Archeologia e Calcolatori
20, 2009, 205-221

FROM ARTEFACT TYPOLOGIES TO CULTURAL HERITAGE ONTOLOGIES: OR, AN ACCOUNT OF THE LASTING IMPACT OF ARCHAEOLOGICAL COMPUTING

1. Introduction

Historical accounts of archaeological computing typically situate its growth as a corollary of the rise of systems theory, positivism and the cult of science of post-Second World War developed Western societies. The number-crunching power of the computer was seen to be a perfect match for the nomothetic aspirations of processual archaeology of the 1960s and 1970s, which was served by a methodological approach based on hypothesis testing and statistical inference. Yet the post-processual shift in 1980s archaeology saw a disillusionment with the objectivist claims of formal and mathematical approaches to archaeological research, and a repositioning of the role of computers as a tool for research: «A mathematical archaeology which could explain material culture as an aspect of a logical relation, which would attempt to explain the complex data we investigate using statistical tests and procedures externally applied to the data is incompatible with archaeology being an active mediation of past and present. However [...] statistical procedures, especially those which are computer-based, are a valuable heuristic device, manipulating large bodies of data, summarizing variability, redescribing, but in no way explaining anything or providing the basis for contentions» (Shanks, Tilley 1993, 245).

Cognitive archaeology was advanced in the mid-1990s as a response to post-processualism by accommodating some of the criticisms of the latter, especially regarding the importance of the symbolic, ideological and cognitive practices of past cultures, while keeping a distance from its assumed relativism and subjectivism. In a recent systematization of the relationship between developments in archaeological episteme and archaeological computing practice, the emergence of cognitive archaeology is associated with the consolidation of Geographic Information Systems and artificial intelligence-based approaches, as well as the emergence of the new application methods of individual modelling, visualization and webography (Zubrow 2006). The prime importance of GIS, visualization and electronic communication in current archaeological practice is acknowledged by other workers (Richards 1998; Huggett, Ross 2004). However, while growing interest in archaeological archives and data management is manifest in recent publications (Lock, Brown 2000; Evans, Daly 2006), early work on formal and computer-based approaches

to archaeological typology and artefact analysis remains peripheral to our current understanding of digital archaeology.

This paper attempts to redress this situation, by reclaiming the theoretical and methodological significance of the work of pioneering researchers, from the 1950s onwards, who contributed to the development of new theoretical and methodological instruments towards the categorization of archaeological artefacts. While their approaches are diverse, their work is invariably grounded on the use of formal and computer-based approaches towards constituting archaeological databases and establishing artefact typologies. Their seminal contribution in problematising established notions of archaeological data constitution, description, style, archaeological typology, and the construction of archaeological knowledge, prefigures recent theoretical developments and can offer valuable perspectives to current research challenges in digital heritage and material culture theory.

The approach followed to establish this goal is based on a biographical narrative of this author's involvement with archaeological computing and cultural heritage informatics from the early 1980s to the present. It may be read as a journal, and a notebook of key influences, readings and research concerns that shaped twenty-years of a professional journey from archaeology to the field of museums and information, but also as an attempt to identify themes in archaeological computing, material culture theory and artefact-based research which remain relevant to current concerns and prospects regarding the role of cultural heritage institutions, memory practices and technological mediation in the information age.

2. From archaeological computing to cultural heritage informatics: a personal account

2.1 *The 1980s*

In 1980, when I went up to Oxford for postgraduate studies in Classical archaeology, the spirit of the place was more humanities than science, more hermeneutics than explanation, and more scriptorium than laboratory. My research was on a series of over a thousand grave-reliefs from Classical Athens, a material already studied literally to death for more than a century, and one that had produced elegant, erudite and insightful monographs, mostly of an art connoisseurship and cultural history slant. At the time I was intellectually stimulated by structuralism and semiotics, promising approaches to decipher the complex world of ideas, symbols and meaning manifest in ancient art and iconography, which also appeared to engage in fruitful dialogue with social, mythographic, and symbolic interpretations of Greek funerary monuments, a central part of my Classical archaeologist's cosmos.

Like others of my generation, I became stimulated by the archaeological theory debates of the time: I shared the promise of a unified science of archaeology; the quest for developing formal methodologies and middle-range theories, applicable across archaeological problems and contexts; the dissatisfaction with the descriptive tedium of traditional archaeology, and with its interpretive timidity; the intense interest in formal approaches to archaeological description and argumentation, such as practised by the French logicistes; and, not least, the fascination with the capabilities of the computer, still novel in archaeology twenty five years after Gardin's pioneering experiments (reported in Gardin 1967), as the new orderer of data, information and knowledge. I was fortunate to join Susan Hockey's humanities computing classes, took courses in computer programming and social science statistics at the Oxford University Computing Service (of which, together with fellow computing archaeologists Sebastian P.Q. Rahtz and Seamus Ross, I had become a regular customer), and started attending CAA and TAG (Theoretical Archaeology Group) conferences. I was fascinated by the rigour and elegance of David Clarke's *Analytical Archaeology* (Glaser, Strauss 1967), impressed by the clarity of Jean-Claude Gardin's *Archaeological Constructs* (Gardin 1980), and intrigued by the new complexities introduced by several of the contributions in Ian Hodder's *Symbolic and Structural Archaeology* (Hodder 1982).

In 1986, I was introduced by Gary Lock to John Wilcock's Research Centre of Computer Archaeology at North Staffordshire Polytechnic. As a visiting research fellow, I spent a couple of days each week at the RCCA, debating anything from the Harris matrix to expert systems, and from polythetic classification to 3D-visualisation, with the young researchers at the Centre, including Gary Lock himself, now of the University of Oxford, a pioneering figure in a field as broad as quantitative archaeology, GIS and archaeological information systems; Jeremy Huggett, and Julian Richards, both established academics with significant research contribution, the latter leading the Archaeology Data Service in the UK; Paul Reilly, whose radical "virtual archaeology" is even more relevant today, but who was virtually lost to archaeology after his conversion to a business career in the 1990s; and, last but not least, Dick Spicer, who met an untimely death, and was thus literally lost to archaeology, and his peers. As for myself, I shortly afterwards returned to Greece with my young family, and took a job in museums.

2.2 *Towards a semantic representation*

My D.Phil. thesis – *The significance of costume in Classical Attic grave stelai: a statistical analysis* – was an attempt to provide a social interpretation of the function of costume and other personal attributa in the iconography

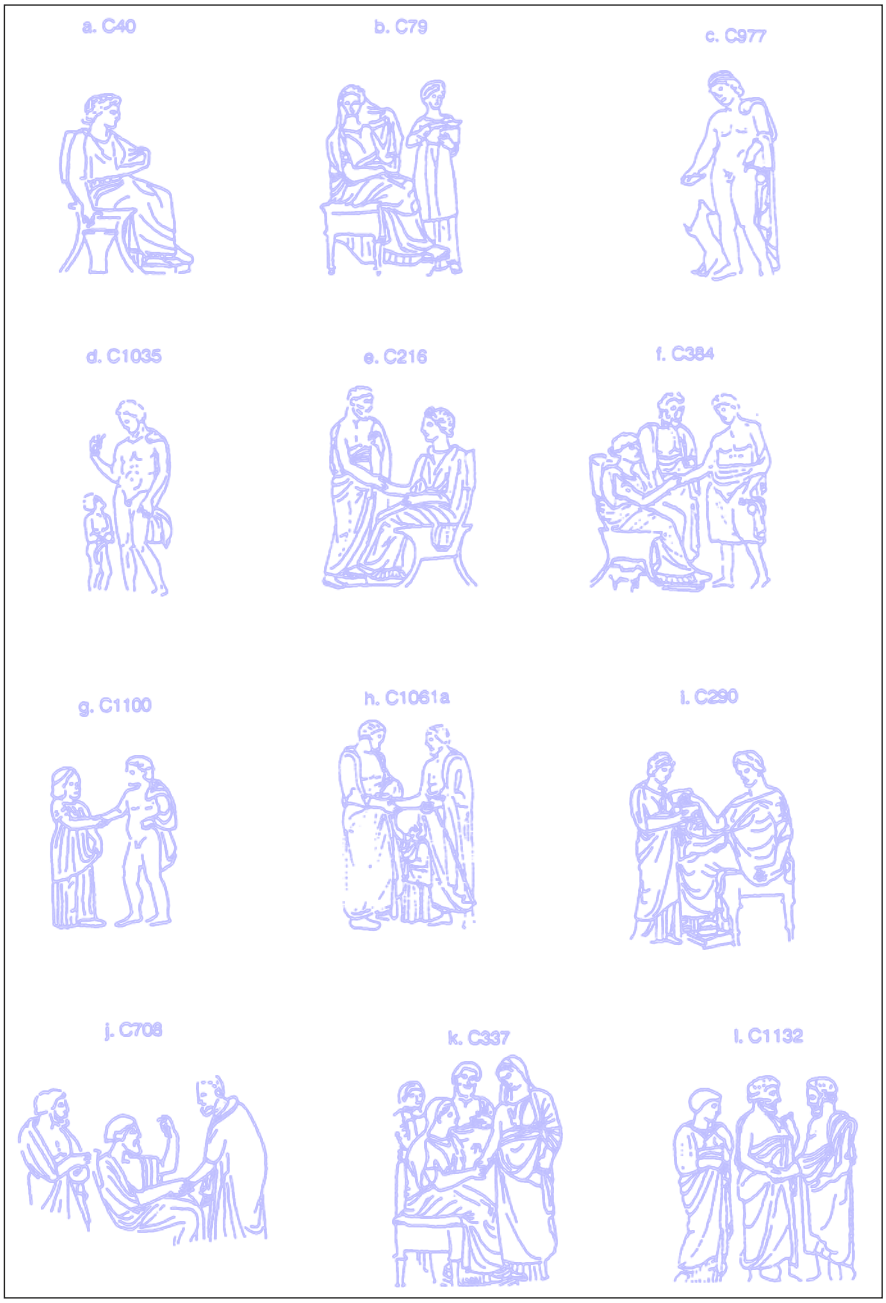


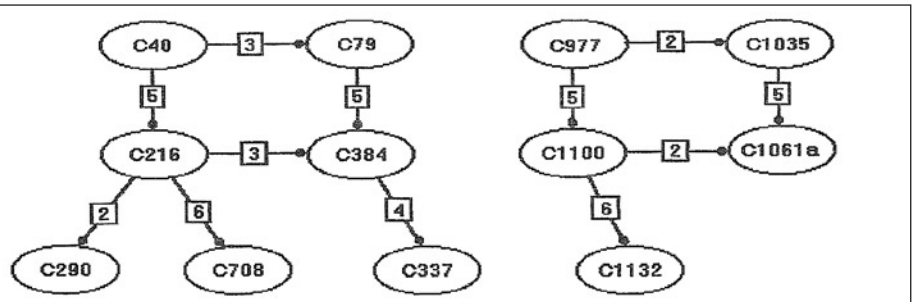
Fig. 1 – Examples of Classical Attic gravestone compositions.

of Classical Athenian funerary monuments. It was based on the quantitative analysis of a dataset of about sixteen hundred formal descriptions of the iconography of human figures on Attic stelai, aiming at the definition of figure types based on costume, and at the identification of social and symbolic associations for these types. Analytical methods used ranged from simple descriptive statistics to hypothesis testing, numerical classification and scaling. Analysis showed that important aspects of social identity, such as social status, deceased vs. survivor status, and social age, categorised according to a formal system of transitions, both constitute and are signified by the typology of costume and other iconographic traits of figures depicted (Dallas 1987a, 1987b; Fig. 1).

This intensive encounter with the power of quantitative analysis, supported by statistical software packages such as SAS and SPSS, made me aware of the acute importance of data constitution – selection of cases, but also, description of the empirical archaeological realities at hand – for the validity of the results, and indeed I dedicated a full chapter in my thesis in discussing the issue. I was already familiar with the early work of Jean-Claude Gardin's research group in CNRS, which from the mid-1950s onwards produced several formal "descriptive codes" for diverse kinds of archaeological entities, from ornament to civic monuments (Gardin 1958, 1967, 1976, 1978; Lagrange 1975; Salomé 1980), and was impressed by his semiotic approach, based on the representation of latent structure by means of a succinct calculus of morphological primitives, defined by virtue of methodological principles of segmentation, orientation and (formal) differentiation (Gardin 1967). I was also fascinated by earlier work of American anthropologists who, under the influence of structuralism and generative linguistics, had introduced structural and apparently fruitful methods for the formal representation of artefacts (Munn 1966; Glassie 1975; Deetz 1977), and found considerable interest in more recent formal, semiotic and structural approaches to iconography, artefact analysis and design systematics (Hoffmann 1977; Hodder 1982, 1987; Lagrange, Renaud 1983; Washburn 1983; Moscati 1986; Guimier-Sorbets 1990).

Critical examination revealed to me some important shortcomings of the traditional quantitative analysis present in my doctoral thesis. In short, crucial aspects of a broad spectrum of complex archaeological entities, including iconographies (and unlike fibulae or arrowheads), seem to require concepts of internal syntactic structure and external relationality lacking from Clarke's elegant attribute-artefact-type conceptualisation (1968, 35-37), and from the consequent quantitative analysis of a global attribute list, on which the whole edifice of archaeological statistical inference and numerical typology, from Spaulding (1953) onwards, is founded.

Increasingly, I saw the issue of data constitution as one of "description as symbolic representation", and sought insight in the relevant literature of



(a)

Rule	*Transformation description*
1	Image inversion
2	Half-size standing figure addition, in front
3	Background standing figure addition, in front
4	Background standing figure addition, behind
5	Foreground standing figure addition, in front
6	Foreground standing figure addition, behind

(b)

Base	Stele description
a	Seated figure (facing right)
c	Standing figure (facing right)

(c)

Fig. 2 – A state transition network and compositional transformation rules for Classical Attic grave stelai (Dallas 1992b).

the field of artificial intelligence (Brachman, Levesque 1985; Charniak, McDermott 1985; Levesque 1986). Further experimentation with the iconography of Classical Attic grave stelai led me to identify and discuss alternative formal representations of stele composition, including one- or two-dimensional strings, classification trees, state transition networks based on geometric transformations (Fig. 2), syntactic categories representing between- and within-scenes functions (such as congruence, congruence of context vs symmetry, parallelism), semantic paths and rewrite-rule grammars (Fig. 3). These conceptualisations appeared to account more fully for the syntactic (i.e., relational) and semantic (i.e., narrative) structure of gravestone compositions than a rectangular, case-attribute matrix (Dallas 1992c).

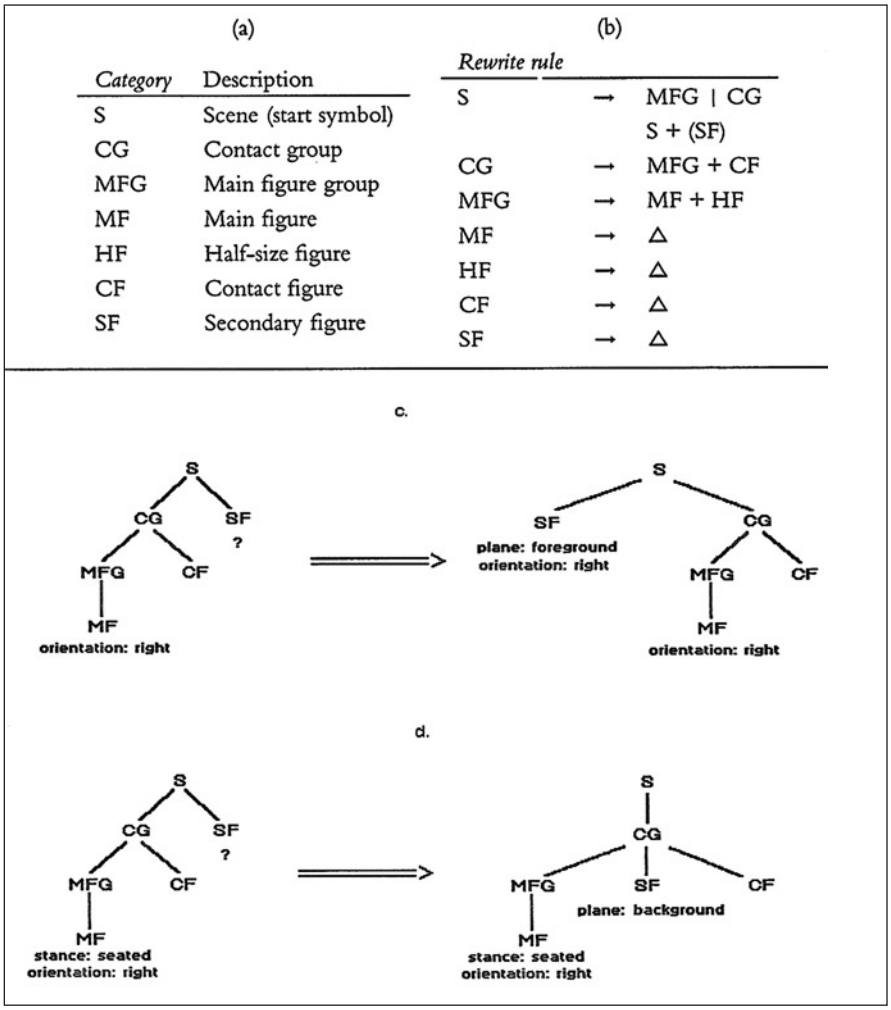


Fig. 3 – A grammar for Classical Attic stele composition (Dallas 1992b).

In an approach inspired by earlier research work in syntactic image recognition (Eshera, Fu 1986) and space syntax in architecture and urban design (Hillier, Hanson 1984; Hillier *et al.* 1987), I also thought that the shortcomings of the global attribute list in capturing compositional structure in iconographies, or ancient Greek house layouts, may be countered by the adoption of an attributed relational graph representation, amenable to classification by means of inexact graph matching and providing for a structural

understanding of emerging archaeological types (Dallas 1992b). Another experiment consisted in identifying graph structures based on a formal measure for the collocation of figurative subjects (or motifs) in iconographic compositions, and examining how such structures may be used as a non-hierarchic, semiotic expression of social categorisation mechanisms (Dallas, Thiopoulos 1993; Dallas 1996).

Complementary kinds of substantive knowledge emerged from each different representation. At a time when information systems had started becoming more widely available in museums and archaeology, and the orthodoxy of the relational data model was being challenged by object-oriented alternatives, it became clear to me that rich semantic representations supporting the multiple embedding of terminological and descriptive systems, multiple specialisation and instantiation, object part composition, uncertainty and temporality (Dallas 1994; Bearman 1996) could provide a potentially more fruitful way to represent and understand material culture.

2.3 *The 1990s*

I had joined the Benaki Museum (Fig. 4) as Head of the newly-established Documentation and Systems Department, in 1990, at a time of widespread increase in the use of computers in cultural heritage institutions. While the immediate task of our small team was the practical generation of simple electronic inventories, we soon came across the object description and representation issues archaeological research was already struggling with: in a heterogeneous collection of archaeological artefacts, art works, ethnographic objects, historical memorabilia and curia spanning from Aegean prehistory to the mid-20th century, the challenge of providing a descriptive system – a structure and a terminology – that could account adequately for variability and complexity in the collection was, indeed, a formidable one. Discussions in the Data Standards Working Group of CIDOC confirmed our suspicion that the problem was not limited to us, but concerned the whole museum community.

Several international museums in the early 1990s were in the midst of notable change, shifting their attention from the care of collections to communicating with their audiences, and changing their interpretive strategies from objects to object histories. Collections management systems had been established for years in major international museums, and many (Dallas *et al.* 1993; Dallas, Garzotto 1993) already experimented with using electronic media for communication with the public. The revered "primacy of the object" was challenged by the ascent of the notion of information, touching upon all aspects of form, function and meaning of museum objects, and bridging the epistemic and pedagogical functions of museums themselves.

We found relational databases, promoted at the time as the new mantra for museum documentation and collections management systems, to be

Fig. 4 – Benaki Museum. Room 4-5.

a poor match for scholarly discourse about museum artefacts, seen as heterogeneous and diverse, complex in terms of part composition and meaning layering, and densely connected with other important information objects, such as periods and events, places, time intervals and relationships, people and an almost indefinite array of possible associations (Dallas 1992a). Since 1992, I worked with Panos Constantopoulos, Martin Doerr and their team at the Centre for Cultural Informatics at ICS/FORTH towards developing a semantic information system for the storage and manipulation of scholarly knowledge on museum artefacts, based on painstaking conceptual analysis of a wide variety of artefact-related information, and involving such issues as the relationship between artefact types, the description of compositional structure of complex objects, and the elucidation of the notions of artefact creation, modification and use. The system, CLIO (or MITOS, as known then internally at the Museum) was based on ICS/FORTH's Semantic Index

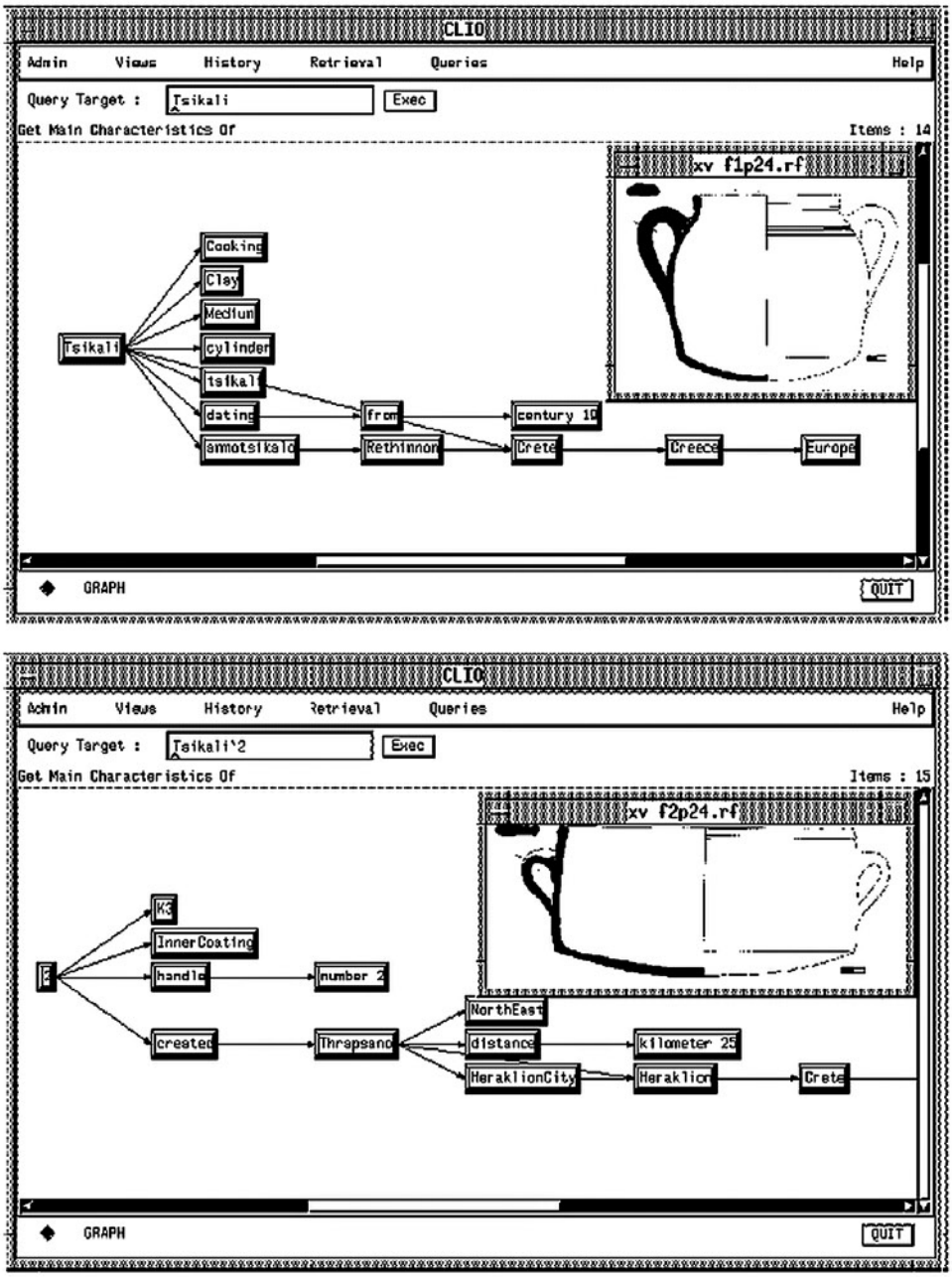


Fig. 5 – Benaki Museum CLIO information system query screen (Constantopoulos 1994).

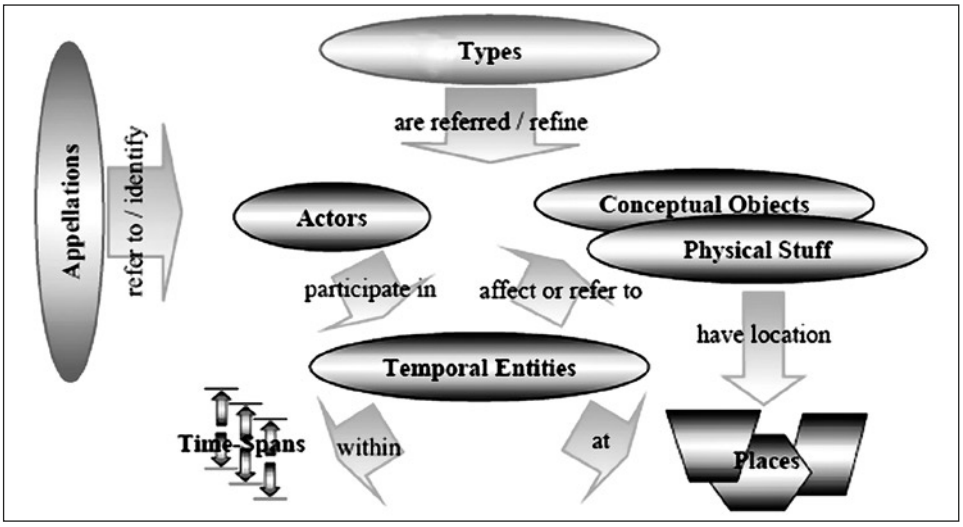


Fig. 6 – Qualitative metaschema of the CIDOC Conceptual Reference Model.

System, an information kernel implementing the Telos knowledge representation language, and capable of incorporating representations of domain knowledge from material culture disciplines (including background information on artefact typologies, styles, periods and provenance places) as well as representations of individual artefacts or "occurrences" (Dionissiadou, Doerr 1994; Christoforaki *et al.* 1995; Fig. 5).

The CLIO conceptual model provided an elegant, parsimonious and expressive framework for the symbolic representation of aspects of artefact knowledge drawn from art historical, ethnographic and archaeological scholarship. While the actual CLIO system was withdrawn from active use at the Benaki Museum a few years after its inception, the model was adopted in 1996 by CIDOC, the International Documentation Committee of the International Council of Museums, as the basis for the definition of an international Conceptual Reference Model, or ontology, for cultural heritage information (Fig. 6). The CIDOC CRM was expanded by a team of international researchers from the museum disciplines, information and computer science, and was accepted in 2006 as ISO standard 21117, still evolving with minor improvements to the present (Crofts *et al.* 2009).

Debate in the CIDOC CRM Working Group focused more on issues of CRM harmonisation with other metadata and cultural heritage documentation standards, as well as on ensuring its interoperability and information integration between heterogeneous cultural heritage information systems, rather than on developing formal representations of material culture amenable to

descriptive analysis and conceptual manipulation, such as envisaged earlier by symbolic and structural archaeology. Nevertheless, as we have shown in our earlier experimentation with CLIO, the CIDOC CRM could be a useful foundation for building information systems for artefact research, providing for the expression of such compositional, locational and relational information as deemed crucial for archaeological knowledge work.

2.4 *The new millennium*

In the last few years, my interests shifted to a quest for broader understanding of the meanings of artefacts in their evolving contexts of use as evidence for scholarship, and as agents for cultural meaning through museum exhibition and digital communication. The intellectual foundations for this quest can be traced back to interpretative approaches to artefact analysis (Pearce 1994; Tilley 1999), notions of object agency and biography of things borrowed from the anthropology of material culture (Kopytoff 1986; Gell 1998) and, not least, the dramatic shift of museum interpretation from objects to object histories (Vergo 1989). My recent exploration of the concept and practice of archaeological virtual exhibition, a site for the situated emergence of knowledge as archaeologists, exhibition curators and audiences engage with symbolic representations of past realities (Dallas 2007b), owes a lot to earlier investigation of artefact-based archaeological representation. Our collective work at the Digital Curation Unit - Athena Research Centre since 2007 is also informed by the need for particular attention to the epistemic traditions and research requirements of material culture disciplines such as archaeology (Dallas 2007a; Constantopoulos, Dallas 2008).

As the spectre of information deluge and the danger for future obsolescence of epistemic memory becomes a pressing reality, the interests of information managers and curators on the one hand, and those of scholars and field researchers on the other, converge (McCarthy 2007; Ross 2007). In our recent work in the DARIAH: Preparing the European digital infrastructure for the arts and humanities projects (in which we are happy to collaborate, among others, with the UK Archaeology Data Service), we consider a key priority for future information systems to be their ability to express, and accommodate, research questions based on the epistemic discourse, domain knowledge, and object representations of the human sciences (Constantopoulos *et al.* 2008; Benardou *et al.* 2009): themes that motivated many of us who, back in the early 1980s, became part of a growing second generation of computing archaeologists.

3. Postscript

The 21st century marks the beginning of an era of post-disciplinarity. In the past decades, archaeology has been moving closer to other human

sciences – both social and historical – and has been increasingly reflexive of its epistemic nature and social role. Artefacts, as "good to think" objects of knowledge, are increasingly seen from multiple perspectives, and the functions of places of memory – archaeological sites, museums, libraries and archives – in promoting engagement with the past become increasingly blurred.

This paper presents a biographical account of a second generation computing archaeologist's engagement with seminal methodological and theoretical perspectives established by some pioneering workers in the field. As such, it supplements rather than attempts to replace an historiography of archaeological computing, or of the methodological and theoretical currents of New Archaeology, structuralist and cognitive archaeology with which it is normally associated (Trigger 1989; Preucel 2006; Zubrow 2006). Based on a phenomenological epistemic stance, it focuses on establishing a "representation of experience" through biographical narrative of an individual's activity, and encounters with others, in a particular area of archaeological research: material culture, and, in particular, artefact description, analysis and classification.

Research activity, viewed through three decades of dramatic change in contemporary archaeology, may be seen as the manifestation of agency of a community of knowers and actors involving their individual motives and goals: archaeologists, workers from fields as diverse as anthropology, folklore studies and art history, museum documentation and information professionals, computer scientists, and others, engaging with cultural heritage informatics at a time of increasing digitisation of the archaeological heritage and the development of major digital repositories and digital libraries of resources relevant to archaeological and cultural heritage research.

The object of such research activity is, from one point of view, the pursuit of particular questions in material culture theory – especially, with regard to artefact description, the definition and status of types and properties, and the elaboration of notions of object history, function and meaning based on a rigorous conceptual model. It is also, from another yet not unrelated point of view, a pursuit of developing good "mediating tools" for the construction of useful representations of artefacts in the context of distributed, heterogeneous information systems. Information technology, in the guise of archaeological information systems, digital repositories, artefacts and digital libraries of archaeological knowledge, has been an important "mediating tool" in its own right, in rendering the research activity related through the above narrative possible. Archaeological computing, its methods and tools, has been an essential, yet culturally embedded, rather than merely instrumental, factor in shaping up the particular paths of research and debts to important first-generation theoretical and methodological traditions presented here. The biographical account can be read meaningfully through the lens, and theoretical vocabulary, of cultural-historical activity theory (Dallas 2007a; Kaptelinin, Nardi 2007; Leont'ev 2007).

Contemporary perspectives to cultural heritage information are informed by the pragmatic need to develop formalisms, schemas and functional specifications for information systems – repositories, digital libraries, services and tools – able to serve the objectives of long term digital preservation and adequate intellectual and physical access to information resources ranging from primary evidence to scholarly argumentation. As such systems are being developed and put in practice, and as vast collections of typically uncategorised, non-curated digital surrogates of cultural objects appear on the web, it becomes evident that a reductionist approach to documenting these objects cannot ensure their future epistemic adequacy (McCarthy 2007). The theory and practice of contemporary digital curation of archaeological, and more broadly, cultural heritage, viewed as an engagement with the conceptual and knowledge-related aspects of material culture as evidence, should, in that sense, be informed by the epistemic traditions of the curating disciplines, including archaeology (Dallas 2007a).

The seminal work of archaeological computing pioneers such as Spaulding, Gardin and Clarke in the field of artefact description and typology, and the complex and fluid insights it created on the emerging nature of archaeological knowledge, remains an essential source of intellectual stimulus for the development of adequate conceptual representation models of material culture, in the context of digital infrastructures for knowledge and communication in the cultural heritage disciplines. It may prove, surprisingly, to be one of the most enduring legacies of a pioneering generation of archaeological thinkers.

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ABSTRACT

Research in theoretical and computer-based archaeology, from the 1950s onwards, established important perspectives for the formal representation and analysis of tangible cultural entities such as complex artefacts, iconographic compositions and archaeological assemblages, and became a precursor for the emergence of knowledge-based tools, methodologies and standards for artefact-centred information systems in contemporary museums. One particular case in point is CLIO, a semantic information system intended for research use, developed by ICS/FORTH and the Benaki Museum in Greece in the early 1990s, which became a foundation for the definition of the Conceptual Reference Model of the International Documentation Committee of ICOM (CIDOC CRM), recently adopted as the ISO standard for cultural information representation. It is argued here that, as the capabilities of computer applications to provide access to complex, multimedia cultural information increase, so does also the validity and importance of earlier research advances in artefact-centred archaeological computing; and, conversely, that the advent of digital infrastructures for material culture disciplines such as archaeology highlights the pertinence, and potential benefits, of further work on archaeological formal analysis and knowledge representation.