Andrea Marraffa
Andrea Marraffa: Ph.D. e Doctor Europeus at the 'Mediterranean' University of Studies of R. Calabria. Winner of the 'De Fiore 2017' award for the best ICAR/17 doctoral thesis. He has collaborated with important European research centers (CNRS of Lyon, Marseille and Paris) and since March '20, he has been working with the company Naos Consulting s.r.l., dealing with 3d modeling and photogrammetry.

Francesca Fatta
Architect and PhD, she is full professor of SSD ICAR / 17 at the Department of Architecture and Territory of the Mediterranean University of Reggio Calabria (Italy). She carries out research in the field of design, representation and communication for cultural heritage; Coordinator of the research doctorate in architecture and President of the UID Unione Italiana per il Disegno.

The digital anastylosis and the semantic segmentation: the case of the Magna Graecia masks in the Mediterranean area

Fifty years of archaeological activities carried out in the Aeolian Islands have made it possible to bring to light the most complete collection of theatrical masks of the ancient world, an important testimony of the material culture of the theatrical world, during the Classical era. The theatrical masks, preserved at the 'L. Bernabò Brea' of Lipari, may be schematized, from a morphological point of view, in three distinct degrees: 'whole masks', whole fragments and 'mute' fragments. The digital reconstruction and anastylosis workflow follow the same breakdown of these three degrees of status: they have been developed through an inverted pyramid trend, in a scalar and hierarchical way. The universality of the method makes it repeatable and universally applicable to other archaeological finds belonging to a proto-industrial and serial artisan production.
The research aims to define a series of methodologies and techniques to be adopted for the direct survey of archaeological artefacts in fragments and for the definition of a reconstruction and digital anastylosis protocol, with the aim to restore a new memory to the so-called 'mute' finds. In order to clarify the genealogical and filiation relationships between the masks, a geometric grid of conspicuous points was identified on each digital model which allowed to rearrange the finds on the basis of their dimensional relationships and to advance, at the same time, a parallel hypothesis of segmentation and semantic annotation, it experimenting the most modern and innovative semantic annotation practices for the Cultural Heritage, in order to improve the understanding, the cataloging and enhancement of the historical data.

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1.   THE STATE OF THE ART

1.1   INTRODUCTION

Nowadays, the enhancement and the dissemination of Cultural Heritage (CH) are always more based on the use of new multimedia supports capable of making their use clearer and more immediate. However, many of the new modern electronic devices allow a type of dissemination that is still too passive and not very dynamic. The content of the cultural offer, in fact, is provided to the users through technologically means advanced, and also through some semantic codes still too tied to an old traditional kind communication. The 3D models of the ancient artifacts represent the most flexible and complete graphic supports for the documentation of the CH.

In fact, they provide a representation that is completely faithful to the original, thanks to reproductions metrically and geometrically detailed and realistic. However, beyond the visual documentation of the objects assets, it seems to be necessary also a clear and precise description, annotation e semantic segmentation of those models. In this brief essay, we will talk about the semantic description methodology applied to ancient theatrical masks, with the aim to define a complete workflow of information encoded in a single coordinated and coherent source. This methodology has been developed to combine a technological asset with an artisan character, allowing to obtain a new way for the documentation, enhancement and dissemination of the Cultural Heritage.

1.2   THE THEATRICAL TERRACOTTAS OF THE MAGNA GRAECIA CHOROPLASTY: THE CASE OF THE LIPARI MASKS

When we think to the ancient theater and the to the genres represented in it, whether referring to Tragedy, Comedy or Satyric Drama, it is impossible to imagine it without referring to the mask. In fact, it is an organic and priority element of the theater, fundamental for the materialization and manifestation of an unprecedented immaterial dialogue between a 'personal Ego and a so-called Other' [1] entity.

In the Mediterranean area, one of the most important and active centers in the coroplastic production of theatrical clay of the Magna Graecia period, was undoubtedly the island of Lipari. From the numerous urban necropolises and from the peri-urban landfill areas, an enormous quantity

Fig. 1 - Finds and fragments of masks of theatrical masks, Aeolian Regional Archaeological Museum of Lipari.

Fig. 2 - Point clouds of the mask of Dionysus or Apollo, by G. Tropea (2016).

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of theatrical (Fig. 1) clay artifacts emerged: they represent one of the most important direct testimonies for the knowledge of the scenic practices of the Greek world.

There are over a thousand pieces, including whole and fragmentary pieces, covering all genres of Greek theatrical production proper, from the Tragedy to the Ancient Comedy, passing from the Satyric Drama to the New Comedy of Aristophanes. In these exhibits the whole world of theater is present in its broadest sense[2] and starting from this artisan production it was possible to trace a stylistic and typological study, able to represent the evolution of all this production[3].

The collection covers around two and a half centuries of craftsmanship. The dating goes, in fact, from the first half of the 4th century BC. in the first half of the third century BC, that is a period in which the works of Sophocles and Euripides were still *in auge*. It probably had to be, on the one hand, either the celebration and lively expression of a well-rooted funerary cult, or, on the other, the testimony of centuries of tradition of the material culture of the theater.

This production included figured craters, theatrical statuettes, *pinakes* and, of course, many models of stage masks. As Vernant informs us, the cult of Dionysus expresses the official recognition, in Greece as in Magna Graecia, of a civic religion that 'in many respects escapes the city itself, contradicts it and surpasses it'[4], operating a sort of new theatricalization of the city itself.

Dionysus (Fig. 2), god of wine, of intoxication, god of the dithyramb and the *thìàsos*, god of theater, of the eternal beatitudes of the afterlife, perfectly embodies the so-called figure of the Other[5]: he is the mask *par excellence*.

1.3 THE PRODUCTION OF CLAY MASKS BETWEEN CRAFTSMANSHIP AND SERIALITY

The masks were, perhaps, obtained from two half shapes: one for the face and the other probably for the rear cap. During the subsequent stages of production, the masks were then painted with natural pigments, applied on a chalky base of white kaolin. of local origin. For the male masks (Fig. 3) a reddish, brown and relatively dark color was used (or sometimes the base color of the figulino was left), while for the female masks (Fig. 4) a lighter color was used, tending to pink. A second firing and the application of an enameled layer made the bare parts of the mask shine. Great attention was also given to the treatment of hair and beards, generally of a opaquer invoice. The latter, although they could be represented in a plastic way, were probably only remotely comparable to the

Fig. 3 - Comic male masks of *Pànchrestoi Neanìskoi*, 'the perfect young men'.

Fig. 4 - Comic female masks: *Etherai*.

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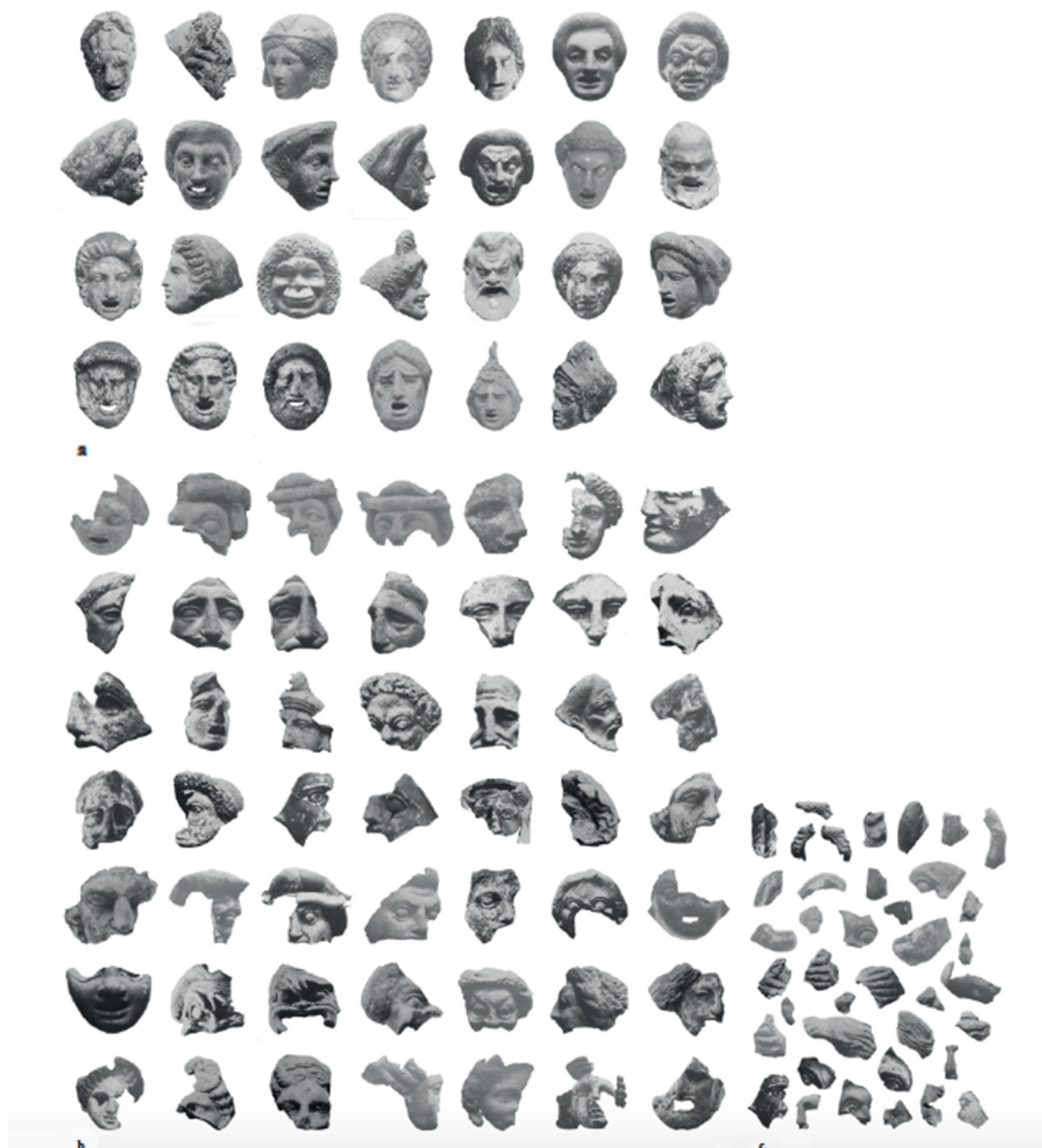
performance of the hair of real masks, for which soft textile materials and wigs were used, made with animal skins.

The archaeologist Luigi Bernabò Brea divides the masks into well-defined groups, according to their belonging to the genres of Tragedy, Ancient Comedy, Satyric Drama and New Comedy. They differ from each other in terms of size, use of materials, colors, stylistic and thematic evolutions. The result is a rich range of types and models, with masks ranging from very small sizes to specimens that almost reach full scale.

Fig. 5 - Female mask: *Pseudokòre*.

Fig. 6 - The three degrees of masks in the Lipari collection: (a) intact masks; (b) fragments of a whole; (c) simple or silent fragments, by A. Marraffa & F. Fatta, (2017).

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1.4 THE CATALOGING OF CLAY FINDS

The masks, all preserved at the Aeolian Regional Archaeological Museum 'L. Bernabò Brea ', have been divided and cataloged, with almost maniacal descriptive care, during the excavation campaigns starting from the '50s of the XX century. Bernabò Brea identified an initial classification by groups on the basis of three main factors: belonging to a specific genre, the dating, the artistic manufacture.

The first masks, the oldest ones, are those that belong to the tragic genre. They are just over twenty specimens of almost constant size and probably produced by a group of *skeuopòioi* belonging to a single shop. We begin to see, already from these finds, a first character connotation which better defines the typology and qualifies the character. In fact, the characters are immortalized, almost as if they were petrified by the gaze of the Medusa, in the moment of maximum climax of the drama. They have, in fact, the expressive traits concentrated and barred on the fatality[6], since the rhythm of the *nòmoi* followed by an ascent of the *pàthos*, thus revealing the moods of the characters and consequently accentuating the main plastic characters of the faces. Bernabò Brea tried to make these masks adhere to the dramatic plays of Aeschylus, Sophocles and Euripides.

At the beginning of the III BC and in the middle of the Hellenistic period, a clay production began to spread in Lipari which, for typological and technical reasons, was detached from the coroplastic production of the previous century. During this period, the choroplastic production began to spread in a very important way, in particular, thanks to the success of the genre of the New Menander' Comedy. It was characterized by a theatrical scene defined by standardized and recurring characters, places, spaces and times. In this genre, the intertwining and progress of the stories developed according to precise patterns and, this vision of events also reflected the staging of stereotyped (Fig. 5) and ever-present characters.

The masks of the New Menander' Comedy represent the large corpus in Lipari, consisting of

Fig. 7 - Automatic search for homologous points, (a) the *Etairika teleion,* and (c) the second *Etairikòn teleion,* (c) sparse point cloud, by A. Marraffa & F. Fatta, (2017).

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about three hundred and fifty specimens, which trace the types widely described by Pollux in the treatise of *Onomasticòn* and found almost slavishly by Luigi Bernabò Brea.

2. FOR A RESEARCH METHODOLOGY

2.1 THE FRAGMENT AND THE ENTIRE: FROM THE RECONSTRUCTION-INTEGRATION PROTOCOL TO THE SEMANTIC ANASTYLOSIS

The Research, starting from the precedent state of the art, has the aim to define some methodologies for the survey of the archeological fragmentary artifacts and to elaborate a protocol for their digital reconstruction and anastylosis.

The masks might be schematized in three different states (Fig. 6): the entire masks, the entire's fragments and the 'mute' or simple fragments. The protocol has a reversed pyramid framework, which from the generic parts goes to until the details. If, from a side, the artifact's integration and reconstruction workflows have been applied on the most representative finds, belonging to the all three genres of the dramaturgy - Tragedy, Ancient and New Comedy, Satiric Drama -, instead, from the other side, the anastylosis's pipeline was mainly focused on the New Comedy's masks. The subdivision in macro-groups (old men, young men, women, slaves, etc.) and in sub-groups, allowed to oriented the protocol of reconstruction towards those categories that present a higher number of samples. In particular, the workflow is articulated in: Photogrammetric survey (Fig. 7); Computing of the point clouds; Meshing; Analysis of the main geometries; Philological detailed study; 3D modeling and sculpting (Fig. 8); Texturing (Fig. 9).

2.2 BETWEEN DOCUMENTARY AND INTERPRETATIVE REPRESENTATION: THE SEMANTIC AND DIGITAL ANASTYLOSIS PROTOCOL OF THEATRICAL FINDS

The synthetic workflow presented in the previous paragraph refers, as we have already said, to whole masks and fragments of the whole. So far, however, nothing has been said about the methodological protocol to be used when dealing, no longer with whole fragments, but with so-called 'silent' fragments [7].

As we will see better in the development of the paragraph, the protocol develops through an inverted pyramid trend, in a scalar and hierarchical way. It starts from the universal and reduces the field more and more, tightening it towards a more specific aspect. The universality of the method makes it repeatable and applicable to every group, sub-group, type and sub-type of the specimens of the Liparota collection. The methodology was thought to answer to two specific purposes: giving a new voice to all those scraps artifacts and to all those 'mute' masks, inscribing them inside a wider dimensional and typological hierarchy; answering to the matter of the 'mute' fragments, by means of a semantic segmentation or description.

2.3 A REFERENCE GLOSSARY

Before presenting the various phases of the workflow, however, it is necessary to clarify the terminology of the nomenclature adopted. When we talk about clay masks, we often refer to groups, sub-groups, prototypes, types,

Fig. 8 - Steps of the organic sculpting modeling of a comic mask, *Pornoboskòs*, Blender, by A. Marraffa & F. Fatta, (2017).

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subtypes, series, matrices (Fig. 10). Taking up the inverted pyramid scheme - from the universal to the particular - the first term that appears, when dealing with specimens deriving from a coroplastic production, is that of 'group'. A group is defined as that particular category, in which 'all the works attributable to the same craftsman, to the same workshop, or in any case stylistically linked' are brought together'[8]. The term group implies the need to find common elements that allow, in fact, to group objects, certainly similar to each other, but each endowed with a profoundly different qualitative value. However, if used only with a typological value, the group can also indicate all those specimens connected by the same formal and distinct characters only on the basis of the most evident external characteristics.

As already mentioned, Bernabò Brea has identified, among the characters of the New Comedy, forty-four groups of masks, already extensively codified by Pollux and identifiable in well-defined and differentiated characters. The groups were, in turn, grouped into macro-groups, which identify the scenic devices based on the two characteristics of age and gender.

In Lipari, as we all know, there are masks depicting elderly characters, youth characters, servants, elderly women and young girls. These categories represent macro-groups [9] of terracottas. Each macro-group can be broken down into further sub-groups, in which the same characters appear, but with some very specific typological and stylistic variants.

As has already been explained in the previous paragraphs, the Lipari's choroplastic production was a proto-industrial one, with matrix and serial features, since all the finds derive from single or double molded matrices. Each matrix presupposes the presence of an original prototype-model, from which a 'series' or 'family' of masks begins. This model-prototype is also called, in jargon, archetype or patrice. The prototype represents the original creation, always positive, the starting point for the serial matrix production.
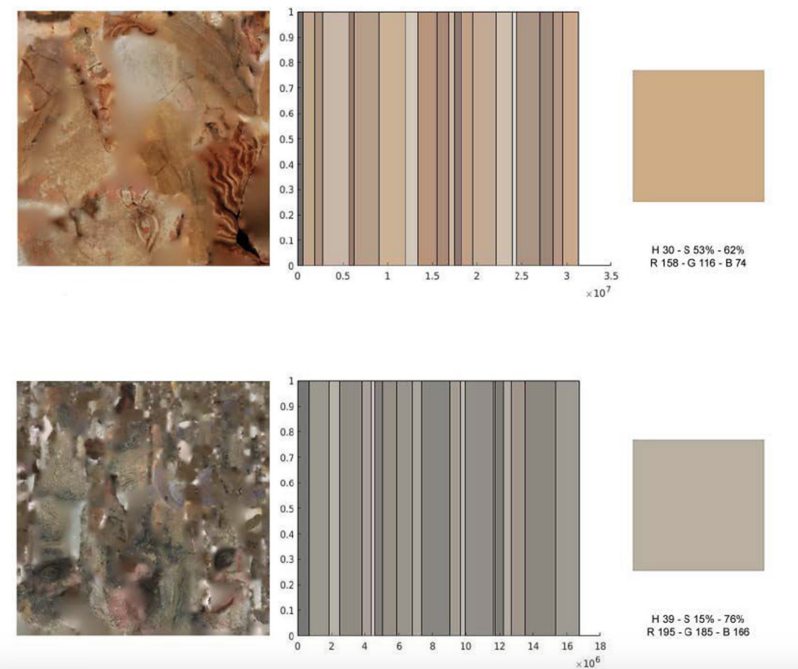

Fig. 9 - Example of the calculation of the color-master (average) for the criterion of the so-called neutral zone, MATLAB, A. Manuel & A. Marraffa, (2017).
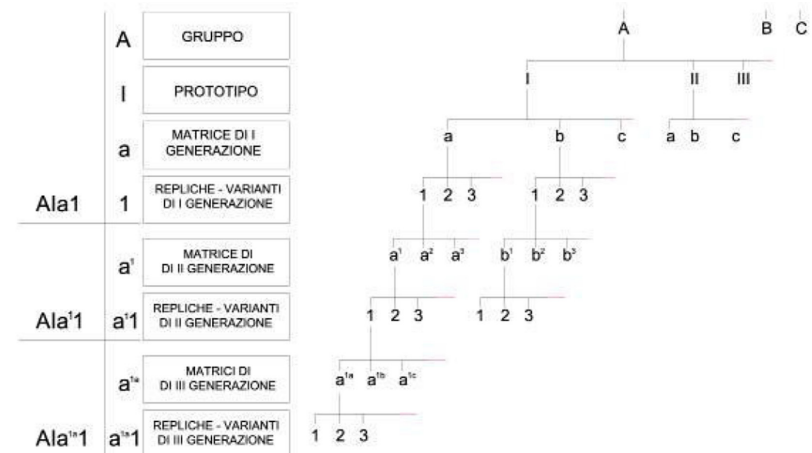

Fig. 10 - Hierarchical diagram of the coroplastic production, by M. Barra Bagnasco, (1986).

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2.4 THE FORMAL CHARACTERS OF THE MASKS OF THE 'YOUNG MEN'

The first phase of the work pipeline is represented by the redrawing (Fig. 11) of all 343 known and published so far, belonging exclusively to the New Comedy genre. The redesign of the masks was useful to understand how the masks relate to each other, from a graphic and morphological point of view. From this preliminary study, the main formal, stylistic and typological characteristics that unite and differentiate the finds emerged. Subsequently, a very specific group was isolated, that of young men [10] (Fig. 12). This group is represented in Lipari by eleven sub-groups, which are distinguished by the fact that they have precise physical characteristics, which help to explain, figuratively and morphologically, the psychological aspects of each character. The choice of this group was by no means accidental: the group of young men appears in Lipari with a greater frequency than all the other groups. Furthermore, it is the group that more than the others, lends itself to the reconstruction and anastylosis protocol, due to the great heterogeneity of specimens that it provides, among whole finds, fragments of whole and 'mute' fragments.

Once the group was identified, the field was then further narrowed, isolating within it, the third sub-group of masks, indicated, according to the classification of Bernabò Brea. This sub-group is called the 'Young with wavy hair' or '*oùlos neanìskos*'. According to Pollux, it must have been the youngest type of the entire category, characterized by a reddish skin, a thick mass of wavy hair, arranged in a crown, a medium round and short face, raised eyebrows, slightly asymmetrical and converging downwards. He is generally referred to as a bold young man with a strong, virtuous and confident character. This sub-group occurs in numerous specimens, among whole and fragmentary, very heterogeneous from each other on a dimensional and

Fig. 11 - The forty-four groups of the New Comedy, by A. Marraffa & F. Fatta, (2017).

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morphological basis. On the basis of slight var-
iations in detail, it is possible to further subdi-
vide the sub-group, into four sizes, distributed
over twenty-six specimens.

2.5 THE DESIGN OF THE RELATIVE PROTOTYPE
In order to define a universal and valid anastylosis
method for the entire sub-group, all known spec-
imens were analyzed and acquired, plus some
fragments never published. The masks, also de-
tected in this case by means of the digital photo-
grammetry method, include, as mentioned sev-
eral times, whole specimens (i), whole fragments
(f.i) and simple or 'mute' fragments (f.s.).
Once all the specimens have been detected - by
means of photogrammetry - and the metrological
data extraction operations have been performed,
all those typological characters considered to
be dominant, functional to the description of the
specimen, have been isolated. They are the topical
elements of recognition of the sub-group and can
be summarized in: cap / mass of hair; face oval;
eyes; nose; mouth (Fig. 13). At the same time as
this first rudimentary semantic segmentation of
primary characters, other measurement criteria
have been defined [11], functional to the geomet-
ric and morphological analysis of the conspicuous
points, or homologies, of each specimen. The ho-
mologies (Fig. 14) concern the main characters
common to all the specimens, found on each
painting, in the vertical and horizontal sense of
the *prosopòn*.
All the measurements extracted from the analy-
sis conducted on whole specimens and fragments
of the whole were, subsequently, reported on a
table. Then, the mathematical average of these
values was calculated. From this calculation, it
was possible to define a reticular-trace scheme,
within which we tried to relocate the main char-
acters of the masks (Fig. 15). For the four medi-
um-patterns, as many medium-sized masks were
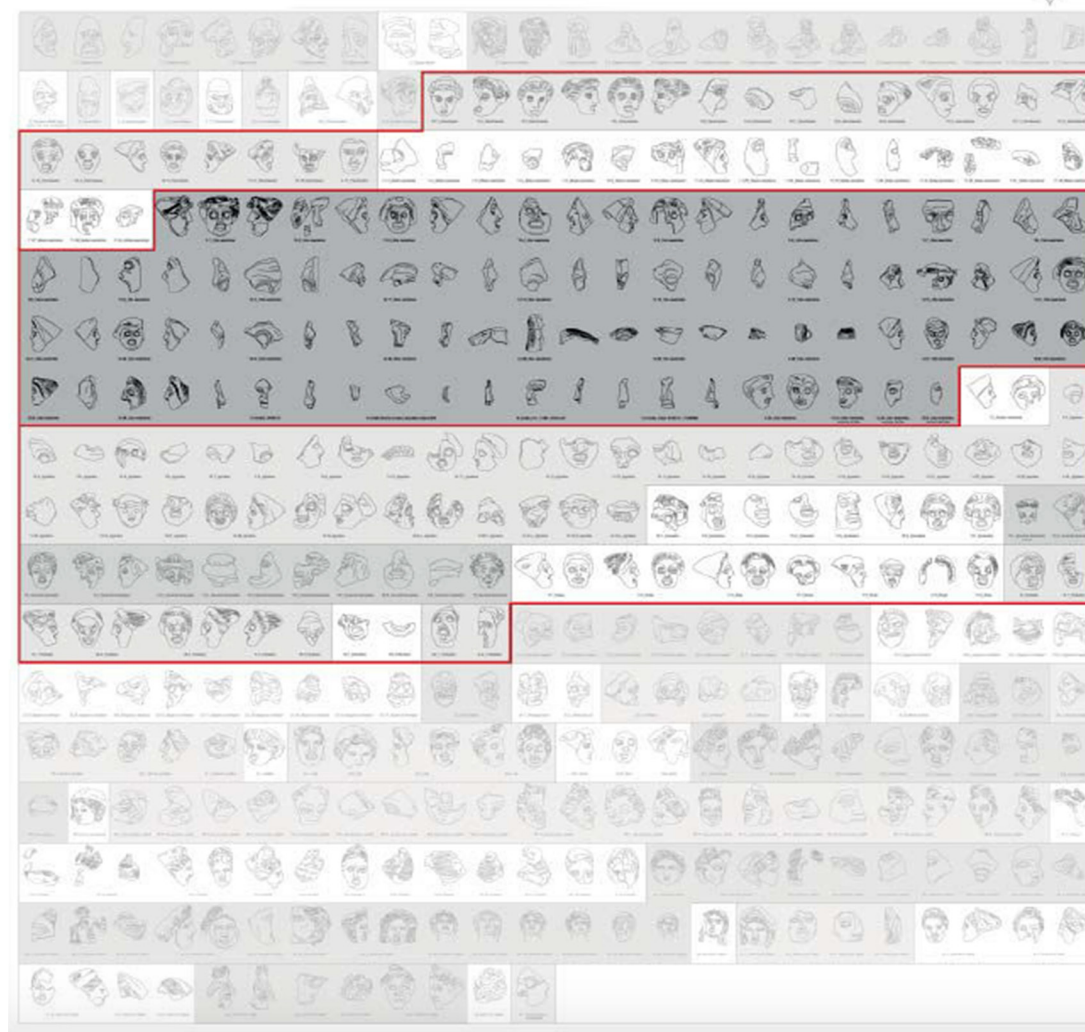created, which in fact do not exist in the Liparote

Fig. 12 - The youth macro-group is highlighted in red; in gray, the sub-group
n. 12, the 'Young man with wavy hair' by A. Marraffa & F. Fatta (2017).

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collection. These masks, called 'relative proto-types' to sub-group 12, are generic examples of masks, created ex novo. They contain, in practice, the average information of all the masks relating to each measure. The 'relative prototype' is a sort of passe-partout, a neutral or a generic one, and is the functional element to 'translate' and systematize all those so-called 'mute' fragments, for which the spatial and the reconstruction work. Following the digital modeling of the relative prototype, through anastylosis exercises it was possible to test the percentage of adhesion (Fig. 16) of each silent fragment with respect to its neutral reference prototype[12]. In particular, in the anastylosis exercises, operated manually through translation and rotation operations, the scale of the fragment remained the original one, while it was only and exclusively the scale of the relative prototype that changed.

2.6 GENEALOGICAL TREE AND GENETIC HISTORY OF THE MUTE FRAGMENTS

In order to rearrange the specimens with each other and in order to reconstruct the 'genetic history' of the archaeological finds, the dimensional relationships of the masks, relating to the second measure, were also studied. This made it possible to define the average reduction coefficients (ARC) or enlargement, which exist between one finding
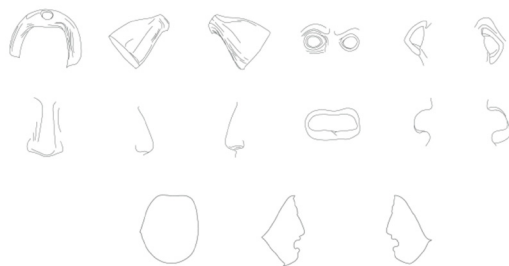

Fig. 13 - Segmentation of the main dominant typological characters: cap, eyes, nose, mouth, oval of the face, by A. Marraffa & F. Fatta (2017).
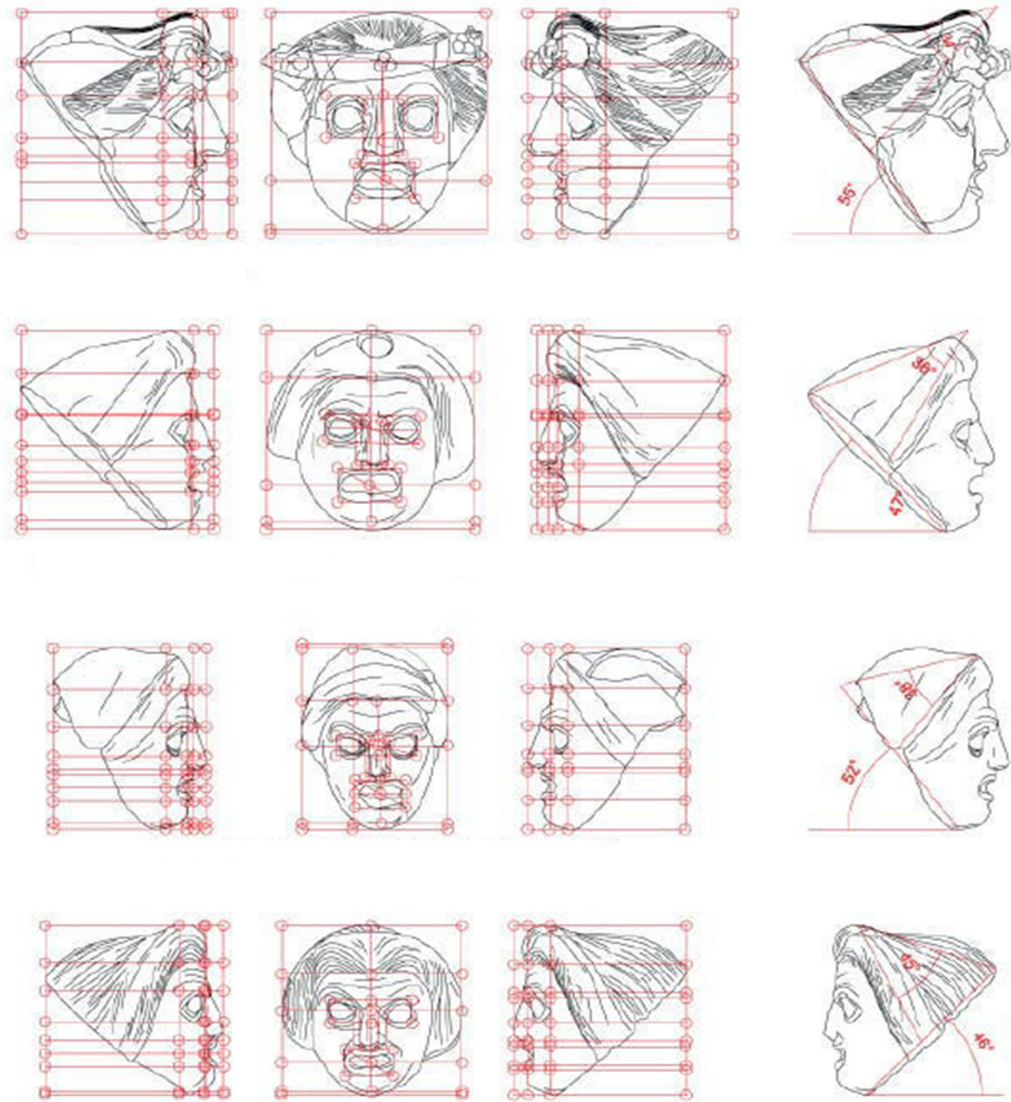

Fig. 14 - Measurement criteria on some of the most representative specimens of the first, second, third and fourth measure by A. Marraffa & F. Fatta, (2017).

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and another[13]. These values allow us to evaluate the finds in relation to the geometric 'deviation' (Fig. 17) that exists between different specimens, but belonging to the same family.

The scientific literature on the subject of choroplastic production attests that between finds belonging to a serial production with common characters, at least from the chronological and stylistic point of view, there is a very precise logical sequence of production. The finds, in fact, dialogue with each other on the basis of precise formal and dimensional relationships. In order to clarify the genealogical and filiation relationships between the masks, a triplet of conspicuous points was identified on each model, always found on the specimens of the second measure, whether they are whole, whole fragments and 'mute' fragments (once placed inside the relative prototype). These points are: the center of the forehead; the tip of the nose; the attachment of the neck. The union of these points allows to define the triangle formed by the vertices ABC. On this triangle, the center O was then indicated, corresponding to the geometric center of gravity of the exhibit. From the ratio of the n sides AB, BC and AC, of the triangles drawn on all the specimens of the second measure (ex. AB/A1B1; BC/B1C1; AC/A1C1; AB/A2B2; BC/B2C2; AC/A2C2), it was calculated the percentage of reduction (or enlargement), defined as the angle of deviation calculated on the surface, between one specimen and another. This percentage allowed, therefore, to reorder the masks, on the basis of their main dimensional relationships. It was possible to calculate this reduction or enlargement percentage, even for all the 'silent' fragments, once inserted, as mentioned, within the formal scheme of the relative prototype.

From these calculations it was possible to establish, more accurately, the degrees of kinship between one mask and another, and a sort of 'family tree of known finds' was developed. Once the key points of the methodological pipeline of the integration and anastylosis protocol have been defined, a whole series of actions has
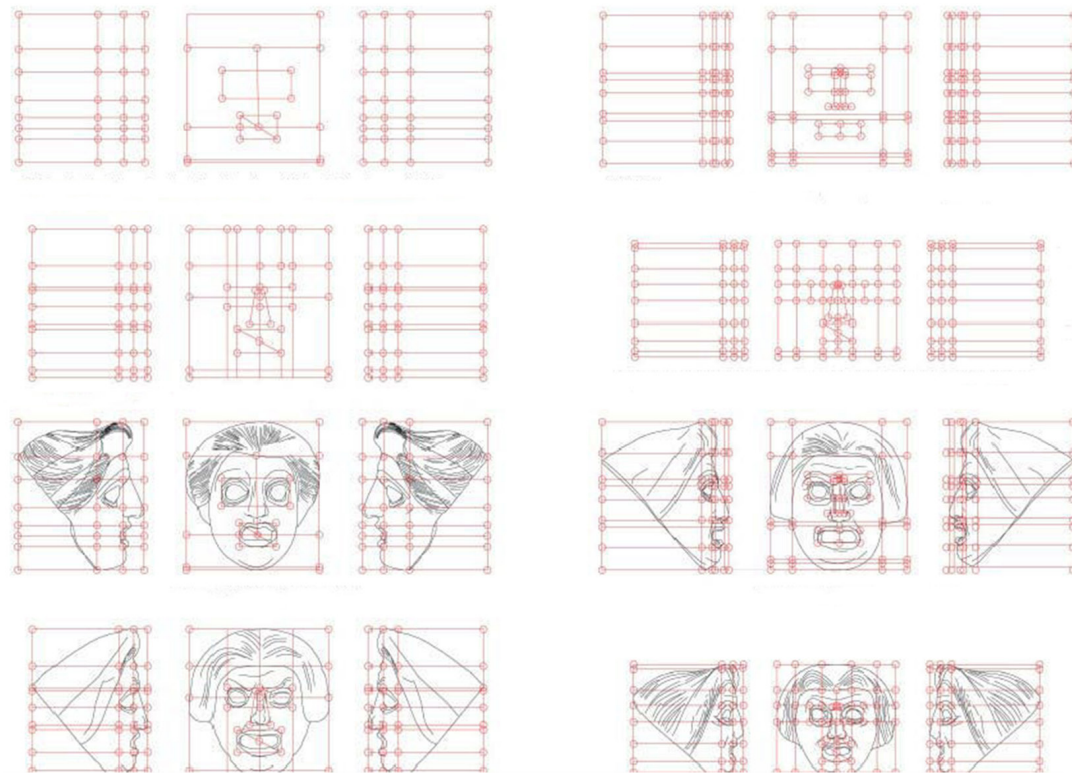

Fig. 15 - Grids for the formalization of relative prototypes by A. Marraffa & F. Fatta, (2017).

also been devised aimed at researching methods of semantic analysis and dissemination of the Research project.

3 CONCLUSIONS

3.1 METHODOLOGY OF ANNOTATION AND SEMANTIC DESCRIPTION OF THE MASKS

Today, the enhancement and the dissemination of cultural heritage are increasingly based on the use of multimedia supports capable of making their use clearer and more immediate. However,

most of these devices allow a type of dissemination that is still too passive, and not very dynamic. The new horizons of CH dissemination, on the contrary, should always become permeable in order to seek solutions, in which the user is personally called upon to be an integral and participatory part of the process of documentation and enhancement of the heritage. The 3D models of the assets represent, nowadays, the most flexible and complete graphic supports for the documentation of the CH. In fact, they provide a representation that is completely faithful to the

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original, thanks to metrically and geometrically detailed and realistic reproductions. However, beyond the visual documentation of the patrimonial objects, a clear and precise description, annotation and semantic segmentation[14] of these models also seems necessary.

In order to ensure a semantic deepening of the vast universe of liparote masks, it was used a recently created semantic annotation platform, called Aïoli[15], tested in beta version during a period of research and mobility at the MAP research center Cnrs of Marseille, created by the research team of MAP-Gamsau. This platform is a collaborative annotation cloud service that allows to process three-dimensional representations through some automated photogrammetry tools, and to enrich the latter through a series of semantic descriptors, names and labels, in order to improve understanding and analysis of the artifacts. The software was created to make documentation of cultural heritage more innovative, flexible - because it is based on the convergence of multi-disciplinary objectives - and, in fact, participatory, to which everyone can give his own contribution. Aïoli offers hybrid synthesis solutions that allow to work more easily on two-dimensional image supports. All semantic analyzes conducted in 2D are automatically transferred to the three-dimensional spatial representations, in the dimension of a point cloud[16]. Furthermore, the program allows to correlate the semantic descriptions, as well as from a spatial point of view, also from a point of multi-scalar and multi-temporal view[17].

Aïoli was tested on all specimens (whole, whole fragments and 'mute' fragments) of masks, belonging to the second measure of sub-group n. 12, defined, 'Young men with wavy hair'. The program's pipeline is very simple and intuitive: after loading a certain number of photos depicting the object to be described, the software extracts a dense point cloud. Once the three-dimensional representation of the data has been processed, it is then possible
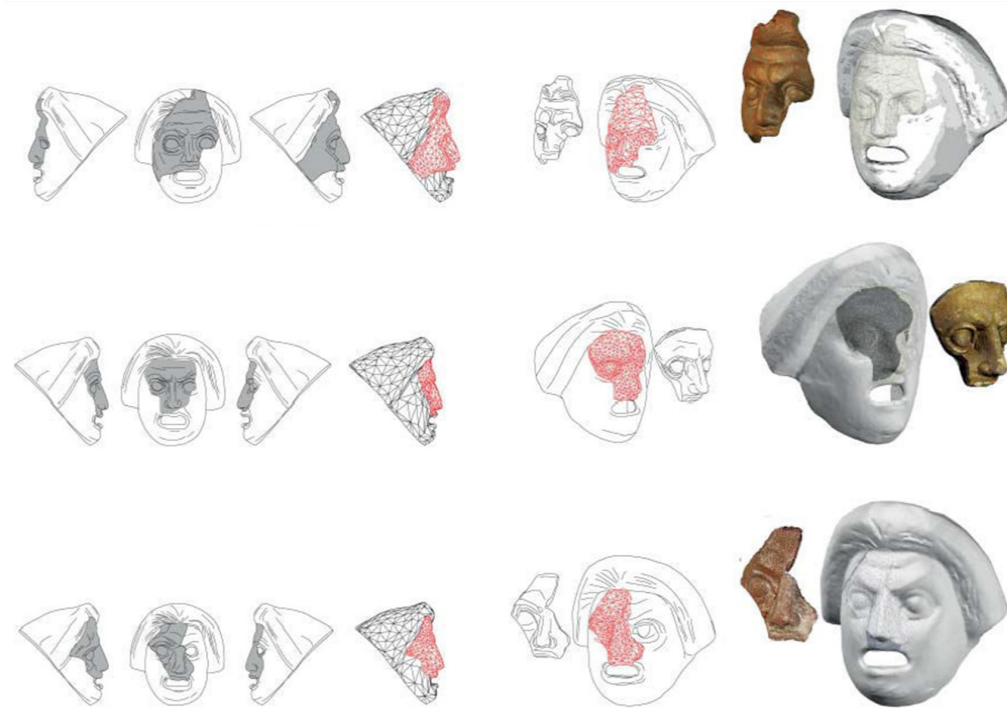

Fig. 16 - Digital anastylosis: adhesion tests of the 'silent' fragments on the relative prototype by A. Marraffa & F. Fatta, (2017).
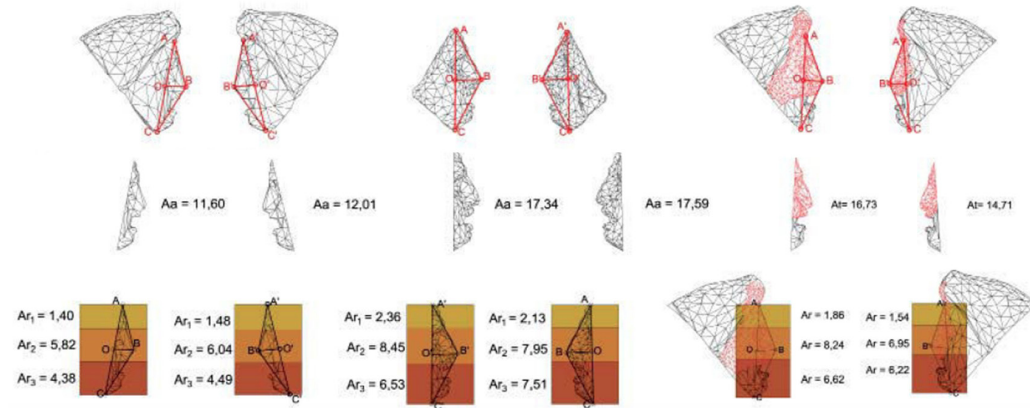

Fig. 17 - Calculation of geometric deviations on surfaces by A. Marraffa & F. Fatta, (2017).

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to start segmenting the model (Fig. 18), starting from a local annotation, conducted in two-dimensional on the images[18]. Each mask model was broken down into a series of sub-elements, based on the formal breakdown previously presented in the anastylosis protocol. This subdivision considered the main morphological and typological characters present in each mask (calotta, oval of the face, eyes, nose and mouth).

Aïoli gives the possibility to create a series of layers, called calques, which correspond to a particular semantic description. The classification of these levels takes place through the definition of a closed region, traced by means of polygonal or free selection tools. The semantic description of each calque is therefore automatically associated with all the two-dimensional representations of the working set, and of course, also with its spatial projection in 3D[19]. A hierarchical scheme of calques was therefore devised, and as many layers were created as there were semantic descriptors to be connected[20]. A series of information relating to the geometric and morphological characteristics was then extracted for each sample of mask, functional to the qualitative and quantitative comparison between one sample and another[21]. Among this information, we cite: complex vertical profiles, radii of curvature of some main elements (mouth, eyebrows, cheeks, nose, eyeball), quantitative analysis of the primary elements related to the totality of the find, main distances, etc.

From a precise shape grammar, consisting of the conspicuous primary characters of each
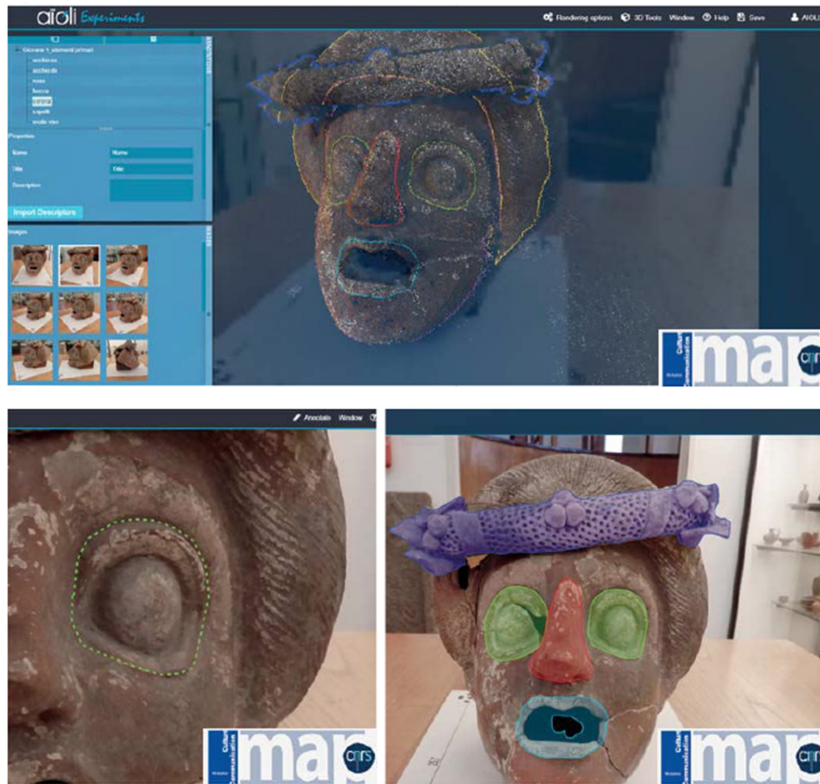

Fig. 18 - Aïöli's workspace for segmentation and semantic labeling of finds, CNRS - Map Gamsau, Marseille, (2017).
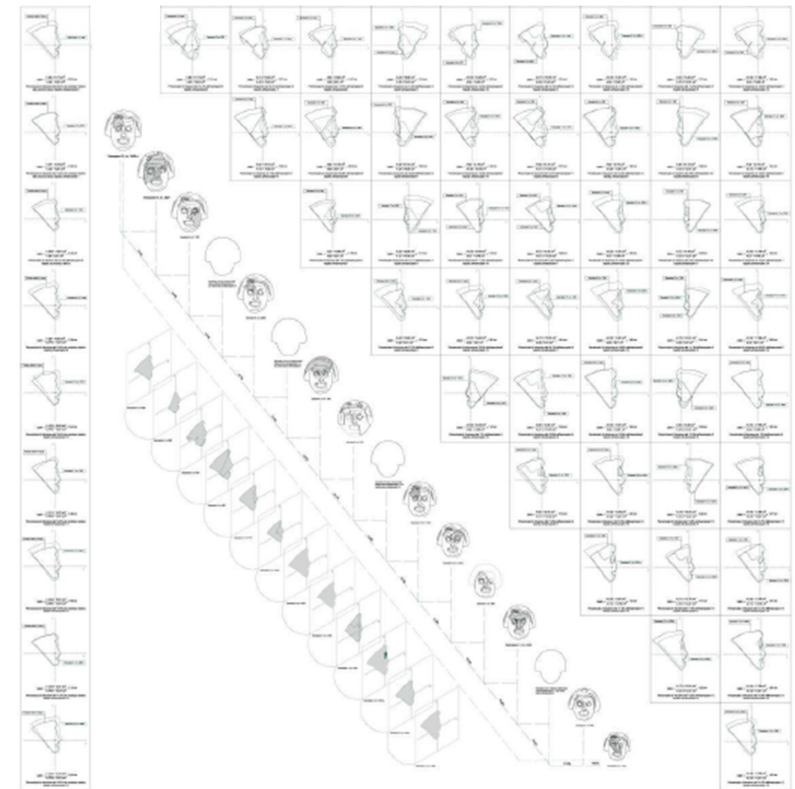
Fig. 19 - Mask's DNA: shape grammar and definition of the production matrix genealogy by A. Marraffa & F. Fatta, (2017).

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model, it was then possible to define a hierarchical clustering (Fig. 19) of the macro-types of the masks and of the main morphological elements that compose them. This type of structure, called a 'tree, and of a philo-genetic type'[22], presides over the semantic description of each mask specimen. The methodology also allows to manage, in each annotation phase, the perfect correspondence between what is the two-dimensional representation and the 3D spatial representation. In particular, five different calques were defined for the Lipari masks (Fig. 20), which took into consideration: the basic typological and formal elements (conspicuous primary characters such as eyes, mouth, nose, cheeks, etc.); the state of deterioration of the property and any gaps; changes in materials; the radii of curvature, the angular-geometric transitions and the singularities of each element and sub-element, etc.

It was then possible to extract a large series of fundamental parametric information from the segmented models: tools of quantitative analysis - tools for measuring, extracting profiles and sections, calculating the points of correspondence between the photo and the 3D model - allow to interact with the three-dimensional model and to extrapolate all possible information from it. Then, this information was associated in the form of attachments to the labeled model. In particular, for each sample of the second size, a .dwg file was associated containing all the extracted profiles corresponding to all the samples of the same size. The profiles, then, were arranged on a series of Cartesian axes with the geometric center of gravity of the profile coinciding with the origin of the axes. The relative (Ar) and total (At) area was calculated for each of them. The relationship between the two areas has determined a value, represented mathematically by the integral underlying the two curves, described by the profiles of the masks.

This value is the Average Reduction Coefficient (ARC) that exists between one specimen and another. The percentage obtained from these values represents a fundamental data for rearranging the finds of the masks and for creating a gene-alogy of families of masks. This process was developed for each specimen: an inverted pyramid structure was thus created, in which each specimen was compared with its successive ones and with its previous ones.

The ability to segment a three-dimensional model, by means of supports and mobile devices, such as smartphones and tablets, allows users to use semantic annotation in an immediate and intuitive way. Thanks to the logic of sharing, the descriptors that enhance the model can therefore be implemented and shared in real time, commented by all users, almost as if it were the content of a classic social network.

Today, the semantic description methodology helps to have a topological control in every phase of model management. It shows us how it is possible to define a continuous flow of information encoded in a single, coordinated and coherent source. This methodology, with a great technological significance but at the same time with a great artisan character, allows to obtain truly 'talking' and multi-resolution models. Labeling and semantic description appear as indispensable processes in the documentation of cultural heritage. More and more, they represent an unavoidable practice for a more complete and continuous communication and dissemination of the CH.

Fig. 20 - Example of semantic segmentation, Aiöli, CNRS - Map Gamsau, Marseille, (2017).

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NOTE

[1] Quote, compare Vernant, J.P., (1990). Figures, idoles, masques. Paris: Julliard, p. 90.

[2] Quote., cfr. Bernabò Brea, L., (1981). Menandro e il teatro greco nelle terrecotte liparesi. Genova: Sagep Editrice, pp. 11-14.

[3] Other examples of theatrical choroplasty are found, as well as in some Greek centers, also in Centuripe, Cefalù, and Glasgow, Oxford and Cambridge. There are other testimonies preserved at the British Museum in London, at some museums in Berlin, at the Louvre in Paris, at the archaeological sites of Naples, Reggio Calabria and Syracuse.

[4] For a complete interpretation of the connotation of the Dionysian cult in Greece and Magna Graecia, connected to the role of theatrical imagery, cf. Bernabò Brea, L., (1981), work already cited, pp. 21-27. See also Green J.R., Theaterin Ancient Greek Society, London, (1994), in particular p. 89 and following.

[5] See Gernet L., Boulanger, A., Le genie grec dans la religion, La renaissance du livre, Paris, (1932), p.43.

[6] 'Their great orbits already know what is about to happen, what, on the path of fate, has already been accomplished. Petrified in the contemplation of destiny, they reflect the enigma and revelation '. Quote, cfr. Pizzorno, A., work already mentioned, p. 74.

[7] By 'silent' fragments we mean all those fragments for which spatial relocation is difficult and not very immediate with respect to a complete model, precisely because there is little information and elements of recognition compared to the entire ideal.

[8] Following the classification of the Barra Bagnasco , the 'group' is indicated with a capital letter of the alphabet, for ex. 'A'. For a more in-depth discussion of the meaning of 'group', in relation to clay production, please refer to the volume by Barra Bagnasco, M., (1986). Protomi in terracotta da Locri Epizefiri. Torino: Il Quadrante, p. 20.

[9] The macro-group is indicated with a capital letter of the alphabet followed by the numeric subscript, for ex. A1. To learn more, cf. Barra Bagnasco, M., *ibidem*, p. 21.

[10] The group of young men was extensively described by Pollux in *Onomasticòn* IV, 146-148. To learn more, compare Bernabò Brea, L., work already cited, p. 154.

[11] Barra Bagnasco, M., opera citata, p. 23. For the measurement criteria adopted, see Nicholls (1982), p. 92 and Barra Bagnasco, M., cited work, p. 23.

[12] This percentage varies between 75% for large mute fragments, and 95% for smaller ones.

[13] This expression, generally, indicates the percentage x reduction of one specimen compared to another, when referring to a matrix production technique. In this regard, Jastrow's work is admirable, certifying the average reduction coefficient of the new matrix and its positive, approximately around 18%. These calculations are confirmed by Bonghi Jovino, and by the Barra Bagnasco, who indicate a reduction coefficient ranging from 12 to 17%. To deepen the subject, see Barra Bagnasco, M., cited work, p. 22; Jastrow

(1941), pp. 1-5; Bonghi Jovino (1965), pp. 17-19.

[14] Annotation and semantic segmentation are taxonomic processes that allow to connect a series of historical, philological, iconographic, morphological, etc. insights to any cultural asset. The semantic description methodology is based on the theories of the 'shape's grammar', developed by Stiny, Gips and Mitchell, but also on the works of L. De Luca, pioneer of semantics applied to the documentation of architectural and archaeological heritage, to the indexing of iconographical sources connected to them, and to the analysis of space-time representations of the historical heritage.

[15] Aïoli is a project presented by the MAP laboratory of the CNRS / MCC, on the occasion of the Salon de la Valorisation en Sciences Humaines et Sociales, Palais de l'Europe, Marseille, May 2017.

[16] This process is called 'automatic propagation' between 3D and 2D representations. To learn more about the topic, see Manuel, A., (2016). Annotation sémantique 2D / 3D d'images spatialisées for the documentation and the analysis d'objets patrimoniaux. Aix-en-Provence, ParisTech, p. 26.

[17] Aïöli allows to add photos to an already defined and semantically described relief set. The photos that are added to the first set can therefore be images acquired in different time periods. They are functional to understand the evolutions of that architectural asset - in terms of decay, restoration, conservation and compositional evolution - over time. For an in-depth analysis on the semantic management of space-time evolutions of

patrimonial objects, cf. De Luca, L., et al, (2010).

[18] The semantic annotation can be distinguished in: global annotation, associated with the entire asset object; local annotation, associated with well-defined portions of an asset and separated from each other. Both types of annotation can take place automatically, semi-automatically or manually. See, Kharkate, S.K., (2013). Automatic Image Annotation: A Review. In 'The International Journal of Computer Science & Applications', Vol. 1, n. 12.

[19] The annotation takes place directly on the two-dimensional image, as the latter represents the best support for the selection and definition of the region. Through operations of correspondence or spatial resection, all the selection information and the related annotations are then transferred to the other images and, therefore, to the point cloud. This occurs through a process of projective relationship, which associates the point of view of a two-dimensional source with its 3D spatial representation. In Aiöli's workspace, the point of view of the image, on which a segmentation work has been started by means of calque, is positioned transparently on the 3D model. For more information on the subject, see Manuel, A., aforementioned work, p. 97.

[20] In the case of particularly complex objects, the software allows the selection of regions and sub-regions of the object, allowing a series of overlaps of different calques.

[21] Through the classification of morphological elements and recurring geometric primitives, it is possible to define automated pro-

cesses of topological recognition: each library refers to a cluster / thesaurus of correspondence of the recurring forms, useful for defining a series and mapping all areas to study. Based on the recurrence of normals, chromatic elements, radii of curvature, etc., the mapping by points manages to put the fragments back into the system and allows them to be placed precisely and punctually on the relative prototype. The relative prototype represents, as seen, a 'regulated' model. It is intended as an ideal and discretized geometric model, defined by the average of all the other mask models. The definition of a normalized model is an essential method for verifying all those proportional and compositional aspects which, otherwise, could not be controlled through numerical modeling.

[22] The 'tree structure' also allows to hierarchize the description levels based on user preferences.

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