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Archaeological Computing Newsletter 67: December 2007

Archaeological Computing Newsletter

Number 67

Supplement to
ARCHEOLOGIA E CALCOLATORI

Archaeological Computing Newsletter
Issue 67, December 2007

EDITORIAL ADDRESS:
Archaeological Computing Newsletter
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PUBLISHER AND DISTRIBUTION:
Edizioni All'Insegna del Giglio s.a.s.
Via della Fangosa, 38
50032 BORGO SAN LORENZO (FI) - ITALY

Telephone: ++39-055-8450216;
FAX ++39-055-8453188
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ISSN 0952-3332

ISBN 978-88-7814-364-7

Printed in Italy by Arti Grafiche BMB, Firenze – December 2007

€ 7,00

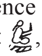
ISSN 0952-3332
ISBN 978-88-7814-364-7
9 788878 143647

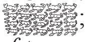
Modelling the archaeologist's thinking for the automatic classification of Uruk/Jamdat Nasr seal images

Introduction

During a long-term study (Rova 1994, 1995; Camiz and Rova 1996, 2001, 2003; Camiz *et al*. 1998, 2003), the authors analysed a corpus of 1247 Near Eastern seal images of the Uruk/Jamdat Nasr period (second half of the IV millennium B.C.) from the point of view of their iconographical content and its relations with their geographic origin and the context of their discovery and of their impressions, as well as their use for sealing different kinds of objects. We believe that a comprehensive iconographical analysis of images needs to consider at least three levels of description:

1) the presence, or frequency, of single elements and their different positions, such as: different types of *human beings*, *animals*, *objects*, *sitting*, *with open arms*, etc.;

2) the presence of small sub-patterns, such as: *woman with open arms sitting left on a bench*: , or *king-priest passing right with asymmetric arms with bow and arrow*: , which can be repeated several times on the same image, or appear identical on different images;

3) the overall syntactic image structure, such as *image on four registers, each one composed of five identical (repeated) elements*: ; or *image composed of two repeated sub-patterns, each one composed of two sub-subpatterns, the first one consisting of a small central element surrounded by two larger elements, the second one consisting of three superimposed elements:* .

For this reason, we applied three different coding systems, capable of describing these three levels, and we checked their ability to reveal similarities and differences between images through exploratory factor analyses, selected according to the kind of data used in each step:

1) A classical coding based on presence/absence of elements and/or characters. In this case we used Multiple Correspondence Analysis (Lebart *et al*. 1995; Rova 1994; Camiz and Rova 2001).

2) A formalised language, able to describe images without any ambiguities or redundancies. In this way, a formalised text is associated with each image. This fully describes both the elements composing the image, their attitudes and attributes, and the relations among elements. In this language, the terms are not declined or conjugated, so that the correspondence among elements, attitudes, and relations and the terms describing them is bi-univocal. We took into account the fact that each image was composed by sub-images via both *repeated segments* and *quasi-segments*, sequences of terms corresponding to these sub-patterns. In this case we used Textual Correspondence Analysis (Lebart and Salem1994; Camiz and Rova 2001).

	Elements		*Relations*
D	Main element right oriented	·	adjacent to (and)
S	Main element left oriented	+	joined with, touching, attribute
X	Main element not oriented	*	intertwined with
F	Main element doubly oriented, main right	/	on
J	Main element doubly oriented, main left	^	on / under and by
d	Secondary element right oriented	*∩*	into
s	Secondary element left oriented	|	above
x	Secondary element not oriented	*Sub-pattern*	
f	Secondary element doubly oriented, main right	*(*	beginning
j	Secondary element doubly oriented, main left	*)*	end

Table 1 – The codes used for the description of the image syntactical structure.

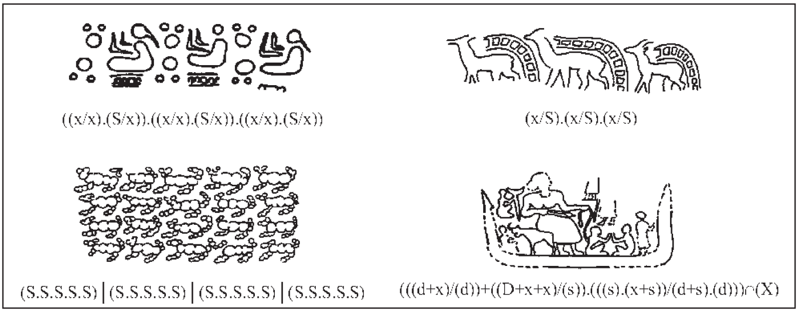


Fig. 1 – Four different seal images with the corresponding symbolic sequences representing their syntax.

3) A symbolic code was developed to describe the image skeleton, that is its syntactical structure, based on the relations among both elements and sub-patterns, regardless of the nature of the former (Table 1; Camiz *et al.* 1998, 2003).

The coding results in a hierarchical sequence of symbols, where couples of parentheses enclose the set of symbols corresponding to a sub-pattern (Fig. 1). For this coding, we had to develop a distance among sequences, able to take into account the differences between the whole image structures and those between the single sub-patterns composing them. Once a distance matrix among sequences had been created, we used the Principal Coordinates Analysis (Gower 1966) in the same way as the other factor analyses.

In all cases, a hierarchical classification of images (Gordon 1999) was obtained, considering the first few factors which seemed important for the description of the images and for their characterisation.

In this paper, we focus on the third coding and on a new proposal for the computation of the distances among the sequences. In the past, we developed a bottom-up technique that, theoretically, should solve all the problems concerning the computation of distances among hierarchical sequences (Camiz *et al.* 1998, 2003). Instead, in practice, the experimentation showed that the method was too sensitive to the alignment of the sequences, in particular as far as the sequences with more than one register were concerned. For this reason, we developed a program able to roughly simulate the archaeologist’s reasoning when dealing with the problem of dividing the image corpus into different image groups in successive steps.

The distance among sequences

In order to define a distance among the sequences corresponding to the seal images, in Camiz *et al.* (1998) a method was proposed, based on weights and factorisation. Its main features are outlined below:

Weighing symbols

The distance between two sequences (Levenshtein 1966) is based on symbols *insertion, deletion*, or *substitution*: each operation has a specific weight, determined by the archaeologist, observing three conditions:

1) all weights should be positive;

2) they must be coherent: thus *insertion* and *deletion* of the same symbol should have the same weight, the main elements should weigh more than the secondary ones, both insertion and deletion of substructures weigh more than those of simple symbols, etc.;

3) the weights should be univocal: if different structures can be described in different ways or the transformation of one sequence into another can be done in different ways, the weights should be determined independently from the different ways.

Factorisation of sequences

Sub-sequences enclosed in parentheses are sub-patterns. Thus, a new representative symbol is introduced for them, together with its corresponding weights. In order to estimate these weights, all possible combinations of insertion, deletion, and substitution necessary to transform one sequence into another are considered as weighed edges of an oriented graph. The weight of the minimum weight paths is thus the weight of the substitution of one sequence with another.

The operation is repeated for all sub-patterns up to the whole image pattern, giving a distance between the two images.

The method for studying symbolic sequences described so far does not consider, however, some elements of similarity between images. In particular:

1) a common structure (or common sub-structures), as long as the differences among elements (main, secondary, orientation, etc.) are ignored, has no weight;

2) the presence of common sub-patterns is ignored. Thus, for instance, the difference between images on one register and images on two or more registers, is not given enough importance (Fig. 3). In the same way, periodical images (that is, images composed of repeated sub-patterns) do not stand out as a separate group. For this reason, when evaluating similarities between different images a more complex algorithm had to be developed, which was closer to the actual archaeologist's chain of decisions. Actually, the basic technique, namely the weighting and the factorisation, remains the same, but the procedure takes into account other aspects that are suitably weighted in order to emphasize the importance of the common structure.

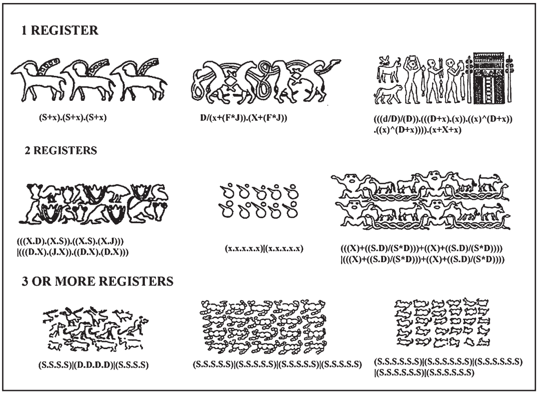


Fig. 2 – Seals with images on one, two, or more registers.

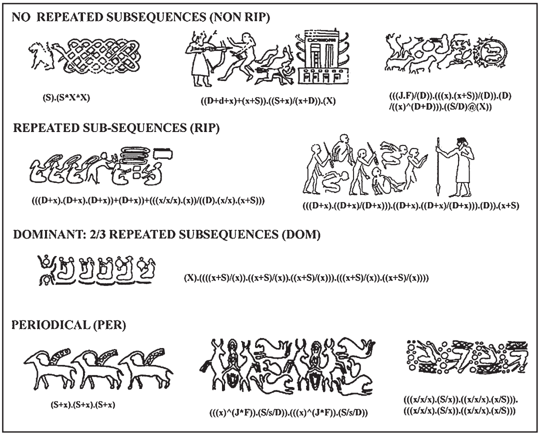


Fig. 3 – Seals with or without repeated sub-sequences.

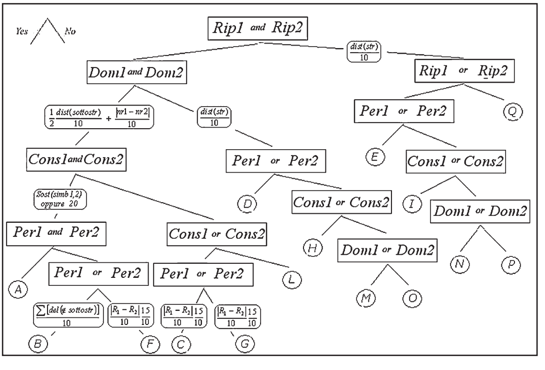


Fig. 4 – The decision tree for the repeated sequences in the images.

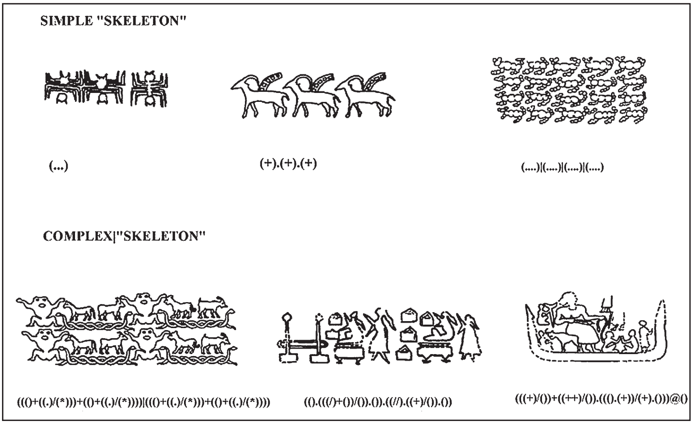


Fig. 5 – The skeletons of some images of the seals.

The new procedure works as follows:

1) as a first step, seals on one register are set apart from those with two, three or more registers;

2) secondly, sequences are examined and characterised according to the pattern of repeated sequences (Fig. 3):

a) *presence of repeated sub-sequences (RIP)*;
b) *dominant (2/3) presence of repeated sub-sequences (DOM)*;
c) *dominant presence of repeated consecutive sub-sequences (CONS)*;
d) *the sequence is composed only by one repeated sub-sequence (periodical, PER)*;
e) *periodicity of the spatial relations (PERSP)*;

this step has the structure of the decision tree represented in Fig. 4;

3) then, the elements contained in the sequences of symbols are compared, according to the rules described above;

4) finally, the sequence *skeletons*, as defined only by parentheses and spatial relations (that is, the left columns of Table 1), are compared.

To each of these operations special weights are given, according to their importance as determined by the archaeologist. Thus, the distance between each two strings of symbols is given by the total of the weights accumulated during the whole comparison process.

First results

We conducted a test to evaluate the ability of this method to effectively characterise the seal images according to their syntactical structure. For the test we used the same 100 seals used by Camiz and Rova (2001, 2003) and Camiz *et al.* (1998, 2003) and we applied Principal Coordinates Analysis (*PCoA*; Gower 1966) in or-

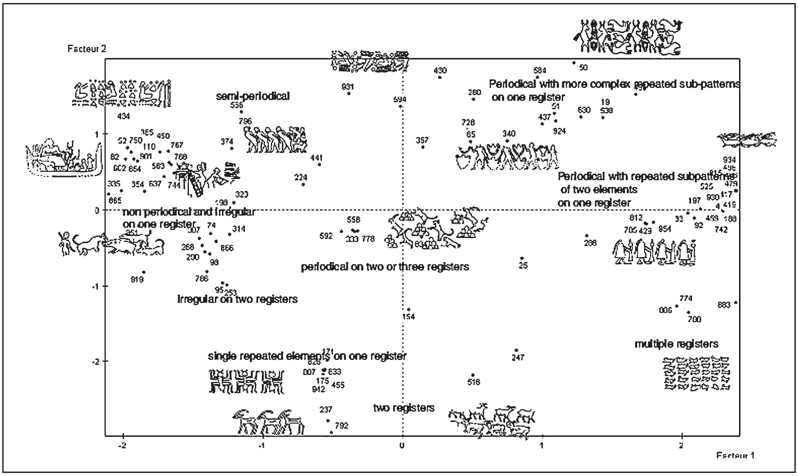


Fig. 6 – The scatter of seal images on the plane spanned by the first two axes of PCoA on the distance matrix given by the newly proposed weighing procedure.

der to check which features of the images appear as significant on the first, most important axes. In fact, *PCoA*, like the other exploratory analyses based on the eigenanalysis, returns a geometrical representation of the units (in our case, the seals) in several dimensions. Since the returned dimensions are given in decreasing order of importance, one can evaluate the importance of the different features, according to their appearance on the different axes of the graphical scatter diagrams. Below, we comment briefly on the results of one of the first experiments, using the same basic weights used in the previous trials.

In this case, the first three axes of *PCoA* summarized over half of the total dispersion of the images, so that attention could be limited for the moment to these three dimension, and in particular to the scatter graphics of the first two axes (Fig. 6). In this one, the first (horizontal) axis outlines the difference among periodic images on the right side and non-periodic on the left; the second (vertical) axis outlines the difference among images with only one register (above) and with two or more (below). As a matter of fact, this distinction seems even more clear on the third axis which is not represented here.

Based on this scatter, the following groups of seals can be distinguished: the irregular and non-periodical on one register on the extreme left, above and to the centre; the same on several registers, a little below; then, on the higher side of the plane, from left to right: semi-periodical seals on one register, periodical seals on one register composed by complex sub-patterns, composed of three or more elements; periodical seals on one register composed of simple two-element sub-patterns, on the right. The periodical seals on two or more registers are close to the origin. Finally, on the bottom, there are the seals with only one register with the repetition of a single element, on the left; those on two registers near to the centre, those on two registers, while those on multiple registers are on the right.

Conclusions

Compared with the results of the procedure proposed by Camiz *et al.* (1998, 2003), the idea of modelling the archaeologist's reasoning seems to give better results, since the distinction among the different image patterns of the image is better defined. Nevertheless, the weighting system should be improved, albeit in the previous essays the procedure turned out to be robust enough in respect to the weight variation.

With respect to the previous experiments, in this study the importance of the archaeologist's thinking is much greater, since with the textual coding his/her role was limited to just the coding, whereas in the bottom-up procedure he was responsible for the weighting system. Now, however, the entire procedure is modelled according to his reasoning. Of course, this reflects the complexity of the problem being considered.

Considering the different types of coding used so far, we think that an integrated approach could be forecast for the future. In fact, we proceeded according to several levels of abstraction (the elements, the sub-patterns, the syntax, and the skeleton) so that one can consider the utility of coding the seals by means of a textual coding that could be easily, perhaps automatically, transformed into the different types of coding required for the other treatments and this would facilitate investigation of the relations among the different elements or the sub-patterns composing the images and the syntax.

Acknowledgements

This paper is based on an article by the authors written for the Computer Applications and Quantitative Methods in Archaeology 2004 meeting, held in Prato, and originally prepared for the meeting proceedings, which have not yet been published. The work was done thanks to grants given by the Faculty of Architecture and by the CNR (last grant CNRC00D101_001). The grants of both institutions are gratefully acknowledged.

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Unsupervised and supervised classifications of Egyptian scarabs based on the qualitative characters of typology

Introduction

Egyptian scarabs with the name of Thutmosis III (Menkheperra, Fig. 1) engraved on the bottom were produced for centuries, so that the dating of examples of unknown provenance cannot be based on the presence of the Pharaoh's name and for this reason dating must be based on different criteria. In her *MA* thesis, Andrenucci (1996) raised this problem and showed a possible solution, based on Jaeger (1982) dating criteria: she defined a special coding of the details carved on the scarab shape, and used a weighted clustering technique that seemed to give acceptable results.

Notwithstanding the quality of the results, the procedure used seems too arbitrary, both in some aspects of the coding and in the clustering technique. In particular, the latter uses the numerical coding of the non-ordered different modalities of each character without any justification of this choice. As a consequence, the clustering model, albeit apparently effective, does not help to explain the difference in the scarab features over time, nor can this technique be applied to other corpora. For this reason, on the occasion of Sara Venditti's (2003) *MA* thesis, we decided to follow a different pathway, aimed at investigating to what extent the Jaeger (1982) dating could be estimated based on the Andrenucci (1996) coding of the morphological characters, and to define some classification functions that could be used to date scarabs with unknown dating.

Our procedure is based on exploratory data analysis techniques, which include some confirmatory procedures, used in order to validate the data suggested by the explorations. The results seem in some respects contradictory, as will be discussed in the last section.

Data and analysis methods

The corpus of scarabs studied by Andrenucci (1996) is composed of 80 Menkheperra scarabs of known date and 90 scarabs with the names of other pharaohs of the same period. For the coding, Andrenucci referred to the previous attempts at coding (Rowe 1936; Martin 1971; Ward 1978; Jaeger 1982; Tufnell 1984) and chose 22 different features of the scarabs, such as the shape and the height of the head, the shape of the eyes, the kind of paws, etc. Each of them was coded according to 4 to 8 different modalities of carving. As an example, the scarab's eyes, shown in Fig. 2 are coded as: 1) no eyes, 2) single inner, 3) single outer, 4) double inner, 5) double outer, 6) other, 7) not coded.

As for the 170 scarabs with known dating, five different periods were taken into account for 146 scarabs that Jaeger dated, according to his criteria: 1) Thutmosis

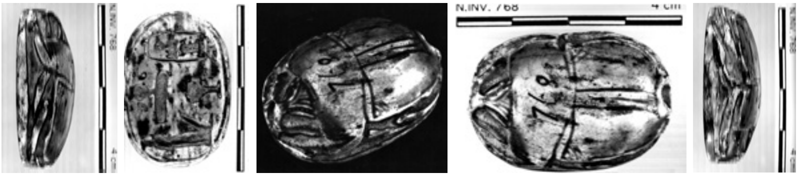

Fig. 1 – Scarab 798 of the Archaeological Museum of Florence.

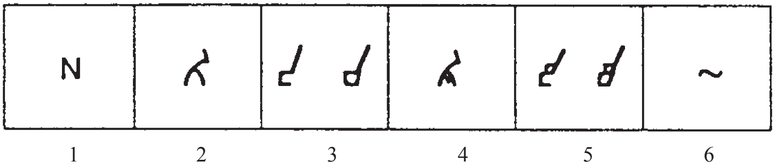

Fig. 2 – The coding of the eyes of the scarabs, as coded by Andrenucci 1996.

III (17 scarabs); XVIII dynasty (38); Ramessid period (59); III intermediate period (17); Late period (15). Another 24 scarabs had a less precise estimated dating, including a span of time longer than one of the said periods, so that they were given a special coding.

Unlike Andrenucci, who used the qualitative coding assigned to the modalities as if it were quantitative, we dealt with the problem by using the qualitative characters as a discriminant. This is not a classical technique, since classical discriminant analysis can be applied only to quantitative characters. We then decided to rely first on exploratory data analysis techniques that could give us an idea of the relationship between the characters and the time periods.

To see if any factor could be associated with diachronic evolution, Multiple Correspondence Analyses (*MCA*; Lebart *et al.* 1995) was used, followed by an Ascendant Hierarchical Classification (*AHC*; Gordon 1999) based on the first three interpreted factors and built considering the Ward method on Euclidean distances among units; as a stopping rule we used the one proposed by Kalinski and Harabász (*ibid.*). In fact, the time periods were projected on the axes as supplemental elements.

In order to check if the position of the time periods was significant on some factor, we tested if their coordinates were significantly different from zero, under the null hypothesis of random distribution. We also tested if any modality was typical of one period: by *typical* we mean that the frequency of a modality in a group of units is significantly higher or lower than the frequency expected by the hypergeometrical law, which is the law that rules the presence of k objects of one kind out of n randomly extracted, if in the population of N objects there are K of that kind. As significance level, the usual 5% of probability was chosen. The same test was used to check if any period could be typical for the groups built by the *AHC*.

To proceed further in the process of classification, we applied two different techniques: a *Segmentation* (Celeux and Nakache 1994), aimed at creating a decision tree, based on the modalities of the characters, in order to correctly attribute the scarabs to a particular period, and a Qualitative Discriminant Analysis (*QDA*; Saporta 1975), aimed at identifying classification functions, and able to automatically assign the scarabs to the appropriate period.

The rationale of the two methods is different: the segmentation aims at enabling the attribution of a unit to a class based on a set of binary rules forming a binary tree, such as *"If a unit has the modalities ai, ah, ..., ar of the character A, then it is likely to belong to the classes bj, bk, ..., bs of B, else to any other one"*. Consequently, to each rule two classes partitioning an already existing one are associated. These rules are found iteratively as those that minimise the risk of errors in attribution of a unit to the wrong class. The Discriminant Analysis (*DA*; Romeder 1973, Hand 1981) aims at providing linear classification functions, one for each class. In order to build these functions, discriminant analysis represents the units in a special Euclidean space, whose coordinate orthogonal axes optimally separate the classes, so that each class centroid (the point whose coordinates are the average of the coordinates of the units belonging to the class) is furthest from all other class centroids. In these spaces, the Euclidean distances of each unit to all class centroids are calculated and the units can be attributed to the class whose centroid is nearest. This could also be transformed into a probability, so that the units are attributed to the class whose classification function is highest.

It is clear that *DA* is not suited for qualitative characters, such as the shapes of the segments carved on the scarabs. To overcome this problem, we applied the *QDA*, developed by Saporta (1975). It is based on the principle that a qualitative data table can be completely rebuilt using all factors of its *MCA*. Thus, in *QDA*, *DA* is applied to the *MCA* factors, giving the representation of the units on discriminant factors and the classification functions are then transformed using the relations among factors and the modalities of the characters, in order to allow a classification based on the 22 modalities of characters.

For the segmentation, the *CART* method (Breiman *et al.* 1984, Celeux and Nakache 1994) was used. This method builds a binary tree so that at each step a binary partition of a group is made according to one character, and the two classes created are more homogeneous: in other words, the group is split so that all units with certain modalities are in one class and all the others are in another. The iterative process stops when no further partition is possible. Subsequently, a sub-tree may be suppressed if it does not give sufficient information, thus producing an optimal or sub-optimal tree. In order to experiment *QDA* efficiency, we tried using different criteria to build classification functions, in particular reducing the number of characters, since reducing the number of extracted factors could not be easily used or interpreted. The first discriminant analysis took into account all factors extracted by *MCA* performed on all characters. In the following analysis, the characters were reduced according to the significance of their contribution either to the increase of the chi-square or the cumulate Tchuprow coefficient (Saporta 1990), a transformation of the chi-square, ranging from zero to one.

Most computations were done using *SPAD* package, release 4 (Lebart *et al.* 1999); only *QDA* was performed with the specific program *DISMOD* (courtesy of Claude Langrand).

The results

After some experimentation, the most interesting *MCA* was performed considering active all the characters describing the typology, removing only the modalities absent or present in just one scarab, and only the scarabs with a known dating period. In this analysis the first factor accounted for 60% of the total variation (re-evaluated according to Benzécri 1979), the first three summarise over 76%: this can be considered a very good performance. Along the first factor (Fig. 3), most characters show a regular pattern, with a slight Guttman effect that bends both the modality pattern and the units in an arch shape (Fig. 4). As a result, one can consider the first coordinate of each modality as an optimal coding for a uni-dimensional coding of the modalities. We will not attempt any tentative interpretation of the second axis here, since the Guttman effect would create a continuous uni-dimensional variation of the carving style of the scarabs, that could be attributed to evolution over time. Unfortunately, the periods on the plane of the first two factors (Fig. 5) show an irregular pattern: the first two periods are on the right side of the first factor and the other three on the left one, but on each side the order of the periods is not consistent, so that one may wonder to what extent the different periods are effectively described.

In fact, the hierarchical classification confirms these doubts. If we consider the partition into six classes as the most suitable, the classes can be characterised as follows, on the basis of the shape of the carvings:

Class 1 (25 scarabs): well separated head and tail, very well carved paws, rounded side profile, V-shaped side callosities, very curved back with backwards unbalanced profile; half of these scarabs were dated to the XVIII dynasty.

Class 2 (24 scarabs): not well separated head and tail, V-shaped incision on shoulder callosities.

Class 3 (27 scarabs): inner eye-sockets, double inner eye, round head, V-shaped incision on shoulder callosities, well outlined paws, well separated head, semicircular outline of the top of the head, rounded convex division between forehead and clypeus, horn represented by two vertical lines; a quarter of them were dated to the Thutmosis III period.

Class 4 (28 scarabs): round head, average curved back, rounded concave division between forehead and clypeus, no incision on shoulder callosities; 28% of these scarabs belong to the Late period.

Class 5 (46 scarabs): head and tail attached to the basis, flat back with many carvings, trapezoidal head, no eyes nor orbits, no carvings on shoulder callosities, no incisions to represent the horn, straight jaws, straight side profile; half of these scarabs belong to the Ramessid period.

Class 6 (20 scarabs): head and tail attached to the basis, trapezoidal head, no distinction between chest and elytron, single curved incision on shoulder callosities, straight side profile, straight jaw edges, flat back with forward unbalanced profile.

The convex hulls of the classes are represented as a contour of the scarabs belonging to it. In each class, the image of the scarab closest to the centroid is represented, thus giving an idea of the style of the scarabs of the class. Apparently, the relations with the

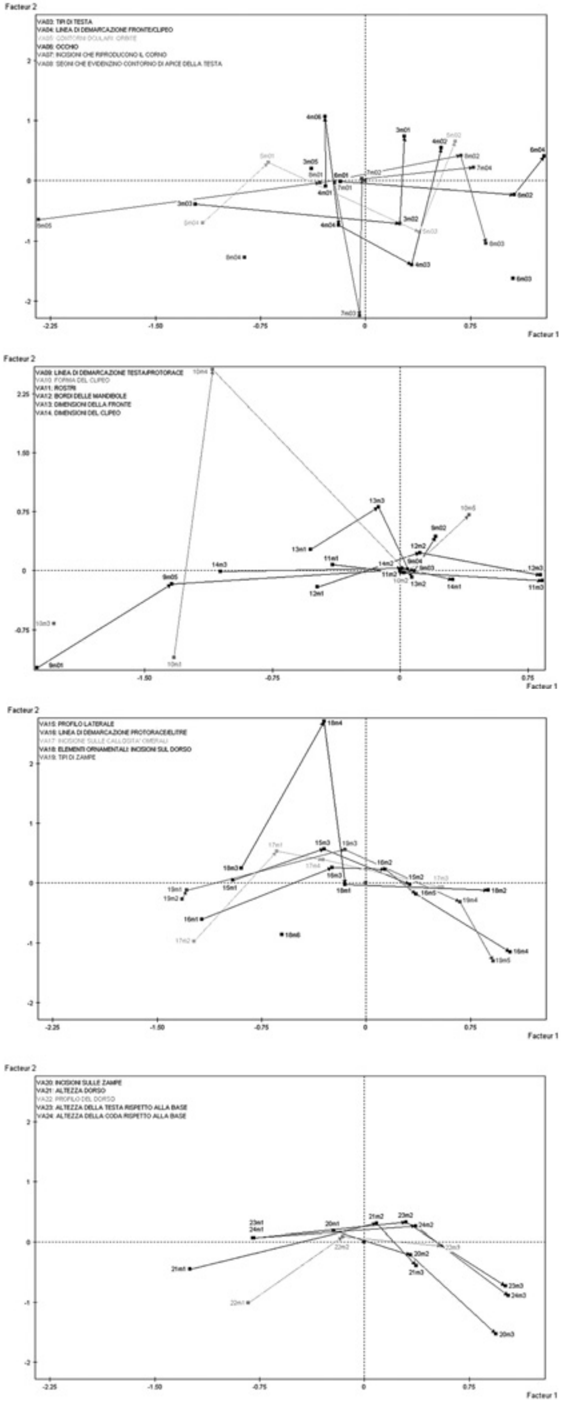

Fig. 3 – The pattern of the 22 characters on the plane of the first two factors of Multiple Correspondence Analysis.

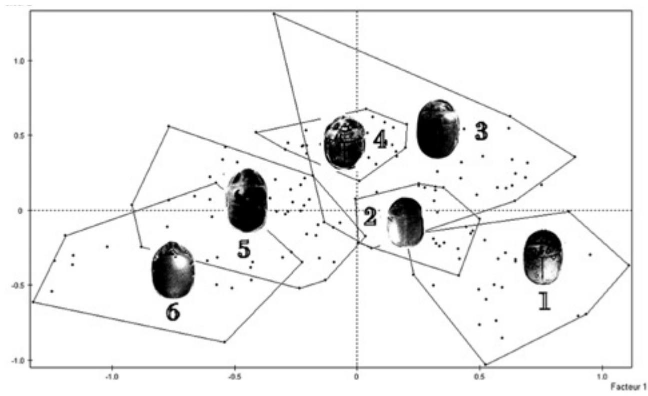

Fig. 4 – The pattern of scarabs on the first plane of MCA, with class contours and most typical scarabs.

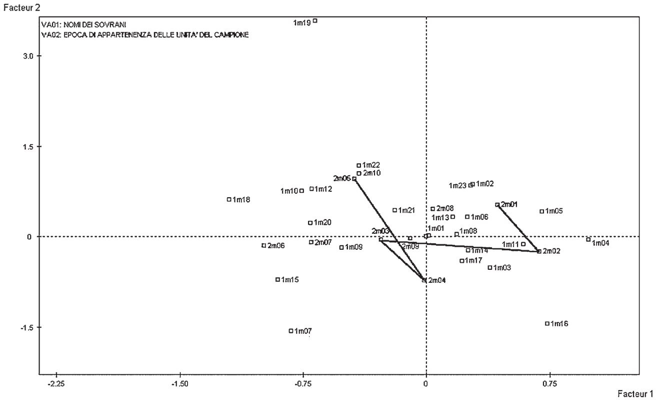

Fig. 5. The trajectory of the time periods on the first plane of MCA.

suggested dates are not very strong. This is confirmed by the period characterisations on the basis of the shape and carving features, which give the following results:

Thutmosis III (17 scarabs): orbits inside the head.

XVIII dynasty (38 scarabs): head and tail well separated from the basis, well carved paws, V-shaped incision on shoulder callosities, backwards unbalanced back, rounded side profile, rounded convex division between forehead and clypeus.

Ramessid period (59 scarabs): tail attached to the basis.

III intermediate period (17 scarabs): no typical characters.

Late period (15 scarabs): no carving on shoulder callosities.

It is clear that, based on these few modalities, one cannot expect to get a reliable dating of the undated scarabs. In fact, the following analyses, segmentation and *QDA,* reflect this problem. Both were performed only on the 146 scarabs whose date was known.

Attributed	29 segments: 82.19% (41.70%)						37 segments 86.30% (37.67%)				
Original	1	2	3	4	5	Original	1	2	3	4	5
1	12	3	2	0	0	1	12	3	2	0	0
2	2	33	2	1	0	2	2	33	2	1	0
3	0	3	55	0	1	3	0	3	55	0	1
4	1	1	3	12	0	4	1	2	2	13	0
5	0	0	7	0	8	5	0	0	2	0	13

Table 1 - The attributions of the scarabs according to two possible segmentations of the scarabs.

Attributed by 4)						Attributed by 1)					
Original	1	2	3	4	5	Original	1	2	3	4	5
1	11	2	2	1	1	1	13	3	1	0	0
2	4	29	3	0	2	2	4	31	2	1	0
3	7	6	35	6	5	3	6	3	45	2	3
4	2	3	1	11	0	4	1	1	0	15	0
5	1	0	3	1	10	5	0	0	1	0	14

Table 2 - The attributions of the scarabs according to two qualitative discriminant analyses.

The default use of segmentation procedure, as described by *SPAD*, suggests limiting its use to only two terminal segments, that consequently could not distinguish more than two classes, namely the *XVIII dynasty* and the *Ramessid period*, according to whether the tail was raised or not on the base. In this case, the percentage of accurate attributions is quite low: 47.26%. We then decided to raise the number of segments to 29 and 37, obtaining much higher percentages of correctly placed items, 82.19 and 86.30% (Table 1), but at the cost of a very complicated set of rules.

These results must be compared with those of *QDA*. In this case, two indices can give information on the quality of the analysis: the chi-square of the reconstruction of the table based on the first *MCA* factors, and the cumulate Tchuprow coefficient. The first one can be used to reduce the dimension of the factor solution, since one can drop the factors that do not contribute significantly to the increase of the chi-square of the rebuilt table. The cumulate Tchuprow coefficient informs us about the relationship between the characters to be explained and the set of characters used to explain it. Indeed, it increases as new explicative characters are taken into account, according to the increase in information due to the introduction of a new character. Thus, sorting the characters in the decreasing order of Tchuprow coefficient, we tried to reduce the number of characters involved according to the maximum number of characters with significant chi-square, or to over 99% or 95% of the total cumulate Tchuprow coefficient. Instead, the attempt in each analysis to reduce the number of factors limiting them to those greater than the average, as suggested by Benzécri (1979) turned out to be very difficult to use, due to limitations in the software. Thus, the four different *QDA* performed were the following, with the given percentage of correctly classified items:

1) all 22 characters: 62 factors, correctly classified = 80.82%;
2) only 17 (significant chi-square): 49 factors, correctly classified = 73.97%;
3) 16 (99.39% of cum. Tschuprow coef.): 47 factors, correctly classified = 71.23%;
4) 10 (95.71% of cum. Tschuprow coef.): 30 factors, correctly classified = 65.75%.

In Table 2 the attributions of the scarabs are shown, according to the worst *QDA* (4) and the best one (1). This gives results similar to the worst segmentation. In all cases, the interpretation of the results, in terms of the style of the scarabs according to the period, seems very difficult to obtain.

Conclusions

The attempt to use qualitative segmentation and discriminant analysis as tools for the dating of the scarabs, based on a very classical coding and on suitable analysis tools, gave good results, but were very difficult to interpret, due to the great number of modalities and characters involved. It is a pity that a quantitative comparison with the results of Andrenucci (1996) is not possible, since no information is given on the correct attributions of her method.

Considering the analysis methods, we think that further investigation on the segmentation techniques could be helpful in the quest for a better procedure. Concerning *QDA*, it is clear that a better synergy of *MCA* and *QDA* should be implemented. In fact, in *DISMOD* the underlying *MCA* is only a tool for the discrimination, and all interpretation aids included in the specialised software are not present. This is a drawback, since facilities like the selection of the modalities, the information on the contributions of both modalities and units to the factors, the re-evaluation of eigenvalues, etc., all of which permit a more accurate selection of both the characters and factors to be taken into account, could greatly improve the selection of a more parsimonious discriminant model.

In any case, some final comments can be made. We think that the coding, as proposed by Andrenucci, is quite adequate for the description of the scarab style. On the other hand, since at first sight the idea of a seriation of the scarabs according to the diacronic style evolution seems effective, one may wonder if the dating of the scarabs, based on Jaeger criteria, was reliable. This could be checked by looking at the scarabs, but even if we had pictures of them, we are not sure that we could complete the task effectively. Supposing that the given dating is reliable, then one could think that the style variation might depend on other factors that could be profitably investigated. As we are not specialists in scarabs, or even in Egyptology, we cannot imagine being able to answer these questions. For this task, a specialist is needed and his advice would be gratefully accepted, as well as any assistance in interpreting our results and cooperation in furthering our investigation of the subject.

Acknowledgements

This article is based on the paper presented by the authors at the Computer Applications and Quantitative Methods in Archaeology 2004 meeting, held in Prato, and originally prepared for the meeting proceedings, which have not yet been published. The research was conducted thanks to grants issued by the Faculty of Architecture and by the CNR (last grant CNRC00D101_001). The scarab data were given to us by Sara Andrenucci, the *DISMOD* program was given to us by Claude Langrand, the scarab images were found by Eleonora Ferrazza. Their valuable contributions are gratefully acknowledged.

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New approaches to scientific archaeological data communication: the “Museo Narrante” of the Foce Sele Hera Sanctuary

Introduction

This paper deals with new solutions for the musealization of scientific archaeological data and their divulgation to the general public, focusing on the case study of the Foce Sele Hera Sanctuary “Museo Narrante”.

The key-concept of this initiative is that a correct archaeological museum should inform people not only about the final theories of scientists and experts, but also on the data and reasoning on which those ideas are based. This concept is even more important when communicating archaeological data for which there is no general agreement in interpretation among scholars. The idea of communicating one century of archaeological investigations at the Foce Sele Hera Sanctuary, and placing the new data from the recent excavations in the context of this research was the main reason for the institution of a new museum in the Paestum area, the Museo Narrante of Foce Sele Hera Sanctuary. It should be noted that the Paestum National Archaeological Museum already displays the findings from the old excavations, so that in instituting a new museum, the “museological” approach had to be completely different and perfectly integrated with the traditional system of display and information.

The new museum is conceived as a “Museo Narrante”, i.e. a museum that tells stories. It is a “museum without objects”. The focus of the exhibition is information and it is presented in new ways: interactive, multi-sensorial, multi-medial and tailored to the particular scientific archaeological data which it intends to communicate. This paper will analyze a few of the case studies conducted in order to follow this methodological scientific archaeological communication approach.

Scientific archaeological communication beyond hypermedia: case studies of solutions tailored to particular cultural concepts

1st case study: the second room. The research: voice, movies, reconstructions

The **second room** of the museum is dedicated to the history of the archaeological investigation of the site, and visitors enter it after viewing a first room dedicated to descriptions of the discovery and the territory, which acts as a kind of reception room for visitors.

The excavations of the Hera Sanctuary were conducted for almost a century, in different phases, starting with the discovery by Paola Zancani Montuoro and Umberto Zanotti Bianco, followed by the mid-century studies, and finally, the recent excavations. The continuous explorations brought about a series of changes in the interpretations of some of the findings: for example, it is well known that the interpretation of the metopes, the reconstruction of their original meaning and the hypothesis related to their placement changed as the archaeological discoveries brought to light new pieces of the frieze and new data on the original measurements of the buildings of the sanctuary hypothetically related to the metopes. The whole research history of the sanctuary area is a complex report that is important to communicate to the public in order to show the evolution and the process of the construction of our knowledge of the past, but using a traditional display it is difficult to describe the development of the various steps, and for this reason a new approach was developed.

As a result, the room is equipped with two displays mounted side by side. Visitors listen to a voice telling the story of the excavations, while the two screens show a reconstruction of the first and the second phase of the excavation and present a review of the scientific archaeological data collected. In selected parts of the narration the two displays act as an extended monitor, to emphasize the transitions from one phase to the next by shifting screens. To complete the cognitive experience, a third display is placed on the floor, at the visitors' feet: while the narration goes on, it shows a movie that simulates the actual excavation, with the different layers of terrain removed step by step, and the discovery of the main finds. The various media used are synchronized in order to create a total information environment. In this way the room shows visitors simultaneously archaeological field work, the history and the reasons for the different excavations phases, and the process and difficulties in data interpretation as new information is discovered.

2nd case study: the fourth room. The Sanctuary: 3D models, the reliability issue

The **fourth room** aims at communicating to the public the history of the sanctuary throughout the different chronological phases of its existence. Today it is difficult for the visitor to imagine the sanctuary by visiting the archaeological site because the remains are not completely visible nor are they self-explanatory. A 3D model of the whole sanctuary was created and is presented to the public by a multimedia interactive totem equipped with 4 interacting points, that correspond to the four views of the sanctuary (North, South, East, West), and their changes in the various phases of frequentation of the place: a customized touch-keyboard makes it possible to switch to the different time-line steps. The 3D reconstruction presented is based on scientific data, both archaeological and palaeo-botanic. Indeed, the visitor is offered not only the possibility of seeing the reconstruction of various buildings but he can interact with the whole sanctuary, rebuilt with its sacred garden. The Hera garden plays an important role in the cult of the goddess, so it was important to describe the general appearance of the vegetation of the place when it was frequented. The palaeo-botanic analyses give exact information on the floral species represented in the sanctuary so it was possible to show a scientific reconstruction of the Foce Sele Hera Garden.

Furthermore the 3D model fulfils other requirements typical of modern trends in Virtual Archaeology: communication of different levels of reliability of the proposed reconstructions. The metaphor chosen to communicate uncertainty is the

Figs. 1-3 – The “Museo Narrante” of the Foce Sele Hera Sanctuary: 3D models and the fifth room.

transparent texture used for the walls of the buildings for which the reconstruction is not sure. In particular, new excavations demonstrated that the dimensions of the so-called Thesauròs do not fit the estimated measurements of the whole metope frieze, as had been supposed in the past without archaeological support. Furthermore, new data give no evidence of a ceiling or covering of the building. Consequently, the building traditionally indicated as "Thesauròs" (with a definition which was not considered definitive even by the first discoverers) is represented in the 3D model with a transparent texture, communicating uncertainty and at the same time somehow attracting the attention of visitors to its unfinished, ongoing and fascinating research history. In this room the informative environment is completed by other communication media as well: the history of the various hypotheses is described to visitors on panels, together with the related archaeological data on which they were based and proposed, in order to let people understand the process of reconstruction of the past and eventually inducing them to create their own opinion.

3rd case study: the fifth room. The metopes

The **fifth room** is dedicated to the Foce Sele metopes, parts of a frieze that has been reconstructed in various ways by scholars.

The archaeological reconstruction of the figurative complex has been discussed since the first discovery and further complicated by the subsequent finds of additional metopes in later excavations. The debate on the reconstruction of the so-called Thesauros and of the other buildings in the sanctuary, proposed because their decoration appears to be pertinent, creates a further difficulty in the final reconstruction of the original meaning and placement of the metopes. This intricate situation makes the exposition of a single reconstruction of the frieze something not only difficult, but, to some extent, scientifically wrong. Consequently, it was necessary to move on to a different method to communicate the information available on the metopes, by proposing a distinctive reading approach. First of all a semantic matrix was created, to analyse the different interpretations of the metopes according to 1- different scholars; 2- different mythological cycles. The semantic matrix was the methodological background for the proposal of a revolutionary exposition of the metopes, of their interpretations and of the history of their study.

The exposition focuses on casts of the metopes, made of a very light-weight material (it should be mentioned once again that the original metopes are displayed in the National Museum in a historical museological context, which is important in itself, so it was neither possible nor useful to move the original stone metopes from the traditional exhibition). The casts were suspended from the ceiling of an almost round room. Visitors stand at the centre of the room. At the beginning of the visit a voice starts to tell the stories of the mythological cycles represented by the metopes. Different spot-lights illuminate only the metopes that can be interpreted according to the particular myth that is being narrated. In this way, a metope can be illuminated as many times as the interpretations it has according to the different myths. Furthermore, a movie, synchronized with the voice and the spot-lights, enhances the narration, offering the visitor additional iconographic material to explain the myths being narrated.

The "Museo Narrante": a new concept of scientific communication. Can customized solutions be modular and exportable?

The solutions presented here share the concept of customizing an exhibition strategy to a specific archaeological problem to be communicated and, at the same time, to offer the visitors not only the results of scientific research but also the archaeological data and the reasoning on those data, in this way stimulating people to think about their past and to form their own opinions about it.

The experience gained during the few years of activity of the Museum shows a successful impact on the public, that encourages us to consider the possibility of applying the "Sele method" to other case studies. Even the exposition proposed here is conceived as ongoing and not definitive, as new solutions will be used to communicate new data as they are collected by the archaeologists conducting research at the Foce Sele Hera Sanctuary.

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Credits

Soprintendenza per i Beni Archeologici delle Province di Salerno, Avellino e Benevento
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