sciences. The genesis of this postmodern scientific mode proceeds within a framework of specific techno-media parameters that classical philosophy and the history of science, for the most part, surprisingly ignore. Although authors

14 Mary S. Morgan and Margaret Morrison: Models as Mediating Instruments, in: ead. (eds.): Models as Mediators. Perspectives on Natural and Social Science, Cambridge, MA 1999, pp. 10–38.

15 Eric Winsberg: Simulation, Models, and Theories. Complex Physical Systems and Their Representations, in: Philosophy of Science 68/3 (2001), pp. 442–454.

16 Johannes Lenhard and Günter Küppers and Terry Shinn (eds.): Simulation. Pragmatic Constructions of Reality, New York, NY 2006.

17 Jean François Lyotard: La condition postmoderne, Paris 1979. One could also of course employ the term »techno-sciences«.

such as Galison, Fox Keller and Winsberg refer to very intriguing phenomena – mostly from the perspective of a history of physics, and those phenomena only tractable by means of CS – very few studies comprise an account of the techno-media parameters involved.[18] On the other hand, the tremendous spate of publications addressing CS in engineering, the social sciences and the various natural and computer sciences substantially lack a thorough media-historical grounding. Despite the fact that discussions of modeling and simulation methods have played an outstanding role in these scientific disciplines for the past several years, almost without exception these approaches focus on the pragmatic demands of research practice with respect to CS and the rapid development of hardware and software applications.

Nonetheless, that zone which comprises the extension of problem-solving strategies to a broad set of complex problems within a wide range of disciplines by means of CS – the so-called trading-zone – fosters particular standardization processes. These procedures express themselves in algorithms, programming languages, programming environments, digital image-processing and computer-graphic visualization techniques, and they ought to be understood from a techno-media perspective since they play a crucial role in the potential of CS to contribute to an advance in both epistemically and technologically innovative capabilities. I should like to derive four working hypotheses therefrom – hypotheses that are certainly exaggerated but are intended to perform a heuristic function:

1) *Performance Disassociates from Accuracy.* Provocatively speaking, CS become more »realistic« through application of theoretically »unrealistic« or artificial accounts – e.g. the explicit disregard of physical knowledge can yield authoritative simulation-models. Küppers and Lenhard explain this by citing what they call »Arakawa's computational trick«:

»Thus did [Arakawa] presuppose the conservation of kinetic energy in the atmosphere – although it was clear that this energy was converted into heat through friction, i.e. that it was definitively *not* conserved. Moreover, the dissipation was presumably significant of the fact that the real atmosphere could show such a stable dynamic. Arguing from the standpoint of physics, one could assert that Arakawa's conservation of kinetic energy artificially limited the increase of instabilities […]. Whereas most [researchers] believed it necessary to find a solution to the base equations that was as accurate as possible, Arakawa undertook an additional step in terms of his modeling – a step that was *not derived from the physical basis* but only with the wisdom of hindsight, i.e. *through the results of the simulation runs*, when a successful imitation could be *justified*.«[19]

18 Soraya de Chadarevian and Nick Hopwood (eds.): Models. The Third Dimension of Science, Stanford, CA 2004.

19 See Günter Küppers and Johannes Lenhard: Computersimulationen. Modellierungen

The result is a partial autonomy which renders the connection between a successful imitation of system-behavior and the physical knowledge of this system increasingly fragile.[20]

2) *Specific Rules Replace General Laws.* This situates CS in close proximity to games. Facing the challenges of non-linear complex systems, the affected sciences were able to establish tentative epistemological strategies through the use of CS. In order to get a firm grip on the behavior of complex systems and accordingly tune the system's parameters, CS have to be run repeatedly through a process that intuitively »plays« with the simulation settings, often on a trial-and-error basis: »A successful parameterization requires understanding of the phenomena being parameterized, but such understanding is often lacking [...]. How best to parameterize various processes is a contentious subject among modelers and model analysts.«[21] In addition, every simulation technology brings about its specific context of application, merging both idealization and realization. CS strike a balance between the mode of reduction and abstraction from the system's behavior that they imitate, and a mode of accumulation and specification negating expected »first principles«. A diversity of specific rules supersedes the small number of reductionist laws and turns every CS into a particular case-study. Hence, they undermine the classical separation between general laws (from which the corresponding equations for a particular case are derived) and boundary conditions (the specifications of the context within which a dynamic process runs). Sciences substantially dependent on CS are being increasingly transformed into what one may call »behavioral sciences«.[22]

3) *Adequacy Replaces Proofs.* This thesis questions the account of scientific proofs implicit in CS. Even if well-known physical laws constitute the basis of a CS, their

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2. Ordnung, in: Journal for General Philosophy of Science 36 (2005), pp. 305–329; and Akio Arakawa: A Personal Perspective on the Early Years of General Circulation Modeling at UCLA, in: David A. Randall (ed.): General Circulation Model Development, San Diego, CA 2000, pp. 1–66. I thank the physicist Marie Farge for apprising me of the fact that the matter is not as simple as portrayed by the authors and for her assurance that my argument is nevertheless correct.

20 Perhaps one could emply Blumenberg's concept of »Vorahmung«, which is basically untranslatable but, to give some notion of its meaning, might be rendered as a kind of premonitional pre-imitation. See Hans Blumenberg: ›Nachahmung der Natur‹. Zur Vorgeschichte der Idee des schöpferischen Menschen (1957), in: id.: Ästhetische und metaphorologische Schriften, Auswahl und Nachwort von Anselm Haverkamp, Frankfurt/M. 2001, pp. 9–46.

21 Myanna Lahsen: Seductive Simulations? Uncertainty Distribution Around Climate Models, in: Social Studies of Science 35/6 (2005), pp. 895–922.

22 Bernd Mahr: Das Mögliche im Modell und die Vermeidung der Fiktion, in: Thomas Macho and Annette Wunschel (eds.): Science & Fiction, Frankfurt/M. 2004, pp. 161–182.

implications and reciprocal effects in complex systems cannot be anticipated, and so a deterministic model can react all the more chaotically and in an even more non-linear fashion to the tiniest disturbances and the smallest parameter changes. Evolution in the CS run-time is therefore essential for validating the adequacy of a simulation model through a comparison of consecutive runs. But this by no means implies »proof« in the classic sense – alternative and competing CS strategies may yield equally adequate results by employing contrasting rules. Hence, the adequacy of a CS model can only be demonstrated by its operation and operability, resulting in the »evaluation« of different scenarios instead of a »validation« in the common sense.[23]

4) The success story of *CS is unimaginable without the simultaneous development of computer graphic imagery* (CGI) whose exploration – at least at its early stage in the 1960s – took place in a twilight zone between science and art. The scope and complexity of the CS models proved incomprehensible to the human observer in the media of letters and numbers. As J. C. R. Licklider put it as early as 1967:

»Patchcords in the one hand and potentiometer knob in the other, the modeler observes through the screen of an oscilloscope selected aspects of the model's behavior and adjusts the model's parameters (or even varies the structure) until its behavior satisfies his criteria. To anyone who has had the pleasure of close interaction with a good, fast, responsive analog simulation, a mathematical model consisting of mere pencil marks on paper is likely to seem a static, lifeless thing.«[24]

In accord with this vividly drawn picture, the new scientific culture of simulation subordinated itself to the hegemony of images and acquired even greater relevance with the development of further inventions in the sphere of dynamic CGI. At least three different aspects must be historicized comparatively: (a) CGI in the framework of scientific research (e.g. the reduction of complexity by an interest-driven, pragmatic and adequate choice of the modes of representation); (b) the more effective controllability and intuitive tuning of parameters in the different run-time scenarios of modeled processes through images and visualization (e.g. graphic user-interfaces, interactive parametrics, graphic programming); (c) the mediation or, more precisely, the »political iconography« of CS (e.g. public images often considerably different from those used for inner-scientific purposes).

23 Paul N. Edwards: A Vast Machine. Computer Models, Climate Data, and the Politics of Global Warming, Cambridge, MA 2010.

24 J. C. R. Licklider: Interactive Dynamic Modelling, in: Gary Shapiro and Michael Rogers (eds.): Milton: Prospects for Simulation and Simulators of Dynamic Modelling, New York, NY 1967, pp. 281–289.

Unless it be the case that a good part of contemporary CS environments are based on a modeling paradigm relying on discrete events,[25] with respect to these four hypotheses it would seem to make more sense to look at agent-based computer simulations (ABCS). In any event, I have chosen an example from this area because the media pertinacity is much more evident here and my attempt to formulate an »Epistemology of CS« can be more vividly demonstrated.

II.

The example I have selected is not illustrative of all of the aforementioned hypotheses, but it will give us glimpses into certain of their aspects. One might also say that my single example is justified for systematic reasons, for I don't believe that one can speak of simulation per se but only about certain types of simulation. It seems to me that much of the confusion rests with the fact that »simulation« is a collective term designating very different things and whose family resemblance can only gradually emerge.

Let me begin with a subject whose history has only been scantily researched: those management simulations and business games whose most recent incarnations are to be seen in companies and university economics courses. My interest in these simulations and games is a certain paradigm of the programming of simulations, namely the so-called object-orientation as starting point for agent-based simulations. Hence, I am less interested in the substantive problems of simulation than I am in the ways of conceptualizing and implementing problems through information technology – and that means from a media-technological perspective.

These management simulations originated in the late 1950s, being derived from military war games – or, more specifically, the American Management Association (AMA) took a close look at the U.S. Naval War College and decided to create its own »war college for business executives«.[26] I am not going to go into these early beginnings here, nor will I be looking at the rapid development and dissemination of such simulations to business concerns and the programs of the larger universities of economics.[27] Of greatest interest to me are the mid-1960s, a period when

25 See B. W. Hollocks: 40 Years of Discrete Event Simulation, in: Journal of the Operational Research Society 57 (2006), pp. 1383–1399; and Richard E. Nance: A History of Discrete Event Simulation Languages, Systems Research Center report SRC 93–003, 11 June 1993.

26 Frane M. Ricciardi et al.: Top Management Decision Simulation. The AMA Approach, ed. Elizabeth Marting, American Management Association, New York, NY 1957. Once again the saying holds: »War is a terrible thing, but so is peace.« (Herman Kahn).

27 See, for example, Proceedings of the National Symposium on Management Games,

computers began to assume a central role – those years when theoretical concepts from sociology, psychology and cultural anthropology were assimilated and when those computer mindsets and tools were being developed that define the research to the present day. Among the objects of such simulations are inchoate problem areas like advertising budgets, sales strategies, and the introduction of products onto the market. Study of the behavior of dynamic systems, the analysis of how to deal with uncertainties, research into systemic sensitivities, and heuristic investigations into finding pretty near optimal strategies – these were distinctive features of people's understanding of computer simulations as well as of what these simulations promised for the future.[28]

The example I will be using for how precisely this was done, for the concepts and knowledge that distinguish these simulations, comes from Arnold E. Amstutz, who had been working on micro-analytic behavioral simulations since the late 1950s,[29] whose purpose was to research how the »attitudes and beliefs« of clients with regard to certain products and companies could be influenced, and whose basic assumption was that people's behavior could only be influenced through persuasion or seduction, through a kind of »indirect control«, for example in the same way as was done in electoral campaigns and in the advertising industry.[30]

In the beginning was the development of models. The first step was through macro-specification, the idea that there was a simple linear link between manufacturers, distributors, sellers and customers. The matter becomes more complex with the next few steps – public officials and competing companies are introduced;

Center for Research in Business, University of Kansas, Lawrence 1959; K. J. Cohen et al.: The Carnegie Tech Management Game, in: The Journal of Business, vol. 33/4 (1960); Robert H. Davis: The Business Simulator, Operations Research, East Pittsburgh Division, Westinghouse Electric Corporation, 12 December 1958; Albert N. Schrieber: Gaming – A New Way to Teach Business Decision Making, in: University of Washington Business Review, April 1958, pp. 18–29; E. W. Martin, Jr.: Teaching Executives via Simulation, in: Business Horizons 2/2 (1959), pp. 100–109.

28 A very good retrospective view of the 1960s is provided by Harold Guetzkow, Philip Kotler and Randall L. Schultz (eds.): Simulation in Social and Administrative Science. Overviews and Case-Examples, Englewood Cliffs 1972.

29 See Arnold E. Amstutz: Management Use of Computerized Micro-Analytic Behavioral Simulations, working paper presented at The Institute of Management Science meeting in Dallas, Texas, 17 February 1966 (the following images are taken from here); A. E. Amstutz and H. J. Claycamp: Simulation Techniques in Analysis of Marketing Strategy, in: Applications of the Sciences in Marketing Management, Purdue University, Lafayette, IN 1966; A. E. Amstutz: Computer Simulation of Competitive Market Response, Cambridge, MA 1967; and Philip Kotler and Randall L. Schultz: Marketing System Simulations, in: The Journal of Business 43 (1970), pp. 237–295.

30 The classic example is the bestseller by Vance Packard: The Hidden Persuaders, New York, NY 1957.

product and information channels are separated out; feedback is installed. In short, the bases for a non-linear system-behavior are being laid out. And finally, after several steps of this kind, a flow-chart emerges which designates the network of dependencies that need to be translated into program code.

Each of these boxes implements certain theoretical assumptions in program code – thus, not only do they contain a decision with regard to what one believes to know but above all what one *doesn't* need to know. Simulations are distinguished by the fact that they can deal operationally with ignorance and can lay claim to its reflected appraisal. What I mean by this in particular is that everything which

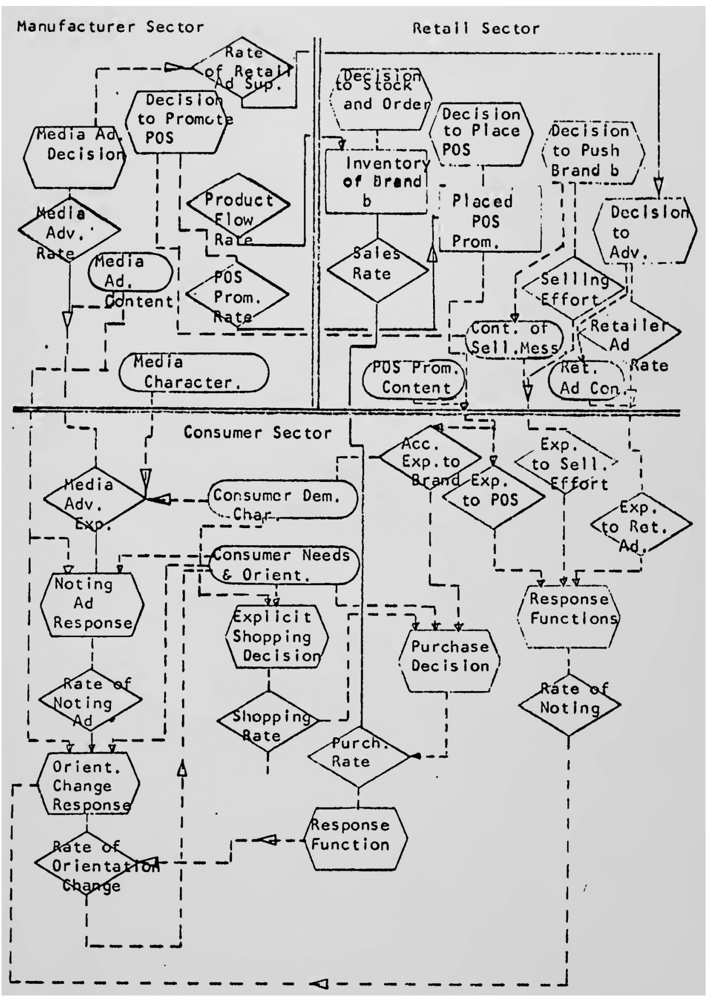

Fig. 1: Macro-flowchart of consumer model interactions.

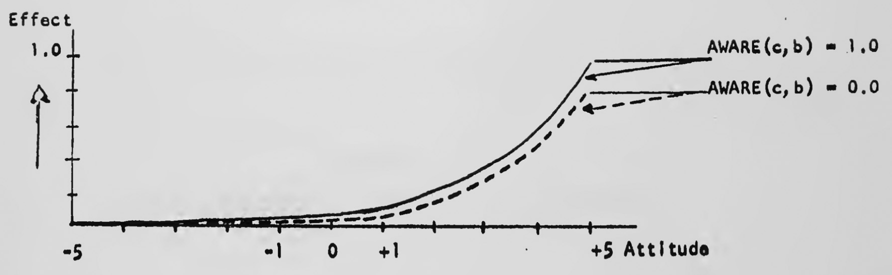

Fig. 2: Effect of attitude on perceived need.

is part of simulated systems must somehow be parameterized but that a successful parameterization requires an understanding of the particular phenomenon under study that is mostly not at hand. (Particularly not in the »harder« numerical simulations, for example climatology.) Simulations, therefore, work far more through trial and error than through first principles – even if the hope of this latter is great. By the phrase »implemented assumptions« I mean such concepts as Paul Lazarfeld's »like-dislike« schema or heuristic curves of »attitude« toward product placement. This one, for example, works on the assumption that at a certain point in one's positive attitude one's stimulus to buy begins to increase exponentially. Those who love Apple products or Italian shoes can certainly testify to such feelings.

Once the program was set up, several simulation run-throughs would be undertaken, the findings printed and then analyzed. What we have here is a run-through of version 3 from 4 April 1965 of over 1400 hours. The decisive aspect here – and to which I will return – is that the simulation is proto-object oriented, or if you like, proto-agent-based.[31] This expression describes week 117 in the life of virtual consumer no. 109. He is a New Englander, lives in the suburbs, is between twenty-five and thirty years of age, has an annual income of between 8000 and 10,000 dollars, and also has a college degree. For the past six years he has owned a Brand 3 appliance and likes to make his purchases at retailers 5, 11 and 3. He consumes the

31 I put it in this careful way because object-oriented simulations and agent-based simulations are difficult to distinguish from one another and the matter is still in solution; that is, in 1966 there was still no programming language for object-orientation – although there was the attempt to implement something similar in procedural languages; which also means that there were still no autonomous agents with their own memory space but rather solely the tendency to implement such through the use of tables. It is from a technical standpoint that the example used here is a classic discrete event-simulation which follows the lead of »systems dynamics« (Jay Forrester), the dominant paradigm of the 1960s. Still, it is clear from the interaction of the customer population that emerging at this time was a specific problem area which object-oriented programming languages and ABCS would address a short time later.

mass media 1, 4, 9, 10, 11 and 12, and he has certain consumer preferences. Because it is indeed a simulation, it culls the entire content of his mind, like a Windows system after crashing – »memory dump«. He is exposed to advertising that makes various impressions on him and he converses with friends and neighbors (agents 93, 104 and 117). At some point he decides to go shopping, has a virtual shopping experience and spends $ 38.50 – even though the salesman hardly gives him the time of day! He relates the experience to his friends – and has to again soon banish it from memory so as to become a purchaser once more.

So what does one do with material like this? What to do with such clusters of artificial narrative, with this mushrooming data of a synthetic or generative structuralism? Of course all this is nothing more than statistics that look as if they were dealing with real-life customers. This is part of the validation of the odd type of knowledge that simulation run-throughs produce and which has a precarious status. Does the simulated system behave similarly to a comparable real-world system for which valid data are available? For example, as in the military sphere, when simulated machine-gun fire shows the same distribution as the targets at real shooting ranges. Or as in particle physics, when simulated detectors have to show the same particle traces as real detectors in ac-

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            SIMULATION APP-03 TEST RUN APRIL 4, 1965 1400 HOURS

-- CONSUMER 0109 NOW BEGINNING WEEK 117  --  FEBRUARY 19, 1962

    - REPORT MONITOR SPECIFIED.  TO CANCEL PUSH INTERRUPT.

    - CHARAC - REGION NE SU, AGE 25-35, INCOME 8-10K, EDUCATION COLLEG

    - BRANDS OWN 3, 6 YEARS OLD.  RETAILER PREFERENCE 05, 11, 03

    - MEDIA AVAILABLE 1 0 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0

    - ATTITUDES .  1   2   3   4   5   6   7   8   9  10 .11..12
      ..................................................................
                .
      PROJ CHAR .  0  +1  +1   0  -3  -1   0  +5   0  +3   0   0
      APPEALS   . -3   0  +1  +5   0  -3  +3   0   0   0  +5   0
      BRANDS    . +2  +1  +3  +2
      RETAILERS . +1  -5  +3  +1  +5  -5  -5  +1  -1  -3  +5  +1
                . -3  +1  -1  +3  +1  +1
      AWARENESS .  1   0   0   0

    - MEMORY DUMP FOLLOWS.  BRANDS LISTED IN DESCENDING ORDER 1 TO 4

   PRODUCT CHARACTERISTIC MEMORY             APPEALS MEMORY

1  2  3  4  5  6  7  8  9 10 11 12 . 1  2  3  4  5  6  7  8  9 10 11 12

2  3 15  0  5  5  4 14  8  7  1  3 . 8  9  7  3  1 11  7  4  4  3  9  3
8  0  6  4  9  5  4 13  0  3  6  7 . 6  8  0  7  0  9  2  4  3 10  3  1
0  6 15  7  0  3 11  3  5  2  5  7 . 0  4  8 10  9  2 14  3  9  7  9  5
7  9  3  7  3  2  7  2  6 12 14  2 . 0  9  7  8 13  9 11  6  0  2  5  9

    - MEDIA EXPOSURE INITIATED

         - MEDIUM 003 APPEARS IN WEEK 117 -- NO EXPOSURES
         - MEDIUM 004 APPEARS IN WEEK 117
              - EXPOSURE TO AD 013, BRAND 3 -- NO NOTING
              - EXPOSURE TO AD 019, BRAND 4
                   - AD 019, BRAND 4 NOTED.  CONTENT FOLLOWS
                   - PROD. C 11 P=4,  4 P=2,
                   - APPEALS  5 P=2,  7 P=2, 12 P=2,
         - MEDIUM 007 APPEARS IN WEEK 117 -- NO EXPOSURES
         - MEDIUM 012 APPEARS IN WEEK 117
              - EXPOSURE TO AD 007, BRAND 2
                   - AD 007, BRAND 2 NOTED.  CONTENT FOLLOWS
                   - PROD. C  8 P=3, 12 P=1,
                   - APPEALS  2 P=1,  4 P=1,  6 P=1, 10 P=1,
              - EXPOSURE TO AD 013, BRAND 3 -- NO NOTING
              - EXPOSURE TO AD 004, BRAND 1 -- NO NOTING
         - MEDIUM 016 APPEARS IN WEEK 117 -- NO EXPOSURES
         - MEDIUM 023 APPEARS IN WEEK 117 -- NO EXPOSURES

   - WORD OF MOUTH EXPOSURE INITIATED

            - EXPOSURE TO CONSUMER 0093 -- NO NOTING
            - EXPOSURE TO CONSUMER 0104 -- NO NOTING
            - EXPOSURE TO CONSUMER 0117 -- NO NOTING

   - NO PRODUCT USE IN WEEK 117

   - DECISION TO SHOP POSITIVE -- BRAND 3 HIGH PERCEIVED NEED
                               -- RETAILER 05 CHOSEN

   - SHOPPING INITIATED

        - CONSUMER DECISION EXPLICIT FOR BRAND 3 -- NO SEARCH
        - PRODUCT EXPOSURE FOR BRAND 3
             - EXPOSURE TO POINT OF SALE 008 FOR BRAND 3
                  - POS 008, BRAND 3 NOTED.  CONTENT FOLLOWS
                  - PROD. C  3 P=4,  6 P=4,
                  - APPEALS  5 P=2,  7 P=2, 10 P=2, 11 P=2,
        - NO SELLING EFFORT EXPOSURE IN RETAILER 05

   - DECISION TO PURCHASE POSITIVE -- BRAND 3, $ 38.50

         - DELIVERY IMEDAT
         - OWNERSHIP = 3, AWARENESS WAS 2, NOW 3

   - WORD OF MOUTH GENERATION INITIATED

         - CONTENT GENERATED, BRAND 3
                  - PROD. C  3 P= +15,  8 P=+15,
                  - APPEALS  4 P= +50, 11 P=+45

   - FORGETTING INITIATED -- NO FORGETTING D

- CONSUMER 0109 NOW CONCLUDING WEEK 117  --  FEBRUARY 25, 1962

- CONSUMER 0110 NOW BEGINNING WEEK 117  --  FEBRUARY 19, 1962

QUIT,
 11.633+4.750
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Fig. 3: Computer output.

Open Access (CC BY-NC-SA 3.0.) | Felix Meiner Verlag, 2011 | DOI: 10.28937/ZMK-2-1

celerators. Or as in astronomy, when simulated red giants have to look like the telescope pictures of red giants which themselves are generated from theoretical and highly charged data.

This validation process, in any case, is comprised of the interplay of sensitivity analyses and model revisions. For example, this functions very simply through means of »curve fitting«; that is to say, you superimpose a graphically rendered system-behavior model, obtained by means of simulation run-throughs, onto the representation of an empirically obtained and rendered model of system-behavior.[32] If the curves match, the simulation is considered accurate; but this would by no means imply that it is »true« in the emphatic sense of the word. (Especially since the comparative curve is only decipherable to the trained eye; but of course it is a mathematically loaded and graphically arranged construct – a historical invention.) Which means to say that we are not here dealing with a dualistic path to knowledge but with a differential one. The point is not to penetrate to the very rhyme and reason of things and thereby perhaps formulating »laws«, but rather, within the parameters of a kind of empirical exoneration, it is sufficient that two systematic contexts behave in a like manner – irrespective of the reasons.

All that might appear trite today, jaded as we are by such virtual worlds as *Second Life*, but in 1965 this was exciting stuff indeed. The scientific and descriptive language for systems was first formulated at that time and – like all languages and notation systems – have since then been working on thinking.[33] It suffices here to cite Dahl and Nygard, whose programming language »Simula« is perhaps the most famous: »Many of the civilian tasks turned out to present the same kind of methodological problems: the necessity of using simulation, the need of concepts and a language for system description, lack of tools for generating simulation programs. This experience was the direct stimulus for the ideas which in 1961 initiated the Simula development.«[34] Interestingly, the metaphors of »customers« and »stations« populate the concepts of Dahl and Nygard (which had their origin in quite different contexts) and one is even tempted to say that Simula's internal workings are ruled by a »business« model whose structures are transferrable to every imaginable area of the interaction of various agents.[35] As areas of application for

32 This comes from K. J. Cohen: Computer Models of the Shoe, Leather, Hide Sequence, Englewood Cliffs, NJ 1960.

33 See Benjamin Lee Whorf: Sprache, Denken, Wirklichkeit. Beiträge zur Metalinguistik und Sprachphilosophie, Reinbek 1963; and Friedrich Kittler: Discourse Networks 1800/1900, Stanford, CA 1990.

34 Kristen Nygaard and Ole-Johan Dahl: The Development of the Simula Languages, in: Richard L. Wexelblat (ed.): History of Programming Languages, New York, NY 1981, p. 440.

35 The developers were looking for a »set of basic concepts in terms of which it is possible

system-description, the authors themselves list production sequences, administrative processes, warehousing, transport and reactor control as well as social systems, epidemics and crisis management. And the concept they proposed as an answer to the demands for recursive types of data and reusability was that of classes and methods – in other words, *object orientation*.[36]

A »class« describes all kinds of similar objects. Call to mind the many customers that have various incomes, ages and media-consumer profiles, while at the same time all being customers with certain shopping requirements. Classes are simply templates from which objects with certain attributes are fashioned in running time (so-called instances) and they establish how individual objects react to one another. Methods are then simply the algorithms associated with the objects and with whose help one determines how the objects are able to engage with one another (object customer_1 calls up method m of object customer_2) and that one can encapsulate so that it all can't be everything all the time.

Certainly one can fault this programming approach for being a kind of anachronistic Platonism, which, with the assistance of a timeless ensemble of »ideas« (i.e. classes) suggests a plausibility of the cognition process that has long been cast into doubt by philosophy. But I am not so sure whether it is not precisely informatics which abducted ontology from the monopoly that philosophy had on it and ever since has been doing »ontology design« or »ontological engineering« – whether this has not in fact directed our gaze to a practice-oriented and linguistic categorization of those spheres encompassing life and knowledge. More important to me, rather, is the media-historical productivity with which the informational and operational linguistic potential of system-description was tested – along with the potential of scholarly linguistics in terms of system-description.[37] And these have been conceived as object-oriented ever since the 1960s as well as preparing the way for what today has become widely known as »agent-based« simulation.

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to approach, understand, and describe all the apparently very different phenomena«. See Kristen Nygaard and Ole-Johan Dahl: SIMULA – An ALGOL-Based Simulation Language, in: Communications of the ACM 9 (1966), p. 671. As is known, every problem becomes a nail when you have a hammer in your hand. The same holds true for people standing in line.

36 Jan Rune Holmevik: Compiling SIMULA. A Historical Study of Technological Genesis, in: IEEE Annals of the History of Computing 16/4 (1994), pp. 25–37.

37 Sociological system-theory would be, to some degree, the natural-linguistic counterpart to formal-linguistic and social-scientific simulation models that originated at the same time. I don't wish to assert any causality but the coincidence of these two is interesting and is likely derived from cybernetics. In any event, experience shows that informatics students have no trouble with Niklas Luhmann's texts.

III.

So as to demonstrate just how great an impact this concept has had on our present age and what it means from an epistemological standpoint, I come now to my second, more recent example (i.e. forty years later), which derives from the field of epidemiology – that discipline literally preoccupied with the distribution of conditions and events among the general population, events that are also but not exclusively related to health. As general social medicine it is not a science dedicated to individual case-studies but to the wider context of populations and health. Because the science of epidemiology regards human existence as being impacted by a multi-factored environment full of myriad influences, the discipline's fund of knowledge is a disparate and heterogeneous one, and the links between correlation and causality had always been problematic. As early as the *Corpus Hippocraticum*, in the sections on epidemics, a decisive role is assigned to air, water, locales, life and work rhythms, nutrition and ethos; and questions of health and sickness are located in a spatial (endemic) and temporal (epidemic) network of environmental relationships.[38] At the same time, these issues were intimately conjoined with political questions because epidemics led to emergency situations, while those necessary social norms and time-frames for sensible action and expectations were resolved.

In the nineteenth century the Enlightenment term »communication« was used to describe this environmental nexus – a term that meant not only the transmission of disease but the entire infrastructure of the circulation and traffic and exchange of people and things. (A meaning that is much more interesting for media science than, for example, the communication concept of so-called communication studies.) It is within this framework that the alliance between epistemology and statistics was sealed. It was William Farr who did a statistical evaluation of the national system for the designation of causes of death, which he himself led, and which numbered Karl Marx and Friedrich Engels among his most attentive readers because his studies didn't lend themselves to medical findings so much as those respective of social conditions. Farr's contemporary John Snow, in his *On the Mode of Communication of Cholera*, published his own findings with regard to that incunabulum of epidemiology.[39] During the London cholera epidemic of the early 1850s, Snow entered on a map the places of residence of five hundred of the epidemic's Soho fatalities and was able to see that there was a clustering of casualties near certain wells. Everyone who had drunk from the well in Broad Street had

38 Hartmut Böhme: Die vier Elemente. Feuer, Wasser, Erde, Luft, in: Christoph Wulf (ed.): Vom Menschen. Handbuch der Historischen Anthropologie, München 1996, pp. 17–46.

39 John Snow: On the Mode of Communication of Cholera, 2nd edition, London 1855.

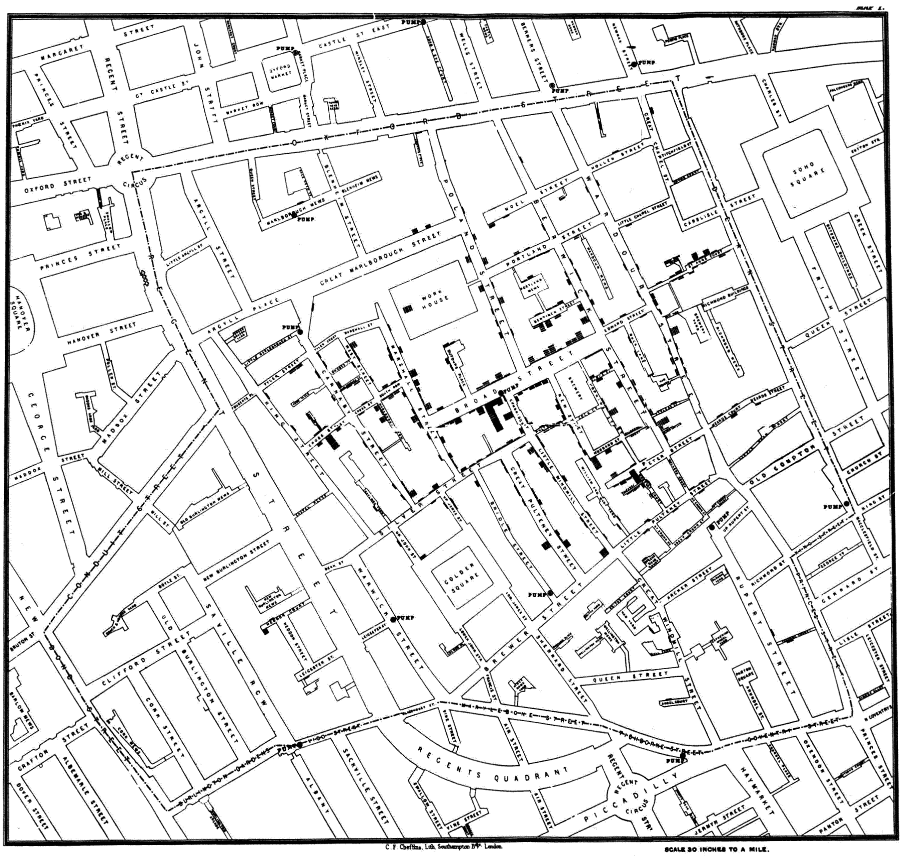


Fig. 4: Map made by John Snow in 1854. Cholera cases are highlighted in black.

become infected. On the basis of statistical visualization it had thus become possible to derive causality from correlations – i.e. transmission of the disease through drinking water – and to limit the final body count to 616.

The emergence of social medicine and the discovery of endogenous agents of infections such as tuberculosis, cholera, diptheria or typhoid fever by Pasteur or Koch (Virchow had also naturally read Farr and had himself lectured at the 1855 Statistical Congress in Saint Petersburg) were major developments in the long history of epidemiology. Immunology, for its part, held the promise, to some degree, of more successfully addressing the problems on other terrain, attempting to address the problem of pestilence as a bacteriological one within the confines of the laboratory and thus discovering not only a place outside of the problem area itself but also the possibility of an immunization that made any further territorial surveillance unnecessary, and thereby allowing for the free circulation and communication of people and things.[40] Authors such as Giorgio Agamben, Roberto Esposito, Jacques Derrida and Philip Sarasin have extensively shown how immunology eventually became the politically resonant technology that it is today.

But a question that is seldom posed is that as to the ways in which knowledge regarding the distribution and calculation of risk is produced and administered, what epistemological status it possesses, what media-technical basis it has, and how it is operationalized. That which has been diagnosed, in a variety of contexts, as the rise of a diffuse operational field of political power, as a deferment of classic politics, as »microphysics of power« (Michel Foucault), or as the rule in »milieus« and »force fields« (Gilles Deleuze) – under whatever rubric you wish to subsume it, it also entails a media-technical infrastructure of knowledge.

In any event, at the start, for epidemiology the media-technical silver bullet was statistics – even in face of the challenge presented by the choice between an individual-clinical experimentation and a »holistic« or integrated observation of social communication. The kicker of all this is that it seems to me that a new epistemic quality had emerged with regard to the complexity of the environmental context, with respect to the modeling of populations, and in terms of the potential for experimentation using computer simulation. It was no accident that I took my first example from that early period of agent-based simulations, for at this point in time it was already clear that aggregate statistical data was no longer to be used but artificial populations of individuated agents whose temporal interaction subsequently allowed for artificial statistics – statistics of the second order, as it were. And on the evidence of epidemiology, it is perhaps even clearer that in simulation we are looking at a kind of knowledge that can be obtained neither experimentally while seated on the laboratory bench nor through pencil-on-paper analysis. For instance, neither can those findings with regard to the infection of animals used for experiments be upscaled in order to obtain knowledge regarding communication in society, nor can a set of general laws or formulas be found that might allow for its numerical calculation. It is rather an »anecdotal complication«[41] that distinguishes the simulation's specific achievement in knowledge – enriching an artificial world with phenomena, encounters and circumstances, its population with all kinds of agents, and the unfolding of this complication throughout the run-time of the program. The extent of this »worldliness« can be simply measured on the basis of the system's computational power, which is why epidemiologists

40 Johannes Türk: Die ›Zukunft‹ der Immunologie. Eine politische Form des 21. Jahrhunderts, in: Claus Pias (ed.): Abwehr. Modelle – Strategien – Medien, Bielefeld 2008, pp. 11–26.

41 Isabelle Stengers: Die Erfindung der modernen Wissenschaften, Frankfurt/M. 1997, p. 210.

are always demanding faster computers. It is in this way that to a certain degree the agent-based simulation removes the scaling problem between experimental-immunological observation in microcosm and statistical-epidemiological observation in macrocosm, which emerged in the nineteenth century.

IV.

Fifteen years ago, in the year 1995 – which for computer scientists is an eternity – a simulation by the name of TranSims (Transportation Analysis and Simulation System) was carried out at the NISAC (National Infrastructure Simulation and Analysis Center). The authors of this simulation proudly proclaimed that »details matter«.[42] The goal was to simulate the traffic system of Portland, Oregon, and the method employed was naturally an agent-based one. Based on population-census data, street maps, and local traffic timetables, here being modeled was not only Portland's entire public transportation network with all its streets, buses, cars, subways, water and power as well as 180,000 distinct locales (schools, offices, movie houses, residential buildings, etc.) but also a virtual population of 1.6 million inhabitants. All virtual residents of Portland go about their individual daily activities and routines – mornings they travel by car to their office or evenings with the bus to the nightshift, afternoons they fetch their children from school, leave the university, and go to the movies in the evening. All this is done through a percentage distribution based on statistical data but in a single workday and individually from agent to agent, with haphazard and, in isolated cases, unforeseen delays, malfunctions, or spontaneous decisions.

Let us now zoom into this somewhat indiscernible and not easily comprehensible daily bustle, for example, focusing on a street, on a freeway entrance ramp, or on a single traffic intersection where one can observe how the agents, for instance, are attempting to make a detour around a snarl-up (and in so doing perhaps producing a snarl-up of their own); for example, focusing on the havoc that creation of a construction site can wreak or on how many accidents a power outage can cause; for example, focusing on what the amalgamation of two schools means or on whether an altered traffic light circuit sinks carbon-monoxide emissions. And this functions down to every single agent and his mobility profile, whose data are disaggregated every second. Of vital interest in all this is the sensitivity of the sys-

42 Kai Nagel and Steen Rasmussen and Christopher L. Barrett: Network Traffic as a Organized Critical Phenomena, Transims Report Series, Los Alamos, NM National Laboratory, 20–28 September 1995. Meanwhile, the software is an open source (http://www.transims-opensource.net/); the »Transims Travelogues«, which reported on current activities within the Transims project, is unfortunately no longer online.

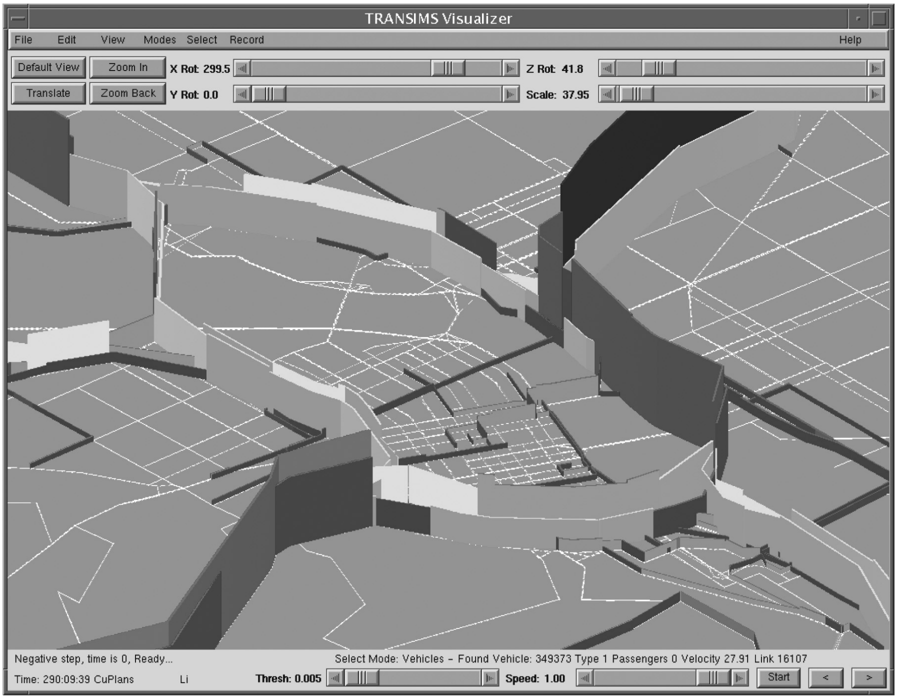
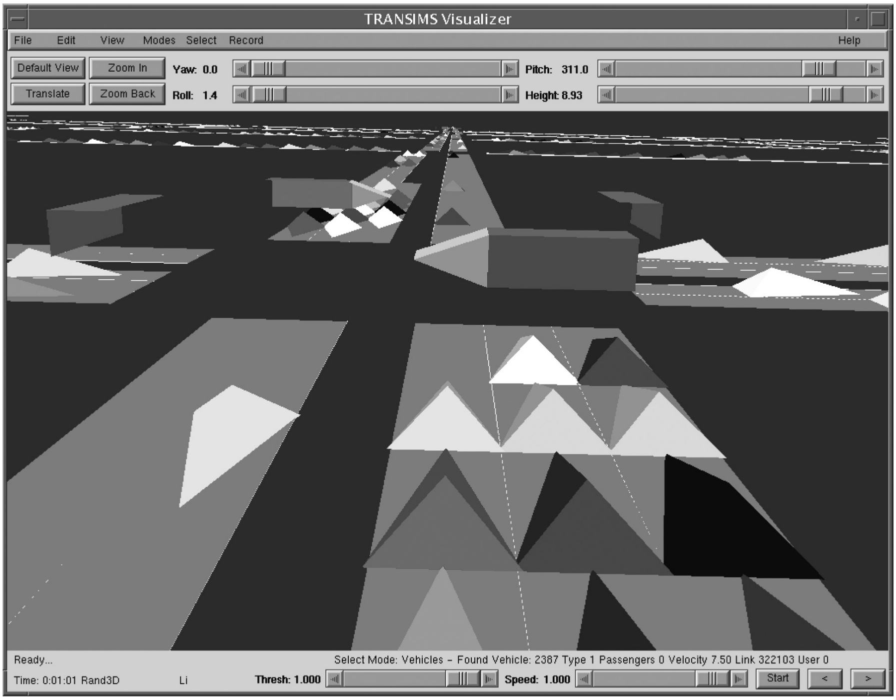


Fig. 5: TranSims Output visualizer displaying cumulative plan data (above), and a view in the Ride-In vehicle mode (right).

tem – that is, the question as to the sensitivity and range of certain events and how the individual components of the system interact with one another.

After 9/11 and in the course of the anthrax threats, it was natural to expand this simulation – which was concerned with the effectiveness and reliability of an infrastructural network – to incorporate routines for epidemiological crisis scenarios. This simulation is now called EpiSims (Epidemiological Simulation System) and simply couples the transmittance of persons with the transmission of diseases. And now they have initiated a »bio-terrorist attack« on the university and are looking at how it is communicated – this, of course, in the way that John Snow would have used the term. The selected pox virus has an incubation period of ten days, during which people go innocently about their everyday business – and the ability to model this is the strength of the simulation. Here too we begin with statistical data (e.g. that teenagers like to be among their own kind; or how many people work days, how many work nights, and where), but all methods are individualized once more (as in TranSims) through the agent system, wonderful contact-graphs for all 1.6 million agents being developed for apartments, movie



houses, streetcars or restaurants and thus allowing for »intriguing insights into human social networks«.[43] And the questions that one poses in view of these so-called »scale-free networks«[44] are of course – Where are the hubs that one has to incapacitate if the thing isn't to spread? Where can the short paths that skirt the hubs be found? How critical is time and when can matters no longer be contained? And what will be the collateral economic damage if one isn't able to react more quickly? Should one go with mass inoculations or quarantines or perhaps a mixed strategy? And where does one start? You can see through this example, which one could say much about, how the question of epidemics and their simulation invariably gives rise to questions of knowledge and the description of society as well as to questions of government, control and power.

Michel Foucault decoded the different ways in which societies and historical eras deal with infectious disease, using as his model three classic contagions –

43 See Chris L. Barrett, Stephen G. Eubank and James P. Smith: If Smallpox Strikes Portland…, in: Scientific American 292/3 (2005), pp. 54-61.

44 Albert-László and Réka Albert: Emergence of Scaling in Random Networks, in Science 286 (1999), pp. 509–512.

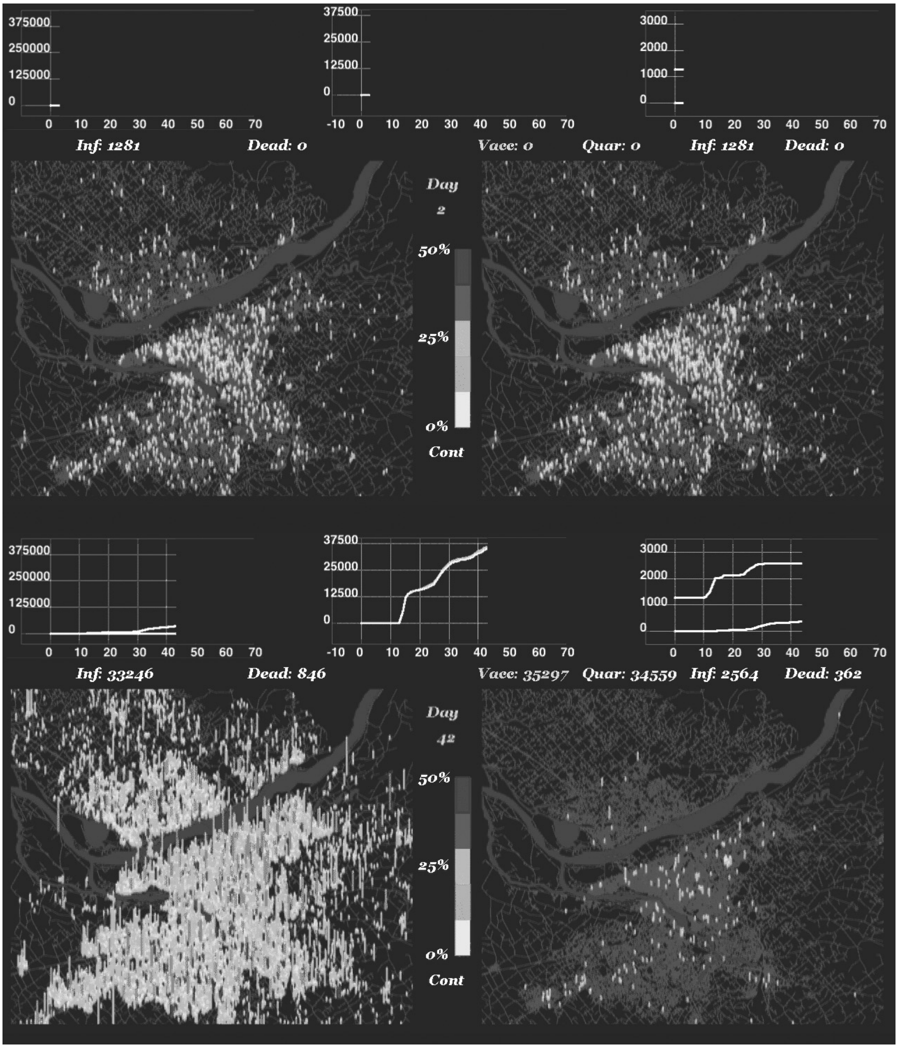


Fig. 6: Comparison of a baseline case with a targeted vaccination and quarantine strategy after 3 (above) and 43 days (below).

leprosy, pestilence, and smallpox – so as to describe just how power functions.[45] It is in this sense that it is a more than wonderful coincidence that EpiSims simulates the spread of pox viruses. If the leprosy model characterizes the epoch of the »great

45 See Philip Sarasin: Smallpox Liberalism. Michel Foucault und die Infektion, in: Claus Pias (ed.): Abwehr. Modelle – Strategien – Medien, Bielefeld 2008, pp. 27–28.

confinement« of deviants and lunatics in asylums, and if the plague model characterizes the »political dream« of discipline and of a monitored space along lines of the pestilence regulations, it is finally the smallpox model that characterizes the problem of not being able to any longer describe modern societies as perfectly monitored and controlled plague-cities. According to Foucault:

»The problem is posed quite differently. The fundamental problem will not bet he imposition of discipline, although discipline may be called on to help, so much as the problem of knowing how many people are infected with smallpox, at what age, with what effects, with what mortality rate, lesions or after-effects, the risk of inoculation, the probability of an individual dying or being infected by smallpox despite inoculation […]«.[46]

As Foucault shows (and echoing the procedural methods of Snow and Farr), the reaction of the public authorities to the pox can be observed statistically by quantifying and charting the incidence of cases, and later on it can also be empirically ascertained through inoculation of the populace against contagion. In short, we are dealing with an instance of »risk management based on a particular perception of the problem« (Sarasin) that does *not* capsize into disciplining but instead respects the relative »impermeability« of society at the cost of a certain risk of infection. Foucault again:

»On the horizon of this analysis we see instead the image, the idea, or the theme-program of a society in which there is an optimization of systems of difference, in which the field is left open to fluctuating processes, in which minority individuals and practices are tolerated, in which action is brought to bear on the rules of the game rather than on the players, and finally in which there is an environmental type of intervention instead of the internal subjugation of individuals.«[47]

This »intervention in the environment«, this »playing with the rules of the game«, this »optimalization of systems« and this »freeplay« of individuals and their practices – all of this is precisely what is subjected to experimentation in simulations such as EpiSims – and then of course implemented in a media-technical way. As indicated, agent-based computer simulations that do not only study real infectious diseases but instead oversee and manage the transmittal aspects of them in addition to their economic, social and health facets as a single communicative complex that allows for all kinds of inquiries into the positions and exchange between people

46 Michel Foucault: Security, Territory, Population. Lectures at the Collège de France 1977–1978, Hampshire 2009, p. 10.

47 Michel Foucault: The Birth of Biopolitics. Lectures at the Collège de France 1978–1979. Hampshire 2010, pp. 259 et seq.

and things – these simulations are not only a kind of signature of the age of liberalism but at one and the same time a media instrument for obtaining insights into society as well as a scientific field of experimentation for this new style of governance. And as I have attempted to demonstrate, simulations proceed in an entirely different manner from statistical readings, for they do not smoothen and lump the details but only disaggregate and unfurl the details if they happen to matter.

V.

Simulations have a particularly epistemic quality, they bring a very particular knowledge into the world. It is no accident that meanwhile professional epidemiologists have become interested in virtual game communities like that of the worldwide *World of Warcraft*, whose membership is 11-million strong, for the knowledge of epidemiologists also has a playful or, perhaps better put, ludic background.[48] The knowledge of simulations is always furnished with a hypothetical index, and because various people model and simulate the same problem in various ways, what eventually emerges – instead of certainty – is an uncircumventable spectrum of opinions and interpretations. And it is to this degree that simulations contain an element of sophistry and take sides. Description, explanation and fiction come together in an experimental compound.

Firstly, the tradition of the philosophy of science and its alignment with physics and mathematics, its demand for propositions, and its wariness regarding falsifiability hardly allows it to take simulations seriously. But in view of computer simulation, I believe that the more recent history of science must rethink the applicability of concepts like »experimental system« and »epistemic thing«. Of course the discipline of Laboratory Studies has hitherto directed its gaze at those historically shifting practices, instruments and imagery that are constitutive of scientific knowledge and without prejudicing this knowledge by virtue of its genesis in these certain practices, instruments and imagery – but the interesting point for me is that the »immaterial culture« of the simulation laboratory (if I be allowed to term it such) is infinitely faster and more adaptable than material culture and that a new quality emerges from all this. Or, in the words of the physicist Herman Kahn, from the 1950s: »If, for example, he were to want a green-eyed pig with curly hair and six toes and if this event had a non-zero probability, the Monte Carlo experimenter, unlike the agriculturist, could immediately produce

48 Eric T. Lofgren and Nina H. Fefferman: The Untapped Potential of Virtual Game Worlds to Shed Light on Real World Epidemics, in: The Lancet Infectious Diseases 7 (2007), pp. 625–629.

the animal.«[49] One might call this the inflation of »epistemic things«. In any event, the sensibility for the material culture of science that has developed over the last few decades requires a corresponding alertness to the immaterial culture of computer simulations that should be expressed and elaborated through the use of historical instances – and this particularly at the level of the code into which scientific knowledge is translated, like the longest time in mathematics, a code which fundamentally differs from this calculation if only by dint of its temporality. In the software itself archeological deposits of scientific reality engenderment have accumulated, and the methods employed by Laboratory Studies to excavate them are not easily transferable.

Secondly, one must ask oneself precisely what form a contemporary criticism of science should take as soon as and to the extent that we are having to deal with sciences that emerge not in the name of truth but in the name of possibilities. Bruno Latour devoted an essay entitled »Why has Critique Run out of Steam?« to a passionate discussion of the aporetic situation of present-day criticism of science – an essay that not without good reason commences with the findings of climate simulation and specifies the pressing questions as being: »Why does it burn my tongue to say that global warming is a fact whether you like it or not? Why can't I simply say that the argument is closed for good? Should I reassure myself by simply saying that bad guys can use any weapon at hand, naturalized facts when it suits them and social construction when it suits them?«[50] If you look at the world of computer simulations, then there would seem to be a simple answer to these questions, namely that the current methodological silver bullet of research into science – the actor-network theory, which is the theory of human and non-human agents – owes its own existence to an epoch of simulation. Or to put it in another way: We are dealing with a theory design that could only emerge because computer simulations have *worked* precisely in this way. The same goes for »radical constructivism«, which transplanted the epistemology of simulations into philosophy.[51] That is why constructivism and actor-network theory are likely unable to offer an explanatory or descriptive model of simulation, but are instead themselves merely symptoms of simulation's hegemony. It is therefore perhaps no coincidence that they have so

49 Herman Kahn and Irwin Mann: »Monte Carlo«, Santa Monica, CA, 30 July 1957 (RAND P-1165), p. 5.

50 Bruno Latour: Why has Critique Run out of Steam? From Matters of Fact to Matters of Concern, unter: http://criticalinquiry.unichicago.edu/issues/v30/30n2.Latour.html (02.02.2011).

51 After the Second World War, Ernst von Glaserfelds programmed computers to do automatic translations – simulating the work of the translator – and only consitituted his philosophical constructivism after the U.S. Air Force had canceled the project's funding. That is perhaps not an apocryphal anecdote.

splendidly preserved their critical potential in terms of laboratories and mode-1 sciences. Mode-1 sciences are wonderfully suitable in attempting to radically historicize truth claims, to deconstruct evidence, and to show the fictive nature of the factual. But to avail myself once more of the term, computer simulations are a kind of postmodern science and are part of another episteme, namely that of constructivism and actor-network theory. Their knowledge is consciously – and as a matter of course – furnished with a hypothetical index, they admit to their fictional components, they position themselves within their conceptual frame of reference, they thematize their performance, they are aware of their problematic genesis, and they specify their limited application. Perhaps Latour's *Elend der Kritik* has less to do with an expropriation of critical concepts than with a media-historical and accompanying epistemic upheaval of the sciences. Or put in yet another way: How does one deal with the fact that research into science draws its concepts from the sciences that it is attempting to describe? And it is to this extent that the critical options of yesterday have become the working conditions of today.

Picture credits:

Fig. 1-3: Arnold E. Amstutz: Management Use of Computerized Micro-Analytic Behavioral Simulations, Texas, February 17, 1966.

Fig. 4: John Snow: On the Mode of Communication of Cholera, 2nd ed., London 1855.

Fig. 5: TRANSIMS, vol. 4: Calibrations, Scenarios, and Tutorials, Los Alamos National Laboratory, March 1, 2002.

Fig. 6: S. Eubank et al.: Supplementary information for »Modelling disease outbreaks in realistic urban social networks«, http://www.nature.com/nature/journal/v429/n6988/extref/nature02541-s1.htm