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**F. Giligny, F. Djindjian, L. Costa, P. Moscati  
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# Art History of the Ancient Near East and Mathematical Models. An Overview

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## Abstract

*The use of mathematical models in the art history of the pre-classic Near East is still comparatively little popular, partly because of cultural as well as technical and logical problems. In the history of research, such kind of approaches have been especially focussed on glyptic productions, but they mainly lack continuity and diffusion in use. Nor is the use of specific models widely spread through scholars originating from different academic institutions. The authors of this contribution review the different uses of quantitative models in Near Eastern art history and offer a summing up and an overview of the underlying approaches and methods. The deep examination of the models and approaches that have appeared up to now in the scientific literature is a first step toward the outline of possible future research courses that could become part of a wide debate on the topic of art history and mathematical models.*

**Keywords:** Art History of ancient Western Asia, Mathematical Models, Figurative Languages, History of Research.

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## 1. Introduction

Beyond the ordinary difficulties and incomprehensions which often affect scholars who make attempts to use quantitative methods in the humanities, the art history of ancient Western Asia traditionally offers further problems. These are partly related to the specific nature of this field of study, and partly connected to the approaches deep-rooted in principal academic institutions.

On the one hand, the figurative languages of pre-classical Western Asia mostly pertain to cultures that are largely unknown and obscure to present-day scholars. A large part of them had already faded into oblivion in ancient times, and very often the documentation is still so scarce that a number of gaps and hard to solve doubts and uncertainties persist nowadays in the cultural basis and achievements of comparatively young disciplines (Sumerology, Assyriology, Archaeology of Western Asia, History of Religion of Western Asia, etc.). On the other hand, a great number of the most traditional approaches of these disciplines either have a Biblical inspiration or are based on perspectives deeply permeated by the logics of Classical studies, alphabet cultures, or similar.<sup>1</sup> Hence, each scholar who prefers, explicitly or not, to follow the *safe way* of adopting so-called *traditional perspectives*, also accepts its logical and cognitive consequences. That the majority of other scholars would agree with such a view only confirms how deeply those habits are rooted. The situation of disciplines related to Classical cultures could be meaningfully different, since they can take advantage of an extended historical continuity in the studies of the products of Classical cultures and of recognisable traces

of cultural continuity between Classical cultures and later European ones.

These basic differences can give a particular value to the use of quantitative methods within the disciplines which deal with the ancient Near East, and especially with reference to the field of art history.

## 2. The problem of coding and the early approaches

For the reasons mentioned above, the relative familiarity of some iconographies or visual themes pertaining to pre-Classical Western Asiatic cultures may be misleading for the scholar, while the effort in looking for a proper coding of those figurative languages in view of their quantitative description or study can disclose interesting and probably fruitful critical courses in the research into their interpretation. To devise a coding system is, in fact, in itself a critical research activity which repeatedly compels the scholar to question and analyse his or her view of the ancient cultures and the relevant products. It is therefore unsurprising that the first innovative uses of quantitative methods in the archaeology and art history of Western Asia originated with the methodological reflections of Jean-Claude Gardin and his colleagues of the Institut Français d'Archéologie at Beirut.

Following theoretical efforts dealing with methods of classification and interpretation and paying great attention to the most recent observations stemming from the international (especially English-speaking) level (Gardin 1958: 335-336; 1967: 13), Gardin developed some proposals for the use of automatic and quantitative methods in the study of various kinds of archaeological artefacts. From the nineteen-fifties, and throughout his rich career, he thus proposed the use of universal codes which could help scholars in representing and comparing the

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<sup>1</sup> Digital culture and the noteworthy qualitative differences between its typical ways of thinking to written texts, and handling them and those of non-digital or oral cultures, or cultures that have other approaches to writing and managing texts should also be remembered here.

content of archaeological reports in a useful manner.<sup>2</sup> His great challenge was to outline a code based on the logics of the *analyse logiciste* in order to describe the relics of ancient cultures fairly precisely in a universal language (see, e.g., Gardin 1958). The same strategies could then also be used to translate the content of archaeological reports into a uniform language (Gardin 2002: 19-21). In Gardin's view, a coding system had to be devised in order to describe systematically all information relevant to a class of artefacts, so that a reduced number of elements could be used in a scientifically satisfying formalised representation of archaeological findings. Of course, each category of relics needed its own code, but the general approach of the logicist was based on assumptions which were fit for universal adoption. Such assumptions were inspired by linguistics, and many explicit linguistic parallels and examples have been recalled by Gardin, while explaining his theoretical perspective (for example, in Gardin 1966; 1967: 18-26).

In Gardin's view, each code had to take into account three features of the object that needed to be described through a coding system: orientation, segmentation and differentiation (Gardin 1967: 13-18). Once defined, these three basic concepts outlined the relations existing between them, Gardin proposed an alphanumeric coding system which could describe the parts which made up the object and the ways in which these parts were related to each other in a concise manner. The material tools used to manage the codes and the coded objects were computer machines and punched cards.

Those efforts and thoughts led to, amongst other results, the development of a computational model in the treatment of ancient Near Eastern figurative languages (first outlines are in Gardin 1967: 21-26), the proposals and first concrete expressions of which concerned the iconographies of glyptic. A number of scholars of French archaeological research institutions located in France and abroad took soon part in the relevant projects, providing them with a considerable specialised scientific support (Moscati 2013: 10-11).

Thus, in the field of art history, Gardin first looked for proper solutions to the descriptive and syntactic problems of the iconography of cylinder seals, experimenting the proper procedures for a formalised representation of the relevant information. The system that resulted was then adopted to carry out the unprecedented *Répertoire Analytique des Cylindres Orientaux* (Digard 1975), a large catalogue of sheets collecting data on cylinder seals that had been published in different journals. Since it was the outcome of the uneven work of the publications of different authors in different periods, this heterogeneous corpus of seals was particularly suitable both to test the methodology and to produce a concrete tool which was ready for use.

<sup>2</sup> The education and research experience of J.-C. Gardin has been described recently and in-depth in Moscati 2013.

The *Répertoire* was designed consistently to summarise in a single publication the general information about those seals and also to provide instruments for automated search and comparisons. It was a model for other initiatives of the same kind dealing with other classes of artefacts and was obviously open to any kind of future enlargement owing to new discoveries. The work was reasonably well-received by specialists, but its authors were already aware that it would have had no follow-up: it was both the turning point and the end of an ambitious project. There were many reasons for this, and some of them had been foreseen years before by Gardin: scholars are often very jealous of their data, and it is rare for a specialist to dedicate his or her time and efforts to build an ordered archive of published materials for the scholars' community.

Gardin's system was largely based on linguistic logics,<sup>3</sup> and it needed to undergo adaptation in order to be applied to a wide range of iconographies. Nevertheless its creator paid great attention to reducing the opportunity for the personal interpretation of iconographies in the coding as much as possible (Gardin 1967). Years before he had expressed an important observation concerning the value and usefulness of such coding systems when he defined their development and use as something very similar to an explicit and conscious version of the usual implicit reasonings of archaeologists looking for typologies.<sup>4</sup>

### 3. American Experiences since the Seventies

During the nineteen-seventies, a new experience of use of quantitative methods in the study of the iconography of cylinder seals was developed in the United States, at UCLA. A project led there by Marilyn Kelly-Buccellati aimed at planning a coding of data related to cylinder seals, and especially to their iconography, in order to allow statistical investigations and cross comparisons of traits or themes at various levels of logics or detail. The coding was based on a number of binary recordings of features chosen to minimise the subjective view and interpretation as much as possible, and to give a set of descriptions of the artefacts that could be not only quite rigorous, but also suitable for computer processing (Kelly-Buccellati 1977).

The digital catalogue obtained in this way would then also include the net of logical relations that had been recognised among those features. The project began within the perspective of the use of statistics as a tool for research in Near Eastern art history (Kelly-Buccellati and Elster 1973; Kelly-Buccellati 1977: 42), and then proposed some initial coding strategies, which included the choice of specific tools, such as photogrammetry for the graphic rendering and preliminary study of each seal.

Following these initial steps, the authors of this research project looked at the study of cylinder seals not just as a

<sup>3</sup> Gardin explicitly compares his coding signs to the phonemes or the graphemes (e.g. in Gardin 1958: 350-355). After all linguistics played a remarkable role in Gardin's multifaceted education (Moscati 2013: 7).

<sup>4</sup> Gardin 1967: 28-29. Gardin kept in considering the opportunity of formally coding also the way archaeologists think and explain their thoughts: see, e.g., Gardin 1997; 2002.



means to understand ancient iconographic cultures, but also with the view to exploring other historical and cultural phenomena, such as the geographic diffusion of cultural traits, social relations or similar phenomena.<sup>5</sup>

Their approach was deliberately different from that which had underpinned the great catalogue prepared by the researchers of the *Institut Française d'Archéologie*: it actually dealt with a specific glyptic production, that of Old Babylonia,<sup>6</sup> and had been thought to be available in the form of a collection of retrievals (coming from computer processes which had already been performed), explaining the types, numbers and the possible contexts of use of the different motifs observed on the seals, rather than being an interactive tool to be used with a computer (Kelly-Buccellati 1979-1980).

That interesting and ambitious project was part of a wider research program looking for a systematic examination through Information Technology of ancient Mesopotamian cultural products, including historical and linguistic traits and relics. The larger project was entitled 'Computer Aided Analysis of Mesopotamian Material', and the series of publications *Cybernetica Mesopotamica* had been prepared in order to publish from time to time the relevant outcomes (Kelly-Buccellati 1977: 45, fn. 2). As far as we know, the various branches of that program, including that concerning Old Babylonian glyptic, were halted before time: four issues of *Cybernetica Mesopotamica* were published<sup>7</sup>, the last of which was in 1984, and all dealt with topics relating to the epigraphic and philologic study of cuneiform. One can thus imagine that the part of the project dedicated to the quantitative study of ancient art ended at the beginning of the nineteen-eighties. Perhaps very close to that project is a further experiment that was proposed in more recent times, but it probably had no actual developments.<sup>8</sup>

#### 4. Glyptic Iconographies and Applied Mathematical Models

In the early nineteen-nineties a new research strategy on glyptic figurative languages was devised at the University of Rome 'La Sapienza' during a cooperation between Elena Rova and Sergio Camiz (Rova 1994). In this case, the chronological and geographical scale was reduced in comparison to that of the experiment of the French logicist school described above, while the aims, the type of mathematical models, and their use, were very different;

<sup>5</sup> Kelly-Buccellati and Elster 1973: 199-200. This also provides the reasons for which seals are especially important in a quantitative study in the history of art of the Ancient Near East: the *corpus* is wide, and thus 'quantifiable', the basic stylistic chronology is known, many of these can be dated with a certain precision, thanks to the imprints on tablets and references in the inscriptions, their publication is usually 'fuller than other classes of artefacts'.

<sup>6</sup> Old-Babylonian glyptic was chosen for the wide range of material datable with a certain precision. (Kelly-Buccellati 1977, p. 45).

<sup>7</sup> See Undena Publications Website: Data Sets - Cuneiform Texts, URL: <http://128.97.6.202/up/dsc.html>; Graphemic Categorization, URL: <http://128.97.6.202/up/gc.html>.

<sup>8</sup> F. Buccellati, Constructing Art Historical Definitions through a Comparative Database: The Evidence of Old Assyrian Glyptics, oral paper presented at the 36<sup>th</sup> CAA, Budapest 2008.

however, the basic logical references for devising a proper coding strategy had quite a lot in common (Rova 1995). On the other hand, with the approach proposed by Kelly-Buccellati this experience shares the limitation of the corpus to a single cultural-historical period, but not the targets and just very few of the basic principles.

Elena Rova investigated with Sergio Camiz the glyptic iconography of the early historical periods of Lower Mesopotamia, with the aim of locating compositional patterns, as well as geographical or diachronic variation features, looking for connections between 'specific iconographic and compositional features' and geographical or chronological variation, and outlining thematic classification.<sup>9</sup>

The tools used in this research are Textual Correspondence Analysis, Multiple Correspondence Analysis, Hierarchical Ascendant Classification, and also Principal Component Analysis. The iconographies were coded according to three types of description: textual, symbolic and presence/absence (Camiz and Rova 2001; 2003; Camiz et al 2003; 1998). The textual coding was the most complex and was investigated on three main levels: distinct icons, sub-patterns of the composition - that is small sets of elements - and whole image syntax.

In the case of this research project the use of quantitative methods and logics is thus embedded in specific ways of investigating figurative languages: it is a tool for searching for answers to specific scientific questions about the glyptic iconography of a specific historical period. This means that in this case the model interacts more dynamically with the data set, the structuring of which can be well adapted to scientific requirements before being formally adjusted according to the adopted algorithms. Furthermore, here the aim is the interpretation of a figurative language and the reconstruction of its functioning. It is an experimental piece of research, both in its methodology and in its pursued results, rather than a formalised systematisation of materials or a tool for other researchers. The procedure adopted can, in fact, be correctly used as a tool for other investigations only following a proper adaptation of the specific needs of each item of research and of the characteristics of the studied corpus.

Similar principles inspired the research project on presentation scenes in third millennium Mesopotamian glyptic which have been developed since the early 2000s by Alessandro Di Ludovico. It was originally a partly analytical and partly qualitative study aiming at outlining the historical developments of the theme of presentation in the glyptic of Lower Mesopotamia from the Akkadian period to the end of Ur III. The first approaches through which the research was undertaken were mainly inspired by structural linguistics, and led to an initial analogue classification and a genealogy of the iconographic traits

<sup>9</sup> Camiz and Rova 2001. It is important to remember here the theoretical contribution provided by Sergio Camiz along this research course (Camiz 2004) where he expressed his view as a mathematician on the coding of archaeological finds.

and the compositions of the scenes (the whole work has been summarised in Di Ludovico 2005). The fuzzy alphanumeric codings were later translated into binary, so that investigations through Artificial Neural Network algorithms could be carried out (Di Ludovico and Ramazzotti 2008). The translation also involved some adaptations of the coding logics which were further refined in the following experiments, the data set of which was largely renewed and centred only on the presentations of the Ur III period (Di Ludovico 2011; Di Ludovico and Pieri 2011a). In parallel to this, further experiments carried out with Giovanni Pieri and the testing of the linguistic logics of the compositional patterns of presentation scenes were performed, through which it was possible to develop machine automated simulations of the structuring of such scenes, which could be profitably used for a graphic rendering of the results of the Artificial Neural Network processing (Di Ludovico and Pieri 2011b).

These investigations allowed a better outlining of the inner relations existing through the compositional patterns, and gave clues for the interpretation of some motifs and their historical developments. Further contributions to these interpretation processes then came from the cooperation with Sergio Camiz, in which the Textual Correspondence Analysis and the Hierarchical Ascendant Classification, which had been profitably used by Rova and Camiz, were employed (Di Ludovico et al 2013; Di Ludovico and Camiz in press). This part of the research project on Ur III presentation scenes is still in progress, and is producing inspiring results.

These research courses refer to a more limited historical and cultural context than that of Rova's works, and the corpus on which they focus is much more homogeneous. However, besides sharing some of the basic principles and some applied methodologies, the two projects follow partly different epistemological approaches; for instance the more recent one is much more heavily based on the topological relations between the compositions and the peculiar development of the cylindrical surface that serves as the field on which they are depicted.

In recent times digital technologies for image acquisition and handling have been dynamically employed with cylinder seals both by an Italian-French international team (Pitzalis et al 2008) and by Paul Boon and Martine de Vries-Melein (2013; both scholars work for Dutch institutions). Both experiences are of great interest because they can provide a remarkable help in the documentation and study of seals in a perspective which is more respectful of their basic physical features and shape. The two different types of three-dimensional modelling that these experiments propose can thus document well the information that is essential for quantitative studies of the iconography of seals, and deserve to be applied on a large scale.

### 5. Iron Age Ivories and Machine Learning

Outside the realm of cylinder seals, a very interesting use of quantitative methods for research in iconography and

artisan traditions is that developed by Amy R. Gansell, with the technical contribution of some specialists of disciplines relating to natural sciences (Gansell et al 2007; Gansell et al 2014). The subject of this research course is a part of the famous corpus of ivory carvings of Levantine production which were found in the excavation of different Neo-Assyrian settlements. The project is still in progress, but has already provided useful results. In the investigation a classification of the ivory fragments through machine learning is attempted, so that, on one hand, the past hypotheses and interpretations of the corpus - mainly based on stylistic analysis - could be critically examined and, on the other hand, new proposals and observations on the corpus itself could be developed. Through the adopted algorithms, a number of features which can be decisive for outlining the classes were identified (Gansell et al 2014: 202). The methodology is of statistical kind, and the basic logics are not far removed from that used for some of the studies on early historic seals by Rova and Camiz, however the whole process and the coding distinguish themselves for paying special attention to metrological features, thus giving an important role to both the artisan's perception and the handling-related characteristics of the artefacts.

The starting point of this investigation was a long and well-established tradition of art historic analyses, documentation, and classification of the corpus. Statistical tools and reasoning were here used to locate the features of resemblance or dissimilarity between classes of artefacts, and to test classifications or trace new classification proposals and relations. The investigation of the cultural (or spatio-temporal) network relations and the enlargement of the corpus to other materials are two basic proposals that will characterise the continuation of this project (Gansell et al 2014: 203), that promises further fruitful outcomes.

### 6. Conclusion

Research in the art history of ancient Western Asia has been only very slightly and irregularly affected by the use of quantitative and computer-aided methods. Most experiences of this kind derived from the initiative of single scholars or small groups of scholars, who were differently fostered by the institutions to which they belonged. Until now, the most systematic and officially supported experience seems to be that developed and carried out by J.-C. Gardin within French institutions.

This notwithstanding, the results that have been obtained through the different research experiences with which we dealt in this paper lead us to take an optimistic view on possible further developments, both in the field of methodologies closely embedded in research courses, and in that of quantitative approaches to documentation and representation. As explained in the introductory notes of this contribution, the field of Western Asiatic art history not only requires coding and description strategies that must deal with very complex objects; it also mostly deals with products of cultures that are quite distant from those pertaining, or somehow related to, the perceptive and linguistic spheres of most scholars, and as such is

particularly exposed to the risk of symmetrisation in the interpretation process (Di Ludovico in press). The experiences with quantitative methods in this specific context give particularly meaningful clues which reveal that the two problems of documentation and (more or less experimental) research are not really distinct, nor complementary: they should be rather thought as integrated parts of the same process.

Of course, as J.-C. Gardin observed many years ago, the problem of involving scholars in actively sharing their efforts to collect data and allowing them to be available for the whole scientific community can hardly find a true solution. Public institutions, at least, should help researchers by giving them free access to their archives of published artefacts (which would also help in preserving their archives), simplifying the bureaucratic steps needed to use technologies in collecting data by the artefacts, and, in general, affirming and promoting the logics of free access.

From the scientific point of view, the basic problems that emerge from an analysis of the experiences with quantitative methods in art history have to do with the coding techniques and logics, all strictly related to the scholar's perception of the artefact. As such they require the scholar to reflect critically on the categories and values that are implicit in his or her way of observing it. In Western Asiatic art history quantitative approaches are still used very little, in comparison with the great potential that their employment showed in the past, but perhaps the reduced costs of digital tools and logistical support could help the development of new ambitious projects, of the kind attempted in the earliest approaches, in the near future.

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