Jean-Claude Gardin on archaeological data, representation and knowledge: implications for digital archaeology

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Abstract This paper presents Jean-Claude Gardin’s distinctive approach to archaeological data, representation and knowledge in the context of his early engagement with semiotics and structural semantics, and his grounding in fields as diverse as documentation, classification theory, material culture studies, argumentation theory, and the philosophy of the human sciences. Pointing at Gardin’s ambivalence vis-à-vis the promises of automated classification and machine reasoning in archaeology, it shows that his approach goes beyond a normative, positivist conception of archaeological research, recognising the contextual, theory-laden nature of archaeological data constitution, the priority of focusing on actual archaeological interpretation practices, and the complementarity between narrative and formal representations of archaeological reasoning. It connects his early development of archaeological descriptive and typological metalanguages with his later elaboration of a theoretically-informed approach to archaeological argumentation, analysis and publication, situates his logicist program as a relevant, contribution to the development of an archaeological “theory of practice”, grounded on reflexivity and modesty vis-à-vis the possibility of knowledge and the limits of scientism, and highlights aspects of Gardin’s work that point to potentially fruitful directions for contemporary research and practice in the field of archaeological informatics and digital humanities communication.

Keywords Jean-Claude Gardin – History of archaeological thought - Logicism - Data constitution - Knowledge representation – Archaeological reasoning - Digital publication

1 Introduction

Jean-Claude Gardin is a seminal figurehead for archaeological informatics. His scholarship transcends
the boundaries of archaeological work, linking out to fields as diverse as documentation, classification
theory, semiotics, material culture studies, archaeological typology, argumentation theory, and the phi-
losophy of the social sciences and the humanities. While his logicist methodological programme has
been followed explicitly only by a relatively limited segment of the archaeological research communi-
ty (see Gallay 1989, 1998; Roux 2004; Barceló 2009; Moscati 2013), his ideas resonate with broader
developments bridging the increasingly digital practices of archaeology, and the interdisciplinary
fields of digital humanities and digital heritage.

Gardin is perhaps the closest the 20th century has produced to a figurehead not of archaeological
computing, but of computational archaeology: an archaeology based on the exploration of the poten-
tial of computability across all aspects of archaeological research, from the production of the archaeo-
logical record through description, to the construction of archeological typologies and the advance-
ment of archaeological explanation. Nevertheless, references to Gardin’s scholarship remain surpris-
ingly scarce in the English speaking literature of archaeological theory and method. This is despite the
fact that extensive parts of his work have been published in English, including his major programmat-
ic synthesis, Archaeological constructs: an aspect of theoretical archaeology (Gardin 1980; in French:
1979). Scholarly reviews of this work have been varied, and he has been largely ignored by recent
handbooks and anthologies on general archaeology and archaeological theory (Bentley et al. 2009;
Bintliff 2004; Greene and Moore 2010; Hodder 2012; e.g., Jones 2001; Preucel and Mrozowski 2010;
Renfrew and Bahn 2012). The last edition of Bruce Trigger’s History of Archaeological Thought does
make a reference to Gardin’s work, but considers his contribution of little theoretical and epistemolog-
ical importance, relegating it merely to the domain of methodology (Trigger 2006). In a contemporary
archaeology mostly occupied with large scale substantive questions, whose disciplinary foundations
were increasingly shaken by the broader concerns and debates linked with post-processualism, Gardin’s almost scholastic preoccupation with formal problems of data representation and reasoning may have indeed seemed somewhat peripheral, and his frequent use of terms drawn from the vocabulary of positive science was surely dissonant with the rising sensitivities of post-processualist archaeology. The fact that his approach could be interpreted, both inside and outside the logicist community, as a prescriptive, positivist dogma may have also contributed to this marginalisation.

Positive accounts of Gardin’s work, and his theoretical and methodological contribution, are therefore rare. Among them, a well-constructed, canonical genealogy of the intellectual and pragmatic development of Gardin’s logicist school, and its relationship with the advances of mathematical and formal methods in archaeology, was published by leading Swiss ethnoarchaeologist Allain Gallay (1998).

Tito Orlandi, the patriarch of Italian digital humanities and a professor of Egyptology and Coptic studies in the University of Rome – La Sapienza, proposed a nuanced historical analysis of the “difficult relationship” between Gardin’s method on the one hand, and archaeological computing on the other, based on a meta-theoretical account of two large-scale examples of logicist scholarship (Orlandi 2004). Juan Antonio Barceló, professor of computational archaeology in Barcelona, situated logicism, and its push towards computability of archaeological knowledge, as an essential foundation for computational intelligence in archaeology, further fuelled recently by “[f]uzzy logic, rough sets, genetic algorithms, neural networks, Bayesian models and agent-based systems” (Barceló 2009, p. 105). Paola Moscati, the editor of the *Archaeologia e Calcolatori* journal, recently published a consummate account of Gardin’s early work, re-establishing his seminal contribution to the development of large scale documentation programmes and descriptive codes for diverse kinds of artefacts and textual materials (Moscati 2013), which Gardin himself disowned as “unsatisfactory” (Gardin 1996, p. 212) after he shifted his attention to the formalisation of archaeological argument in the 1970s. Moscati’s analysis substantiates Gardin’s involvement with the humanities and social science research scholarly community of his times, his active links with scholars such as André Leroi-Gourhan, Claude Levi-
Strauss and Fernand Braudel, his international standards work and pioneering archaeological computational analyses, and his seminal conceptualisation of databases as “virtual catalogues” and “potential classifications” (Moscati 2013), an notion which, while advanced more than half a century ago, still resonates with contemporary developments and approaches to digital heritage.

In light of this scholarship, I provide a reading of Gardin’s work from the viewpoint of current challenges regarding the information infrastructure of archaeological research, and the emerging landscape of technologically-mediated knowledge construction and publication in archaeology. My concern is to address the limited appreciation of Gardin’s work in the English speaking world, and to provide a framework that will enable workers in the rising field of digital archaeology to benefit from his thinking. Gardin’s scholarly output was extensive, but, as my aim is to engage a predominantly English speaking community on its value, I focus here on using his works available in English. My reading of Gardin seeks, firstly, to connect his early development of archaeological descriptive and typological “metalanguages” with his later elaboration of a theoretically-informed approach to archaeological argumentation, analysis and publication; secondly, to situate his logicist program as a relevant, contribution to the development of an archaeological theory of practice, grounded on reflexivity and modesty vis-à-vis the possibility of knowledge and the limits of scientism; and, thirdly, to highlight aspects of Gardin’s work that point to useful directions for contemporary research and practice in the field of archaeological informatics and digital communication.

2 Archaeological data, description and classification

Gardin is credited as the initiator of the first actual computer-based analysis of archaeological materials, a numerical classification of Eurasian Bronze axes conducted with Peter Ihm as early as 1958/9 (Cowgill 1967; Huggett 2013), only a few years after quantitative archaeology pioneer Alfred Spaulding had advocated the use of “computing machines” for the statistical discovery of artefact types
(Spaulding 1953). But, in fact, his involvement with archaeological information had started as early as 1955, when, encouraged by Henri Seyrig, then director of the French Institute of Archaeology in Beyrut, he designed and implemented an original, indexed, searchable finds catalogue on peek-a-boo punched cards, “an ancestor of the modern data banks [which] included most of the known tools ascribed to the Bronze Age in the Near East — over 4,000 in number — published or unpublished”.

This was followed by experimental catalogues for other classes of archaeological material such as pottery, geometrical ornaments, and iconographic objects (Gardin 1989, p. 6; cf. Moscati 2013). Gardin’s “Centre d’analyse documentaire pour l’archéologie” was founded soon thereafter as part of CNRS to take forward this work. As he explains:

“My concern [was] the study of mental processes at work in archaeological reasoning, with a view to making them amenable to machine handling in a Turing sense — that is, with or without computers. In other words, the goal was not primarily to introduce new information technology in our discipline, but rather to gain a better control of archaeological reasoning per se, through some kind of formalization. [...] [E]ven simple operations [involved in sorting objects] raised epistemological and methodological problems of some size: on what basis do we select the particular features to be used as potential sorting criteria from among others which we decide to ignore? Are the designations of these features unambiguous, so that different observers, describing the same artefacts or monuments, will come up with the same representations?”

(Gardin 1989, p. 7).

The task of defining documentary languages ( “analytical codes”, “metalanguages”) capable of capturing unambiguously the properties of particular classes of cultural objects (both artefacts and texts) so as to aid the discovery of groups conforming to a set of specific criteria, was the springboard for Gardin’s engagement from the late 1950s until the early 1970s with salient questions of data constitution, raising both practical and theoretical concerns as to the nature of the archaeological record and the process of archaeological description. In 1958, he publishes “Four codes for the description of arti-
facts: an essay in archaeological technique and theory”, a remarkable case study of archaeological methodology based on principles of analytical, rather than synthetic description, achieved through systematic segmentation of each class of artifacts, and expression of pertinent descriptive traits by means of a finite set of predefined values for each trait. The four documentary languages (or metalinguages, as he would later come to call them), destined for the description of metal tools, containers, ornament, and iconography respectively, present overlapping problems and approaches. The code for ornament, for example, employs an artificial syllabic language, where suffixes and prefixes are used to indicate syntactic “modifiers” bearing similarities with the operators in Dorothy Washburn’s symmetry analysis (cf. Shepard 1948; Washburn 1977). The code for iconography, on the other hand, draws from Erwin Panofsky’s distinction between pre-iconographical description, iconographical analysis and iconological interpretation (Panofsky 1962). Gardin uses these “three aspects”, “[firstly] a factual inventory, inferred from the observation of constant relations between certain forms and the ‘natural’ objects which they are meant to represent, [secondly] the ‘conventional’ meaning of the motifs thus isolated, the allusive quality of the picture which together they compose, [and, thirdly] the ‘symbolical’ values of such themes, considered in relation to large cultural context” (Gardin 1958, p. 350) to differentiate between levels of iconographic description characterised by increasing degrees of subjectivity and, at the same time, richness of signification, a situation analogous to the well-known trade-off between epistemic warrant and explanatory power in scientific reasoning.

A subsequent article, “Methods for the descriptive analysis of archaeological material”, further systematises Gardin’s theory of archaeological description by codifying “three kinds of rules, applicable to the analysis of any of the foregoing data: rules of orientation, rules of segmentation, rules of differentiation” (Gardin 1967, p. 13, my emphasis). Gardin recognises the arbitrary, subjective nature of the operations of orientation, segmentation and differentiation underlying the construction of descriptive codes as documentary languages occupying a middle ground between natural language and scientific language. He admits that the codification process linking artefacts with their symbolic representations
is not strictly formal, the resulting documentary languages are not universal, the reduction of observations to data is not unique, and, finally, that the analysis performed has no intrinsic cognitive value. He suggests, nevertheless, that adherence to strictly defined prior conventions or rules for these operations can ensure the construction of useful potential classifications, even if these classifications consist, at first instance, by -etic (or purely analytical) classes. The validation of their cultural significance, or -emic status, lies in his view outside the actual classification, and could be sought, for instance, in seeking to identify cultural pattern (with regard to time, space, function, etc.) in groupings of artefacts brought together according to some formal criteria (Gardin 1967, pp. 27–29).

Gardin’s work on archaeological description may be read as an advocacy for the adoption of a prescriptive positivist methodology, equating archaeology with the exact sciences. However, on closer examination, his motive appears to stem from an acknowledgment that the “focal point for archaeological theory [is] the concept and operation of classification” (Gardin 1971, p. 191), and from an appreciation of the constitutive role of the definition of the archaeological record, through description, on the production of archaeological classifications, and by extension, archaeological knowledge. Gardin objects to Spaulding’s contention that archaeologists are sharply different to humanities scholars in studying only groups or sets of finds rather than single artefacts (Spaulding 1960), suggesting, instead, that “archaeologists tend to follow the same general procedure whatever they are studying, be it pottery, sculpture, neolithic or Greco-Roman bas-reliefs, everyday objects or works of art”, and large sets or single objects. In fact, while Spaulding sees archaeology as a nomothetic social science, Gardin, stemming from the tradition and the concerns of Classical archaeology, considers archaeology to be an idiographic, historical discipline. At a time when the introduction of computers to prehistoric archaeology accelerates the application of analytical methods of numerical taxonomy, polythetic classification and quantitative analysis, he is quick to point out that, routinely, “the archaeologist also classifies when, without performing any actual calculation, he makes statements of the following kind, so current in specialized literature that they appear to be platitudes: ‘x is related to m(n, o, p ..)’, ‘the para-
els for x are m(n, o ...)’ or again ‘compare x to m(n ...), etc.” (Gardin 1971, p. 191). He thus calls attention to the argumentation structure underlying the narrative form of archaeological publication, anticipating the launch of his logicist programme a few years later.

Given his view that archaeological argument is based on symbolic expressions relating objects on the basis of particular properties, Gardin asks:

“[H]ow are the ‘properties’ of the monuments under consideration to be chosen, described and arranged? The question is of the greatest importance, but it is treated with such scant attention, if not entirely ignored, in the writings of archaeologists […] It is obvious that classifications or typologies obtained by any process, whether empirical or formalized, are first and foremost the product of an initial choice as to how to ‘view’ the monuments, by means of a formulation chosen from an infinite number of possible formulations […] In other words, the initial description of the monuments, i.e. their arrangement according to a list of properties […], obviously governs the results of the subsequent classification, whatever the method employed” (Gardin 1971, p. 193).

Concerned “to stress the limitations of automatic classification methods, or rather the basic problems raised by their use in archaeology”, Gardin thus questions the taken-for-grantedness of archaeological classification. He advises caution at the fetishisation of numerical classification, noting that “[i]t can and does happen that types defined intuitively by the archaeologist within a collection of given objects prove to be more meaningful and fruitful than the clusters or other groups calculated by computation from the same data”, and denouncing the vanity of the quest for universal classification (Gardin 1971, pp. 194–195). This appears to be the origin of his interest in archaeological description, and a vindication of his concern with the theory-laden nature of analytical codes. His conclusion, noting the routine archaeological use of “specialized designations [that] reflect choices as to the manner of viewing which are apparently so much regarded as ‘natural’ that they are nowhere explained or justified”, is
that “there is nothing less natural than the language of science; the experimental processes which alone make it possible to construct this language on a firm foundation generally take us far from the a
priori attitude of immediate perception” (Gardin 1971, p. 194).

To further understand the importance of these considerations for Gardin’s archaeological thought, it is useful to consider his earlier call, in the 1965 paper “On a possible interpretation of componential analysis in archaeology” (Gardin 1965a), for a more liberal use of linguistic methods such as componential analysis to non-verbal, observational (“perceptual”) data such as those constituting the bread and butter of archaeological description:

“As far as the logical operations involved are concerned […] there is no reason to separate the linguistic from the non-linguistic interpretation of the method […] Instead of aiming at a formal ordering of terms, through a study of various physical and behavioral features attached to them, one could try to organize physical data – here, monuments – on the basis of their semiological constituents in a given code, [but] because monuments and languages of past cultures are ‘dead’ objects, the archaeologist has little means to establish the kind of initial groupings and discriminations needed in componential analysis” (Gardin 1965a, p. 21).

This distinction between textual documents and archaeological remains forms the rationale for Gardin’s early advocacy of a formal methodology and unambiguous, clearly defined schemes for archaeological description. His adoption of a framework drawing from structural linguistics and semiotics, on the other hand, becomes the foundation for his subsequent development of a computational theory of archaeological reasoning.

Writing in 1971, Gardin still considers “documentary applications” – databases allowing the identification, filtering and sorting of archaeological facts on the basis of descriptions produced by researchers – as central in his account of the potential usefulness of computers in archaeology. He attributes the reluctance to undertake such projects to the fact that they “presuppose […] a certain degree of
agreement among specialists as to the nature of the data: the choice of corpus, in the case of the ‘monuments’ to be taken into account, and the choice of descriptive language, in the case of the ‘properties’ to be entered”, and to an attitude against data sharing by traditional scholars “who jealously keep all this material to themselves”. Yet, despite this, he concludes that “[b]efore twenty years are out we shall see the rapid, large-scale proliferation of international banks of archaeological data similar to those already taking shape in certain countries for museum collections […] or inventories of historical monuments” (Gardin 1971, pp. 197–198). His prediction may have been somewhat optimistic, but, with the establishment of large-scale archaeological data repositories, registries and archive networks (Kintigh 2006; McManamon et al. 2010; Niccolucci and Richards 2013; Richards 2002), the development that he foresaw almost fifty years ago is now a central part of contemporary archaeological reality.

3 Schematisation of archaeological reasoning and scholarly practice

Gardin’s article on “Artificial intelligence and the future of semiotics: an archaeological perspective” (Gardin 1989) starts with an intriguing autobiographical section, casting light on his epistemological concerns with regard to archaeological knowledge in the 1950s, the developments that led to the abandonment of his work on archaeological databases (later pursued by other scholars, cf. Borillo and Gardin 1974; Guermandi 1999; Guimier-Sorbets 1990), and his re-orientation towards the formalisation of archaeological reasoning in the 1970s. Gardin speaks of his growing detachment from the computer-based multivariate methods of data analysis (such as Benzecri’s correspondence analysis) and their scientistic underpinnings:

“our position in the early 1970s was a kind of constructive skepticism with respect to the new approaches advocated in the human sciences to ‘make sense’, literally speaking, of objects, events, texts, or behavior of any kind […] What we had come to question, in brief, was the so-called heuristic strategy which underlay all such approaches — i.e., the assumption, explicit or
implicit, that the use of a ‘formal’, ‘scientific’ or otherwise established methodology was likely to improve our ways of making sense of anything human.” (Gardin 1989, p. 13).

Gardin’s disillusionment with the prospects of automatic processing of archaeological descriptions led to the development of a different research agenda in the 1970s. As he states, “instead of trying to devise descriptive and computational tools that were expected to outdo our traditional or ‘natural’ constructs, we now considered the latter as a given, which we had to reformulate” using formalisation as a methodological approach, i.e. re-expressing traditional archaeological argument in terms of a lexicon of symbols and a set of argumentation operations (Gardin 1989, p. 14). This had a notable implication: shifting the focus of inquiry from the domain of data to the domain of interpretation, and from descriptive analysis to an analysis of archaeological reasoning. This shift of emphasis is not unique to Gardin, but resonates with epistemological concerns shared with the post-processual shift towards reflexivity, contextuality and interpretation (Hodder 1987; Hodder and Hutson 2003).

The shift of attention from descriptive analysis to the analysis of reasoning, prefiguring the development of Gardin’s logicist program, is already present in “Document analysis and linguistic theory”, published in the June 1973 issue of the Journal of Documentation (Gardin 1973). Gardin makes here a distinction between tabulation methods of document processing, based on the listing and ordering of lexical items or atomic traits of documents (e.g., in indexes) and interpretative methods, whereby “natural language (NL) texts (whether of documents or of queries) are the object of more complex operations: indexing, syntactical and/or semantic analysis, representation in an information or documentary language; etc.” (Gardin 1973, p. 138). After summarily dispensing with the earlier contribution of linguistics in the construction of indexes and concordances, semantic tools and grammars, he turns to demonstrating the links between a free structure indexing approach, formalised in his Syntol language, and contemporary developments in information science and linguistic theory. He stresses the rising importance of machine languages, based on the transformation of properties of documents.
and/or queries into binary or ternary statements of a machine language. He critiques the classical theory of Chomsky’s structural linguistics, whereby “the meaning of a sentence […] is wholly determined by a syntactically defined deep structure, in which the only semantic data are the various markers associated to lexical entries”, noting that “the boundary between syntax and semantics becomes so fuzzy that it is not possible any more to regard syntax as independent nor to confine semantics to an interpretative function.” On this basis, he concludes, “the concept of ‘deep structure’ tends in turn to fade away: room must now be made for ‘rules operating at a point prior to, or no more ‘abstract’, more semantic-like structures, than the deep structure permitted by classical theory” (Gardin 1973, p. 155).

The convergence of structural linguistics with computer science in the 1960s, and the association of computational linguistics with knowledge representation and artificial intelligence, becomes a springboard for the elaboration and subsequent realization of central aspects of Gardin’s subsequent logicist program. Drawing from George Lakoff’s association of linguistics with the study of natural logic (Lakoff 1970), and from his own conviction that “the predicate and propositional calculus of standard logic provide suitable approximations” of the logical structure of natural language, Gardin advances the notion of:

“[…] expressing semantic as well as syntactic representations” through ‘n-place predicates’ – that is, sets of formal attributes – in conjunction with the two following “corollaries”: (a) the need to categorize the symbols of the vocabulary (words, descriptors) in such a way that formation rules equivalent to the phrase-structure rules of grammar can be stated adequately with no regard to the grammatical status customarily assigned to the words concerned (b) the need to account for the derivation of propositions from one another, in the adopted formalism, as a necessary component in the understanding of language behaviour” (Gardin 1973, p. 159).

The identification of these two separate components of document analysis, firstly, of a vocabulary of descriptive symbols, and, secondly, of rules allowing the derivation of propositions, is an essential step
for the elaboration of the two central pillars of Gardin’s contribution to archaeological theory: his earlier account of archaeological documentation – apparent in his work on analytical codes, and the further codification of methodological terms for archaeological observation and description – and his subsequent logicist approach to archaeological reasoning. Taken as a unity, these two aspects of Gardin’s work constitute an attempt to define a general language for archaeological representation, discourse and reasoning.

The major work codifying Gardin’s contribution to the theory of archaeological reasoning is *Archaeological constructs: an aspect of theoretical archaeology* (Gardin 1980), published in 1980 as the English version of his *Archéologie théorique* (Gardin 1979). It is worth noting that the book was originally announced under another title, “Formal methods in archaeology”. Gardin abandoned this title shortly before publication, when he realised that “formal methods were only part of the subject,” as he was led by his research to consider also “non-formal methods” which, he adds, “often manage to produce empirically valid conclusions, despite their formal weaknesses”. His objective is wide-ranging: “[m]y goal”, he states in the book’s preface, “is to present the schematisation as well as certain aspects to be drawn … regarding the scientific status of archaeological constructions, the opposition […] between traditional [and] new archaeology, the virtues and limitations of formal procedures […] in handling archaeological data, the need for reform of publication patterns in archaeology, etc.” (Gardin 1980, p. xi).

*Archaeological constructs* is a formidable theoretical construction in its own right. In the first chapter, it introduces definitions of main concepts and terms, it outlines an iterative model linking the acquisition of archaeological objects with their annotation, the generation of propositions, etc., and offers examples of a logicist analysis of the processes of cataloguing, classification, pattern recognition and historical inference, which constitute, in Gardin’s scheme, the ‘lifecycle’ of archaeological knowledge process. It then goes on to address methods of analysis suitable for the two polar kinds of archaeologi-
cal publication distinguished, namely compilations, and explanations. In the next chapter, it provides a pragmatic rationale for the differentiation between compilations and explanations, identifies shortcomings in the current way archaeologists communicate explanations through narrative prose, and introduces a set of principles for archaeological publication according to the distinct functions of the two genres. In the final chapter, Gardin compares approaches to archaeological publication based on formal reasoning and schematisation with alternative, narrative forms derived from traditional and systematic-modern archaeological practice, and situates the logicist program in a broader epistemological context.

The notion of “construct” forms the main focus of Gardin’s logicist account of archaeological knowledge. The two kinds of archaeological constructs he posits, compilations and explanations, are an elaboration of his earlier distinction between tabulation and interpretation genres of document analysis. Compilations – for example, catalogues of finds, or excavation reports – are concerned with material remains of the past and their attributes, while explanations – for example, synthetic monographs and interpretative works – are concerned with ancient societies, their history and mode of life.

Gardin differentiates these kinds of constructs on account of their major function, and purpose. In his conceptualisation, compilations are (better) made for information retrieval, and thus are destined not to be read from end to end but to be skimmed, searched, and filtered according to the reader’s specific interests. Explanations, on the other hand, are the only kind of archaeological constructs that he considers to be truly important carriers of archaeological knowledge (Gardin 1980, p. 148).

Gardin recognises that there are also intermediate kinds of archaeological constructs, such as typologies, which, sometimes, may go beyond the descriptive nature of compilations (e.g., just asserting chronological order) to contribute to archaeological explanation. In fact, he notes that compilations and explanations manifest themselves as two poles of archaeological publication, and in practice, archaeological works may combine elements of both. In the context of archaeological practice, when he
states that “the course taken for describing each class [of archaeological objects] necessarily rests upon more or less learned and explicit considerations regarding the present or potential utility of those classes for explaining the variability of archaeological record”, Gardin accepts that explanatory considerations enter even the descriptive work underlying the construction of compilations (Gardin 1980, p. 20).

Gardin, however, is not merely proposing a theoretical scheme differentiating between kinds of archaeological publications. His objective is to mitigate what he sees as a failure of archaeological publication to attend to the imperatives of methodological rigour and parsimony, clarity, and even sound reasoning, required of scientific research. He makes no bones of his grim view that much archaeological scholarship of his times is “without either practical or rational worth”, attributing firmly and squarely the reason for this apparent inadequacy to the ill-structured argumentation connecting field observations with higher order interpretative syllogisms, encouraged by the dependence of archaeological publication on narrative prose. In this regard, Robert Whallon is surely correct in detecting, as a crucial imperative of Gardin’s vision, the rise of a science of archaeology which would use logicist analysis to “unmercifully reveal flaws and weaknesses, gradually forcing the field into a rigorousness that presently it lacks” (Whallon 1985). His logicist alternative to this conundrum consists in the “condensation” of archaeological scholarly prose through schematisation, taking initially the form of an ordered path of logical inferences using modus ponens and operating on a lexicon of symbols representing propositions.

Yet, what may be legitimately interpreted as Gardin’s normative call on how to best conduct and publish archaeological research through logical inference, either inductively by proceeding from initial empirical observations and presuppositions to their final conclusions, or deductively by establishing epistemic warrant for a hypothesis or theory on the basis of sufficient presuppositions, can also be read as a retrospective method of inquiry, capable of producing an enriched understanding of the content of
archaeological arguments through an analysis of existing archaeological texts and their re-expression form natural to a formal language. In this light, starting from a set of descriptive statements or presuppositions based on observations of the empirical domain of material objects (the “explanandum”), archaeological interpretation, originally in the form of natural language, can be re-expressed as a sequence of “rewrite rules” supporting, inductively, a succession of intermediate and, finally, higher order terminal propositions, i.e. archaeological theories (the “explanans”). Conversely, it is possible to construct, and understand, this schematisation in the opposite direction: to start from the hypothesis, or theory, advocated by a particular archaeological publication, and show how this may be confirmed deductively by means of rewrite operations connecting it, through intermediate consequent propositions, to facts in the original observations or presuppositions claimed by the author (Gardin 1980, p.103, fig. 20; Gardin 1996, pp.213–214).

Gardin is therefore proposing a comprehensive rethinking of how one does archaeology: not merely suggesting, as a methodologist, how one should perform archaeological research, but providing, as an epistemologist, a whole new theory of how archaeological knowledge is produced. Recognising this duality of Gardin’s approach to archaeological reasoning, Alison Wylie agrees that he “eschews top-down, philosophically driven models […] to capture the range of operations by which archaeologists proceed in even the most mundane practices of observation, description, compilation, and explanation. Despite the formalism of these models, Gardin is compelled by the practice he considers to foreground the selective, the interpretive, and even the normative dimensions of archaeological inquiry” (Wylie 2002, p. 18). In the same vein, it has been acknowledged that Gardin’s argument oscillates between an evaluative, normative, mode and a complementary, but no less prominent, descriptive and representational mode (Stockinger 1990). On the other hand, Barceló goes so far as to note that “instead of a normativist approach to archaeology, suggesting the best way of constructing the archaeology we need, [Gardin] took an analytic point of view, looking for ways of deconstructing what archaeologists believe they do” (Barceló 2009, p. 100).
In fact, reinforcing the praxiological importance of his work, Gardin himself makes it clear that in *Archaeological constructs* he is “not proposing a new handbook on archaeological theory. […] My goal”, he states, “is an analysis of the mental operations carried out in archaeological constructions of all sorts, from the collecting of data to the writing of an article or book in published form” (Gardin 1980, p. xi). Applications at archaeological schematisation using the logicist approach (e.g., Gardin and Lagrange 1975; Lagrange and Bonnet 1978) seem to support an interpretation of the logicist approach applied in practice as, mainly, the “analysis of mental operations carried out in [actual] archaeological constructions”. Such “condensations” of archaeological interpretation could encourage sound, coherent and parsimonious argumentation, and could facilitate and speed up consultation of the substance of the core ideas proposed, liberating readers from the obfuscation of rhetorical artifice.

The purpose of logicist analysis for Gardin is thus to support a “practical epistemology” applicable not only to archaeology but also to other disciplines (Gardin 1989, p. 15). While, in his own words, this practical epistemology “is bound eventually to acquire a normative aspect”, it should be noted that this is merely to the extent that “it makes us more aware of the empirical or social limits of our interpretations”. At the same time, Gardin insists that the logicist approach maintains a stance of “neutrality with respect to the substance of theories or to the philosophy of the various schools in contemporary archaeology […] a correlate of our will to reach first a better understanding of ‘what they are’ and ‘what they do’ in practical terms […] without *a priori* bias for or against any of them in particular” (Gardin 1992, pp. 98–100). In fact, a central dimension of logicism as “practical epistemology” concerns the establishment of a reliable and pragmatic descriptive method for a systematic analysis of archaeological scholarship which, it may be argued, could also help reveal the limitations of nomothetic, systems-theoretical, anti-traditionalist, and scientistic approaches.

Gardin admits, thus, to a principle of taking stock of the *practice* of archaeological research which he then uses as a foundation in order to elaborate a critique, and propose alternatives. The process by
which he develops his argument is driven predominantly by attention to actual archaeological research in action, rather than to positivist norm. As he emphatically states:

“If properly understood, […] the logicist perspective should not be regarded as another manifestation of scientism or neopositivism in the humanities. […] Far from being an apology for science, the logicist program is an attempt to demonstrate its limitations in the humanities. Other schools seem to pursue the same goal (e.g. ‘radical’ or ‘post-modern’ archaeology); the difference, however, is that our motivations are not ideological (anti-science, counter-culture, etc.), but strictly epistemological” (Gardin 1990, p. 26).

It is no accident, then, that the value and originality of Gardin’s explicit engagement with intellectual processes in archaeological practice is acknowledged by as unlikely a pair of supporters as postprocessualist scholars Michael Shanks and Chris Tilley. They are quick to add that Gardin is acting so for merely instrumental reasons, “aiming at efficiently harmonizing means with ends; with the explosion of archaeological information he wants a more efficient form of storage of basic data than site reports and suchlike” (Shanks and Tilley 1992, p. 16), but such an exclusive representation of Gardin’s motives is unwarranted. While he does indeed argue for the usefulness of schematisation as a method of providing more succinct representations of archaeological syllogisms, his concern is arguably broader, and at the same time pragmatic and epistemological in nature. On the one hand, he notes the growing proliferation of research publication that makes it almost impossible for scholars to study – rather than consult – more than a small percentage of the works published in their field (Gardin 1996, pp. 216–217); and, on the other, he is concerned from the outset of his logicist project with the lack of parsimony and rigour in archaeological research, a fault encouraged, in his view, by the narrative genre of research publication.

Gardin’s attention to the material vestiges of the past that contribute to archaeological inquiry, as well as to the catalogues, perforated card indexes, and publications that constitute the material traces of
archaeological epistem work, reveals an understanding of archaeology as a kind of “objectual prac-
tice” which prefigures theorisations of the centrality of materiality in the production of scientific
knowledge by Science and Technology Studies scholarship (e.g., Knorr-Cetina 2001). And, the very
shift from archaeological description to archaeological reasoning, signalled by his engagement with
how archaeologists appraise and document archaeological data, analyze them and produce archaeo-
logical publications, may be seen as a pioneering, early example of a reflexive archaeology. His con-
tribution lies in the development of a framework for a reflexive consideration of the epistemic practice
of archaeology, albeit not based on ethnographic observation of archaeologists at work (Edgeworth
2006), but on a practically applicable method for the documentary analysis of the archaeological con-
structs – archives, databases, field reports, and publications - that form the record of archaeological
scholarship.

4 Archaeological publication and modes of knowledge

The primary pragmatic domain which Jean-Claude Gardin selects for the application of his logicist
analysis of archaeological reasoning is publication. He frames his approach precisely as “an analysis
of archaeological publications proposed […] under the name of logicism” (Gardin 1996). Archaeolog-
ical publication, in Gardin’s terms, does not just concern the mediated way in which archaeological
knowledge is communicated, but also the very structure and content of the outcomes of research, in
other words, the constitution of scholarly objects in archaeology. For this reason, his work in the 1990s
is increasingly inspired by a wish to produce new, useful ways of archaeological publication, contrib-
uting to what he considers a better, more explicit and sound exposition of archaeological reasoning,
and a clearer, more effective, foundation for scholarly communication. To achieve this result, he en-
visages, besides the aspect of archaeological publications as vehicles for narrative prose a complemen-
tary aspect of publication, based on a hypertext-based presentation of models which encapsulate a
succession of inferences, operating on propositions linking material observations with archaeological interpretations or hypotheses.

Gardin’s approach to archaeological publication is elaborated in his “Calcul et narrativité dans les publications archéologiques” (Gardin 1999), where, on Moscati’s invitation, he takes stock of the new challenges introduced by the proliferation of information technology in the archaeology of the 1990s. Among these, besides the known issues of terminological fluidity and resistance to standardisation in archaeological documentation, he points at the “institutional deficit” in addressing the issues related with the long term sustainability (“une certaine perennité”) of archaeological research databases (Gardin 1999, p. 2). This problem has since become a major dimension of current considerations in the field of archaeological information, framed more broadly as an archaeological “curation crisis” connected with the proliferation of partially recorded, disorganized, and fragile archaeological collections and documentation archives (Bawaya 2007; Bustard 2000; Childs 1995). Gardin’s concern for long term preservation and open access to archaeological data is not new, as it even precedes his first experiments introducing computers to archaeology. In fact, as early as the late 1950s, when he was experimenting with storing archaeological data in the form of peek-a-boo punched cards, he had advocated that “[d]ecks of punch cards [storing descriptive information about archaeological objects] should be as publicly available as any book and as widely circulated as significant archaeological monographs or general treatises” (Gardin 1958, p. 335). He can thus be recognised as a pioneering precursor of contemporary developments in research data publication, sharing, citation and peer review (Faniel and Zimmerman 2011; Lawrence et al. 2011; Smith 2011).

Yet Gardin is not merely advocating data publication. The logicist approach to archaeological publication, manifested in the Arkeotek project developed by ethnoarchaeology expert Valentine Roux (Gardin and Roux 2004; Roux 2004), goes beyond that to acknowledge the interdependence between data constitution on the one hand, and scholarly argumentation on the other, and thus, implicitly, the futility
of attempting to publish one in separation from the other. Using hypertext, the proposed “Scientific Construct and Data” (SCD) format provides for the integration of argumentation structure of an archaeological publication with circumstantial and descriptive data, methodological principles adopted, and results. The vision presented goes beyond the transcription of scholarly narrative into schematisations of arguments. Publications of archaeological research are framed not as passive diagrammatic summaries, but as performative, interactive mechanisms (cf. Roux and Courty 2013a), allowing active access to descriptions and interpretations of the archaeological record, conceived as a schematised sequence of inferences between propositions organically connected with supporting archaeological data. Readers (“consultants”) of a digitally-enabled logicist archaeological publication would be able to navigate interactively through its argumentation structure, traversing the inference tree of the authors’ arguments, and filtering, juxtaposing and analysing data, both qualitatively and quantitatively (Gardin and Roux 2004, pp. 32–25). Further work in the Arkeotek project demonstrates that it is possible to model the logicist scheme of scholarly reasoning as a formal ontology (Aussenac-Gilles 2006). While experiments with digital archaeological publication integrating narrative presentation of archaeological research with data, and the ability to manipulate them interactively, had appeared already since the first issue of the Internet Archaeology online journal (Heyworth et al. 1996; Dallas 1997; Richards 2006), Gardin’s vision extends, and deepens considerably, the articulation between data and interpretation in archaeological publication.

In Archaeological constructs, Gardin contrasts his archaeology, based upon logicist premises and practices of description and explanation, with the traditional narrative mode of archaeological writing, connecting the former with “Science” and the latter with “Literature” in the spirit of C.P. Snow’s “two cultures” (Snow 1959). The assimilation of scholarly archaeological prose with literature seems, as first look, to undermine its epistemic claim. This reading is admittedly consistent with Gardin’s frequent advocacy of a scientific archaeology based on logicist principles as he compares it, firstly, with traditional archaeology, which he does not hesitate to relegate to the status of “practical lore” for lack
of rationality (an ability “to demonstrate a continuous and consistent chain of operations linking observation and theory”), and, secondly, with data-intensive modern archaeology which he calls “alchemy” on account of its dependence on unwarranted heuristic or axiomatic rationalisation, and hence lack of efficacy. But then he further qualifies his position, by suggesting that both an insightful yet methodologically flawed traditional archaeology, and an ineffectual yet rigorous modern archaeology, are essential parts of archaeological research, and necessary foundations for a logicist theorisation and synthesis aiming at efficacy and rationality. And, noting the legitimacy of critiquing logical empiricism as a potential Trojan horse of technocratic ideology, Gardin poses the following question, leading to a surprising dénouement:

“[if] the logicist way of going about archaeological constructions [were to be extended] to the human events and behaviour which we propose to ‘explain’ through the study of material remains […] would we not] then be contributing, if only in proportion to the significance of our field, both to an unhealthy organization of labour, reflecting the order of technocracy, and to an abstract, cold vision of human history in which it is not sure that our descendants or ourselves will take a lasting interest? […] I feel no embarrassment in confessing that the historical works which I prize most are those which bear the mark of a strong personal relation between the author and his subject, a relation expressed and communicated through a kind of discourse which has little to do […] with the logicist rhetoric” (Gardin 1980, pp. 178–179).

In a logicist fashion, it would be suitable to use symbols or expressions neutral to value judgment (such as inevitably elicited by assimilating archaeological scholarship to literature) to represent Gardin’s judgment on these two different modes of knowledge. Quoting the following excerpt from Archaeological constructs, I substitute $K_1$ for the mode of knowledge Gardin associates with “science”, represented in archaeology by logicist schematisation, and $K_2$ for the mode of knowledge he relates to “literature”, represented by archaeological publication in the narrative genre:
“I should end my excursion into the ways of \( K_1 \) by a defense of \( K_2 \); the two forms of mental activity are for me alternative ways by which we give free rein to the same impulse, ignorant of its origin or destination; but aware at least of the aberrations that inevitably occur when one form of knowledge want to impose the condemnation of the other. I therefore do not consider tolerance in this case as a matter of ethics, but rather, in an evolutionary perspective, as a matter of survival” (modified quote, after Gardin 1980, p. 180).

Gardin’s unequivocal defense of the complementarity between two modes of knowledge, based on humanistic narrative prose and logicist schematised reasoning respectively, calls for a re-examination of his epistemology outside of the realm of positivism and scientism. Borrowing the notion of “reasonableness” from argumentation theorist Stephen Toulmin (2001, p. 2), he seeks to provide foundations for an archaeology whose propositions and theories, as supported by its publication practice, stand the test of reason (Gardin 2002). The purpose of his logicist schematisation is not only “to gain a deeper understanding of what our interpretive writings ‘are’, as symbolic constructs; we also wish to evaluate what those constructs can ‘do’, in the universe of discourse under study” (Gardin 1989, p. 15). His approach acknowledges the interdependence between description and interpretation as theory-laden processes, and resonates with a critical view on the objectivism of the descriptive apparatus of archaeology, and of the humanities and social sciences in general. In fact, his most enduring contribution may be in his calling attention to the articulation between different genres of archaeological publication and different modes of archaeological knowledge, the interdependence between data and interpretation, and the possibilities for archaeological research and scholarly communication afforded by formal representation and digital technology.
5 Gardin and contemporary challenges in archaeological informatics

The last ten years saw a proliferation of archaeological information in digital form. Gardin’s early vision for openly accessible catalogues of archaeological finds, monuments and sites is gradually becoming a reality, by virtue of the emergence of data depositories such as the Archaeological Data Service (ADS) at the University of York in the UK (Richards 2008) and the Digital Archaeological Record (tDAR) in North America (Kintigh 2006; McManamon et al. 2010), common and interoperable archaeological data standards such as MIDAS (Lee 1998) and CARARE Schema (Papatheodorou et al. 2011), and large-scale archaeological metadata aggregation by related projects such as CARARE – Connecting Archaeology and Architecture for Europeana (Hansen and Fernie 2010), 3D ICONS – World Heritage Sites for Europeana (D’Andrea et al. 2012) and LoCloud – Local Institutions in an Europeana Cloud, based on the development and deployment of metadata repositories endowed with affordances of semantic enhancement, digital preservation and digital curation (Gavrilis et al. 2013, 2014). The application of online, social and semantic technologies to the human and automated enrichment and curation of archaeological information introduces additional possibilities and concerns (Huggett 2012; Kansa et al. 2011).

The launch of ARIADNE – Advanced Research Infrastructures for Archaeological Dataset Networking (Niccolucci and Richards 2013), the major European initiative in the field of archaeological digital research infrastructures, is a notable step in the direction foreseen by Gardin half a century ago. ARIADNE brings together expertise and assets of initiatives such as ADS, the Dutch archaeological archives (EDNA), the Fasti Online database of archaeological publications and reports, the archaeological datasets of the Swedish National Data Service (SND), and the Arachne online database of the German Archaeological Institute (DAI) and the Institute of Classical Archaeology in Cologne. It promises to deliver harmonized access to archaeological archives and datasets across Europe, currently in different languages, adopting a Babel of uncoordinated metadata schemas, descriptive standards
and often uncontrolled vocabularies, created and curated by different actors including researchers and field archaeology projects, institutional archives and repositories, and national authorities and infrastructures. It seeks to complement, integrate and provide access to a broad ecosystem of archaeological archives and resources, accounting for the fragmentation and diversity in their documentation systems and semantics, as well as for their potential multidisciplinary use (Aspöck and Geser 2013). By addressing the entire range of archaeological constructs, from excavation data and logbooks to 3D models, archaeological gazeteers, field reports and publications, and by adopting an explicitly knowledge-based, semantic approach to the construction and representation of registries, thesauri and datasets, ARIADNE confronts the full gamut of intellectual and epistemic challenges foreseen by Gardin’s scholarship.

A consistent realisation from these developments, vindicating the value of Gardin’s early attention to archaeological description, is the importance of the scope, expressiveness and affordances of metadata schemas employed to represent the archaeological record, as conditions for the future reliability and usefulness of archaeological information systems such as registries, finds databases, excavation archives, or digital libraries. As noted by archaeological computing experts Franco Niccolucci and Julian Richards, archaeological metadata should “be rich and specific enough to provide researchers with information useful and relevant for specific research questions”, but also – in a spirit akin to Gardin’s call for operationalization – amenable to automated recording, extraction and processing using standardized procedures and tools (Niccolucci and Richards 2013, p. 80). In fact, even the most elementary descriptive identifications recorded in archaeological metadata are, as a rule, dependent on Gardin’s framework of orientation, segmentation and differentiation governing the practice of archaeological documentation (‘‘compilations’’), but also of the processes of archaeological curation and reasoning that are in the centre of archaeological knowledge production (‘‘explanations’’), as he pertinently demonstrated. But all too often, the information content of archaeological metadata aggregated in digital repositories remains partial, inconsistent, and lacking the necessary forethought that Gardin had
campaigned for as early as the 1950s. In this light, work on content and metadata standards is of essential importance (Richards 2009). Such work should be driven by recognition of the ontological and semantic complexity and heterogeneity of archaeological and cultural heritage objects (Dallas 1992, 1994), taking heed of Gardin’s caution regarding the impossibility of universal standards of description and classification. The dynamic nature of online archaeological information and systems, and their emerging capabilities of ontological modeling, interoperability and semantic enrichment (Binding et al. 2008; Charles et al. 2013; Gavrilis et al. 2013), provide further substantiation for the importance of archaeological description as advocated originally by Gardin. Besides, the potential of free structure representation such as offered by Gardin’s Syntol documentary language (Gardin 1965b) becomes especially relevant in the context of semantic linking based on Linked Open Data triples (Hyvönen 2012; Isaksen 2011), as well as of open tagging (Boast and Biehl 2011; Kansa and Whitcher Kansa 2011) of archaeological information.

The introduction of digital information systems for scholarly research in recent years brought also to the fore the interplay between knowledge practices and the epistemic objects these practices call upon, create and curate. Studies of digital research infrastructures in the arts and humanities, and of scholarly research activity making use of digital materials, tools and services, indicate that researchers engage concurrently with both data and scholarly information objects – with compilations and explanations, in Gardin’s terms – and, in doing so, they do not just need effective ways to discover, identify, filter, order and consult such objects, but to also actively modify, link, annotate and enrich them (Benardou et al. 2013). In contemporary digitally-enabled excavations such as Çatalhöyük (Tung 2013), researchers engage in a range of activities encompassing the capture, description, annotation, classification, knowledge enrichment and dissemination of documents such as computerized single-context sheet documentation, digital diaries and audio memos, digital photography, reflexive video recording, sketching and drawing, stratigraphic sequence matrices, 3D models, GIS representations, and hypertextual, diagrammatic and narrative interpretations of particular aspects of the archaeological record.
Documentation and curation of archaeological data is as a rule enmeshed with interpretation (Dallas 2007a, 2007b), in line with Gardin’s position on the inseparability of data publication from the publication of archaeological argument. The increased recognition, in the ARIADNE project, of the importance of synthetic research spanning across different datasets and scholarly objects, the promise of integrating collection registries and datasets capable of capturing the complexity of archaeological objects with semantic knowledge organization systems, and the call to build on the conceptualization of provenance in the CRMdig extension of the CIDOC Conceptual Reference Model (Crofts et al. 2010; Doerr and Theodoridou 2011) so as to account better for complex relations and entities (e.g. time-space relations for historic changes, part-whole relations for complex structures) are all indications of growing sophistication of archaeological infrastructures to address the complexity of archaeological knowledge, in a way that resonates with Gardin’s vision.

Plans for large-scale digital scholarly research infrastructures (ACLS 2006; Anderson 2013; Blanke and Kristel 2013; Constantopoulos et al. 2008; Niccolucci and Richards 2013) also underline the urgency of developing a firmer understanding of what researchers actually do, and how, in particular, information resources are called upon in the construction of knowledge in scholarly research practice (Benardou et al. 2010a, 2012, 2013; Blanke and Hedges 2013; Speck and Links 2013). Gardin’s definition of the structure of scholarly research activity in the form of consecutive yet overlapping processes of cataloguing, classification, pattern recognition and historical inference (Gardin 1980) finds parallels in accounts of artefact analysis from museum and material culture studies (Elliott 1994; Prown 1982), as well as in fine-grained models of humanities research process deriving from the scholarly information behaviour and digital humanities fields (Benardou et al. 2010b; Ellis 1993; Meho and Tibbo 2003; Palmer et al. 2009; Unsworth 2000). In the light of earlier research, logicist analysis can be a particularly salient complement of observational and interview-based methods in the effort to develop an understanding of scholarly research activity, as it allows the extrapolation of a reliable,
evidence-based representation of the propositional structure of scholarly objects such as research publications, and, thus, indirectly, of the intellectual operations underlying archaeological argument.

A critical dimension in the specification of digital research infrastructures in archaeology concerns the provision of fine-grained affordances for the discovery, retrieval and presentation of archaeological argumentation, by means of digital tools and services designed to support the scholarly research process. Gardin’s logicist analysis of archaeological constructs is a useful, even necessary, step in the direction of enabling a succinct, unambiguous and useful “condensation” of archaeological argument which is amenable to digital manipulation for information seeking, retrieval, and visualisation. The June 2013 issue of the *Journal of Archaeological Method and Theory* illustrates convincingly the pragmatic usefulness of logicist enrichment of traditional archaeological research by presenting the outcome of an Arkeotek workshop through a combination of the textual form of each paper with a logicist diagram capturing its argumentation structure (Roux and Courty 2013b). A fuller integration of archaeological publications with data, in the vein of the SCD format originally proposed by Gardin and Roux (Roux 2004), based on the integration of domain ontologies with an inference engine operating on a rule base, and building on the promise of the Logicist Corpuses and DynamO projects (Roux and Aussenac 2013), could yield additional benefits for researchers, allowing access, inference, visualisation and annotation at the level of the particular propositions included in an archaeological study, and its epistemic warrant. Notably, by closely coupling archaeological data with their role in argumentation, the promise of Gardin’s theoretical contribution exposes the limitations and goes beyond the now increasingly popular idea of “data publication” (cf. Parsons and Fox 2013). Relevant recent research, with which Gardin’s vision resonates, advances solutions for the publication of compound information objects including data and scholarly text (Cheung et al. 2008; Gerber and Hunter 2009; Hunter 2006), for semantic annotation (Hunter 2009; Khare and Çelik 2006; Kiryakov et al. 2004), and for the use of argumentation schemes and ontologies in supporting scholarly research, cita-
tion and publishing (de Waard et al. 2009; Pike and Gahegan 2007; Renear and Palmer 2009; Shotton 2009; Shum 2008).

In the spirit of Gardin’s vision, such an approach could support the simulation of archaeological reasoning which, rather than predominantly focusing into automated reasoning using artificial intelligence (as advocated by Barceló 2007, 2009), could be amenable to providing support for the integrated retrieval, display, manipulation and collaborative curation of both descriptions and interpretations of the archaeological record, in the context of an appropriately featured information system combining data processing with argumentation support affordances (de Waard et al. 2009; Doerr et al. 2011; Li et al. 2002; Shum 2008; Shum et al. 2006). Recognizing, with natural argumentation scholar Jean-Blaise Grize, that scholarly reasoning is not composed by propositions standing in abstract, but by enunciations or statements that are part of discursive practices reflecting the point of view of their authors (Grize 2000), it may be necessary to extend Gardin’s approach so that besides concepts and propositions entering scholarly reasoning, and related data and descriptions, it models adequately the subjects, or actors, of archaeological reasoning, their disciplinary identity, motives and goals, and the conditions and discursive context of the research activity (Dallas 2007b). A salient approach in addressing this requirement would be to integrate logicist analysis with ontological models capable of representing the cultural-historical activity context of archaeological curation and reasoning (Benardou et al. 2010b; Doerr et al. 2012; Gonzalez-Perez et al. 2012; Hug et al. 2012). Reaching beyond support for the cycle of logico-deductive and empirical-inductive argumentation originally accounted for by logicism, such a system could also allow the representation and manipulation of the all-too-common archaeological arguments based on abduction, i.e., on “inference to the best explanation” (Douven 2011; Harman 1965; Lipton 2000), in line with Grize’s critique to Gardin (Grize 2000) and in recognition of the centrality of abduction in archaeological research practice (Fogelin 2007; Hanen and Kelley 1989).
6 Conclusion

In this paper, I introduce a hitherto unappreciated aspect of Jean-Claude Gardin’s contribution to archaeological theory and method: namely, I show that his approach goes beyond a normative, positivist view of archaeological research to recognise the contextual, theory-laden nature of archaeological data constitution, the priority of focusing on actual archaeological interpretation practices, and the complementarity between narrative and formal representations of archaeological reasoning. I seek the origin of Gardin’s distinct approach to archaeological data, representation and knowledge in his early engagement with semiotics and structural semantics, and point at his ambivalence vis-à-vis the promises of automated classification and machine reasoning in archaeology. To substantiate this reading, I draw extensively from Gardin’s published work in English, starting from his early contribution to the development of documentary languages and principles for archaeological description since the 1950s, and ending with the practical application of his logicist approach to archaeological publication in the 2000s. My aim is to suggest neither a revision of established codifications of Gardin’s logicism as a methodology nor an alternative intellectual genealogy of his thought, but to illustrate salient dimensions of his theoretical contribution that may deserve further critical attention in the context of contemporary trends and developments.

The timeliness, and urgency, of Gardin’s seminal theoretical and methodological contribution is clear in the context of emerging challenges and concerns for digitally-enabled archaeology. The pervasive, interconnected world of archaeological databases he foresaw, the relevance on relying on formalized vocabularies and propositional calculi for archaeological description, the historical contingency and complexity of archaeological entities, the interdependence between data and argumentation in archaeology, are key attributes of the situation workers in the field of archaeological informatics face today. His vision for a radically different model of archaeological publication, based on the schematization of archaeological syllogisms and their reliance on the construction of the archaeological record through
recording and documentation, and served by semantic, interactive technologies of presentation, linking and reasoning, does not merely resonate with current work on digital archaeological infrastructures. It also provides useful inspiration for future developments, towards a vision of semantically enriched information integration that does justice to the complexity and human agency underlying knowledge construction in archaeology. His call towards the development of more effective methods of capturing, communicating and analyzing the knowledge structures embedded in the actual products of archaeological research – archaeological data, catalogues and research publications – is critically relevant today, in the context of the archaeological curation crisis connected with the glut and fragmentation of information produced by disparate archaeological projects (Bawaya 2007; Bustard 2000; Childs 1995), and the proliferation of orphaned, under-reported and under-analyzed archaeological collections (Voss 2012). It is also hugely relevant in the service of a reflexive archaeology, as it provides an operational framework for the elucidation of the historical situatedness and context dependency of archaeological knowledge. A more detailed elaboration of the implications of Gardin’s work for current and future challenges in archaeological informatics remains a task for the future.

Gardin is recognised as a pioneer in developing theoretical principles for the constitution of archaeological databases, expert systems and knowledge bases. As the intellectual concerns and working methods of archaeological informatics are integrated into standard archaeological research practice, and as they inform further developments in the fields of digital heritage and digital humanities, Gardin’s key ideas, research initiatives and contributions remain “good to think”. His contribution to the constitution of archaeological data, description and classification, the practices, representations and modes of archaeological knowledge, and archaeological publication, is a seminal foundation for debating and evaluating current developments. His foundational work on the constitution and formal representation of archaeological constructs – ranging from description to interpretation – bears on pragmatic considerations regarding contemporary application domains as diverse as cultural heritage information integration, digital scholarly infrastructures, electronic publication in the humanities, and
cultural heritage ontologies. By viewing his work in the context of a historical epistemology of late 20th century and contemporary archaeology, this paper purports to throw light on an aspect of the history of archaeological computing which, despite its fundamental significance, remains hitherto underestimated and only partially studied, and thus to draw useful conclusions for current research challenges in archaeology, and beyond.

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