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Aurignacian ethno-linguistic geography of Europe revealed by personal ornaments

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Abstract

Our knowledge of the migration routes of the first anatomically modern populations colonising the European territory at the beginning of the Upper Palaeolithic, of their degree of biological, linguistic, and cultural diversity, and of the nature of their contacts with local Neanderthals, is still vague. Ethnographic studies indicate that of the different components of the material culture that survive in the archaeological record, personal ornaments are among those that best reflect the ethno-linguistic diversity of human groups. The ethnic dimension of beadwork is conveyed through the use of distinct bead types as well as by particular combinations and arrangements on the body of bead types shared with one or more neighbouring groups. One would expect these variants to leave detectable traces in the archaeological record. To explore the potential of this approach, we recorded the occurrence of 157 bead types at 98 European Aurignacian sites. Seriation, correspondence, and GIS analyses of this database identify a definite cline sweeping counter-clockwise from the Northern Plains to the Eastern Alps via Western and Southern Europe through fourteen geographically cohesive sets of sites. The sets most distant from each other include Aurignacian sites from the Rhône valley, Italy, Greece and Austria on the one hand, and sites from Northern Europe, on the other. These two macro-sets do not share any bead types. Both are characterised by particular bead types and share personal ornaments with the intermediate macro-set, composed of sites from Western France, Spain, and Southern France. We argue that this pattern, which is not explained by chronological differences between sites or by differences in raw material availability, reflects the ethnolinguistic diversity of the earliest Upper Palaeolithic populations of Europe.

Keywords: Ethnicity; Linguistic diversity; Early Upper Palaeolithic; Beads; Seriation analysis; Correspondence analysis; Contour mapping; GIS

1. Introduction

In spite of the considerable effort displayed in the last decades by geneticists, palaeoanthropologists, linguists, and archaeologists, our knowledge of the degree of biological, linguistic, and cultural diversity of the first anatomically modern populations colonising the European territory at the beginning of the Upper Palaeolithic is still vague. Were these first colonisers, traditionally identified with the Aurignacian, a culturally, linguistically, and genetically homogeneous population? Did they penetrate the European territory in one wave or in successive waves, and follow a single path or multiple paths? Can any discipline determine regional trends reflecting the ethnolinguistic and genetic diversity of these populations?

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Current Europeans are African immigrants [12,38,92,169] and their gene diversity reflects demographic phenomena that occurred in Europe after 40,000 BP. The mtDNA sequences determined so far in nine Neanderthal specimens lie outside the range of variation of modern European sequences [105,108,128,150,152], suggesting that Neanderthals did not significantly contribute to the present mtDNA gene pool. However, although these results do not exclude the possibility of a genetic Neanderthal input to the gene pool of early modern colonisers that was later rubbed out by intervening bottlenecking and replacements [70], a recent modelling of potential admixture between the two populations excludes an interbreeding rate higher than 0.1% [47]. The recent genetic analysis of seven Upper Palaeolithic individuals [35,152] also seems to exclude any large genetic contribution by Neanderthals to early modern humans.

For the time being, recorded genetic differences between Neanderthals and Moderns can be used to support placing the former in either the same or different species [77,164]. Considering that there are similarities in behaviour between Neanderthals and modern humans, even if Neanderthals belonged to a different species, as suggested both by recent analysis of morphological differences among Neanderthals, modern humans, and 12 species of extant primates [81] and by differences in dental growth [135], this would not necessarily have precluded cultural [49,53,203] and perhaps biological interactions between them [177,204].

Identifying geographical patterns of genetic diversity among the early modern colonisers seems, for the moment, a largely unexplored field of population genetics, a discipline that, so far, has been more concerned with interpreting the current gene pool as a legacy of past populations' migrations. Clines in genetic markers coalescing before the Holocene have been interpreted as reflecting either successive migrations into Europe or autochthonous re-colonisations from southern refugia post-dating the Last Glacial Maximum (LGM). From a Y-chromosome perspective [37,142,151,188], the M173 lineage is considered an ancient marker that was brought by or arose in Aurignacian moderns colonising Europe about 40,000–35,000 years ago. M170 and haplogroup I would have instead originated in Europe about 22,000 years ago among Gravettian populations descendant of men who arrived from the Middle East a few thousand years earlier. A similar conclusion is reached by calculating the probable age and studying the frequency of mtDNA haplogroup H [139,174,175]. Of more recent origin, the haplogroup V is thought by the same authors to represent the genetic marker of an Upper Magdalenian expansion from a Pyrenean refugium into southern Iberia and northern Europe some 13,000 years ago.

It is plausible, considering positive correlation between linguistic and genetic data [11,13,132,155,156], that demographic scenarios suggested by genetic markers may reflect, to some extent, language spreads and related cultural contacts. To date, however, genetic studies have not identified geographic patterns that may be representative of Palaeolithic ethno-linguistic entities.

Historical linguists, for their part, are sceptical that any language or linguistic geography from the Upper Palaeolithic could be reconstructed. Even the more convinced proponents of the Nostratic hypothesis and of a monogenetic theory for language origin [26,63,75,137,143,144] admit that they have little to contribute about the languages spoken in Europe before 12,000 years ago.

The contribution of human palaeontology to advancing the understanding of the Early Upper Palaeolithic (EUP) human geography is also limited. Although accepted for the late Aurignacian, the attribution to the moderns of the early manifestations of this culture remains tentative ([41,164,203,204], but see [117]). A number of human remains traditionally attributed to the Aurignacian have recently yielded radiocarbon dates incompatible with this attribution [45,167,171]. The 27,680 ± 270 date (Beta-157439) for a shell bead from the Cro-Magnon site [87] suggests a similar post-Aurignacian age for the type-specimen of Early Upper Palaeolithic AMH.

Amongst the five morphologically diagnostic early modern humans considered older than 28,000 years—Mladec, Rois, La Quina, Kent's Cavern, and Oase 1—only the last two are directly dated. Four come from old excavations, and the more recently discovered one, the Oase 1 mandible, lacks for the moment a cultural attribution [177]. On the basis of this evidence, it is challenging to evaluate the potential role of local Neanderthals in the morphological evolution of incoming modern populations and to identify regional trends that may reflect related cultural processes. This is the more so given the uncertainties about the biological affiliation of the authors of the other EUP cultural traditions. Widely accepted for the Chatelperronian, the only tradition associated with Neanderthal human remains [91,114], the Neanderthal authorship of EUP technocomplexes, even if plausible considering technological and geographic continuity with preceding local Mousterian industries, is still undemonstrated, and it has been proposed that some of them such as the Bachokirian or the Bohunucian may have been produced by moderns [127,165,167].

The elaboration of testable scenarios is further complicated by the limitation of radiometric dating for this time span (see [202,203] for discussion). The hypothesis that the earliest Aurignacian predated the emergence of the Chatelperronian and other EUP cultural traditions has been used to support the view that the Neanderthals and moderns lived side by side for a long time, during which the latter went through a process of gradual acculturation [17,91,104,117]. This would have triggered the adoption of a new lithic technology, ornaments, and bone tools by some Neanderthals groups. According to a recent variant of this scenario, designated the *Kulturepumpe* model, the Aurignacians would have reached the Swabian Jura precociously (ca 40,000 BP), from which they would have spread their civilisation into the remainder of Western Europe [44]. Instead, reappraisal of the radiometric and stratigraphic evidence supports the view that the earliest diagnostic occurrences of the Aurignacian are not older than ca 36,500 BP and postdate the emergence of the other EUP cultural traditions [1,202,203]. This has been used to suggest an autonomous evolution of local Neanderthal Mousterian traditions toward behavioural modernity before the arrival of Aurignacian moderns [53]. Such a model does not rule out the possibility that subsequent cultural contacts took place between Aurignacians and other EUP populations and played a role in shaping their respective cultures. The nature and extent of these contacts, however, as well as their impact on both populations, remains largely a matter of speculation.

To address this question, it would be helpful to reach a better understanding both of what the Aurignacian is and of the extent to which this broad archaeological entity can correctly be assimilated to a culturally and ethno-linguistically homogeneous population. The question of the regional variation in the material culture of the Aurignacian has been addressed by a number of authors (e.g. [30,32,57,62,79,103,160,203]). Recent analysis of early Aurignacian stone tool assemblages seems to confirm the presence in Western Europe of two different techno-typological traditions: the Archaic or Proto Aurignacian, mostly found at Mediterranean sites, and the Ancient Aurignacian, common in south-western France and Germany [27,172]. However, only a few assemblages are securely attributed to one of these two traditions and no agreement exists on whether these should be considered expressions of different cultural entities or about their possible contemporaneity. The fact is that Palaeolithic archaeologists have no obvious means by which to infer ethno-linguistic diversity from the more commonly studied components of the archaeological record [115,137]. Although constantly recurring associations of artefact types and manufacturing techniques are interpreted as signatures of Palaeolithic populations sharing some degree of cultural similarity [42,112,113], it has been repeatedly stressed that this assumption does not rely on any robust analogy [153]. In the last three decades cultural anthropologists [95] have gradually changed their view on the nature of ethnic groups and shifted from "objectivist" definitions (based on cultural practices independent from the perceptions of individuals) to a conception of ethnic groups as "self-defining systems" (based on the adhesion by the individual to a shared sense of distinctiveness). While traditional definitions of ethnic groups tended to conceive these as isolated and, to some extent, unhistorical entities, current approaches focus on the dynamic nature of ethnic affiliation, constantly subject to re-definition and re-negotiation. No consensus exists on what features or association of features of the material culture could more reliably identify such dynamic past entities in the archaeological record. Symbolic behaviours such as artistic activities, mortuary practices, and decorations on utilitarian and non-utilitarian objects, which need to be transmitted from generation to generation through language, are probably among the more informative elements for tracking down ethno-linguistic entities [10,23,90,96,110,153,197,199,200]. Artefact types and manufacturing techniques might hold information similar to that contained in symbolic behaviours (e.g. [112,113]). These links, however, are neither warranted nor univocal and must be supported, for each of the above cultural traits, by explicit analogies.

2. Personal ornaments as a proxy for ethno-linguistic diversity

We argue that personal ornaments are the trump card for addressing this issue. Archaeologically, personal ornaments offer four advantages which are not met together in other artefact categories: (1) Their function is exclusively symbolic; (2) they have been used by a large number of ethnographically well-documented traditional societies, which allows, in perspective, the creation of an informed analogy linking beads to ethnicity, language, and genetic/biological diversity; (3) they are common at Upper Palaeolithic sites; and (4) they occur during this period in many distinct types.

Ethnographic studies [84,89,100,176,198,199] have shown that beadwork, like body painting, scarification, tattooing, garment, and headdress [34,138,173] is perceived by the members of traditional societies as a powerful indicator of their ethno-linguistic identity, enhancing within-group cohesion and fixing boundaries with neighbouring groups. Ethnographic studies also indicate that the ethnic dimension of beadwork is conveyed through the use of distinct bead types and/or by particular combinations and arrangements on the body of bead types shared with one or more neighbouring groups [64,65,89,163]. Since the other functions of personal ornaments—i.e., markers of gender, age, class, wealth, social status, and use as exchange media, etc. [178,179]—are governed by rules shared by the members of a community, beadwork used in these ways also contributes, even if unintentionally, to differentiate a society from a neighbouring one. As a consequence, we may expect that ethno-linguistic entities will be identified archaeologically by geographically coherent clusters of sites yielding particular ornament types as well as by characteristic proportions and associations of types found over larger areas.

In this respect, the potential of personal ornaments has remained largely unexplored. The pioneer study by Newell et al. [124] on Mesolithic ornaments has gained no followers. A number of authors have analysed Upper Palaeolithic personal ornaments found at habitation sites to characterise their technique of manufacture [16,51,72,126,168,180–184,192,195] and their economic significance [106,162], and to identify exchange networks [3,4,9,51,168,185] and the earliest occurrences of beadmaking and use [7,54,88,107]. Others have analysed beads associated with burials in search of information on social stratification [180–184,194]. No attempt has been made so far to create and make available a comprehensive database of Upper Palaeolithic personal ornaments, and analyse it with adapted statistical tools. Here we present results on the geographical distribution and association of Aurignacian bead types, and explore their potential to identify patterns of ethno-linguistic diversity and population dynamics.

3. Methodology

Using ArcView GIS software, we have created a geospatial database of bead types found at Aurignacian sites. Data were obtained from the literature, direct analysis of published and unpublished archaeological collections. In a few cases, unpublished information was kindly provided by colleagues (Table 1).

Our typology of Aurignacian personal ornament takes into account cross-cultural studies on classification of beads [20,64,65,69,82,98,99,133,189] and, in a more general way, studies of the categorisation of the natural world [59] by traditional societies, as well as current debate on criteria used to classify archaeological artefacts [2,189,196]. Discrete bead types were created by reference to raw material, morphology, mode of suspension (e.g., perforation, groove), dimension, and, when applicable, to species (Figs. 1–3). In the case of animal teeth, we also considered the tooth type. In the case of fully shaped objects, mutually exclusive types were created by considering the raw material and comparing on a one-to-one basis the objects' morphology and size.

The taxonomy of shells has changed considerably since the first publications of Palaeolithic shell beads [109,141] and still varies today according to research traditions and specialists. To prevent having different taxa correspond to the same shell, taxonomic identifications given in the literature were updated and standardised using CLEMAM, the Check List of the European Marine Mollusca (www.somali.asso.fr/clemam/index.clemam.html). Shell bead types refer to species when the latter can be visually discriminated; otherwise they refer to genus.

Taphonomic [52] and cross-cultural studies [40] indicate that not all objects with a perforation or a gouge are personal ornaments. We have excluded from our database objects bearing no compelling traces of human involvement and, in general, included objects small enough to be worn as personal ornaments, and showing clear anthropogenic suspension devices.

Seriation and correspondence analyses of this database were performed using *BASP* software (www.uni-koeln.de/~I001/basp.html). Multiple seriation runs were performed experimenting with all sites and bead types, eliminating types occurring at just one site, and associating spatially close sites when such association increased the incidence matrix correlation coefficient. Sites that have not yielded at least two types and types not present in at least two sites were excluded from the correspondence analysis. Contour maps were created by applying the non-zero weight coordinates attributed to sites by each component of the correspondence analysis in Surfer7, Golden Software, Inc. Triangulation with linear interpolation and kriging methods were used to create maps. The former uses an algorithm that creates triangles by drawing lines between data points and is, among the available methods, the one that honours the data most closely. The latter is the most popular method, effective with almost any type of data set.

Although arguably meaningful, the proportion of the different ornament types at each site was not considered in our analysis. The low amount of ornaments yielded by excavations during which sediment was not systematically sieved with small mesh grid suggests that tiny or fragile ornaments are under-represented in most collections, and recorded proportions cannot be considered representative of the importance given to different ornaments types in Aurignacian beadworks.

4. Ornament types

Personal ornaments of 157 distinct types (Table 1, Figs. 1–3) are recorded at 98 Aurignacian sites in Europe and the Near East (Fig. 4). Of these types, 62 represent ornaments made of shells, 31 of teeth, 30 of ivory, 11 of stone, 11 of bone, 7 of deer antler, and one each of belemnite, nummulite, ammonite, sea urchin, and amber. Shell beads (Fig. 1) comprise 16 types corresponding to species restricted to the Mediterranean Sea, 5 to the Atlantic Ocean, and 12 to fossil outcrops. The remaining 23 shell bead types represent marine species found in both Mediterranean and Atlantic waters and, in one case, in fossil outcrops or fluvial environments. With the exception of *Dentalium* and *Vermetus*, which bear natural apertures, the shells were transformed into pendants by making one or, occasionally, two perforations.

To make pendants of teeth (Fig. 2), Aurignacians used the incisors, canines, premolars, and molars of 20 different mammals, including humans and, in one case, a shark. The use of deciduous horse or hyena teeth is recorded at three sites. With the exception of mammoth tusks, which were used as raw material for the manufacture of ivory beads and pendants, teeth from the other species were transformed into ornaments by making a perforation into or a circular groove around the root.

Twenty-one manufactured bead and pendant types (Fig. 3), made in a variety of raw materials, are found at Aurignacian sites, along with ivory and stone rings, possible diadems and labrets made of ivory, bone, or antler, as well as imitations in bone and antler of horse incisors and red deer canines. To this category of manufactured beads and pendants also belongs a single occurrence of an antler split-base point transformed into a pendant. Manufactured ornaments show single or double perforations, or grooves made to facilitate suspension.

Five ornament types consist of unmodified bones bearing an anthropogenic perforation (the fox metapodial and humerus, the reindeer phalange and vestigial metapodial, fish vertebra, and the mammal femur head).

5. Seriation analysis

The seriation of bead-type associations (Fig. 5) shows a good compactness along the diagonal of the incidence matrix. It also identifies fifteen *sets*, defined as clusters of three or more spatially cohesive sites sharing similar bead type associations. Set 1 groups ten sites from Germany. Set 2 groups five sites from Belgium. Sets 3, 6, 7, and 10 consist of a total of 27 sites from the southwest of France. Set 4 assembles seven sites from northern Iberia. Set 5 groups three sites from the northwestern Pyrenees. Set 8 groups five sites from the northeastern Pyrenees. Sets 9 and 13 comprise nine sites located in the southeast of France. Set 11 brings together seven

Table 1
Aurignacian Bead Database

Site	Ornament type	References
Austria		
Krems-Hundsteig	Clanculus, Columbella, Cyclope, Dentalium, Melanopsis	[71,78]
Langmannersdorf	Dentalium	[78,79]
Senftenberg	Dentalium, Turritella	[78,79]
Krems	Dentalium, PAnthropSt	[123]
Willendorf	Dentalium	[103]
Belgium		
Goyet	CBear, CFox, CDeer, IDeer, IHorse, IDcHorse, IWolf, Lip-plugIv, BEloIv, PEloIv, PDropIv, PEloAnt, ImIHorseBone	[60,111,126], Germonpré, pers. comm.
Prince	IDeer, POgivalIv	[60,111,126]
Princesse	CDeer, RIv, PTrapNotchIv, PTrapNotchAnt	[60,111,126]
Spy	CFox, CDeer, IWolf, IBoar, RIv, Lip-plugIv, BEloIv, B8Iv, PDropIv, BEllFlatNotchIv, BDiskIv, BDiskBlSt, BTubIv, BTubBone	[60,111,126]
Trou Magrite	CFox, CDeer, IDeer, Crommium, RIv, B8Iv	[60,111,126]
Croatia		
Sandalja	CBadger, CDeer, IDeer	[97]
Czech Republic		
Mladec	CWolf, CBear, DiademBone, IBeaver, IHorse, IMoose, VstMtpReindeer	[78,125,166]
France		
Abri Peyrony	CDeer, CFox, Dentalium, Turritella, Pecten	[118,119]
Balauziere	Acanthocardia, CDeer, L obtusata, Natica, Osilinus, Phalium, Tapes, Turritella, Venus	[14,71]
Blanchard	Ancillaria, Aporrhais, Belemnite, Columbella, Conus, Cypraea, Dentalium, Homalopoma, L littorea, L obtusata, L saxatilis, N corniculus, N gibbosulus, N mutabilis, N reticulatus, Natica, Nucella, Urchin, Potamides, Theodoxus, Turritella, BBasketIv, DiademIv, DiademBone, PForkIv	[61,121,131,168]
Caminade Est	Dentalium	[121,168]
Canecaude	CBear	[145]
Castanet	CHyena, CFox, IBovid, IDeer, IFox, Ancillaria, Aporrhais, Charonia, Cypraea, Dentalium, Homalopoma, L obtusata, L saxatilis, N gibbosulus, N incrassatus, N mutabilis, N reticulatus, Natica, Nucella, Phalium, Potamides, Surcula, Turritella, DiademBone, DiademIv, BGIv, BBasketIv, BBasketSt	[131,168]
Cellier	CWolf, Dentalium, Turritella, L obtusata, N reticulatus, DiademIv, PPointedNotchGIv	[131,168,191,195]
Chevre	Nucella, Potamides, BTubBone	[121,168]
Combe	Arca, CDeer, IFallowdeer, THuman, L littorea, L obtusata, Natica, N reticulatus, Nucella, Turritella	[86,121,168]
Combe Capelle	Urchin	[168]
Combette	Cypraea, Thais	[14]
Ferrassie	Ammonite, Architectonatica, Turritella, CDeer, DiademIv, IBovid, Nucella, Urchin, BTubBone, PPointedAnt	[120,130,168]
Festons	Ammonite, Cardium, Urchin, Pecten	[168]
Figuier	Glycymeris	[168]
Flageolet I	CFox, Cardium, CDeer, L littorea, BRectanFlatIv	[140,168]
Gatzarria	CFox, CDeer, IIbex, IDeer, IHorse, IFox, BBasketAnt, BBasketIv, BBasketSt, DiademAnt, DiademBone, RSt, BTubBone, PEloAmber, PTrianguloidIv, FishVertebra	[5,146]
Grotte des Fours	BTubBone	[121]
Grotte des Hyenes	CLion, CWolf, CFox, CDeer, THuman, DiademIv, Natica, Nucella, BBasketIv, BBasketSt	[27,86]
Isturitz	CHorse, CHyena, CWolf, CBear, CFox, CDeer, IBovid, IDeer, IHorse, IWolf, Thuman, L obtusata, Turritella, VstMtpReindeer, PEllIv, BBasketIv, BBasketSt, DiademBone, PEloAmber, PFlatSt, PRectangIv	[86,147,191]
La Quina	CHyena, CFox, Colus, IBovid, IHorse, IDcHorse, IWolf, IFox, MolWolf, PremolHorse, L littorea, L obtusata, Turritella	[66,67,74,85]
Laouza	Cypraea, Dentalium, N gibbosulus, N mutabilis, N reticulatus, Natica, Trivia	[71]
Lartet	Glycymeris, N gibbosulus	[121,168]
Le Piage	CFox, TShark, IIbex, IBovid, IDeer	[39]
Pages	CWolf, CFox	[121]
Pasquet	L obtusata, N gibbosulus, N mutabilis, Nucella, Turritella	[121,168]
Patary	CBear	[121]
Pataud	FemurIbex, CLion, CFox, CDeer, DiademBone, HumFox, IBovid, IWolf, L littorea, MtpFox, VstMtpReindeer, Pecten, BBasketIv, PhalFox, PhalReindeer, PRectangIv, Rhynchonella	[33,168,186]
Pecheurs	CDeer, Cyclope, Dentalium, Homalopoma, N mutabilis, N reticulatus, Natica, Ringicula, Trivia	[14]
Poisson	L saxatilis, N reticulatus, Natica, Theodoxus, Trivia	[168]

(*continued on next page*)

Table 1 (*continued*)

Site	Ornament type	References
Pont-Neuf	Pecten	[121]
Régismont	Acanthocardia, Glycymeris, Phalium	[71]
Renne	RProtrusionIv, Crommium, IBear, PEloIv	[195]
Roc de Combe	CLynx, CFox, IBovid, FishVertebra	[161]
Rochette	CLion, CFox, Dentalium, BTubBone	[121]
Rois	CHyena, CWolf, CFox, CReindeer, CDeer, THuman, DiademAnt, IBovid, IHorse, IReindeer, GastMould, Urchin, BBasketIv, BTubBone, PPointedAnt	[120]
Rothschild	Ammonite, Aporrhais, Cardium, Columbella, CDeer, Cyclope, Cypraea, Dentalium, Glycymeris, L littorea, L obtusata, Mitra, N gibbosulus, N mutabilis, N reticulatus, Natica, Nucella, Ocinebrina, Patella, Pecten, BBasketSt, Phalium, Potamides, Theodoxus, Trivia, Turritella	[14,71,168]
Saint-Cesaire	CDeer, IBovid, Turritella	Morin, pers. comm.
Salpetriere	Cardium, Cypraea, Dentalium, N gibbosulus, N mutabilis, Natica, Pecten, Phalium, Potamides	[14,71,168]
Solutre	BBasketIv, BDiskIv	Connet, pers. comm.
Souquette	Ammonite, CHyena, CFox, CDeer, IBovid, L littorea, L obtusata, L saxatilis, N gibbosulus, N mutabilis, N reticulatus, Natica, Nucella, Urchin, BBasketIv, BTubBone, Potamides, PPointedDecIv, PSplitAnt, Trivia	[13,19,27,56,168,195]
Sous-le-Roc	L obtusata, N reticulatus, Turritella	[121]
Sous-les-vignes	Cdeer, Cfox, Homalopoma, Trivia	[134]
Tournal	Acanthocardia, CBear, CDeer, Cyclope, Dentalium, L obtusata, Natica	[71,145,168]
Trou Mere Clochette	IBearG, BRectanFlatIv, PZoomorphicIv	[58], Monnier, pers. comm.
Tuc d'Audoubert	BBasketAnt	Pastoors, pers. comm.
Tuto de Camalhot	Buccinum, CFox, CDeer, Dentalium, DiademAnt, DiademIv, IBovid, L littorea, L obtusata, L saxatilis, N gibbosulus, N mutabilis, Pecten, BBasketIv, BBasketSt, BTubBone, POvoidDecIv, PPointedIv, Turritella	[27,168,187]
Vachons	CWolf, CFox, Colus, CDeer, Dentalium, IDeer, IWolf, Natica, Nucella, Ostrea, Pecten	[31,168]
Germany		
Bockstein Torle	IBovid, RNotchSt, PDropIv, POvoidSt	[78,101]
Bockstein Hohle	Cbear	[101]
Breitenbach	CFox	[78]
Geissenklosterle	CFox, DiademAnt, DiademIv, BEloIv, BBulgEllDpIv, BBilobateIv, PDropIv, PPyramidalIv, BTubBone, PZoomorphicIv	[44,101]
Hohle Fels	CDeer, IIbex, Lip-plugIv, BBulgEllDpIv, BBilobateIv, B8Iv, BDiskIv, BTubIv, PZoomorphicIv	[44,101]
Hohlenstein Stadel	CFox, PDropIv	[101]
Lommersum	PDropIv, PConIv	[80]
Sirgenstein	BBulgEllDpIv	[101]
Vogelherd	CDeer, BTubBone, PTrapNotchIv, PZoomorphicIv	[43,101]
Wildscheuer	CWolf, IHorse, POvoidSt	[170]
Greece		
Klisura	Clanculus, Columbella, Cyclope, N reticulatus, Natica, Ocinebrina, Potamides, Theodoxus, Trochus	[102]
Hungary		
Istallosko	ImCDeerAnt, BEloIv, GRoot	[78]
Italy		
Bombrini	Aporrhais, Clanculus, Cyclope, Gibbula, Homalopoma, N gibbosulus, N reticulatus, Ocinebrina, Osilinus, Trivia, Turritella	[71,76]
Cala	Astraea, Cantharus, Clanculus, Columbella, Conus, Cyclope, Dentalium, Gibbula, Glycymeris, Haliotis, Homalopoma, Jujubinus, Mitra, N gibbosulus, N incrassatus, N mutabilis, N reticulatus, Natica, Osilinus, Pecten, Phalium, Potamides, Tricolia, Trivia	[71,76]
Castelcivita	Homalopoma	[71,76]
Cavallo	Aporrhais, Cardium, Columbella, Cyclope, Dentalium, Glycymeris, Mytilus, N gibbosulus, Natica, Patella, Pecten, Potamides, Trochus, Turritella, Venus, Vermetus	[129]
Fanciulli	Acanthocardia, Aporrhais, Arca, Cyclope, Cypraea, Dentalium, Glycymeris, N mutabilis, N reticulatus, Nucella, Pecten, Potamides, Cdeer	[14,71]
Fossellone	CFox, CDeer, BEloSt	[24]
Fumane	Aporrhais, Cantharus, Clanculus, Cyclope, Cypraea, Dentalium, Epitonium, Gibbula, Glycymeris, Homalopoma, Jujubinus, L obtusata, L saxatilis, Mangelia, Mitra, Mytilus, N gibbosulus, N incrassatus, N mutabilis, N reticulatus, Natica, Ocinebrina, Osilinus, Patella, Potamides, Rissoa, Theodoxus, Trochus, Trivia, IDeerG	[71,76]
Mochi	Acanthocardia, Aporrhais, Arca, Astraea, Callista, Charonia, Clanculus, Conus, Cyclope, Cypraea, Dentalium, Epitonium, Fusus, Gibbula, Glycymeris, Haliotis, Homalopoma, Jujubinus, L obtusata, L saxatilis, Mitra, Mytilus, N gibbosulus, N incrassatus, N mutabilis, N reticulatus, Natica, Nucella, Nummulite, Ocinebrina, Osilinus, Ostrea, Patella, Pecten, Potamides, Strombus, Trivia, Turritella, BBasketBone, BBasketSt	[14,162]

Table 1 (*continued*)

Site	Ornament type	References
Near East		
Hayonim	CWolf, CFox, CDeer, Dentalium, IDeer, IHorse	[22]
KsarAkil	Columbella, Dentalium, N gibbosulus	[93]
Sefunim	Columbella, Conus, Cyclope, N gibbosulus	[17]
Yabrud	Dentalium, N gibbosulus, Theodoxus	[17,136]
Romania		
Cioclovina	CBear	[21]
Ohaba-Ponor	CFox	[21]
Russia		
Kostienki 1	CFox, Cyclope, N reticulatus, BWedgeIv, Potamides, Theodoxus	[6,78,103,154]
Muralovka	CFox	[78]
Spain		
Beneito	CLynx, Dentalium, Theodoxus	[94,159]
Cobalejos	CFox, CDeerG, IDeer, L obtusata, PPointedAnt	[148]
Cueva Morin	CDeer	[46]
Foradada	Buccinum, CLynx, Columbella, Glycymeris, Mytylus, Pecten, Theodoxus, Turritella	[36]
Garma	BBasketSt, BTubBone	[8]
L'Arbreda	Dentalium, Homalopoma, Pecten, Potamides, Trivia	[116]
Mollet	IDeer	[116]
Otero	CFox, CDeer, IIbex, IDeer	[46]
Pendo	CDeer, BAsyEloSt, BEloSteatite PEloSt, BBasketSt, BRectanFlatIv	[46]
Reclau Viver	CDeer, FemurIbex	[157,158]
Ukraine		
Siouren	Aporrhais, CDeer, IBeaver, Theodoxus	[6,103]

Abbreviations of ornament types (see Figs. 1–3) combine information on size (B, bead; P, pendant), tooth type (C, canine; Dc, decidual; I, incisor; Premol, premolar; Mol, molar; T, tooth), bone type (Phal, phalange; Hum, humerus; Vst, vestigal; Mtp, metapodial; Epi, epiphysis), shell type (Gast, gastropod), species (D, red deer; Lit, *Littorina*; N, *Nassarius*), raw material (Ant, antler; Iv, ivory; St, stone), morphology (Im, imitation; Con, conical; Elo, elongated; Bulg, bulged; Ell, elliptical; D, drop-shaped; R, ring; Disk, disk-shaped; 8, figure-eight-shaped; Ovoid, ovoidal; Trap, trapezoidal; Tub, tubular; Rectan, rectangular; Asym, asymmetrical; Split, split based point; Wedge, wedge-shaped) and other features (G, grooved; Dp, double-perforated; Notch, notched; Dec, decorated; Bl, black).

sites from Italy and Greece. Set 12 groups three sites from the Mediterranean coast of Iberia. Set 14 includes five sites from Austria. Finally, Set 15 comprises three sites from the Near East, attributed to the Levantine Aurignacian. The 12 remaining sites scatter between these 15 sets and correspond almost exclusively to geographically isolated occurrences.

The histograms composing Fig. 6 visually present the number of ornament types that each set shares with the other sets, as well as the number of types peculiar to each set and found therein at single or multiple sites. Five of the 15 sets (1, 2, 5, 7, 11) reveal particular ornament types occurring at more than one site within each set. Noteworthy, Sets 1, 2, and 3 have no ornament types in common with Sets 10 through 15 although both share a number of types with intermediate Sets 4 through 9.

These three clusters of sets are called hereafter *Macro-sets A* (Sets 1–3), *B* (Sets 4–9), and *C* (Sets 10–15).

5.1. Discrete ornament types

Macro-set A differs from B and C by its proportionally higher number of discrete bead types. Types specific to this macro-set and found therein in at least two constituent sets, consist of a repertoire of ivory beads (elongated, figure-eight-shaped, drop-shaped, disk-shaped), ivory pendants (zoomorphic, trapezoidal), and ivory lip-plugs.

Discrete types found in more than one set of the intermediate Macro-set B comprise perforated teeth (wolf premolar, fox incisor, hyena and lion canines, human tooth), shaped ornaments (rectangular ivory and pointed antler pendants, bilobate notched ivory beads, antler basket beads), perforated bones (femur heads, vestigial reindeer metapodials, fish vertebrae), and Atlantic shell beads (*Colus, Littorina littorea*). Only two ornament types, the Mediterranean *Clanculus* shell and the *Mytilus* shell bead common in both the Mediterranean and the Atlantic, are specific to Macro-set C and found therein in more than one constituent set.

Four sets (1, 2, 5, 7) within Macro-sets A and B, and one (Set 11) within Macro-set C yielded ornament types specific to each of the five and found within each set at more than one site. Bulged elliptical double-perforated and bilobate ivory beads, ovoidal stone beads only occur in Set 1. Ivory rings occur in Set 2, amber pendants in Set 5, and fossil *Ancillaria* shell beads at sites from Set 7. Nine marine shell beads made either from species restricted to the Mediterranean (*Clanculus*, *Tricolia*, *Trochus*, *Gibbula*, *Jujubinus*, *Cantharus*) or from both the Mediterranean and the Atlantic (*Epitonium*, *Haliotis*, *Astraea*) are only found at sites in Set 11.


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With the exception of Sets 10, 12, and 15, all the sets comprise types only found at a single site. In Set 1 these are the conical ivory pendant, the pyramidal ivory bead and the notched stone ring. In Set 2 these are the elliptical flat notched ivory beads, the ogival ivory pendant, the disk-shaped black stone bead, the elongated antler pendant, the wild boar incisor, and the imitation horse incisor made of bone. The grooved shark tooth occurs at only one site in Set 3.

Types unique to single sites from Set 4 are the elongated steatite bead, asymmetrical elongated stone bead, and the grooved red deer canine. The five ornament types unique to Set 5 are the elliptical ivory bead, the trianguloid ivory pendant, the flat stone pendant, the stone ring, and the perforated horse canine.

Twelve unique bead types occur in sites from Set 6: perforated animal bones (the reindeer phalange, the fox phalange, metapode, and humerus); the fossil *Rhynchonella* and *Architectonatica* shell bead; the perforated gastropod mould; the perforated reindeer canine and incisor; the horse premolar, the wolf molar, and the pointed bone pendant.

Sites from Set 7 have seven unique types: the pointed ivory bead decorated with punctures; the pendant made of an antler split-base point; the grooved and notched ivory pointed pendant; the perforated forked ivory pendant; the fossil *Surcula* bead; the perforated fallow deer incisor; the belemnite bead, and the *Nassarius corniculus* bead. The decorated ovoid ivory pendant was found at a single site from Set 8. Two shell beads, one Mediterranean (*Ringicula*) and one common in the Mediterranean and the Atlantic (*Tapes*) are specific to single sites from Set 9.

Specific types found at single sites from Set 11 are the bone basket bead, the grooved red deer incisor, and marine shell beads made from species occurring in both the Atlantic and the Mediterranean (*Callista*, *Vermetus*, *Mangelia*, *Rissoa*), as well as beads made from the fossil *Strombus* shell, nummulite, and *Fusus*, a typical Mediterranean shell. The *Thais* seashell has been exclusively found at one site from Set 13, and two types, the anthropomorphic stone pendant and the fossil *Melanopsis* shell bead, occur at single sites from Set 14.

Other discrete ornament types individualise geographically scattered sites that occur in between the identified sets. One type, the perforated beaver incisor, is exclusively found at two such sites (Mladec, Czech Republic, and Siuren, Crimea). A grooved tooth root and an imitation in antler of a perforated red deer canine are found solely at Istallosko in Hungary. A perforated wolf incisor and ivory rings with a protuberance are found at the Grotte du Renne in northern France, a perforated badger canine at Sandalja in Croatia, a perforated moose incisor at Mladec, and a wedge-shaped ivory bead at Kostienki 1 in Russia.

5.2. Shared ornament types

Macro-sets B and C have in common a much higher proportion of shared ornament types than that observed between A and B. Fourteen ornament types are shared by Macro-sets A and B, which assemble sites from the north of Europe, France, and the north of Spain. Thirty-seven types, absent in Macro-set A, are shared by B and C, the latter of which includes sites from southern Europe, Austria, and the Near East. Among shared ornament types some are more widely diffused than others.

The most popular types shared by the first two macro-sets are found at eight of nine constituent sets. They consist of perforated fox canines and tubular bone beads, found in Sets 1 through 8, and perforated red deer canines, present in Sets 1 and 2 and Sets 4 through 9. It is noteworthy that this last type is the only one that Set 9 (in the southeast of France), shares with the sites from Macro-set A.

Less trendy ornament types occurring in Macro-sets A and B are perforated bovid incisors, occurring in seven out of nine constituent sets and absent in Sets 4 and 9. Ivory diadems, perforated red deer incisors, and bear and wolf canines occur in five sets each. Antler diadems and perforated ibex, wolf, and horse incisors occur in four sets. Tubular ivory beads occur in three sets, and decidual horse incisors in two sets.

The most widespread type common to the second and third macro-sets, the *Turritella* shell, is found in nine of 12 constituent sets and is only absent in northern Spain (Set 4), in one of the two sets from southeastern France (Set 13), and in the Near East (Set 15). Found in eight sets, *Littorina obtusata* and *Dentalium* shells are the second most frequently shared types. The

Fig. 1. Major shaped ornament types. 1, elongated steatite bead (Pendo); 2, asymmetric elongated stone bead (Pendo); 3, conical ivory pendant (Lommersum); 4, elongated ivory bead (Geissenklösterle); 5, bulged elliptical double-perforated ivory bead (Hohle Fels); 6, drop-shaped ivory pendant (Hohle Fels); 7, elliptical ivory pendant (Isturitz); 8, ovoid stone pendant (Wildscheuer); 9, bilobate ivory bead (Hohle Fels); 10, ivory lip-plug (Spy); 11, trianguloid ivory pendant (Gatzarria); 12, disk-shaped black stone bead (Spy); 13, disk-shaped ivory bead (Solutré); 14, ivory basket bead (Solutré); 15, stone basket bead (Garma); 16, bone basket bead (Mochi); 17, ivory ring (Spy); 18, ivory ring with protrusion (Renne); 19, stone ring (Gatzarria); 20, notched stone ring (Bockstein Torle); 21, tubular ivory bead (Spy); 22, tubular bone bead (Geissenklösterle); 23, rectangular flat ivory bead (Pendo); 24, elliptical flat notched ivory bead (Spy); 25, ogival ivory pendant (Prince); 26, pyramidal ivory pendant (Geissenklösterle); 27, figure-eight-shaped ivory bead (Spy); 28, pointed ivory pendant (Tuto de Camalot); 29, decorated pointed ivory pendant (Souquette); 30, wedge-shaped ivory bead (Kostienki 1); 31, ivory diadem (Ferrassie); 32, antler diadem (Geissenklösterle); 33, notched trapezoidal flat ivory pendant (Vogelherd); 34, rectangular ivory pendant (Isturitz); 35, pointed antler pendant (Rois); 36, elongated stone pendant (Pendo); 37, elongated amber pendant (Isturitz); 38, pointed notched ivory pendant with suspension groove (Tuto de Camalhot); 39, antler pendant on a split based point (Cellier); 40, forked ivory pendant (Blanchard); 41, zoomorphic ivory pendant (Vogelherd); 42, anthropomorphic schist pendant (Galgenberg); 43, flat stone pendant (Isturitz); 44, imitation in bone of a perforated horse incisor (Goyet); 45, imitation in antler of a perforated red deer canine (Istallosko); 46, elongated ivory pendant (Goyet); 47, elongated antler pendant (Goyet); 48, decorated ovoid ivory pendant (Tuto de Camalhot). 1–2, 23, 36: after Corchon, 1986 [46]; 3, 8: after Hahn, 1977 [79]; 4–6, 9, 20, 22, 26, 32–33, 41: after Kölbl and Conard, 2003 [101]; 7, 34, 37, 43: after de Saint Perrier and de Saint Perrier, 1952 [147]; 10, 12, 17, 21, 24–25, 27, 46: after Lejeune, 1987 [111]; 11, 19: after Saenz de Buruaga, 1991 [146]; 15: after Arias Cabal and Ontañón Peredo, 2004 [8]; 16: after Stiner, 1999 [162]; 18: after White, 2001 [195]; 28, 38, 48: after Bon, 2002 [27,28]; 29: after White, 1996 [193]; 30, 45: after Hahn, 1972 [78]; 31: after Peyrony, 1934 [130]; 39: after White, 1989 [190]; 40: after White, 1989, 1993 [190,191]; 42: after Neugebauer-Maresch, 1999 [123].

Fig. 2. Teeth used as personal ornaments in the Aurignacian. 1, badger canine; 2, bear canine; 3, bear incisor; 4, fox canine; 5, bovid incisor; 6, fox incisor; 7, reindeer incisor; 8, reindeer canine; 9, beaver incisor; 10, horse canine; 11, horse incisor; 12, fallow deer incisor; 13, red deer canine; 14, red deer incisor; 15, hyena incisor; 16, hyena canine; 17, horse decidual incisor; 18, lion incisor; 19, wolf canine; 20, ibex incisor; 21, lion canine; 22, shark tooth; 23, human tooth; 24, wolf molar; 25, wolf incisor; 26, moose incisor; 27, lynx canine; 28, wild boar incisor.

Fig. 3. Shells used as personal ornaments in the Aurignacian. 1, *Acanthocardia* sp.; 2, Ammonite; 3, *Ancillaria* sp.; 4, *Aporrhais* sp.; 5, *Arca* sp.; 6, *Architectonatica* sp.; 7, *Astraea* sp.; 8, Belemnite sp.; 9, *Buccinum* sp.; 10, *Callista* sp.; 11, *Cantharus* sp.; 12, *Cardium* sp.; 13, *Charonia* sp.; 14, *Clanculus* sp.; 15, *Columbella* sp.; 16, *Colus* sp.; 17, *Conus* sp.; 18, *Crommium* sp.; 19, *Cyclope* sp.; 20, *Cypraea* sp.; 21, *Dentalium* sp.; 22, *Epitonius* sp.; 23, *Fusus* sp.; 24, Gasteropod mould; 25, *Gibbula* sp.; 26, *Glycymeris* sp.; 27, *Haliotis* sp.; 28, *Homalopoma sanguineum*; 29, *Jujubinus* sp.; 30, *Littorina littorea*; 31, *Littorina obtusata*; 32, *Littorina saxatilis*; 33, *Mangelia* sp.; 34, *Melanopsis* sp.; 35, *Mitra* sp.; 36, *Mytilus* sp.; 37, *Nassarius corniculum*; 38, *Nassarius gibbosulus*; 39, *Nassarius incrassatus*; 40, *Nassarius mutabilis*; 41, *Nassarius reticulates*; 42, *Natica* sp.; 43, *Nucella lapillus*; 44, Nummulite; 45, *Ocinebrina* sp.; 46, *Osilinus* sp.; 47, *Ostrea* sp.; 48, *Patella* sp.; 49, *Pecten* sp.; 50, *Phalium* sp.; 51, *Potamides* sp.; 52, *Rynchonella* sp.; 53, *Ringicula* sp.; 54, *Rissoa* sp.; 55, *Strombus* sp.; 56, *Surcula* sp.; 57, *Tapes* sp.; 58, *Thais* sp.; 59, *Theodoxus* sp.; 60, *Tricolia* sp.; 61, *Trivia* sp.; 62, *Trochus* sp.; 63, *Turritella* sp.; 64, urchin; 65, *Venus* sp.; 66, *Vermetus* sp.

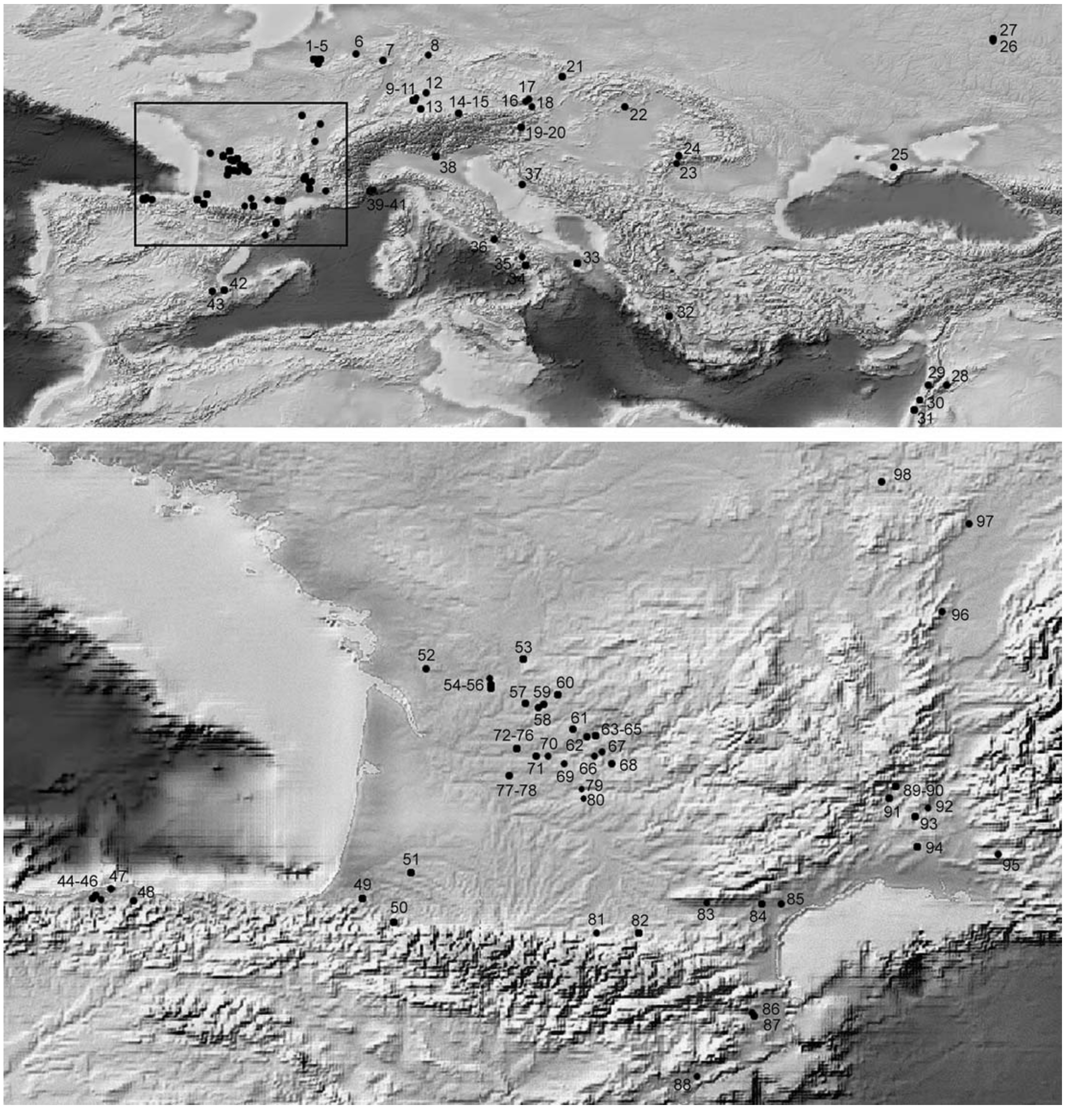

Fig. 4. Geographical distribution of the Aurignacian sites that yielded personal ornaments. 1, Spy; 2, Prince; 3, Princesse; 4, Goyet; 5, Trou Magrite; 6, Lommersum; 7, Wildscheuer; 8, Breitenbach; 9, Hohle Fels; 10, Sirgenstein; 11, Geissenklösterle; 12, Hohlenstein Stadel; 13, Vogelherd; 14, Bockstein Torle; 15, Bockstein Hohle; 16, Willendorf; 17, Senftenberg; 18, Langmannersdorf; 19, Krems-Hundsteig; 20, Krems; 21, Mladec; 22, Istallosko; 23, Ohaba-Ponor; 24, Cioclovina; 25, Siouren; 26, Kostienki 1; 27, Muralovka; 28, Yabrud; 29, KsarAkil; 30, Hayonim; 31, Sefunim; 32, Klisura; 33, Cavallo; 34, Cala; 35, Castelcivita; 36, Fossellone; 37, Sandalja; 38, Fumane; 39, Mochi; 40, Bombrini; 41, Fanciulli; 42, Foradada; 43, Beneito; 44, Pendo; 45, Garma; 46, Cobalejos; 47, Cueva Morin; 48, Otero; 49, Isturitz; 50, Gatzarria; 51, Grotte des Hyenes; 52, Saint-Cesaire; 53, La Quina; 54, Pont-Neuf; 55, Rois; 56, Vachons; 57, Cellier; 58, Chevre; 59, Festons; 60, Ferrassie; 61, Le Piage; 62, Rochette; 63, Blanchard; 64, Castanet; 65, Souquette; 66, Grotte des Fours; 67, Caminade Est; 68, Roc de Combe; 69, Combe Capelle; 70, Patary; 71, Flageolet I; 72, Combe; 73, Lartet; 74, Pasquet; 75, Pataud; 76, Poisson; 77, Pages; 78, Sous-le-Roc; 79, Abri Peyrony; 80, Sous-les-vignes; 81, Tuc d'Audoubert; 82, Tuto de Camalhot; 83, Canecaude; 84, Tournal; 85, Régismont; 86, Reclau Viver; 87, L'Arbreda; 88, Mollet; 89, Balauziere; 90, Laouza; 91, Pecheurs; 92, Figuier; 93, Salpetriere; 94, Rothschild; 95, Combette; 96, Solutre; 97, Trou Mere Clochette; 98, Renne.

former is only absent in Sets 13, 14, and 15, the latter in Sets 4, 5, and 6. *Nassarius gibbosulus*' distribution resembles that of *Dentalium*, except for its absence in Set 14 (Austria). *Natica*, also present in seven sets, is absent in Sets 4, 6, 12, and 14 through 15. Six types (stone basket bead, *Nucella lapillus*, *Pecten*, *Nassarius mutabilis*, *Theodoxus*, *Trivia*) are found in six sets. Nine types (*Nassarius reticulatus, Cardium*, *Acanthocardia*, *Aporrhais*, *Phalium*, *Potamides*, *Cyclope*, *Columbella*, *Glycymeris*) are found in five sets. Five types are found in four sets (*Littorina littorea*, ammonite, *Littorina saxatilis*, *Cyprea*, *Homalopoma*), and three types are found in three sets (urchin *Arca*, *Conus*). Eleven types are found in just two sets (*Ostrea*, *Charonia*, *Venus*, *Nassarius incrassatus*, *Patella*, lynx canine, *Osilinus*, *Mitra*, *Ocinebrina*, *Clanculus*, *Mytilus*).

6. Correspondence analysis

The plane created by the first two axes shows a parabolic crescent pattern (Fig. 7a). The first axis ranks sites in an order that closely follows the one identified by the seriation. The second axis identifies a similar trend with the exception of sites from Sets 1–2, which are found on either extremes of the range. This depends on the fact that the sites with the

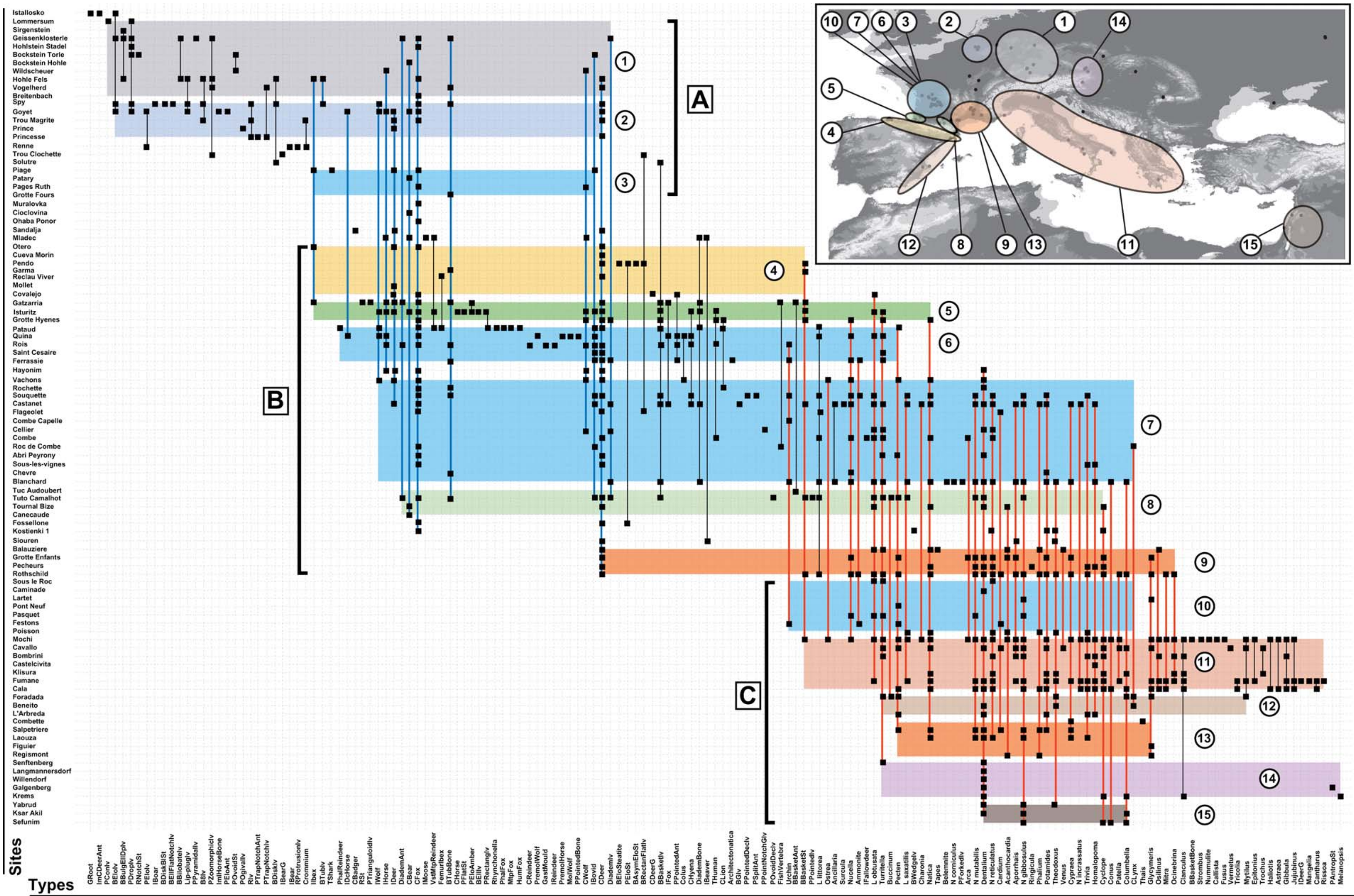

Fig. 5. Seriation of Aurignacian ornament types. Black squares indicate occurrences ($n = 691$) of types at sites. Sets are identified by encircled figures and highlighted by colours according to the geographical location of their constituent sites (see map in top-right box). Macro-sets are identified by brackets and capital letters in squares. Black vertical lines join occurrences of types specific to each macro-set. Blue lines tie occurrences of types shared by Macro-sets A and B, absent in C. Red lines put together ornaments found in Macro-sets B and C, absent in A. Abbreviations used for ornament types are explained in the legend of Table 1.

lowest values (Trou Magrite, Geissenklösterle, Spy, Vogelherd, Princesse, Hohle Fels) have in common a number of bead types absent in the other sites of their sets and a proportionally higher number of types shared with sites from sets 3–9. However, all sites from sets 1–2 join when the first three axes of the correspondence analysis are rotated under a certain orientation (Fig. 7b). This setting confirms the pattern identified by the seriation: sites from the same set plot together and sets are ranked according to their geographic proximity. The only notable exception to this trend is the site of Hayonim from the Near East, which plots with the sites of southwestern France instead of clustering near those from Southern Europe and Austria, as is the case with the other sites from the Levant (Set 15). This is due to the presence at Hayonim of five bead types (red deer, fox and wolf canines, horse and deer incisors) that are common at sites from Macro-sets A and B (Fig. 5) but absent at sites from Macro-set C. The presence of these bead types at Hayonim does not seem to be due to percolation of Natufian beads into Aurignacian layers since three of these types (wolf canine, horse and deer incisors) have never been found in Natufian contexts [18,19,22].

7. Geographic mapping

The maps obtained by plotting individual bead type occurrences (Fig. 8) and by gridding the values provided for each site by the first component of the correspondence analysis visualise the geographical differences in bead type associations (Fig. 9). Both kriging and triangulation methods identify a South-North decreasing gradient. The steepness that characterises this gradient in the Eastern Alps materialises the clear-cut difference in bead type association between German (Set 1) and Austrian (Set 14) sites. The gradient dissipates east- and westward but shows a promontory-like feature in the South West of France. This is mostly determined by the arrival at sites from this region of Mediterranean shell beads that do not reach sites located in the North fringe of Western France and the Cantabrian coast. A single site (Hayonim) is responsible for the "bull's-eye" pattern created in the Levant by the kriging method.

8. Discussion

Seriation and correspondence analysis of Aurignacian ornaments identifies a geographic cline in ornament type association sweeping counter-clockwise from the northern plains to the Eastern Alps through western France, northern Spain, the Pyrenees and Mediterranean Europe. A clear contrast is observed between the extremes of this cline—Germany and Austria—which, in spite of their geographic proximity have no ornament types in common. Three explanations may account for this pattern: (1) it reflects changes over time in personal ornament preference; (2) it is determined by availability of raw material used for beadmaking; (3) it mirrors long-lasting cultural differences between the human groups that have lived in these areas.

The first hypothesis implies that each of the identified sets corresponds to a particular time period and that changes between sets reflect a gradual evolution in bead use. Given that a clear correlation between sets of bead types and geographical regions is observed, the diachronic argument entails that the population or populations involved moved during their cultural evolution from one region to another. However, no evidence exists for such a chronological cline between the identified sets. Quite the opposite. With the exception of Southern Iberia, where sites attributed to the early phases of the Aurignacian are absent, each region identified by our analysis consists of Aurignacian sites dated and/or attributed to multiple periods or cultural phases within this technocomplex and each includes sites with long sequences spanning most of the Aurignacian interlude.

Six facts contradict the hypothesis that the observed pattern is determined by raw material availability. First, almost all the mammal species (fox, wolf, horse, ibex, bovid, bear, lion, hyena) that provided teeth used to manufacture personal ornaments in Germany, Belgium and the southwest of France were also available in southeastern France, Italy, Greece, Mediterranean Spain, and Austria, as demonstrated by the presence of remains of these animals at the Aurignacian sites from these areas [15,102,106,116,122,123,129,201]. Yet they were not used as beads.

Second, some clusters of coastal sites (Sets 4 and 5) reveal little use of shell for beadmaking in spite of its great availability in those areas. Third, absence of suitable raw material does not appear to have been an obstacle for Aurignacians bead users. Five shell species only available on the Mediterranean coast (*Columbella rustica, Homalopoma sanguineum, Nassarius corniculus, N. gibbosulus, N. mutabilis*) are found at five sites from the southwest of France (Lartet, Pasquet, Blanchard, Castanet, Souquette), which is located more than 300 km from the Mediterranean Sea. Similarly, three Atlantic shell species (*Littorina obtusata, L. littorea, Nucella lapillus*) are found at five Mediterranean sites (Balauzière, Rothschild, Enfants, Fumane, Mochi). Also, Mediterranean shell beads are common at sites in Italy (Fumane) and Austria (Krems Hundsteig, Senftenberg) that were at least 300 km inland, considering sea level during OIS 3.

Fourth, raw material availability cannot explain the lack of interest among Atlantic Aurignacians in shell beads since more than half of the shells (*Acanthocardium, Astrea, Epitonium, Callista, Haliotis, Mangelia, Mitra, Mytilus, Ocinebrina, Osilinus, Patella, Ringicula, Rissoa, Tapes, Thais, Tricolia, Trochus, Venus, Vermetus*) used as beads by Mediterranean Aurignacian did not fulfil this function at Atlantic sites in spite of their presence on oceanic shores. Fifth, one may reasonably assume that human teeth were available to all Aurignacians. Still, personal ornaments made of human teeth are only found at four sites (Combe, Grotte des Hyènes, Isturitz, Rois), all located in southwestern France.

Finally, the raw material explanation is contradicted by differences between regions in the shapes of manufactured bead and pendants. If the observed pattern were simply due to the availability of raw material such as ivory, we would expect

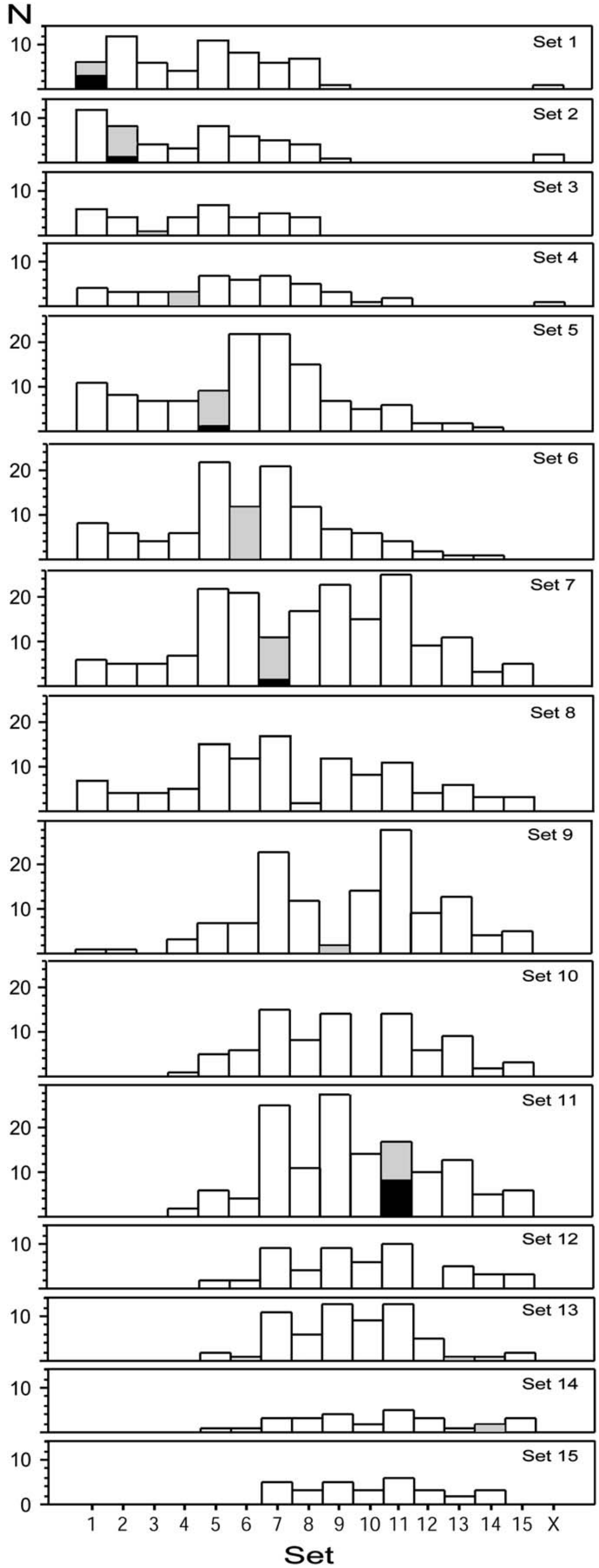

Fig. 6. Number of ornament types specific to each of the sets identified by the seriation analysis and found at more than one site (black pattern), at a single site (grey pattern) and number of ornament types that each set shares with the others (white pattern). "X" corresponds to sites that cluster in between the identified sets.

to find the same bead shapes over all the area where mammoth ivory was available. Instead we see highly distinctive ivory bead morphologies confined to particular regions (cf. the flat elliptical double-perforated ivory beads from Set 1 or the ivory rings from Set 2) and imitations in bone or stone of ivory bead morphologies (e.g., basket beads) at sites located at the periphery of areas where ivory was available (e.g., Garma and El Pendo in the Cantabrian region, and Rothschild and Mochi in southeast France and Liguria).

Therefore, we must conclude that regional differences in personal ornamentation reflect cultural differences among the human groups that have inhabited Western Europe between ca 37,000 and 28,000 BP. The clear contrast between Aurignacian sites from Italy, Austria, Greece and Southeast France, on the one hand, and northern Europe, on the other hand, indicates that cultural differences between these areas were at work during the whole Aurignacian time span. This observation contradicts the view of the Aurignacian as single cultural entity, and supports instead the affiliation of the human groups from these regions to distinct cultural traditions.

How to interpret such long lasting regional trends? Available information on the role of beads in traditional societies suggests that identified sets and macro-sets may reflect ethno-linguistic diversity. We argue that the three macro-sets, each characterised by distinct bead types and bead-type associations, may represent distinct language families. Identified sets could mirror fluctuating boundaries between ethnic groups speaking different languages within these families.

The fact that sites from two regions, southwest and southeast France, create multiple non-juxtaposed sets does not contradict this interpretation. Such splitting cannot be attributed, or solely attributed, to a differential preservation or selective recovery of personal ornaments since sites preserving faunal remains and submitted to high-quality excavations are found in each of these six sets. We must therefore interpret such splitting as the consequence of an occupation of the sites in these two regions by different ethnic groups in the context of dynamic population processes that for the time being are difficult to disentangle due to the low chronological resolution provided by radiocarbon dating. That symptoms of the course of history come into sight in these two regions may be a function of the wealth of excavated sites therein, which allows for thorough comparisons.

At the opposite end of the archaeological resolution are the Aurignacian sites from eastern Europe and the Near East. These sites, which share some bead types with Northern or Mediterranean sets but which also yielded a few specific bead types, can be interpreted as single representatives of enshrouded sets belonging to one of the three identified macro-sets or to a macro-set still to be defined.

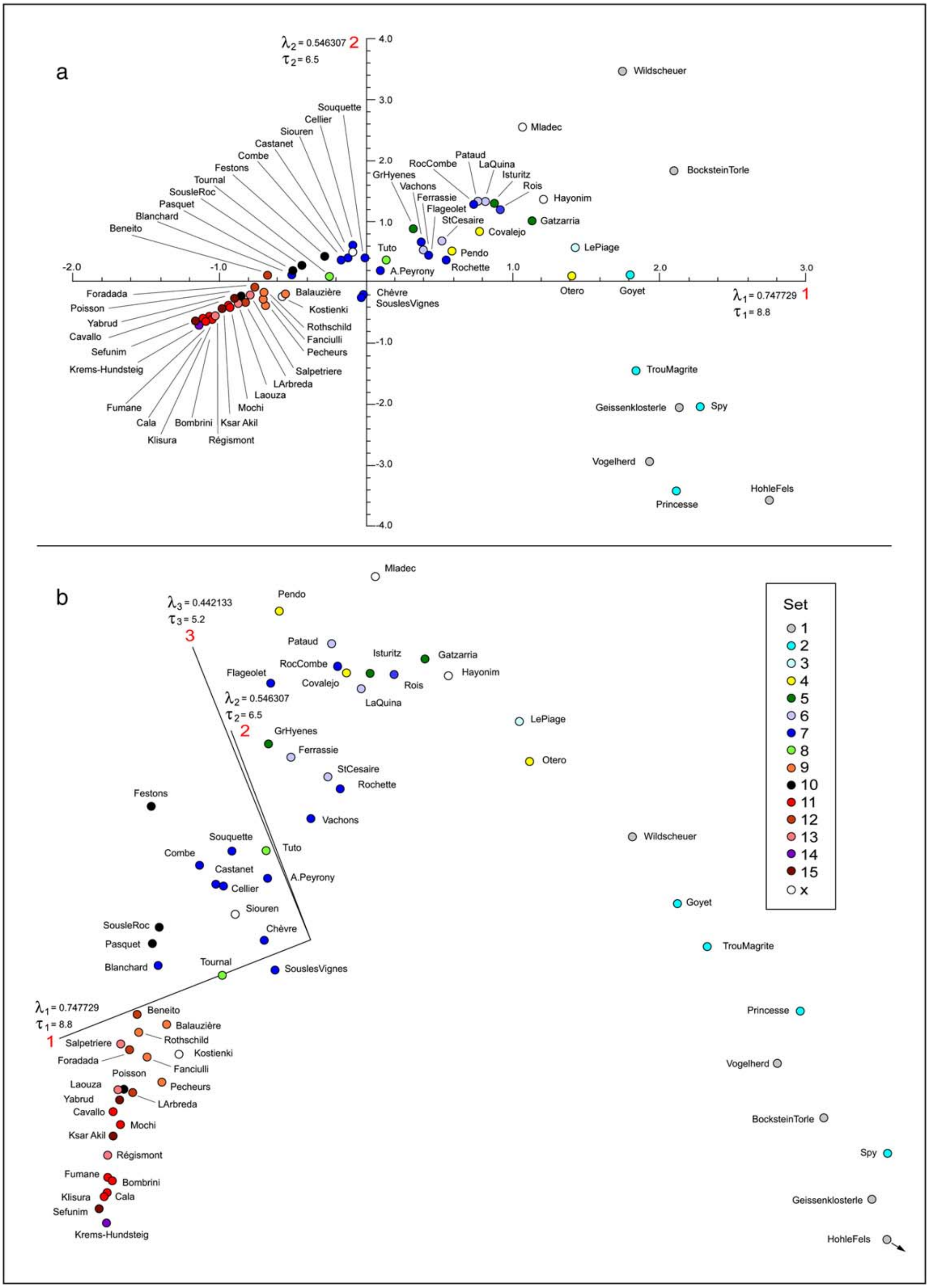

Fig. 7. (a) Projection of the first two axes of the correspondence analysis. (b) Projection of the first three axes of the correspondence analysis according to an orientation that positions the sites along a parabola. Colours indicate the sets identified by the seriation (see Fig. 5).

Our interpretation of the observed cline as a reflection of long-standing regional ethno-linguistic diversity is not contradictory to the hypothesis that a part of the observed variability in ornament type associations is due to changes in bead type preference through time within each of the identified regions. To identify these regional trajectories we would need more precise chrono-stratigraphic attributions of Aurignacian assemblages. Unfortunately this is difficult for the large majority of the sites in our database since they were excavated long ago, and due to the known drawbacks of radiocarbon dating

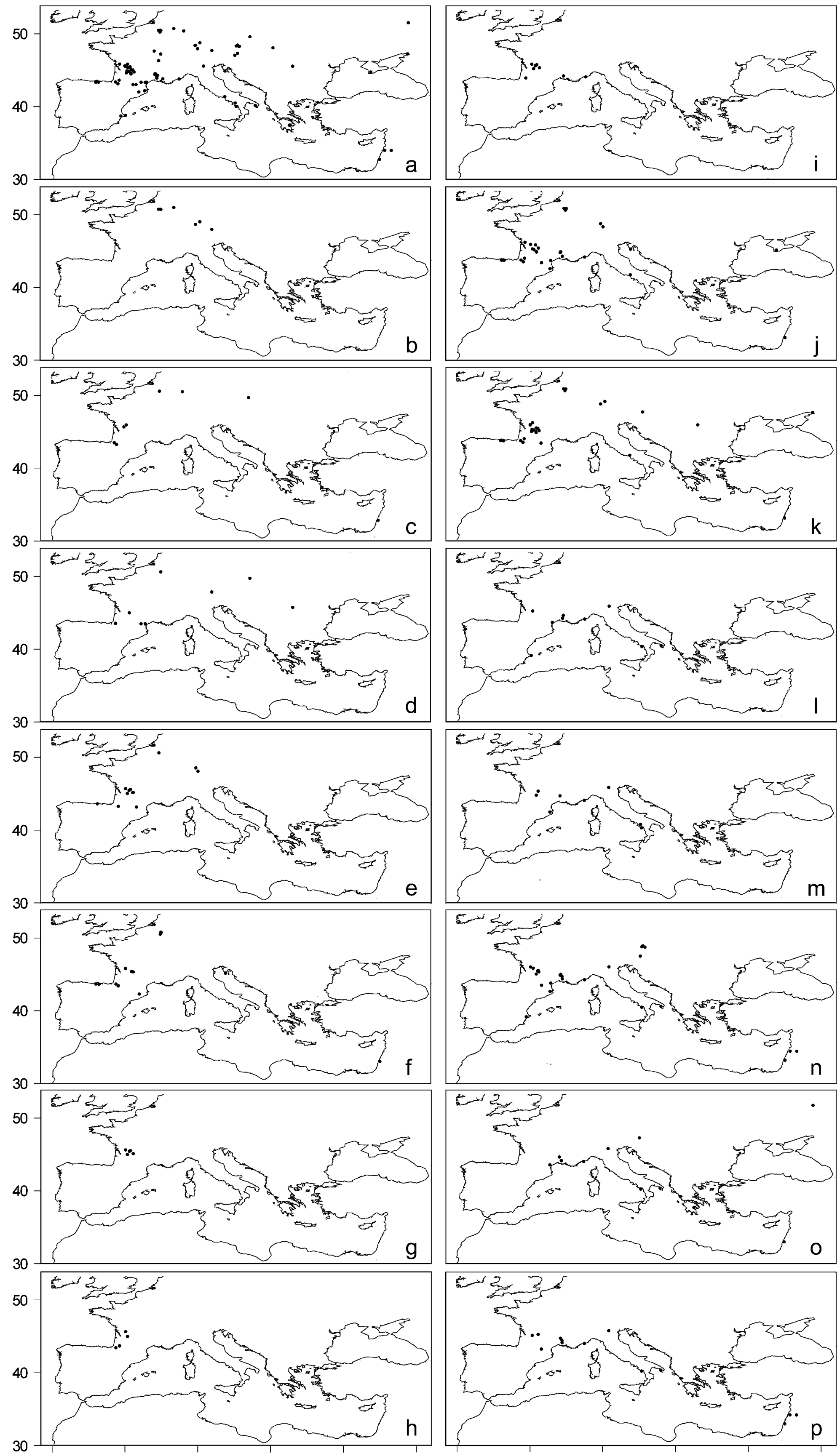

Fig. 8. Geographic distribution of Aurignacian bead type occurrences. a, all; b, drop-shaped ivory pendant; c, horse incisor; d, bear canine; e, tubular bone bead; f, deer incisor; g, urchin; h, human tooth; i, *Nucella lapillus*; j, deer canine; k, fox canine; l, *Glycymeris* sp.; m, *Homalopoma sanguineum*; n, *Dentalium* sp.; o, *Cyclope* sp.; p, *Nassarius gibbosulus*.

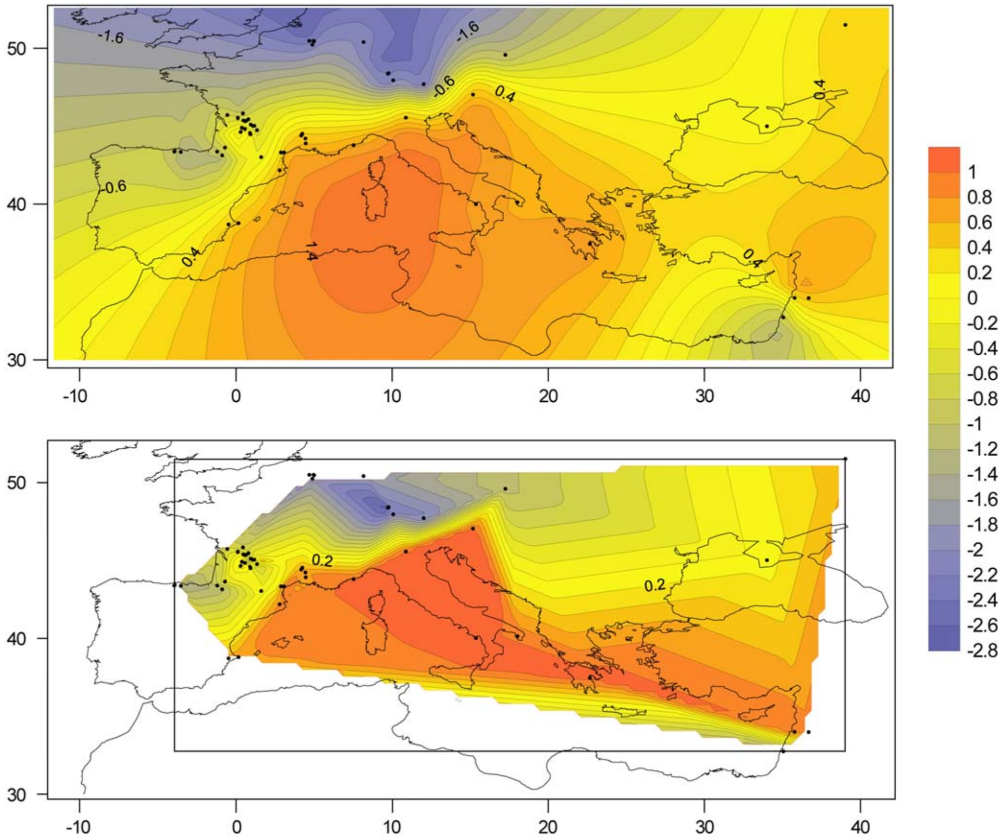

Fig. 9. Contour maps created by gridding with kriging (top) and triangulation (bottom) methods the values provided for each site (black dots) by the first component of the correspondence analysis.

for this period. Should this become feasible in the future, our dataset will increase its heuristic potential and be able to better follow cultural changes at regional levels and explore cultural boundary dynamics.

The cultural geography identified by personal ornaments does not closely match differences observed in other elements of Aurignacian material culture. Comparing our results to the assignments- Archaic *versus* Ancient - proposed for sites dated to the early phases of the Aurignacian [27,28,172] is problematic. Many assemblages are still not attributed to one component or the other, and the stratigraphic provenance of personal ornaments from sites that have yielded both components are in a number of cases, particularly for old excavations, ambiguous. However, bead associations found at sites that have only yielded one of these components reveal no obvious match with personal ornaments associations. Tuto de Camalhot, Salpetrière, Balauzière, Castanet, Pataud, Régismont, Geissenklösterle, Vogelherd, attributed to the Ancient Aurignacian, are scattered within the three identified Macro-sets; Rothschild, Fumane, Laouza, Grotte du Renne, and Trou de la Mère Clochette, attributed to the Archaic Aurignacian, are found in both Macro-sets A and C. We observe that sites attributed to one techno-typological component are more similar, from a bead point of view, to neighbouring sites attributed to the other component than to far away sites yielding the same stone tools. Split based bone points, a traditional *fossil directeur* of the early Aurignacian are found at sites from all three Macro-sets and although generally associated with the Ancient, are also found in a few Archaic Aurignacian assemblages [149]. These mismatches are not surprising. As Jones ([95]: 100) correctly points out ethnicity is a multidimensional phenomenon and

> “there is rarely a one-to-one relationship between representations of ethnicity and the entire range of cultural practices and social conditions associated with a particular group. From a ‘bird's eye view’ the resulting pattern will be one of overlapping ethnic boundaries constituted by representations of cultural differences…”.

The main advantage of personal ornaments to accomplish this multiplex endeavour rests in the possibility they offer to translate the cultural signal into meaningful spatially correlated networks. This allows in perspective to effectively contrast the cultural geography of Upper Palaeolithic populations with hypotheses put forward by geneticists on the peopling of Europe during OIS 3–2.

9. Conclusion

Cultural entities of the European Upper Palaeolithic and the attempts made to infer cultural boundaries have been traditionally based on chronological and geographic variations in the technology and typology of lithic and bone artefacts. Our results show that personal ornaments can complement this picture by taking into account another dimension of the human experience. Seriation, correspondence analysis and contour mapping of bead association appear to be robust and previously unexplored tools to identify the geography of prehistoric ethno-linguistic entities and determine the cultural affiliation of future archaeological sites yielding personal ornaments. Future research will focus on personal ornaments from the remaining Upper Palaeolithic technocomplexes in order to explore how the ethno-linguistic geography of human populations—reflected in ornament use—changed through time. In particular, comparison between the Aurignacian Bead Database and personal ornaments associated with the other Early Upper Palaeolithic technocomplexes can shed new light on the highly debated topic of cultural and biological interactions between the last Neanderthals and Anatomically Modern Humans.

By comparing the same database with personal ornaments associated with Upper Palaeolithic technocomplexes that post-date the Aurignacian, one may be able to establish if and to what extent the cultural geography identified by our analysis applies to the remaining European Upper Palaeolithic. In the event that such continuity is verified, and its independence from raw material availability confirmed, personal ornaments could be recognised as a category of Palaeolithic material culture particularly well suited for investigating fundamental aspects of prehistoric societies such as continuity in population, exchange networks, ideology and language. On the other hand, if analyses of an enlarged bead database reveal discontinuities in the cultural geography of Upper Palaeolithic populations, it will be necessary to establish the tempo and mode of such changes and determine whether or not they are correlated with the millennial scale climatic variability of OIS 3–2 [29,48,68,83]. The rapid climatic fluctuations that characterised this period certainly had an impact on population dynamics and may have periodically reshaped the human geography of Europe [25,50,55,73].

Our results suggest that personal ornament associations reflect the systemic relationships that existed at an ethno-linguistic level between different population clusters. In this respect, changes in bead type associations may be instrumental in investigating, at a regional level, the possible impact of specific environmental shifts on the construction and expression of hunter-gatherer ethnicity.

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