Foreword

I wish to thank Juan A. Barceló for asking me to write the foreword to his fine book on *Computational Intelligence in Archaeology*. As he writes in the prologue, we might sometimes disagree, but he still regards himself as a kind of "gardinist" in his more modern world. One example is the place we both gave to the conference on computer applications and quantitative methods in archaeology (http://caa.leidenuniv.nl). Barceló indicates that he attended nearly all the annual meetings of that series since 1991. I personally was invited to present the initial paper of the 2002 meeting of that conference, as an interim report on the logicist program. There are differences between that program and those that formed the basis of all the computer applications discussed at this conference. Before going into them, I shall first summarize Barceló's views here presented on the subject.

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Section I, *From Natural Archaeology to "Artificial" Intelligence*, establishes first the automated form of archaeology in an Input →STATE → Output format. The analysis of such forms calls for some inferences that are social interpretations of the input data, that is, 'inverse engineering' distinct from 'real' data. The major question is problem solving in the brain and by the machine. The answer here is the machine, but with a difference between expert systems, in which the mechanisms of human conceptualization are lacking (as in our view of expert rules), and a neurocomputational one where the "rational" automated archaeologist makes more sense.

Section II, *Learning and Experimentation in Historical Sciences*, takes on this neurocomputational framework of study through the concept of "inverse reasoning," an inverse engineering based on 'the generalization of input-output mappings connecting cause and effect in certain fields of regularity. Inverse reasoning starts not with observations but with conjectures, hence a predictive task depending on social processes more than on the accumulation of data. The 'Introduction to neurocomputing' is a way to answer this schematic representation between neurons from input detectors to integrated outputs (there are many ways to account for the relation between neural including the recurrent networks, which I shall not summarize here).

Section III, is titled *Practical Examples of Automated Archaeology*. The starting point is a recall of the principle of visual and non-visual analysis in automated archaeology, from observable effects to unobservable causes. The automated archaeologist should first find the social cause of what it 'sees' and extract from that analysis a number of unobservable questions which should be included in the initial computer classification of the data. Examples are given for shape analysis, texture and compositional analyses, spatiotemporal analysis. In this last case, the most provocative of all questions asked along

this book is raised: “Can an automated archaeologist not only ‘forecast’ the future, but even explain how our social action will be?” The provisional answer to that problem tends to call more on studies of social causation than on particular objects. In other words, we should concentrate on the function of the objects mentioned as inputs in order to convert into output actions that seem reasonable, that is, neither too general nor too specific. Some of the material elements in given social activity will be used to guide inferences and to fill gaps in the knowledge of the element’s function.

Section IV consists of the Conclusions. Summarizing the argument, the automated archaeology actually sees humans acting socially and perceives their variation in time backwards, explaining it through some causes. This may be understood as seeing the past or the present. In this second case, the inverse reasoning or inverse engineering approach is used to simulate unobservable mechanisms that link the input (observation) with the output (explanation), or to predict properties of parts of the social process from properties of other parts. The case of organized “libraries” of internal representations of various prototypical perceptual situations has not been discussed here.

The last section of the book *Towards a Computational Philosophy of Science* is particularly interesting to understand its purpose. First, an artificial archaeologist is defined as “a physically instantiated system that can perceive, understand and interact with its environment, and evolve in order to achieve human—like performance in activities requiring context—(situation and task) specific knowledge.” Second, we therefore need “a theory of why a specific computation or a group of related computations performed by a system that has (those) abilities.” Among them, “computer programs (that) do work in real science, not only in archaeology ” that is, “not simulating or reproducing the way archaeologists think today because we are doing archaeology in the wrong way.” Thirdly, in this purpose, “the robot scientist can infer hypotheses with integrated reasoning, perception, and action with a uniform theoretical and implementation framework (derived) from cognitive robotics. Computational cognitive models of archaeological abilities should be based on the study of particular human capabilities and how humans solve certain tasks, but still models will never be like human archaeologists, nor do I pretend to substitute human scientific endeavor by slave androids.” Finally, in other words, the preference is “to discuss how to design the theory of the computation (knowledge level) rather than the possible implementation (physical level) “hence a “ top-down strategy” with three kinds of assumptions: social activity, rather strong and daring; a more predictive hypotheses; or closely related to them but in terms that run the risk of certain distortions.

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I wish now to go back to the logicist program and its interim report presented at the CAA 2002 meeting which I attended (Doerr & Sarris, 2003). The main point was to recall the two ‘natural kinds’ developed by Jerome Bruner in his theory in*Actual Minds, Possible Worlds* (1986): one is the logic-scientific way used in the “hard” sciences, the other is the way of thought presented in the liberal kinds such as the ‘soft’ studies including literature. The example given by Bruner belonged all to the narrative kinds, which made it difficult to know whether a ‘third’ way of knowledge was possible existing beyond his two natural kinds, covering ‘between’ the two other points. Bruner was wise enough to avoid that question so that I myself had to propose an answer; it consisted in focusing that the logico-scientific part was applicable to our studies as well, while seeing in their case a large number of ‘complements’ differently named, from the more advanced to the more journalistic or literary ones. Our research on ‘Conceptual modeling and digitalization’ was logic-scientific in this case, but it did not hesitate to raise questions about the many computer works presented at the same meeting (Gardin, op. cit, p. 5-11).

Yet my view is "wrong" according to Barceló because "it lacks the mechanism of human conceptualization," as done in his understanding of computational intelligence. I accept this criticism given the fact that " problem solving never ends."

My understanding then went back to my initial book presented in 1980, Archaeological Constructs: an aspect of theoretical archaeology. The analysis was a set of basic data used in the picture (declaration propositions) without explicit antecedents in the discourse, followed by inferences practiced by the author (rewriting, derivation, detachment) to reach his conclusion or hypothesis according to his way of presenting the argument (mode empiric-inductive or hypothetic-deductive). The argument itself thus took the form of a sequence of rewriting operations "p→q," read as "IF p, THEN q." Each of the operations mark in the discourse the passage of a set {Pi} to another set {Pj} following a logic of "natural reasoning" as understood in historical disciplines as later named by J.-C. Passeron (1991). Two interesting properties of this sort of writing were named: (a) the function of the parts of discourse that are not present in the logicist modelization, provisionally regarded as 'literary' in a vague sense of the word ; (b) the metatheoretical aspect of the most diverse schools of thought mentioned, for example, 'traditional' or 'new archaeology,' post-processual, marxist, structural, contextual, symbolic, cognitive, and many others.

The next book mentioned was *Expert Systems and Human Sciences: The Case of Archaeology, Produced by Several of us in 1987* (English version in Gardin et al., 1988). In the same year, I was invited by the Société Française de Philosophie to present my views on the 'Questions d'épistémologie pratique dans les perspectives de l'intelligence artificielle.' The name of 'practical epistemology' was essential in all such matters, implying the same relative view of the artificial intelligence to which it was applied. The decisive position then was to show that the use of computers should be regarded as an interesting part of the process but by no means as an essential one since a large number of articles on the problem were raised even before computers were used (ex., Binford, Renfrew), and so forth.

It was only in the 90s that our situation changed in that respect with the appearance of computers in archaeological publications, but not at first in Barceló's views. My first example was an addition of a 'Problème de formes' in a book on the long-term interpretation of certain facts observed in archeological sites of North-eastern Afghanistan, from the Bronze Age to Islamic times (Gardin, 1998). A computer system was envisaged to simulate the 'data' and successive 'inferences' necessary to justify the proposed 'hypothesis,' using ways of presentation that entirely differed from the initial lines. An example of the kind was given by Valentine Roux in a collective publication of the Cornaline de l'Inde using two forms of writing: (a) the presentation of numerous techniques of fabrication (space, artisans, economics, workshops, etc.), followed by socio-historical hypotheses for each one of them; (b) the expression of such constructions by a set of logicist analyses submitted to practical epistemology and to different modes of computer writing. The book published in 2000 followed the same distinction: (a) first came a large set of individual collections (ca. 500 pages, rich in scientific studies of all sorts: psychometric, mathematics, economics, etc.), each ending with the kind of conclusions called 'natural reasoning;' (b) the second part was a CD-ROM in which Roux tried to represent the logico-empirical data mobilized in each of the hypotheses, using the more efficient multimedia required for this work developed by Philippe Blasco under the name of SCD (scientific constructs and data).

Seen like this, the CD-ROM could be understood as a way to replace the book rather than to complete it. The opinion of Roux was that this way of thinking was erroneous, as much as trying to distinguish the respective merits of models and literature in the human sciences. The position taken after the publication of the Cornaline de l'Inde was to considerably reduce the purpose of the objects and ideas presented in such books, while trying to observe the principle of 'conceptual modeling and digitalization' adopted

for the logico-scientific part of the work. A new collection came out called Referentiel at the Maison des Sciences de l'Homme, in which the CD-ROM became the major part of the argument delivered on the left-hand side of the book in a logic-empirical form. An added part was available on the right-hand side, limited to a few dozens papers written in linear format to expose the author's complements (e.g., history of the methods used, their conception and structure, suggestions for future research, etc.). The first study of Referentiel was published after a thesis on the technical tradition of modern ceramics observed in the Senegal valley (Gelbert, 2003). Others followed on the archaeology of Bronze Age in the Middle East (Boileau, 2005), the relation between India and South-East Asia in and after the passage to the first millennium (Bellina, 2007), the sequence of medieval traditions in Central France till the present (Zadora, in press), and so forth. The SCD format is still a relatively fixed way of presenting the logic-empirical reasoning, but with differences in some applications, where inverse reasoning may lead to the varied predictive analysis in Barceló recommendations.

Another development is oriented in the same program in the name of Archaeotek, the European Association for the Archaeology of Techniques. Its purpose is to encourage studies in a special journal of new works on the logicist analysis of archaeology of techniques (in English only). An article recently published (Gardin, Roux 2004) presents this project, its origin and attended programs, together with the reasons expected against its formal applications (op. cit., p. 35 – 39). Some of them may have to do with the historical and social exploitations in the internal analysis of the observed features, in which case the Archaeotek Journal approaches the phenomenon of computational intelligence. The existing examples already published raise different technical problems leading to interesting discussions of their rewriting procedures. In such features, it may happen that 'new ways of thinking old concepts' are formed, as required in Barceló's computable archaeology. A true intelligent machine thus appears in his own sense of the word, "based on the study of particular human capabilities and how humans solve certain tasks, but such models will never be like human archaeologists" as understood in his notion of artificial intelligence.

This book has a subtitle on Investigations at the Interface between Theory, Technique and Technology in Anthropology, History and the Geosciences. I regret not being able to extend this foreword to this large subject, except perhaps regarding my own views on ethnoarchaeology. We all know that many studies come out on surface features, characterizations, production systems and social groups in ethnoarchaeology, but with few correlates on regularities between material cultures and dynamic phenomena. This problem has been described recently by Valentine Roux in an interesting article on 'Ethnoarchaeology: a Non-Historical Science of Reference Necessary for Interpreting the Past' (Roux, 2007). In reading it, I could not avoid some thought on the inverse reasoning recommended by Barceló for the computer systems, namely 'the observation of the presence of actions that were probably performed in the past' using the computational intelligence. However, the fact that it is regarded as a non-historical science of references is another question, which I prefer to leave opened.

Similar questions have been raised at the Commission IV of the International Congress on Prehistorical and Protohistorical Sciences that took place last year in Portugal (Lisbon, 2006). The following title was asked: "Reconstruction, simulation, reconstitution: how 'real' is our thought? How 'imaginary' is our view of the past?" The first seven papers tried to answer that point with reference to the 'new paradigm of technology.' My own position was that the problem could be raised in the wider perspective of cognitive archaeology presented by James Bell and Colin Renfrew. It was not evident that the inferences or imaginary visions of such 'paradigms' had more or less reality than the modes of writing or reasoning of another order in which technology did not have the same place. Moreover, 10 papers presented under the title of "Emergence of cognitive abilities" seemed to prefer a more general answer

with reference to wider ways of thought—neurophysiology, ethology, and so forth—than to the new paradigms of technology. Computer technique is then a particular detail of the 'reality' artificially observed using different 'paradigms' in each case. This view is again in favor of Barceló's view on computational intelligence in archaeology based on models that are never like human archaeologists although they are able to solve certain human tasks.

Jean-Claude Gardin
Former Research Director at
Centre National pour la Recherche Scientifique
Ecole de Hautes Etudes en Sciences Sociales

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