Special Issue: Personal Ornaments in Early Prehistory

Living Among Personal Ornaments During the Magdalenian: Some Reflections About Perforated Marine Shells in Cantabrian Spain

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ABSTRACT

Personal ornaments are some of the most emblematic elements of the Magdalenian in Cantabrian Spain and are also quite abundant. This paper reviews the available evidence dated between 17,000 and 12,000 BP (20,500–14,000 cal BP) in this region. In order to define their context precisely, first a critical analysis has been made of the levels in which they were found (stratigraphic position, dates, etc.) and new unpublished and published finds have been assessed and included. With these criteria, the number of objects in the subsequent study is 1,272. By focusing on the raw material in which these objects were made, this study shows that they were made predominately from mollusk shells (57%), followed by other materials with an animal origin (teeth, bone, and antler). The proportion of mineral raw materials is <5%.

The personal ornaments made exclusively from marine mollusk shells are then studied in greater depth. Only objects from levels dated to the Magdalenian by the radiocarbon technique are taken into account. A total of 655 perforated shells have been included, and their classification to species level, taphonomy, and provenance (Atlantic and/or Mediterranean) have been considered. Small specimens of species with no nutritional value predominate, particularly gastropods (*L. obtusata* followed by *Trivia* sp. make up ca. 67% of the total) rather than scaphopods and bivalves. The percentage of Mediterranean specimens is <5%. The statistical classification techniques applied to the different levels ascribed to the Magdalenian do not allow them to be discriminated according to either chronological or geographic characteristics.

Additionally, to determine whether the use of different shell-types varied in the course of the millennia that the Magdalenian lasted in Cantabrian Spain, five phases have been established by filtering the radiometric dates of the levels in which the objects were found. A Biplot analysis characterizes the phases according to the preponderance of the shell-types. A clear difference is seen between Phase II, characterized by the scaphopod *Antalis* sp., and the other phases, in which gastropods predominate, mainly *L. obtusata* + *L. fabalis* and *Trivia* sp.

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INTRODUCTION

The Magdalenian is the Upper Paleolithic period for which the largest number of sites has been documented in Europe, from the south of the Iberian Peninsula to Poland, although they are unequally distributed. The settlements are located over a wide variety of geological and topographic settings, from the deeply incised limestone valleys to the relatively open and exposed river valleys of the loess plains in Central Europe. Cantabrian Spain (which includes the provinces of Asturias, Cantabria, the Basque Country and Navarre), like Périgord and the Pyrenees, possesses a high density of sites. The greater intensity in the occupations may, *a priori*, be indicative of population growth.

From the point of view of material culture, this period is characterized typologically by the manufacture of very standardized lithic tools shaped on blades and by an elaborate and varied range of osseous tools. Portable art is often seen on abundant utilitarian and non-utilitarian objects decorated with geometric motifs and animal and anthropomorphic representations (e.g., Bosinski 1989; Rivero 2004; Sacchi 2003). The same depictions are seen in parietal paintings and engravings in caves and rock-shelters, particularly in the Franco-Cantabrian area (e.g., González 2004).

Personal ornaments are very common at Magdalenian sites all over Europe. They were made from different raw materials—fossil and recent shells, animal teeth, ivory, antler, bone, and different kinds of stone. These objects have formed part of numerous investigations (see, among others, Álvarez-Fernández 2006; 2009; Méreau 2012; Peschaux 2017; Ladier and Welté 1994; Taborin 1993; 2004; Vanhaeren and d´Errico 2003). Personal ornaments offer a wide range of possibilities for the reconstruction of behavioral patterns of the hunter-gatherers who made and used them.

In Cantabrian Spain, one of the characteristics defining the Magdalenian, in comparison with other periods in Prehistory, is the huge number of beads and pendants that are found in archaeological sites. The publication of the doctoral thesis of one of the present authors included all the information available at that time about this kind of objects, in relation to prehistory in general and the Magdalenian in particular. Apart from a few exceptions, all the objects were studied directly from different points of view: archaeozoological, taphonomic, technological, morphometric, stratigraphic and spatial, as well as determining their provenance (Álvarez-Fernández 2006).

The present paper aims to update information about Magdalenian personal ornaments in Cantabrian Spain, in a similar way to the study of these kinds of objects found in the same region and dated to the Gravettian and Solutrean (Álvarez-Fernández 2011; Álvarez-Fernández and Avezuela 2012; Avezuela and Álvarez-Fernández 2013). The available information, including the beads and pendants researched previously (Álvarez-Fernández 2006) is reappraised and the new evidence from sites excavated since the previous study is added. Firstly, the study focuses on the determination of the raw material used for personal ornaments (shell, tooth, bone, antler, rocks, and minerals) in the Magdalenian period. In second place, the different marine shell species used as personal ornaments are identified and related to the chronology of the archaeological sites where they were found in order to observe any similarities between the different levels. In addition, and equally based on dated deposits, several phases are established in order to observe changes in the use of different marine mollusk shells as personal ornaments over the five thousand years of the Magdalenian period.

The analyses of the shell bead data were carried out with univariate statistical techniques and multivariate analysis. Principal coordinates analysis (PCoA) (Gower 1966) and Ward's method of hierarchical clustering (Ward 1963) were used to analyze similarities between the archaeological levels dated in the Magdalenian period in Cantabrian Spain with the aim of establishing their classification in terms of the perforated shell-types that have been found in them. The analysis by phases has been approached from a Biplot perspective (Gabriel 1971) to determine the most important types in each of the phases.

GEOGRAPHIC SETTING

The northern coastal strip of Spain (Western Europe) includes, from east to west, the Basque provinces of Gipuzkoa and Biscay, and the provinces of Cantabria and Asturias. Cantabrian Spain is bordered to the north by the Bay of Biscay, to the south by the Cantabrian Cordillera, to the east by the Pyrenees, and to the west by the gentler relief of the ancient shield rock landscapes of Galicia. The distance between the present Cantabrian shore and the crestline of the Cordillera, with summits reaching 2500m above sea level, varies from only 25km to 50km. In a narrow strip, between 15km and 30km wide and about 400km long, a large number of caves and rock-shelters, and a few open-air sites, contain deposits ascribed to different periods in the Paleolithic, particularly including the Magdalenian (Figure 1).

MAGDALENIAN IN CANTABRIAN SPAIN: CHRONOLOGY AND MATERIAL CULTURE

The Magdalenian period is dated in Cantabrian Spain during the final phases of the Pleistocene, following the Last Glacial Maximum, between ca. 20,500–14,000 cal BP (ca. 17,000–12,000 BP), that is, during Greenland Stadial 2 (GS2c, GS2b, and GS2a) and during Greenland Interestadial 1 (GI1) (Andersen et al. 2006; Grootes et al. 1993; Lowe et al. 2008; Svenson et al. 2006). The abundance of sites, in which several archaeological levels often are documented, associated with cave systems in both coastal areas and inland valleys, suggests that this area enjoyed great potential for the subsistence of hunter-gatherer-shellfishing groups during the Magdalenian. Indeed, the number of sites must have been even higher (Álvarez-Fernández 2011; Fano 2007) because during the second part of the Last Glacial Period, the very narrow continental shelf off the coast of Cantabrian Spain was displaced northwards by sea level regression some 5–12km (García 2007; Uriarte 2003) and any sites in that area will now lie submerged.

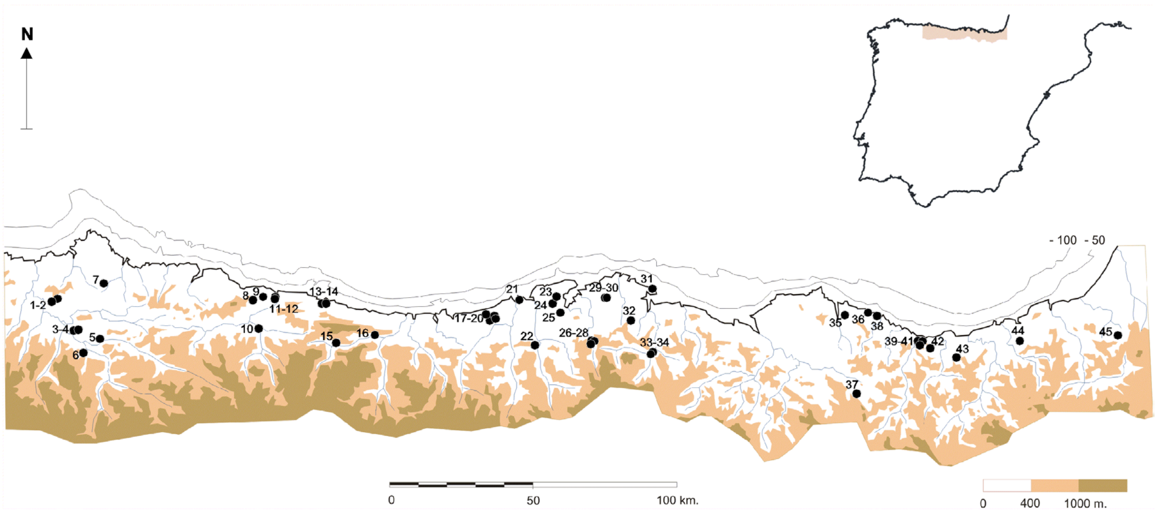

Figure 1. Sites in Cantabrian Spain where personal ornaments in different raw materials have been recorded in contexts clearly assigned to the Magdalenian. ***Asturias****: 1. Oscura de Ania; 2. La Paloma; 3. Las Caldas; 4. La Ancenia; 5. La Viña; 6. Entrefoces; 7. El Olivo; 8. Cova Rosa; 9. El Cierro; 10. La Güelga; 11. Tito Bustillo; 12. La Lloseta; 13. La Riera; 14. Cueto de la Mina; 15. Los Canes; 16. Coímbre B;* ***Cantabria****: 17. El Linar; 18. Las Aguas; 19. Cualventi; 20. Altamira; 21. La Pila; 22. El Castillo; 23. El Juyo, 24. El Pendo; 25. Cueva Morín; 26. El Piélago I; 27. El Piélago II; 28. El Rascaño; 29. La Garma A; 30. La Garma-Lower Gallery; 31. La Fragua; 32. El Otero; 33. El Mirón; 34. El Horno;* ***Basque Country****: 35. Santimamiñe; 36. Santa Catalina; 37. Bolinkoba; 38. Lumentxa; 39. Iruroin; 40. Praileaitz I; 41. Ermittia; 42. Urtiaga; 43. Erralla; 44. Aitzbitarte IV;* ***Navarre****: 45. Berroberria.*

The Cantabrian Magdalenian has been defined by the remains documented in the archaeological levels, which have been dated mainly by the ^{14}C technique. Since the early 20th century, researchers have divided the period into sub-periods, according to the presence or absence of some *fossiles directeurs*, both lithic (e.g., square section points during the Lower Magdalenian) and osseous artifacts (e.g., barbed points during the Upper Magdalenian) (see for example, Álvarez Alonso 2014; Utrilla 1981; 2007; Vega del Sella 1917). The nomenclature used by most researchers studying this period is used here: Archaic, Lower, Middle, and Upper/Final Magdalenian.

The Archaic Magdalenian is characterized by tools made by retouching flakes, while from the Lower Magdalenian onwards blades tended to be used within a gradual microlithization of implements. Backed bladelets, end-scrapers, and burins alternate in their percentages until the upper-final Magdalenian, when the reduction in their sizes is accentuated (Chauvin 2007; 2012; Utrilla 2004). Local raw materials were normally used for artifacts, although flint of more distant provenance also has been documented, from the eastern part of Cantabrian Spain (e.g., Urbasa and Treviño) and also from southwest France (Chalosse), as at the Lower Magdalenian sites of El Cierro (Álvarez-Fernández et al. 2016), El Linar, Cualventi, and Las Aguas (Tarriño 2016), and in the Middle Magdalenian at Las Caldas (Corchón et al. 2009). These finds demonstrate the existence of long-distance contacts during this period.

Magdalenian osseous industry is very abundant and frequent, compared with earlier periods, and almost exclusively in antler and bone. The different kinds of sagaie points changed from the "Placard-type" in the Archaic Magdalenian, to types with a square cross-section in the Lower Magdalenian, or with a forked base in the Middle Magdalenian, and barbed points (used perhaps as harpoons) in the Upper Magdalenian. Domestic utensils, such as needles, awls, and spatulas, are equally abundant (Aura et al. 2012; Fano et al. 2013; González and González 2004; Tapia et al. 2018).

If there is anything that characterizes the Magdalenian, it is the portable and parietal artistic representations. In the lower Magdalenian, scapulae were decorated with striated images of hinds (e.g., El Cierro), whereas from the Middle Magdalenian, animals were represented both naturalistically (particularly sculpted figures such as those from Las Caldas) and schematically (for example, ibex in a frontal view at Llonín) on a wide range of objects—perforated bâtons, sagaie points, atlatls, spatulas, etc. The same kinds of motifs are also found on stone objects, e.g., at Las Caldas, and in parietal art. Non-figurative representations include such signs as chevrons, which is a type characteristic of the Middle Magdalenian (Arias and Ontañón 2005; Corchón 1986; Corchón et al. 2017; Garate el al. 2015; González 2004; Rivero 2015).

The most abundant information about the subsistence of the Magdalenian groups comes from archaeozoological research, mainly of mammal remains and the shells of marine mollusks. Different biotopes were exploited. Sites in valleys located near the coast specialized in hunting red deer, whereas in inland valleys, near the mountains, ibex were hunted most (Altuna 1995; González 1989). The percentages of chamois and horse, and other mammals, vary depending on the location of the caves and rock-shelters. Recent archaeozoological studies of sites such as Levels F and G at El Cierro and Level F at Arangas (Cueto et al. 2015; Portero et al. in press) and the Magdalenian levels at Las Caldas (Altuna and Mariezkurrena 2017; Mateos 2017) and Coímbre (Yravedra et al. 2017) have confirmed this pattern. Sites such as Zone IV at La Garma-Lower Gallery are the exception (Cueto et al. 2016). The gathering of marine mollusks is thought to have been complementary to hunting. It is clearly documented at sites in the proximity of the coast, where there was a preference for species that live on rocky substrates in the intertidal zone, such as limpets (*Patella vulgata*, and from the Upper Magdalenian, *Patella depressa* and *Patella ulyssiponensis*) and snails (*Littorina littorea*, and from the Upper Magdalenian, *Phorcus lineatus*) (Álvarez-Fernández 2011). Information about fishing and fowling is more limited, except in the case of Santa Catalina (Laroulandie et al. 2016; Roselló et al. 2016) in the recent and final phases of the Magdalenian.

Territoriality and mobility between different regions in southwest Europe in general and Cantabrian Spain in particular is widely demonstrated for the Magdalenian not only by the circulation of objects (including marine archaeozoological remains, as well as the lithic raw materials mentioned above) but also by the sharing of ideas (which are reflected in the representation of different kinds of decorative motifs and the techniques used to manufacture artifacts). In this sense, the study of personal ornaments can provide more detailed information about the territoriality and mobility of Magdalenian groups. It can contribute data about the provenance of the raw materials with which they were made, the method used to suspend them, the type of decoration on their surfaces, etc.

PREVIOUS STUDIES OF MAGDALENIAN PERSONAL ORNAMENTS IN CANTABRIAN SPAIN

Personal ornaments have been discovered and reported since the very start of prehistoric research in Cantabrian Spain, in the late nineteenth century. Thus, Sanz de Sautuola recorded the first personal ornaments in his explorations of the Magdalenian cave sites of Altamira and Venta del Cuco between 1875 and 1880. In the first decades of the 20th century, such researchers as Vega del Sella and Hernández Pacheco studied different kinds of objects that they found in their archaeological excavations (Cueto de la Mina, La Paloma). Since then, archaeologists have continued to study specimens from old excavations and new finds (see specific literature in Álvarez-Fernández 2006). Within these studies, B. Madariaga laid the foundations for research in personal ornaments in the late 1960s (e.g., Madariaga 1967). Researchers working in Cantabrian Spain since the 1990s have been influenced by his work, as well as by that of researchers in other "archaeological schools" (Barge-Mahieu et al. 1991; d´Errico et al. 1993; Newell et al. 1990; Taborin 1993; Vanhaeren 2002; White 1999, among others). This work led to the first summary of all the personal ornaments dated in the Paleolithic and Mesolithic in Cantabrian Spain (Álvarez-Fernández 2006). Since that publication, old collections have been re-examined and new assemblages from recent excavations have been studied, particularly in reference to the Magdalenian (see information and detailed literature below).

METHODOLOGY

SELECTION OF SITES WITH MAGDALENIAN PERSONAL ORNAMENTS

The present study includes all the information so far recorded about Magdalenian personal ornaments in Cantabrian Spain (see Figure 1) as regards the raw materials used for them. Other aspects, such as the techniques employed to suspend them, the type of use-wear observed around their orifices, and the decoration on their surfaces, are not considered here.

First, it takes into account the information and the methodology published by E. Álvarez-Fernández (2006). Second, in the last ten years, the same author has carried out further investigations, some of which have been published—Altamira (Álvarez-Fernández 2009); El Horno (Fano and Álvarez-Fernández 2010); La Garma-Lower Gallery –Zone IV (Arias et al. 2011); Las Caldas (Corchón et al. 2012); Tito Bustillo (Álvarez-Fernández 2013); El Olivo (Álvarez-Alonso et al. 2014); Level F at El Cierro (Álvarez-Fernández et al. 2016); and Coímbre B (Álvarez-Fernández 2017). Other examples of personal ornaments have remained unpublished until now (Tito Bustillo, Cova Rosa, El Cierro, and Cualventi - García Guinea's excavation). Third, the present study also includes information about new personal ornaments published by other researchers in the last decade—Las Aguas, Cualventi and El Linar (de las Heras 2016), La Fragua (Gutiérrez, 2009), El Mirón (Gutiérrez and Cuenca 2016), Santimamiñe (Gutiérrez et al. 2011), Santa Catalina (Berganza et al. 2012), and Praileaitz I (d´Errico et al. 2017; Vanhaeren and d´Errico 2017).

In this overview of the role played by personal ornaments in Magdalenian groups, as information about beads and pendants comes from very different sources, the objects from unreliable sources or where levels may have been contaminated by materials from higher in the stratigraphy (Azilian, Mesolithic, or later) or lower (Solutrean or earlier) layers have been filtered out. Personal ornaments from levels with different dates that cover several periods or which are incoherent with the published assemblages have similarly been excluded. Objects found in superficial layers, or about which publications do not give any specific information of their provenience or age have not been taken into account either.

In contrast, personal ornaments documented in archaeological levels, with or without radiocarbon dates, that are coherent with the occupation of the site, or found in old excavations (before 1960) whose radiocarbon dates are coherent with the assemblages, even despite large standard deviations (e.g., Paloma 4 and Castillo 8) have been included. Pieces found in levels that have not been dated have been incorporated, if the overlying and underlying levels were dated, particularly if the dates are similar to each other (e.g., El Juyo 9, Pila IV.3). This analysis also includes objects from undated levels in old excavations provided that it was possible to correlate them with new excavations (e.g., the earlier excavations in El Cierro and El Juyo). Objects found in barren layers have also been taken in consideration, if we know that they come from a later occupation (Las Caldas IX). It equally takes into account the beads that have been studied specifically by other researchers, provided that the documentation has been appraised, for example, through detailed photographs allowing the correct identification of the shell to species level or of anthropic modification of the shell.

This research is affected by a series of limitations. For example, generally speaking, in archaeological excavations prior to the 1960s, the sediment was not systematically sieved with small-mesh screens. The consequence was an absence of personal ornaments at those sites that is very difficult to assess, for example, at El Castillo (Álvarez-Fernández 2006; 2011). The authors are equally aware that a bead or a pendant might have been used by Magdalenian groups in the course of several generations or it might have been in circulation over quite a wide territory (Álvarez-Fernández 2016).

MARINE SHELLS AS RAW MATERIAL FOR PERSONAL ORNAMENTS DURING THE MAGDALENIAN

After a consideration of the number of personal ornaments made from different animal and mineral raw materials, the present study will focus in greater detail on the beads and ornaments made from marine mollusk shells. This particular raw material has been chosen because it is the one most widely used for this type of artifact and because the shells are of many different types (various gastropod, bivalve and scaphopod species). In addition, their identification to species level provides information about, for example, whether the mollusks were gathered as food, if they were collected on beaches, their provenance (Atlantic or Mediterranean coasts), etc.

Whenever possible, each shell has been classified to species level. This has been carried out with reference collections in the Department of Prehistory, Ancient History and Archaeology at the University of Salamanca. The biotopes of the taxa have been taken from specialized literature (Consolado et al. 1999; Gofas et al. 2011; Palacios and Vega 1997). The classification of the species has followed the nomenclature of the WoRMS-World Register of Marine Species (WoRMS Editorial Board 2017).

For a more precise characterization of personal ornaments made from marine shells in the Cantabrian Magdalenian, only sites with these objects from levels that have been dated by C^{14} are taken into account. The number of perforated shells in each level will be quantified. The methodology of the analysis of shell ornaments (taphonomy, technology, use wear, etc.) was previously defined in Álvarez-Fernández (2016). The statistical methodology used to classify the archaeological levels according to their similarity in shell-type composition is Principal Coordinate Analysis (PCoA) (Gower 1966), for which the original counts are transformed into presence / absence (coded as "1" and "0" respectively) data. These data are used to compute a similarity matrix with the Dice similarity index (Harmmer and Harper 2006) because it has the property that mismatches do not influence the similarity between two archaeological levels.

Dice index between levels i and j, is calculated as follows:

$$D_{ij} = \frac{2a}{2a+b+c}$$

Where:

- a is the number of perforated shell-types that are present in the two levels
- b is the number of perforated shell-types that are present in the i-th level.
- c is the number of perforated shell-types that are present in the j-th level.

PCoA of the pairwise similarity matrix between archaeological levels is performed and a graphical representation in a low-dimensional Euclidean space is obtained, where the distance between two points representing two levels reflects their similarity in terms of their perforated shell-type composition. Therefore, the more similar two levels are, the shorter the Euclidean distance is between them. Ward's hierarchical clustering method is applied to the archaeological levels' scores obtained from the PCoA, to characterize and discriminate between groups of levels and to highlight their similarities and differences in relation to their composition in perforated shell-types. Chae and Warde (2006) established that the information retrieval capacity of clustering algorithms is greatly improved by using the primary coordinates of the individuals (levels, in our case), since the original data are affected by the noise, and, therefore, it is expected that for the same agglomeration method, the classification obtained from the main coordinates of the retained k-dimensions is similar or superior to that obtained using the matrix of observed distances. The convex hulls are used to represent the partitions in the graphical results obtained from PCoA.

DETERMINATION OF PHASES WITHIN THE MAGDALENIAN

Different phases have been discriminated in the Magdalenian in order to observe any changes in the use of personal ornaments in general, and shell beads in particular, in the thousands of years that Magdalenian occupations lasted, taking into account only the archaeological levels that have been dated exclusively with the radiocarbon technique. Levels with dates obtained from samples of marine origin (e.g., shells) which have standard deviations encompassing several Magdalenian phases (dates obtained with thermoluminescence or amino acid racemization), or with two or more dates that are mutually incoherent, have not been included. In addition to calibration using CalPal 2007 Hulu (Weninger et al. 2012, www.calpal-online.de), a curve was obtained for each one of the five Phases (Phase 1: ca. 20.5–

19.0 kyr cal BP; Phase 2: ca. 19.0–18.2 kyr cal BP; Phase 3: ca: 18.2–17.2 kyr cal BP; Phase 4: ca. 17.2–16.0 kyr cal BP; Phase 5: ca. 16.0–14.0 kyr cal BP) (Table 1; Figure 2**)**. Each phase corresponds approximately to the classic sub-periods into which the Magdalenian period is traditionally divided in the literature (from the oldest to the youngest period: Archaic, Lower, Lower/Middle, Middle, and Upper/Final Magdalenian).

The archaeological sites for which dates were available were grouped into five chronological phases. Phase I with only two sites, Phase II with 12, 14 archaeological sites in Phase III, six in Phase IV, and 18 in Phase V. As stated above, the present study aims also to determine whether changes exist in the composition of the assemblages (perforated shell-types) in the different phases.

In order to determine the most important perforated shell-types in each phase, in terms of their preponderance, a matrix with rows (types) and columns (phases) is built, where each element in this matrix is the total number of individuals of each type in each phase. For this, the percentages of each type are calculated within each phase, and these new data are used as input in the statistical analysis. The JK-Biplot method (Gabriel 1971) is used as the multivariate statistical tool to observe visually which are the most important perforated shells-types in each of the phases. This analysis makes it possible to jointly represent, in a low-dimensional Euclidean space (usually a plane), the rows (as points) and columns (as vectors) of a data matrix to interpret their relationships. In our case, the rows of the matrix are the perforated shell-types and the columns, the chronological phases.

As a dimensionality reduction technique, the axes retained for the representation are those with which the greatest amount of explained variance is obtained, as does Principal Component Analysis. The axes are centered, so the origin coincides with the average percentage of the phases. To interpret the graphical results, it is necessary to interpret that acute angles between arrows that show similar direct behavior between the phases they represent, that is, they are highly-positively correlated; when they point in opposite directions they correlate in an inverse sense. Distance between points can be interpreted in terms of their similarity that is, perforated shells that have a similar distribution of percentages through the phases, tend to be closer. The points that have a percentage in a phase greater than the average are projected on the vector that represents that phase towards the side where the arrow points or beyond the tip of the arrow; if the projection is on the other side, their percentage is below average. In any case, only the positions of the elements (rows or columns) with a high quality of representation indicated by numerical results issued from the analysis can be interpreted.

To implement the PCoA, cluster analysis, and Biplot analysis, the Multbiplot software was used, developed for free use by Vicente-Villardón (2015).

RESULTS

TYPES OF MAGDALENIAN PERSONAL ORNAMENTS

A total of 1,272 personal ornaments were studied, from 45 archaeological sites in Cantabrian Spain—16 in Asturias, 18 in Cantabria, 10 in the Basque Country, and one in Navarre (see Figure 1).

The raw materials used during the Magdalenian were of two types: animal (shells, teeth, bones, and antler) and mineral (rocks, minerals, and fossils) (*cf.* Álvarez-Fernández 2006) (Figure 3). The former type is the most common (95.3%). Of this total number of personal ornaments, pierced shells form 56.9%. They have a mostly marine origen; only three beads made from fluvial shells (e.g., *Teodoxus* sp.) are documented.

Pierced teeth are 29% of the ornaments. They come from animals belonging to four different orders. Teeth of taxa in the Artiodactyla Order predominate, above all red deer canines, but reindeer, ibex, roe deer, bovid, and red deer incisors also have been documented. Perforated teeth belonging to the Perissodactyla (incisors and a canine of horse), Carnivora (a canine of lynx, canines of fox and wolf, canines and incisors of bear, and a seal tooth), and Cetacea Orders (a sperm whale tooth and some pilot whale teeth) also occur. Different complete (phalanx) and fragmented bones (diaphysis, hyoids, scapulae, ribs) of different animals and fragments of antler (reused sagaie points, with holes made through their bevels; a pierced sculpture, etc.) also are documented and represent 7.6% and 1.4%, respectively.

Personal ornaments made from raw materials of mineral origin represent 4.7%. They are made in organogenic (jet and amber) and metamorphic (e.g., quartzite, schist) and sedimentary rocks (e.g., hematite, sandstone, lutite). Various fossils have been recorded (e.g., crinoid stems) although they are much rarer. The remaining percentage (0.4%) refers to personal ornaments made from indeterminate raw materials.

MAGDALENIAN MARINE SHELL PERSONAL ORNAMENTS

When only personal ornaments made from marine shells found in dated levels are taken into account, a total of 655 objects are available. They come from 67 levels belonging to 24 archaeological sites. A total of 26 perforated shell-types have been established.

During the Magdalenian, gastropods were used predominantly (91.3%), with a much lesser use of scaphopods (*Antalis* sp.: 7%) and bivalves (1.7%) (Figures 4, 5, and 6). Among the gastropods, above all, shells of *Littorina obtusata* + *Littorina fabalis* + *L. obtusata* / *L. fabalis* (similar in shape but of different size) were used, at 49.9%. These are followed by *Trivia* sp., which reaches 25.9%. *Tritia reticulata* + *Tritia incrassata* + *T. reticulata* / *incrassata* (similar in shape but of different size) represent 6.35%. They are followed by *Nucella lapilus*, *Turritella* sp., and *Littorina littorea* + *Littorina saxatilis* (with similar shape and size), represented by nearly 3.5%

TABLE 1. LIST OF SITES SELECTED FOR FIGURE 2.*

SITE	LEVEL	PHASE	REFERENCE
CUEVA OSCURA DE ANIA	3b	IV	Pérez 1992
LA PALOMA	4	V	Barandiarán 1988
LAS CALDAS-SALA II	XIII	II	Corchón 2000
	XII	III	
	III, IV, VI, VIII, IX	IV	
	II, I, -II	V	
LA VIÑA	IV	IV	Fortea 1990
ENTREFOCES	B	III	González 1992
EL OLIVO	2	IV	Álvarez-Alonso et al. 2014
EL CIERRO	F	II	Álvarez-Fernández et al. 2016
LA GÜELGA-SECTOR A	3c	III	Menéndez and Martínez 1991-1992; 1992
LA GÜELGA-SECTOR C	2b	IV	Menéndez and García 1998
TITO BUSTILLO-ÁREA DE ESTANCIA	1	III	Moure 1997
LOS CANES	2c	V	Arias 2013
COÍMBRE B	1a, 1b	V	Álvarez-Alonso et al. 2016
EL LINAR	3	II	Rasines 2016
CUALVENTI	E	II	García 2000; Rasines 2016
	6a	III	
LAS AGUAS-SECTOR 2	C2	I	Rasines 2016
	B, C1	III	
LAS AGUAS-SECTOR 3	3sup	IV	Rasines 2016
ALTAMIRA	2	II	Barandiarán 1988
LA PILA	IV.2	V	Bernaldo de Quirós et al 2002
EL CASTILLO	8	I	Barandiarán 1988
EL JUYO	4.7	IIII	Barandiarán et al. 1987
EL RASCAÑO	5	I	Barandiarán and González 1981
	3.4	II	
	2	V	
LA GARMA A	L	IV	Arias and Ontañón 2008; inedit
	N, O	V	
LA GARMA LOWER GALLERY-ZONE 4		IV	Arias and Ontañón 2008; Cueto et al. 2016; inedit
LA GARMA LOWER GALLERY-ZONE 1		III	Arias and Ontañón 2008
LA FRAGUA	4	V	González 1999

TABLE 1. LIST OF SITES SELECTED FOR FIGURE 2 (continued).*

SITE	LEVEL	PHASE	REFERENCE
EL MIRÓN-CABAÑA	15.17	II	Straus and González 2003; 2007; 2010; Straus et al. 2015
	14	III	
EL MIRÓN-VESTÍBULO	503, 504, 505	II	
	308	V	
EL MIRÓN-CORRAL	106	V	
EL HORNO	1, 2	V	Straus et al 2002
SANTIMAMIÑE	H-Csn, Camr	III	López and Guenaga 2011
	Almp	V	
SANTA CATALINA	III	V	Berganza and Arribas 2014
PRAILEAITZ I-VESTIBULO	IV	II	Peñalver et al. 2007

*It gives the levels analyzed from each dated site, the phase or phases each level corresponds to, and the bibliographic references to the radiocarbon determinations.

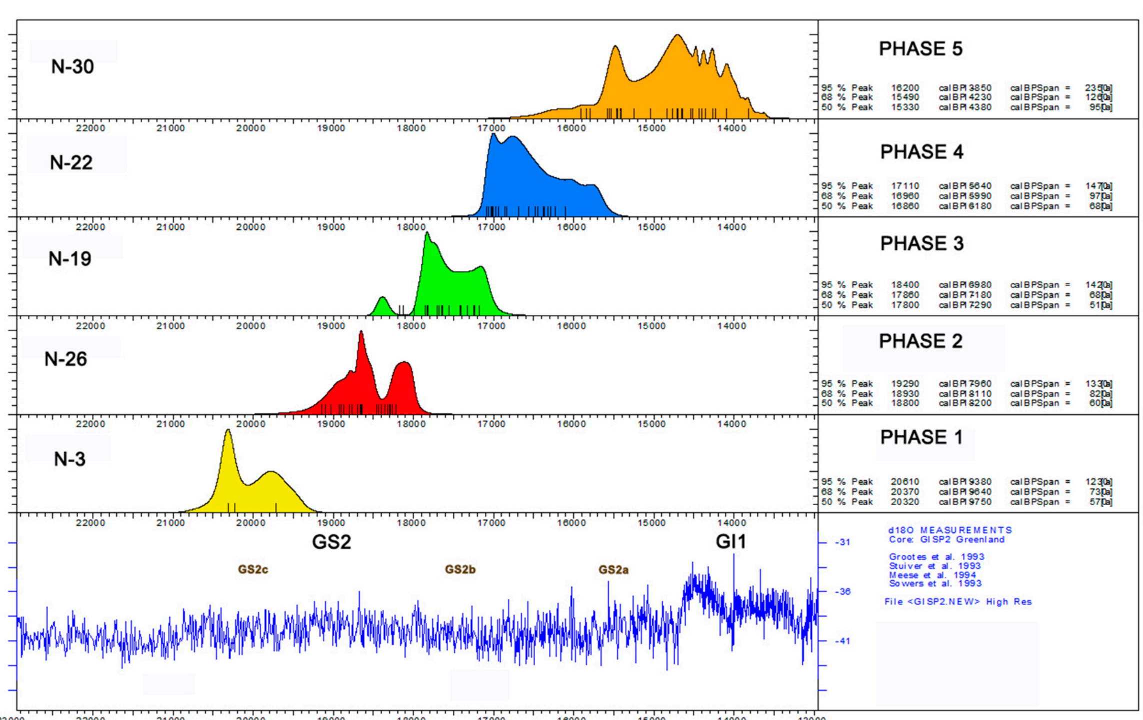

Figure 2. Cumulative probability curve of the valid radiocarbon dates (N) from Cantabrian Spain. For calibration, CalPal 2007 Hulu (Weninger et al. 2012) was used. The curves for Cantabrian Spain are arranged in each one of 5 phases. Palaeoclimate proxies: ^{18}O GISP2 Hulu Age Model (Grootes et al. 1993; Meese et al. 1994; Wang et al. 2001); Heinrich Events (Elliot et al. 2002).

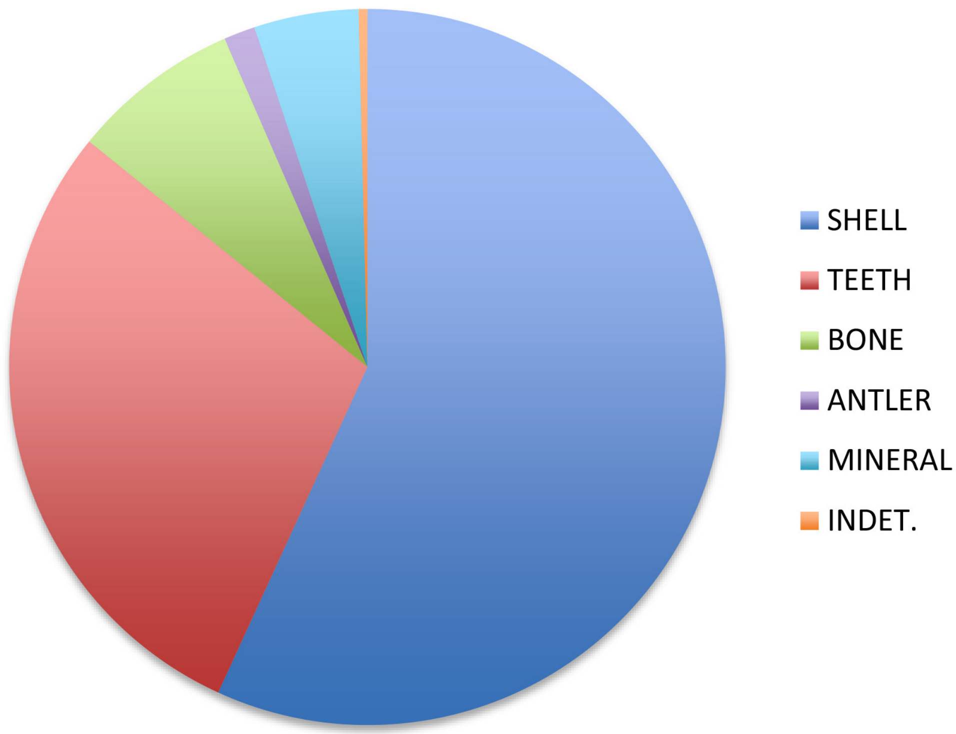

Figure 3. Percentages of different types of raw materials used to make personal ornaments (n=1,272) in Cantabrian Spain in the Magdalenian.

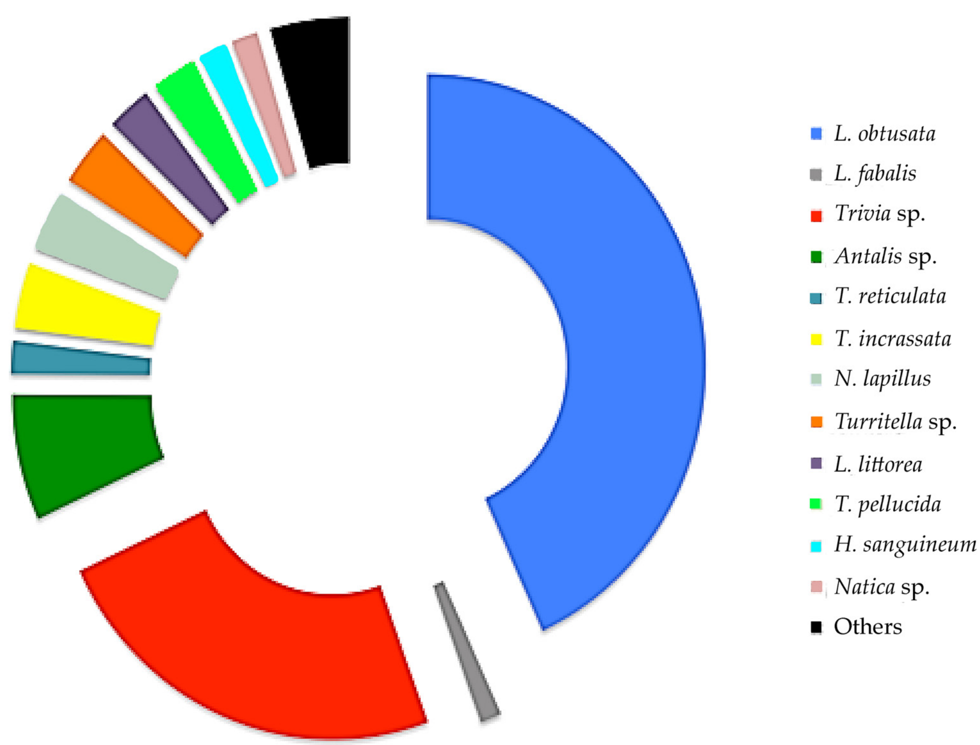

Figure 4. Percentages of personal ornaments made from marine mollusk shells (n=655) recovered in Cantabrian Magdalenian levels dated by ^{14}C.

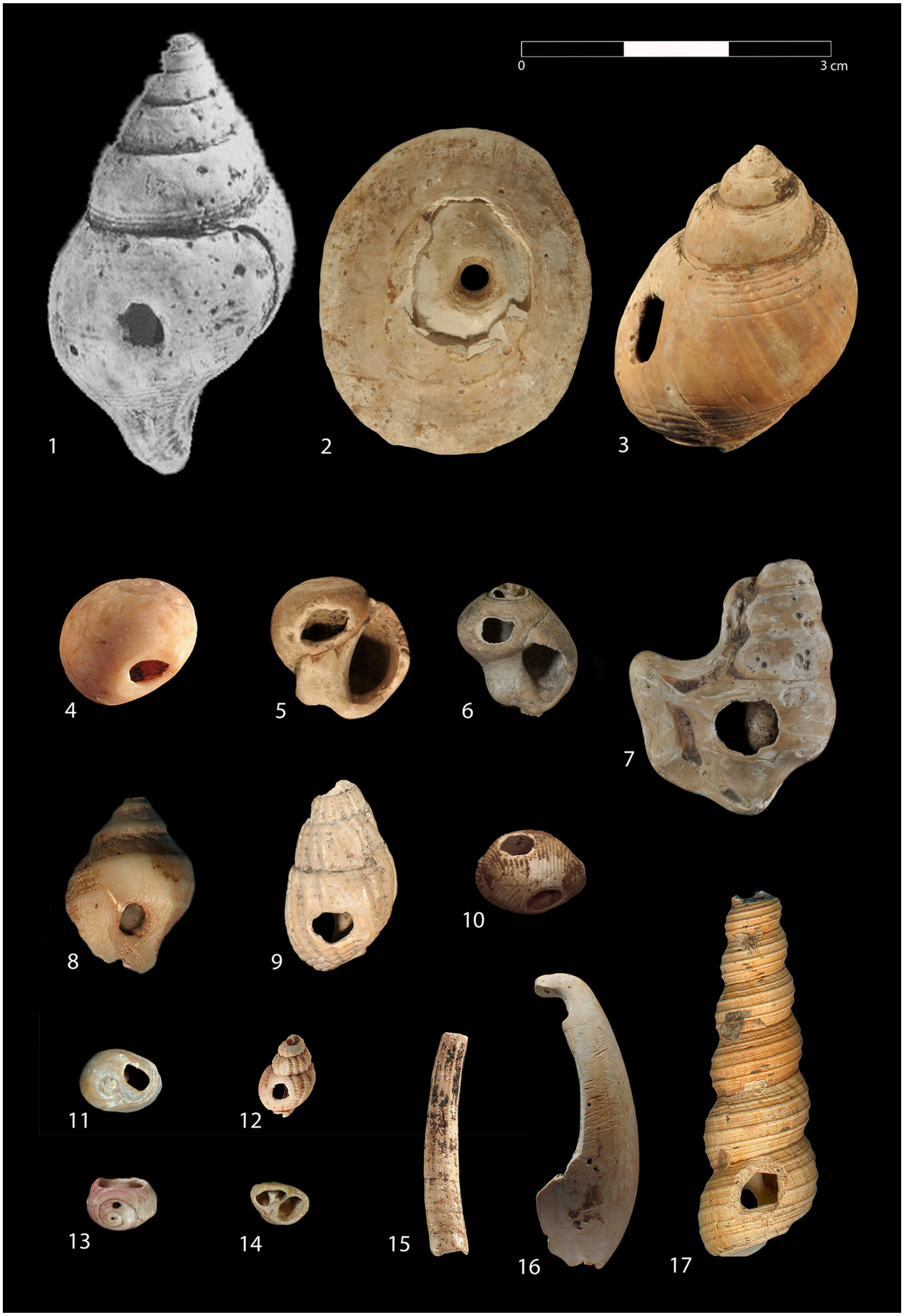

Figure 5. Selection of perforated shells of marine mollusk species found at Magdalenian sites in Cantabrian Spain. 1) Colus *sp. (Cueto de la Mina); 2)* Patella vulgata *(Tito Bustillo); 3)* Tritia mutabilis *(Tito Bustillo); 4)* Littorina obtusata *(La Garma A); 5)* Natica *sp. (Tito Bustillo); 6)* Littorina littorea *(Tito Bustillo); 7)* Apporhais pespelecani *(Tito Bustillo); 8)* Nucella lapillus *(El Horno); 9)* Tritia reticulata *(Coímbre B); 10)* Trivia *sp. (El Olivo); 11)* Tritia pellucida *(Coímbre B); 12)* Tritia incrassata *(La Garma A); 13)* Homalopoma sanguineum *(Tito Bustillo); 14)* Littorina fabalis *(Tito Bustillo); 15)* Antalis *sp. (La Garma A); 16)* Zonaria pyrum *(La Garma A); 17)* Turritella *sp. (El Horno).*

Figure 6. Selection of perforated shells of marine mollusk species found at Magdalenian sites in Cantabrian Spain. 1) Semicassis saburon *(Coímbre B); 2)* Pecten maximus *(Las Caldas); 3)* Mytilus galloprovincialis *(Tito Bustillo); 4)* Glycymeris *sp. (Tito Bustillo); 5)* Chlamys islandica *(Santa Catalina); 6)* Laevicardium crassum *(Tito Bustillo).*

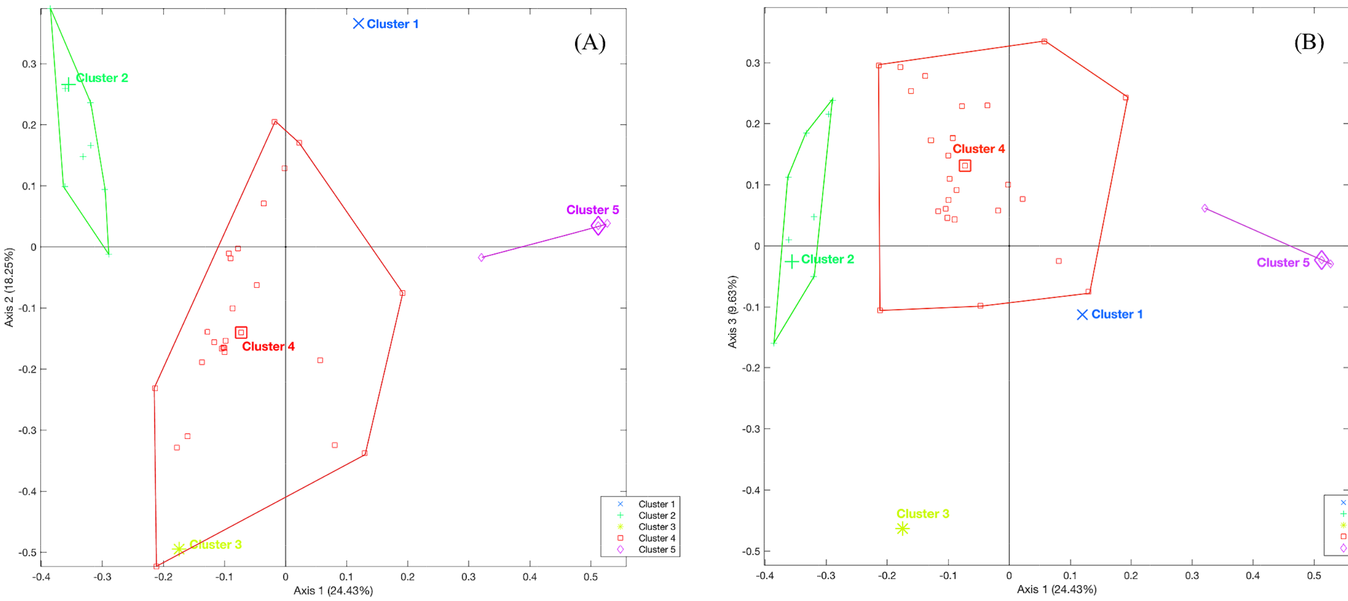

Figure 7. Principal Coordinate Analysis results of Magdalenian data analysis. A) Plane 1–2 with convex-hulls; B) Plane 1–3 with convex-hulls. Each point in the convex-hulls represents an archaeological level. The names of each level are identified in Figure 8 using the same colors.

each. *Tritia pellucida* is 2.9% and *Homalopoma sanguineum* and *Natica* sp. are 1.7% each. The other species are represented by two specimens (*Semicassis saburon* and *Aporrhais pespelecani*) or by only one (*Patella vulgata* and *Tritia mutabilis*).

The bivalve most often found is *Glycymeris* sp., with five specimens, followed by *Cerastoderma* sp. with two, and *Mytilus* sp., *Laevicardium crassum*, *Chlamys islandica*, and *Pecten maximus* with one specimen each.

The results of the application of the PCoA technique to the pairwise similarity matrix between archaeological levels show that three axes are enough to explain 52.3% of the total variance. Figures 7A and 7B represent the ordination diagrams obtained from this analysis, where each point represents an archaeological level. Figure 7A shows the first two PCoA ordination axes; Figure 7B represents ordination axes 1–3. The nearer two points are in the diagram, the more similar the two levels that they represent are.

Ward hierarchical clustering analysis on the three-dimensional scores issued from the PCoA results shows five clearly identified groups, as seen in Figure 8, indicated with different colors. The convex hulls have been depicted in the ordination diagrams according to these five clusters to help the interpretation (see Figures 7A and 7B). Two large convex hulls (2 and 4) and three small hulls (1, 3 and 5) can be observed. In Figure 7A, axis 1 (accounting for 24.43% of total variation) separates Cluster 5 (on the right side) from Cluster 2 (on the left), while the second axis (18.25%) differentiates mainly between Cluster 1 in the upper part and Cluster 3 in the lower part. All archaeological levels belonging to Cluster 5, except one (corresponding to Juyo 9) lie in exactly the same position on the chart, and the same is true for all levels in Clusters 3 and 1, showing, in all cases, the large similarity in terms of perforated shell-types within each set of levels. The convex hulls of Clusters 4 and 3 overlap in this plane. However, the third PCoA axis (9.6%) positions Cluster 3 levels away from those of Cluster 4 (see Figure 7B). Convex hull for set Cluster 4 reflects a high degree of internal heterogeneity in perforated shell-type diversity, followed by Cluster 2. Cluster 1 (with only six levels) and Cluster 3 (with only five levels) present, contrariwise, very high homogeneity; Cluster 5 has an intermediate position in relation to this variability.

Next, each cluster was characterized in relation to the percentage of presence of perforated shell-types by means of a Chi-square test. Table 2 shows the percentage of levels within each cluster where the corresponding bead-type is present. Only a few of the types allow significant differentiation between them (Chi-square p-value <0.05). These types are *L. obtusata*, *Trivia* sp., *N. lapillus*, *Antalis* sp. and *Turritella* sp. In all six levels of Cluster 1, *L. obtusata* and *Trivia* sp. were both present; furthermore, no more bead-types were found in them. Cluster 3 is characterized by the presence of *N. lapillus* in all its sites, and only this type. *L. obtusata* appears in all the levels in Cluster 5, the only bead-type in all of them except Juyo 9 (where *T. incrassata* also was present). *Trivia* sp. was present in all the sites in Cluster 2, but in two of them *Antalis* sp. or *Turritella* sp. also were present. The heterogeneity of Cluster 2 also is shown by the percentage of sites where the significant species were present. Cluster 4 is the most heterogeneous and is mainly characterized by the presence of *L. obtusata* and *Antalis* sp. *L. obtusata* was present in 50% of these sites, as was *Antalis* sp. *Trivia* sp. appeared in a nearly 36% of the archaeological levels in this cluster, followed by *Turritella* sp., with 32.14%.

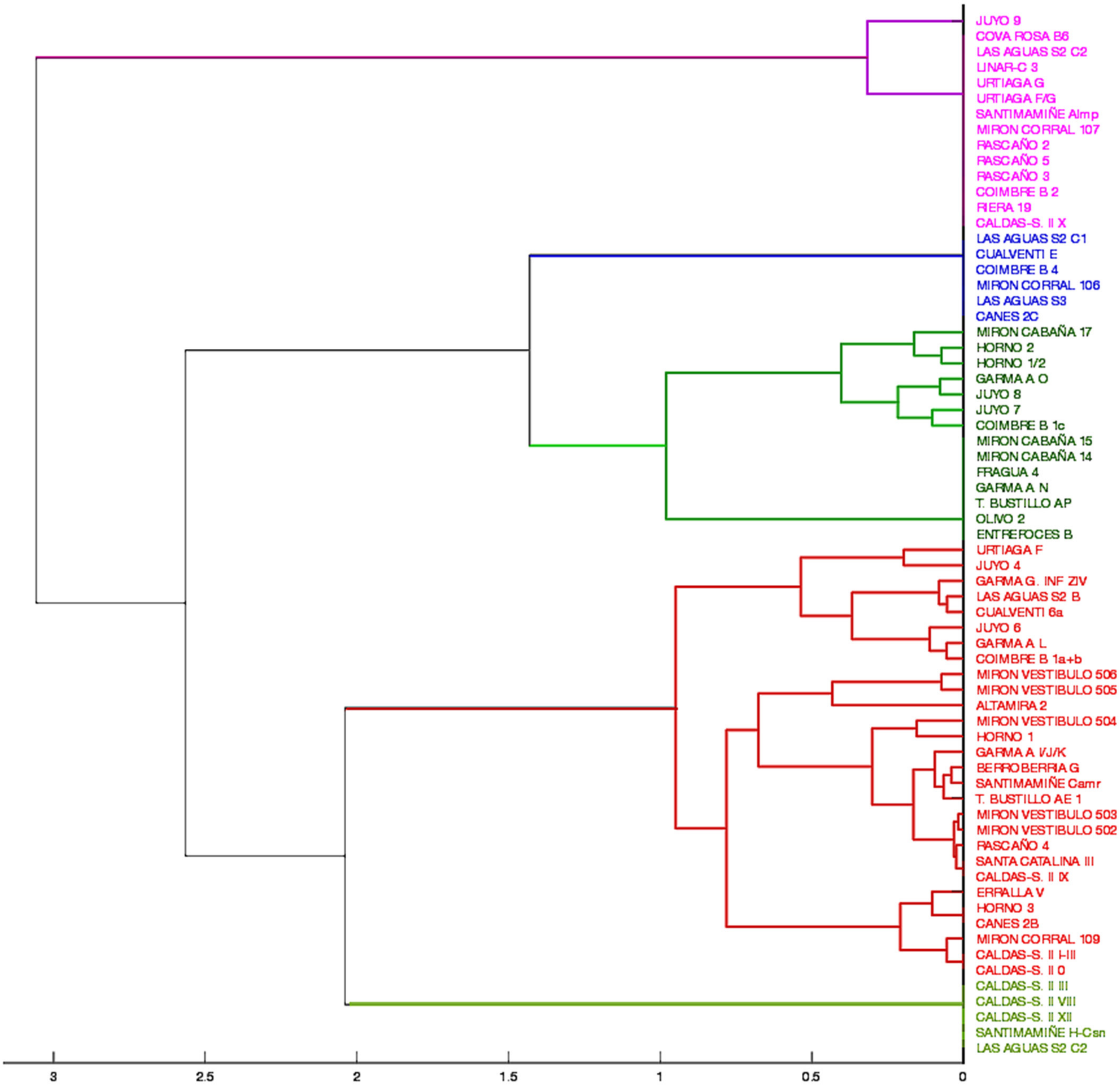

Figure 8. Hierarchical Cluster with the Euclidean Distance using the ordination scores (PCoA)-linkage (Ward 1963).

TABLE 2. PERCENTAGE OF SITES WITHIN EACH CLUSTER WHERE THE SIGNIFICANT SHELL BEAD-TYPES WERE PRESENT.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Chi-square	p-value
N	6	14	5	28	14		
%	8.96%	20.90%	7.46%	41.79%	20.90%		
Littorina obtusata	**100%**	0	0	**50%**	**100%**	38.99	<0.000
***Trivia* sp.**	**100%**	**100%**	0	**35.71%**	0	41.00	<0.000
Nucella lapillus	0	0	**100%**	25%	0	31.29	<0.000
***Antalis* sp.**	0	14.29%	0	**50%**	0	19.06	<0.000
***Turritella* sp.**	0	14.29%	0	**32.14%**	0	10.00	0.040

PHASES IN CANTABRIAN SPAIN DURING THE MAGDALENIAN: INFORMATION ABOUT PERFORATED MARINE SHELLS

From the total of the shell ornaments documented in Cantabrian Spain during the Magdalenian, 429 are taken into consideration. Their assignment to the five chronological phases into which this period has been divided shows that gastropods, scaphopods, and bivalves are present in all the phases, except Phase I, the oldest, in which a single species, *L. obtusata*, was recorded (*n*=3)

The taxa that appear in the other four phases in differing numbers (Phase II: *n*=60; Phase III: *n*=216; Phase IV: *n*=73; Phase V: *n*=77), are the gastropods *L. obtusata, L. fabalis*, *Trivia* sp., *N. reticulatus, N. incrassatus*, *N. lapillus*, and *Turritella* sp., and the scaphod *Antalis* sp. The other taxa are found in three phases (the gastropods *L. littorea, L. saxatilis*, and *T. pellucida*, and the bivalve *Glycymeris sp.*); two phases (gastropods *H. sanguineum*, *Natica* sp., and *S. saburon*); or only in one phase (the gastropods *A. pespelecani*, *P. vulgata*, and *T. mutabilis*, and the bivalves *Cerastoderma* sp., *M. galloprovincialis, L. crassum, P. maximus*, and *Ch. islandica*). It should be noted that the shells of gastropod species with a clear Mediterranean origin (*H. sanguineum*, *T. pellucida*, *T. mutabilis, Z. pyrum*, and *S. saburon*) are found in Phases II, III, IV, and V. Most of these (9.7%) correspond to Phase III and were all found in the *Área de Estancia* in Tito Bustillo. Others, dated to Phase V (9.1%), were all found in Coímbre B.

A total of 21 different perforated shell-types in all phases were established. In this case, some of the types were grouped according to the external form and sizes of their shells: 1. *Littorina obtusata* / *Littorina fabalis* (*L. obtusata* + *L. fabalis* + *L. obtusata* or *L. fabalis*). 2. *Tritia reticulata* / *Tritia incrassata* (*T. reticulata* + *T. incrassata* + *T. reticulata* or *T. incrassata*) 3. *Littorina littorea* / *Littorina saxatilis* (*L. littorea* + *L. saxatilis* + *L. littorea* or *L. saxatilis*).

To determine whether changes exist in the composition of the types in each phase, a matrix with 21 rows (21 types) and 4 columns (4 phases) was built. Phase I is not included in this analysis because very few individuals belonged to a single species (*L. obtusata*). Two axes were able to explain 96% of the data variability. Nevertheless, the results in plane 1-2 and plane 1-3 are depicted in Figures 9A and 9B to better interpret the results. Axis 1 captured the main information (it comprises 70.42% of the total inertia of the system). The vectors representing the phases are scaled (in the original scale, that is, percentages) to aid interpretation.

In Figure 9A (plane 1–2) small angles are observed between Phases III, IV, and V. They indicate their similarity in relation to the distribution of perforated shell-type percentages. The main fact of these phases is that, in all of them, *Trivia* sp. and *L. obtusata* / *L. fabalis* were the dominant types, with percentages much greater than the average. *Antalis* sp. characterizes Phase II (its vector points towards the bottom of Axis 2) representing nearly 50%. Also *L. obtusata* / *L. fabalis*, *T. reticulata* / *T. incrassata*, and *Trivia* sp. present a percentage in this phase above the mean. As an example of interpretation, Figure 9A shows the projections of each type onto the vector representing Phase III.

Although Axis 3 only explains 2.61% of the total variability, plane 1–3 (see Figure 9B) improves the characterization of the different phases, because the points that represent some perforated shell-types can only be interpreted in this plane. Thus, the percentage of *T. reticulata* / *T. incrassata* is above the average in both Phases III and V, but not in Phase IV. *Natica* sp. appears in a higher percentage than the average in Phase IV, unlike the rest of the phases. *Turritella* sp. and *Tritia pellucida* only represent a higher percentage than the average in Phase V. The rest of the perforated shells are all less numerous in all phases, with percentages, in general, <5%.

The Biplot analysis has enabled the determination of the most important species characterizing and differentiating each phase. Consequently, Figure 10 only shows the percentages of the most important perforated shell types (the other shell types are not shown in the chart). These results are summarized as follows:

1. In Phase II, the most common types are *Antalis* sp. followed by *L. obtusata* / *L. fabalis*, and *T. reticulata* / *T. incrassata*.
2. In Phase III, *Trivia* sp. and *L. obtusata* / *L. fabalis* are the most important, followed, with a much lower percentage, by *T. reticulata* / *T. incrassata.*
3. Phases IV and V, like Phase III, are characterized mainly by the high number of *Trivia* sp., and *L. obtusata* / *L. fabalis*, but in Phase IV, *Natica* sp. is close to 10%.
4. In Phase V, *Turritella* sp. represents almost 15% of the total, and the percentages of *T. reticulata* / *T. incrassata* and *T. pellucida* are lower.

DISCUSSION AND CONCLUSIONS

Cantabrian Spain has contributed one of the largest collections of personal ornaments documented in Europe for the Magdalenian. The number of objects (1,272 are known to date) is also much higher than in other Upper Paleolithic periods in the same region (almost 70% of the total number).

During the Magdalenian in Cantabrian Spain, beads and pendants made from biotic raw materials predominate (<95%). Of these, mollusk shells are in the majority (mostly marine species, although terrestrial and fluvial species are found) and represent *ca*. 57%, followed by teeth of different taxa (mainly Artiodactyla, but also Perissodactyla, Carnivora, and Cetacea) at 29%. Objects made from bone and antler make up the remaining percentage. Abiotic raw materials (lignite, quartzite, etc.) were used for <5% of the personal ornaments. These adornments have been found almost exclusively in archaeological levels, although some of them come from "deposits" (e.g., atrophied canines in a hearth in Tito Bustillo 1); from places in a site where the manufacture of beads has been documented (e.g., the manufacture of *L. obtusata* beads has been demonstrated in Urtiaga F/G); or on the occupation floors in La Garma-Lower Gallery-Zone 4 (Álvarez-Fernández 2006; Arias et al. 2011). To date, no personal ornaments have been found in association with human remains in the Cantabrian Magdalenian.

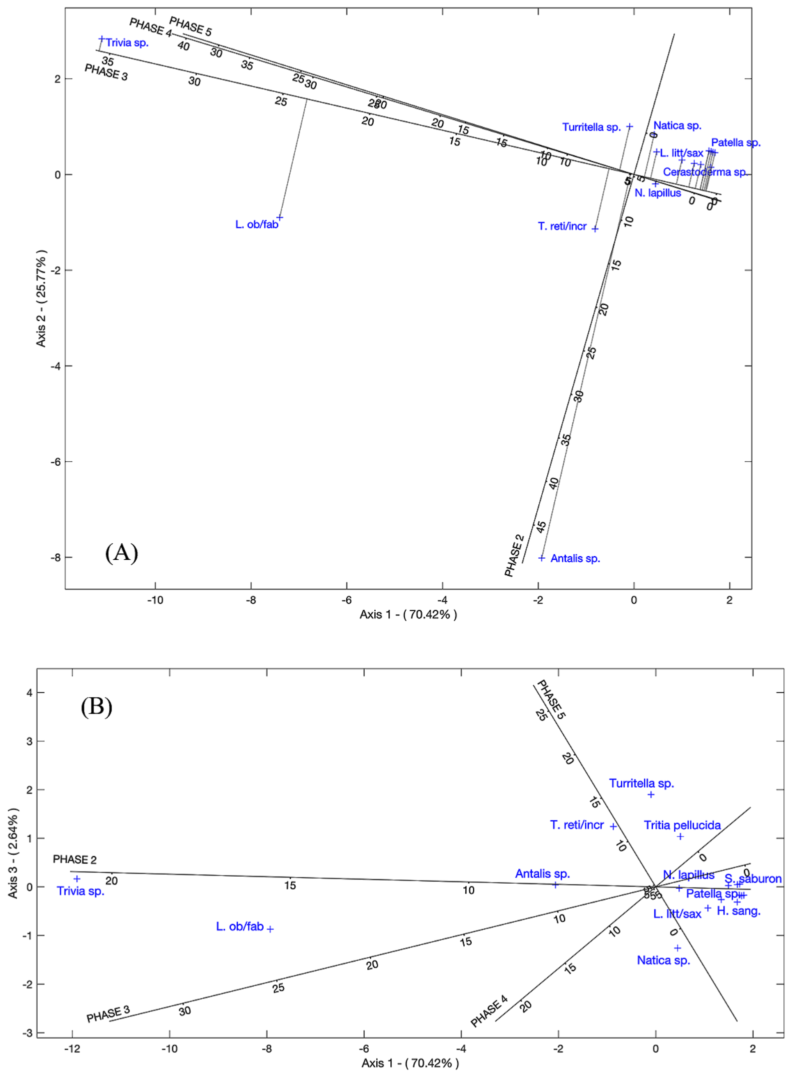

Figure 9. Biplot results of Chronological Phases data analysis. A) Plane 1–2; B) Plane 1–3. Labels of some perforated shell types are not shown for clarity.

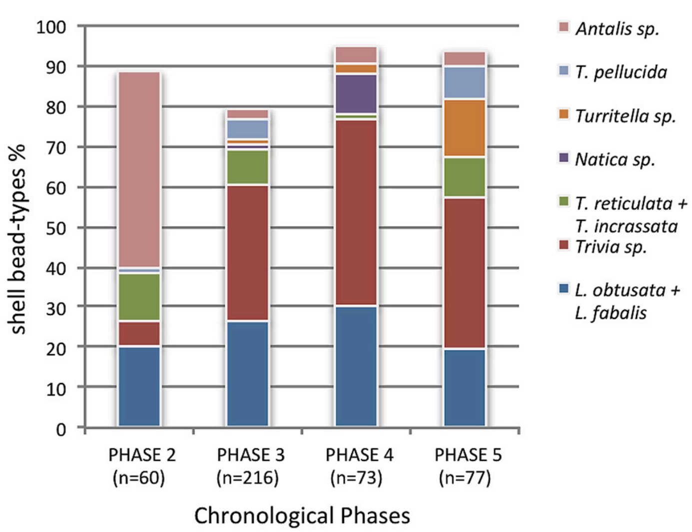

Figure 10. Most abundant perforated shell-type percentages within Phases.

If we concentrate exclusively on the marine mollusk shells documented in archaeological levels dated by radiocarbon, 655 objects in total, gastropods were used predominantly (>91%). Of these, *L. obtusata* and *L. fabalis*, species of a similar appearance but different size, and *Trivia* sp. amount to over 75%. The remaining percentage is formed by a further 14 gastropod taxa. The bivalves are represented by six taxa, whereas the scaphopod remains have been grouped as *Antalis* sp.

Nearly all the pierced shells belong to taxa that lack nutritional value (96.5%). Taphonomic observations (presence of holes caused by perforating organisms, epifauna inside the shells, or abrasion caused by a sandy environment and sea water) indicate that most shells were gathered on beaches after the animal had died. We cannot be sure whether the specimens of *Mytilus* sp., *P. vulgata*, *L. littorea* and *L. saxatilis*, *C. islandica*, and *Cerastoderma* sp., were first collected as food on rocky substrates in the intertidal zone (the former individuals) or in sandy and muddy substrates in tidal flats, bays, and estuaries (the last species) and their shells later turned into personal ornaments, as they may also have been picked up on beaches. The shells of bivalves belong to species with nutritional value but, apart from the mussel and cockles, they were not gathered as food as the shells display signs of marine abrasion and they live in the sub-tidal zone, which was not accessible to the Magdalenian groups. The presence of *Ch. islandica* at Santa Catalina may indicate that the sea water temperature was lower in Cantabrian Spain in the Upper Magdalenian, if it can be supposed that this shell was gathered on the shore in this region. The modern distribution area of this cold-water species is much further north of Cantabrian Spain (Norway, Iceland, and Faroe Islands).

Most of the shells belong to taxa that currently live on the coast of Cantabrian Spain. The Magdalenian groups would enjoy more or less direct access to these resources, which would explain from a geographic point of view the presence of practically the same species at the different Cantabrian sites throughout the Magdalenian. However, the exchange of objects among hunter-gatherer groups, not only at short-distance but also at medium and long-distance, cannot be ruled out (Álvarez-Fernández 2016). The percentage of species exclusively living in the Mediterranean Sea (*H. sanguineum*, *T. pellucida*, *T. mutabilis*, *Z. pyrum*, and very probably *S. saburon*) is only 4.7%. However, these Mediterranean shells are found in all the phases, except Phase I, which is clear evidence for long-distance social interaction during much of the Magdalenian in Cantabria Spain.

All these considerations are corroborated by the results obtained in the statistical analyses. Thus, five groups of Magdalenian levels have been established based on the perforated marine shells documented in each one, but these groups do not differ from one another from a chronological and geographic point of view. Thus, it may be concluded that the shells alone do not allow the levels to be classified with these criteria. This suggests the need for additional analyses that include objects of adornment made from other raw materials.

The different chronological phases established for the Magdalenian, based on the radiocarbon dates of the levels in which the perforated shell-types were found, have been characterized by statistical analysis. Thus, in Phase II, *Antalis* sp. predominates, whereas in the central Magdalenian phases (III and IV) the predominant species are *L. obtusata* + *L. fabalis* and *Trivia* sp. *Natica* sp. is characteristic of Phase IV. In the most recent Magdalenian phase (V), some species less represented in the earlier phases gain in importance (especially *Turritella* sp.), whereas *L. obtusata* + *L. fabalis* and *Trivia* sp. decline in frequency.

This research aims to approach the role that personal ornaments might have played as a way to reconstruct cultural diversity and change during the Upper Paleolithic and Mesolithic in Cantabrian Spain. To achieve this, it is necessary to study directly the largest number of personal ornaments found in reliable contexts, as well as appraising critically the information published about objects not studied directly. The present study of Magdalenian ornaments must be regarded as a first approach, as the other ornaments made from different animal and mineral raw materials still have to be characterized and analyzed, as well as the marine shells. In addition, as pointed out above, we believe that other aspects of the adornments should be considered, such as the decoration on some of them, the manufacturing techniques, and the contexts in which they appear. The distribution of the objects among the sites in the region equally needs to be analyzed (e.g., between sites in different valleys, between sites near and distant from the coast, etc.).

Some researchers have cited ethnographical studies to note that, through the association of ornaments, it is possible to determine different ethnic units and more or less apparent linguistic groups in European prehistory (Newell et al. 1990; Rigaud et al. 2015; Vanhaeren and d´Errico 2006). Our future research will be able to contribute data on the role played by personal ornaments among the hunter-gatherer-shellfishing groups in Cantabrian Spain and proximate regions during the Upper Paleolithic and Mesolithic.

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