Symbolic use of marine shells and mineral pigments by Iberian Neandertals

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Two sites of the Neandertal-associated Middle Paleolithic of Iberia, dated to as early as approximately 50,000 years ago, yielded perforated and pigment-stained marine shells. At Cueva de los Aviones, three umbo-perforated valves of *Acanthocardia* and *Glycymeris* were found alongside lumps of yellow and red colorants, and residues preserved inside a *Spondylus* shell consist of a red lepidocrocite base mixed with ground, dark red-to-black fragments of hematite and pyrite. A perforated *Pecten* shell, painted on its external, white side with an orange mix of goethite and hematite, was abandoned after breakage at Cueva Antón, 60 km inland. Comparable early modern human-associated material from Africa and the Near East is widely accepted as evidence for body ornamentation, implying behavioral modernity. The Iberian finds show that European Neandertals were no different from coeval Africans in this regard, countering genetic/cognitive explanations for the emergence of symbolism and strengthening demographic/social ones.

behavioral modernity | Iberia | Middle Paleolithic | shell ornaments | symbolism

Items of body decoration—perforated and pigment-stained shells of marine mollusks—are a feature of the Middle Stone Age (MSA) of southern Africa and the Middle Paleolithic (MP) of the Maghreb and Near East (1, 2). Dated to 70–120 ka calendar (cal) B.P., these finds are widely accepted as evidence of symbolic thinking among the earliest anatomically modern humans of Africa and adjacent regions of Southwest Asia (3).

An absence of similar finds from the coeval archeological record of Europe has supported the notion that Neandertals were devoid of symbolism, their cognitive inferiority explaining why modern humans dispersing out of Africa eventually replaced them across the entire continent approximately 40 ka cal B.P. (4, 5). In this view, claimed instances of Neandertal symbolism are disregarded on different grounds—e.g., as coming from old excavations and too ill-recorded to be certain or of ambiguous interpretation and in any case too scant to be meaningful. A case in point is the Mousterian cemetery of La Ferrassie (6), for which regional culture-stratigraphy indicates an age of approximately 65–70 ka cal B.P. (7) and where the burial pit of an adult male contained a bone fragment decorated with four sets of parallel incisions, whereas that of a 3- to 5-year-old child was covered by a cupule-decorated limestone slab.

In this context, the presence of body ornaments (namely, pierced and grooved animal teeth) in Neandertal-associated archeological cultures (such as the Châtelperronian of France) has been variously explained by stratigraphic mixing, acculturation, "imitation without understanding," or independent Neandertal innovation (8–14). As this evidence comes from near the time of contact with modern humans in Europe, unresolved issues of dating and taphonomy impacting the broader paleoanthropological problem explain the persistence of the debate (15–18).

Here, we report secure evidence that, approximately 50 ka cal B.P., 10 millennia before modern humans are first recorded in Europe, the behavior of Neandertals was symbolically organized and continued to be so until the very end of their evolutionary trajectory. This conclusion is based on the same types of finds and criteria used to assess the African and Near Eastern evidence—pigment-stained, perforated marine shells and the associated procurement, processing, and application of colorants for body ornamentation. The evidence comes from two sites in the Murcia province of southeast Spain, Cueva de los Aviones (37°35′7.30″N, 0°59′8.66″W) and Cueva Antón (38°3′51.84″N; 1°29′47.20″W) (*SI Appendix, Sections I and II*).

Results

The Sites. Aviones is a large cave whose fill has for the most part been eroded away by postglacial marine erosion (*SI Appendix, Section I,* Figs. S1–S4). At the time of occupation, the Mediterranean was 50–90 m lower (19), implying a distance of 1.5–7.0 km between site and shore (or more, because the Murcia coast is a subsidence area). A brecciated baulk preserved against the northwest wall of the cave was excavated in 1985 (20, 21), revealing an MP stratigraphy resting on an Eemian rock beach and made up of slope deposits of continental origin interspersed with flowstones and carbonate crusts (*SI Appendix, Section I,* Tables S1 and S2). The archeological levels (I–V), separated from the rock beach by a thick, sterile deposit (level VI), date to the approximately 45–50 ka cal B.P. interval (*SI Appendix, Section III,* Table S4, Fig. S13). They yielded abundant lithic assemblages—primarily made of quartz but with a significant component of flint sidescrapers and points (*SI Appendix, Section I,* Fig. S5)—in

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association with marine mollusk shells and bone remains of horse, deer, ibex, rabbit, and tortoise.

Antón (22) is a large rockshelter excavated by the Mula river, which runs through an interior basin located approximately 60 km from the present shore line. The MP occupations are preserved in a more than 4-m-thick sequence of low-energy flood deposits overlain by silts accumulated during recent episodes of inundation by a dam reservoir (*SI Appendix, Section II,* Table S3, Figs. S11 and S12). The levels are artifact-rich and organized around hearth features in the lower part of the sequence, but occupation remains are scarce toward the top, reflecting sporadic and ephemeral incursions. The uppermost fertile units are levels II-l and I-k, for which the ages indicated by radiocarbon dating are, respectively, greater than 43.5 and approximately 37.4 ka cal B.P. (*SI Appendix, Section III,* Table S5, Figs. S13 and S14).

The Aviones Finds. Three categories of species are represented in the Aviones marine shell assemblage (Table 1). Most (95.7%) are of edible intertidal genera (*Cerastoderma*, *Monodonta*, *Mytilus*, and *Patella*) and have well preserved surfaces, indicating collection of living animals. A residual proportion (0.2%) are accidentally introduced *Nassarius incrassatus* and *Gibbula* sp. As these taxa live or feed on algae, their presence is likely to reflect packaging of the edible species in water-soaked algae, a traditional, preindustrial technique of maintaining harvested mollusks alive (they rot very rapidly and must be eaten or cooked extremely fresh) during transportation from the point of collection to the point of consumption. Indeed, remains of *Jania rubens* var. *corniculata*, an intertidal epiphytic alga whose calcareous articulated frond allows preservation and recognition in carbonated cave fills, were recovered in levels I and II (20, 21).

The remaining 4.0% are infra- and circalittoral genera with variably abraded and bioeroded surfaces, reflecting beach collection of the shells of dead animals (*SI Appendix, Section I,* Figs. S8–S10). The *Chama*, *Laevicardium*, *Charonia*, and *Thais* material is too broken to assess original condition, and the one *Trunculariopsis trunculus* is a complete specimen with an irregular, probably postdepositional perforation of the body whorl in an area where the shell is very thin.

Of the three *Acanthocardia tuberculata*, one is complete, another bears an excavation break with loss of the umbo area, the third is a conjoin of two fragments with an ancient, postdepositional break, and all must have been collected and introduced to the site as whole valves. The smaller, from level II, is umbo-perforated (Fig. 1, *1*).

Of the *Glycymeris insubrica*, four are complete, ten are ventral margin fragments, and four are small fragments of the middle of the shell; although excavation breaks are apparent in a few, most feature ancient breaks only. Two complete specimens from level II are umbo-perforated (Fig. 1, *2–3*), and residues of a red colorant, identified as hematite (*SI Appendix, Section IV* Figs. S15 and S16), were found while cleaning the carbonate coating around the perforation of the larger shell. As argued for the comparable modern human-associated material from Near Eastern sites of the MP and early Upper Paleolithic (UP) (Qafzeh, Ksar 'Akil, Üçağizli), the parsimonious interpretation of *Glycymeris* shells, even in the absence of pigment residues and irrespective of the origin of the perforation, is that they are personal ornaments (23, 24).

The three *Spondylus gaederopus* shells were originally complete. The inner side of a level II upper valve (Fig. 2) bears residues of a pigmentatious mass composed of a red lepidocrocite base mixed with ground particles of charcoal, dolomite, hematite, and pyrite (*SI Appendix, Section IV,* Table S6, Figs. S17–S19), suggesting use as a container for the storage of colorants or as a kind of paint cup for their preparation. Although examination of their surfaces for pigment residues is hindered by extensive carbonate coating, a similar function can be envisaged for the other valves of *Spondylus* as well as for those of taxa with a similar concave morphology—an excavation-broken *Callista chione* and two lower valve fragments of *Pecten maximus* (*SI Appendix, Section I,* Figs. S9 and S10).

Table 1. Cueva de los Aviones mollusks: taxa and provenience

	I	II	III	IV	V	Total
Food taxa						
Cerastoderma edule	—	8	1	5	—	14
Monodonta turbinata	12	14	234	151	16	427
Mytilus edulis	36	11	31	30	—	108
Patella sp.*	10	61	96	69	—	236
Nonfood taxa						
Acanthocardia tuberculata	—	1	1	1	—	3
Callista chione	1	—	—	—	—	1
Chama gryphoides	1	—	—	—	—	1
Charonia lampas	—	—	—	1	—	1
Gibbula cf varia	—	—	—	1	—	1
Glycymeris insubrica	10	6	2	—	—	18
Laevicardium oblongum	—	—	—	1	—	1
Nassarius incrassatus	—	—	—	—	1	1
Pecten maximus	—	—	2	—	—	2
Spondylus gaederopus	1	1	—	1	—	3
Thais hemastoma	—	1	—	—	—	1
Truncularia psis trunculus	—	—	1	—	—	1
Unclassified bivalve	1	—	—	—	—	1
Total	72	103	368	260	17	820

*Mostly *P. ferruginea*; a few are *P. aspera* and *P. lusitanica*

Orange pigment was also observed on the tip of an unmodified ancillary metatarsal of *Equus* sp. from level III, but its composition could not be established, due to the extensive carbonate coating and attendant high fluorescence of the specimen (Fig. 3; *SI Appendix, Section IV*, Fig. S20). This naturally pointed bone may have been used as a stiletto for the preparation or application of mineral dyes or as a pin or awl to perforate soft materials (e.g., hides) that were themselves colored with such dyes.

Lumps of red and yellow colorants were noted and sampled at the time of excavation (25) (*SI Appendix, Section V*, Table S7, Figs. S21–S23). X-ray diffraction showed the reddish material to be siderite, goethite, hematite, and nontronite, and the yellow to be siderite and natrojarosite. These pigments can only be manuports because both the cave and the catchment of its sedimentary fill are in Mesozoic limestone and dolomite bedrock, where the identified minerals either do not exist or do not occur as masses of macroscopic size (in the region, such masses formed as a result of volcanism and hydrothermalism processes of Neogene age; *SI Appendix, Section V*).

Sources for the red colorants can be found 3–5 km to the northwest, in the mining district of La Unión, exploited for gold, silver and base metals since antiquity. For the yellow natrojarosite, the purity of the level III sample—a large (23 g) and homogeneous accumulation of prisms, granules, and powder, probably the contents of a small purse made of perishable material—constrains potential sources to a limited number of localities, the closest lying approximately 7 km to the east (*SI Appendix, Section V,* Figs. S22 and S24).

The Antón Finds. Level I-k of Cueva Antón, which caps the MP archeological succession and is directly overlain by the reservoir inundation silts, yielded half of an upper, flat valve of *P. maximus* featuring a circular perforation approximately 6 mm in diameter (Fig. 4). The shell's numerous sponge holes indicate that it was beached after laying on the sea bottom for a significant amount of time. Whether the circular perforation relates to the same bioerosion processes (i.e., is natural) or was made after collection (i.e., is anthropogenic) cannot be assessed due to postdepositional

Fig. 1. The perforated shells from level II of Cueva de los Aviones (after cleaning): (*1*) *Acanthocardia tuberculata*; (*2–3*). *Glycymeris insubrica* (maximum internal diameter of the perforations: 4.2, 9.5, and 6.8 mm, respectively). See also *SI Appendix, Sections I and IV,* Figs. S6, S7, S15, and S16.

degradation of the hole's margins (e.g., by exfoliation and rubbing against the angular clast matrix), which caused the extant sharpness of its paper-thin edges. But we can exclude a postdepositional origin for the perforation itself because the presence of orange pigment residues on the interior surfaces of the exposed structural hollows of the shell implies that the perforation preexisted the application of the colorant.

The pigment—a mix of yellow goethite and red hematite for which potential sources exist within approximately 5 km from the site—is ubiquitously preserved but on the shell's external, discolored side only, suggesting that it may have been deliberately painted, either to regain the original appearance or to make it the same color as the internal side, which remained its natural red (*SI Appendix, Section VI*, Figs. S25 and S26). The ephemeral nature of the occupation of level I-k argues against on-site tool production or tool maintenance tasks and strengthens the case for the interpretation of this shell as an item of body decoration. The alternatives—use as a container or palette—could hold for a lower valve color-stained on the inner, concave surface or if the perforation was postdepositional, but neither is the case.

Comparative Study. It has been argued that symbolic interpretations of the African and Near Eastern MSA/MP marine shell beads are questionable because the anthropogenic nature of their perforations is uncertain, whereas those in the marine shell beads found among modern human-associated cultures of the African Late Stone Age (LSA) and the European UP are clearly manmade (26). By extension, this argument applies to the material presented here too, but is it valid? To assess this issue, we collected from regional beach thanatocenoses a modern reference sample of shells of the bivalve genera that are most common in ornamental assemblages of prehistoric Iberia—*Acanthocardia*, *Cerastoderma*, and *Glycymeris* (*SI Dataset* and *SI Appendix, Section VII,* Tables S8–S10, Figs. S27–S30). We then compared the

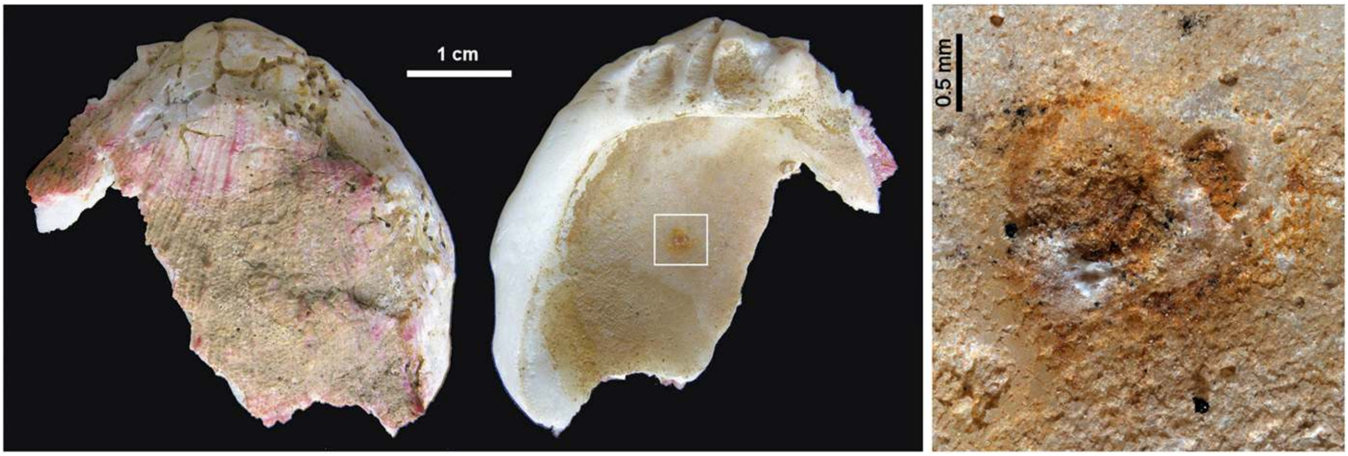

Fig. 2. (*Left*) Excavation-broken upper valve of *Spondylus gaederopus* from Cueva de los Aviones (the pigment residue is indicated); (*Right*) close-up view of the pigment residue. See also *SI Appendix, Section IV,* Figs. S17–S19.

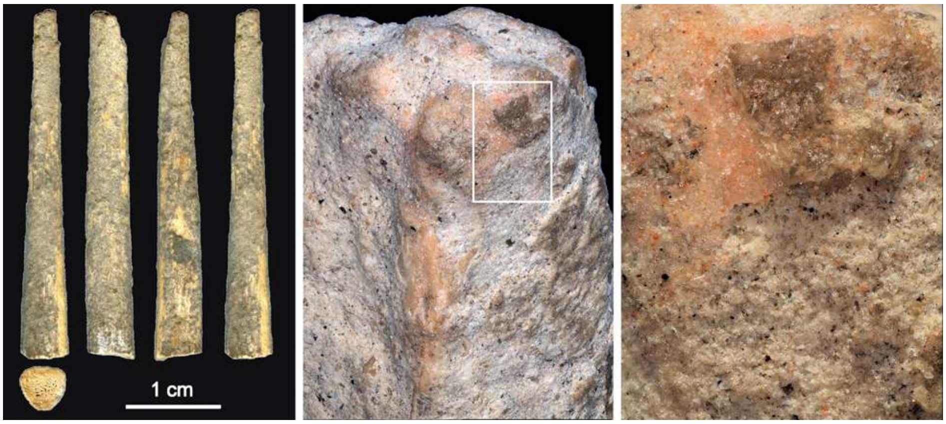

Fig. 3. Different views of an ancillary metatarsal of horse with an excavation break from Cueva de los Aviones (*Left*) and binocular microscope close-ups of its pigment-dotted tip (*Center* and *Right*). See also *SI Appendix, Section IV,* Fig. S20.

Murcia MP specimens with that collection and with (*i*) the early modern human-associated MP material from the Near East, and (*ii*) the relevant components of ornament assemblages from the UP and the Neolithic of Mediterranean Spain (*SI Appendix, Section VIII,* Table S11, Figs. S31–S42).

In the natural collection, umbo-perforated shells occur frequently (45.4%) in the case of *Glycymeris*, less so in the case of *Acanthocardia* (2.7%). Both the occurrence and the size of the perforations correlate positively with discrete indicators of weathering such as decalcification/exfoliation, sponge holes, and abrasion (Table 2). Thus, in the absence of production toolmarks, perforations can be presumed anthropogenic only if the umbo holes are large but the shell is fresh or only lightly weathered. Conversely, as umbo perforations occur in 90% of the modern *Glycymeris* that feature advanced weathering, a natural origin must be presumed for archeological *Glycymeris* in similar condition. Based on these uniformitarian criteria, the perforations in the MP *Glycymeris* from Qafzeh and Aviones, as well as in those from the UP and the Early Neolithic of Mediterranean Spain that we examined, are natural, and so too are those in all of the *Acanthocardia* and *Cerastoderma* shells from the same sites.

The archeological *Glycymeris*, however, were not gathered completely at random. When our three collections (MP, UP, and Neolithic) are considered together, a pattern of selection based on perforation size emerges—irrespective of height, shells with holes in the 4.5–6.5 mm interval were targeted (*SI Appendix, Section VIII,* Fig. S31). These observations suggest that the pattern is cross-cultural and determined by threading constraints, with color, shine, and overall surface appearance being of secondary importance—explaining why all of this material features advanced weathering, despite lightly weathered shells (that preserve more of the original color but lack a perforation or only have a very small one) being rather easy to find in nature too.

Although the perforations on the *Nassarius kraussianus* from the MSA of Blombos are anthropogenic (1), only one out of the 41 *Nassarius gibbosulus* beads from Skhul and the North African MP sites featured striations made by a stone tool—most are weathered specimens with types of holes whose size and placement on the shell can also be found in natural thanatocenoses, albeit in different frequencies, indicating selection but not necessarily modification. The use wear, however, is distinctive, and shows they were used as beads even when their perforations are natural (2).

In the Murcia MP shells—as is the case, due to the high water content of depositional environments, in most ornamental shell assemblages of the European Paleolithic (27)—chemical microweathering (*SI Appendix, Section I,* Fig. S7) would have long erased any perforation-associated use wear evidence. Shallow notches observed on the internal contour of the perforations of two *Glycymeris* from Qafzeh, where they were interpreted as caused by friction from a string (23), are also apparent in the Aviones specimens (Fig. 1 and *SI Appendix, Section I,* Fig. S7). However, because similar notches exist in naturally umbo-perforated material (*SI Appendix, Section VII,* Fig. S28), this evidence is inconclusive. Such irregular internal contours may be caused by continued abrasion in sandy, high-energy burial environments, eventually eliminating the shell margin side of the contour and creating an "open hole" perforation. Although not uncommon in shells from natural assemblages (*SI Appendix, Section VII,* Table S10), we found no such "open holes" among the archeological specimens—as should be expected, given their unsuitability for suspension, and strengthening a link between perforation and suspension even when preservation factors prevent assessment of use wear.

The "origin of perforation" argument is therefore not valid. Our findings suggest that naturally perforated marine shells were extensively used at the time of emergence of the European MP and African MP/MSA traditions of body decoration and continued to be very much in fashion even as the repertoire of ornament types expanded to include more elaborated items.

Discussion

Natural surface processes and animal behavior can explain inland marine shell accumulations but, as discussed for the South African and Near Eastern beads (2, 23), distance to shore and difference in elevation preclude involvement of such agents in the Murcia sites. The use of the robust shell of *C. chione* as a replacement for flint is documented in the coastal MP of Italy (28), and the taxon is represented at Aviones by one specimen (*SI Appendix, Section I,* Fig. S10). Conceivably, this site's thicker ventral margin and middle-of-the-shell *Glycymeris* fragments (*SI Appendix, Section I,* Fig. S8) could represent broken-and-discarded instances of such tools and the complete specimens unmodified blanks for their manufacture. However, neither use wear nor any kind of retouch, even incipient, were observed in the specimens' intact edges, so the parsimonious interpretation of this *Glycymeris* material is that it reflects post-depositional breakage or on-site discard of broken shells that were beach-collected and used as complete valves—for ornamentation, when perforated, perhaps as containers, when not.

Although, at Aviones, mineral colorants were present in the deposits, the residues observed on the finds discussed here are not incidental or postdepositional contamination. If so, one would expect pigment to be randomly distributed across the different find categories. This expectation was not met for a sample of 50

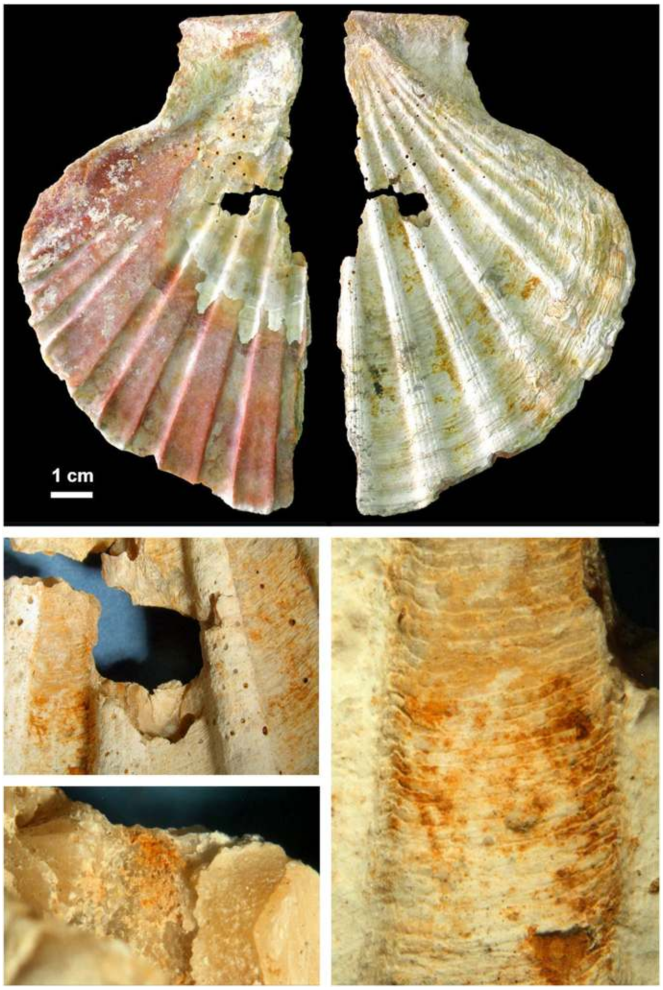

Fig. 4. K19-3, a perforated upper half-valve of *Pecten maximus* from level I-k at Cueva Antón (height: 120 mm). (*Upper*) The internal, naturally red side (*Left*) and the external, whitish side that was painted with an orange colorant made of goethite and hematite (*Right*). (*Lower*) binocular microscope close-ups on pigment masses and pigment stains around the perforation. See also *SI Appendix, Section VI,* Figs. S25 and S26.

shells of different species examined with a 10× hand magnifier after cleaning in an ultrasound vat (examination of the totality of the assemblage was not possible due to the extensive carbonate coating of the surfaces): no pigment was found on the food shells, and, of the nonfood ones, only the one *Spondylus* discussed above (in addition to one of the two perforated *Glycymeris*) had any. Moreover, all of the lumps of red pigment sampled during excavation feature in their composition siderite, a mineral that was not identified in the pigment residues of either the *Spondylus* or the *Glycymeris* (*SI Appendix, Sections IV and V*, Tables S6 and S7, Figs. S16–S19, S22, and S23); therefore, these residues cannot be accidentally derived from pigments present in the shells' immediate burial environment.

It has been argued that "ochre" does not necessarily equate with symbolism, as its manipulation may relate to technology, e.g., the preparation of mastics for hafting (29), and we cannot exclude that the Aviones pigments are in part related to such tasks. However, no pigment residues were observed in the Aviones stone tools (20), and no tool production or tool maintenance tasks were carried out at Antón, so such activities cannot provide a functional context for the pigment-stained shells found at both sites.

Table 2. Modern reference collection: perforation and weathering

	Perforated	Nonperforated
Cardiidae	(*n* = 55)	(*n* = 770)
Exfoliation	50.9%	9.7%
Sponge through-holes	3.6%	0.6%
Glycymeris	(*n* = 132)	(*n* = 150)
Weathering stages 2–3	99.2%	50.7%

Moreover, the limited capacity (approximately 5 cm^3) of *S. gaederopus* upper valves argues against their use for the processing or storage of material related to routine tooling activities. The addition to the pigmentatious mass of ground bits of hematite and pyrite (which, when fresh, have a brilliant black, reflective appearance) is also inconsistent with that function, and suggests instead the kind of inclusion "for effect" that one would expect in a cosmetic preparation. The use of *Spondylus* shells for such a particular purpose may relate to their attention-grabbing crimson, red, or violet color and exuberant sculpture, which have led to their symbolic- or ritual-related collection in a variety of archeological contexts worldwide, namely Neolithic Europe and pre-Columbian America (30, 31).

These inferences are consistent with the fact that, in the recorded history of pigments, all known uses (in Ancient Egypt) of yellow minerals of the jarosite family are in cosmetics or painting (namely, for the rendition of female skin) (32). Decoration—of body, clothing, living space, or artistic representations thereof (33)—is also the only archeologically and ethnographically documented function of colored, umbo-perforated *Glycymeris* and *Acanthocardia* shells. The well known use of *P. maximus* valves underlying the species' common name (pilgrim shell) is the same, and the Antón specimen may be exceptional for the MP only in its degree of preservation, as *P. maximus* fragments were also found in level III of Aviones (Table 1) and level V of Higueral de Valleja (Cádiz) (34), an Andalucian cave located almost as far inland (more than 50 km) as Antón.

Conclusion

The *Pecten* from Antón and Higueral de Valleja relate to the very end of the period of late persistence of Neandertals in Iberian regions to the south of the Ebro drainage (in the Andalucian site, the find comes from undated deposits capping a thick MP sequence, a chronostratigraphic position akin to Antón's and suggesting a similar age) (35). Therefore, they cannot be disentangled from the controversies surrounding the interpretation of "contact period" ornaments found elsewhere in Europe (8–18). The Aviones material, however, comes from the approximately 50 ka cal B.P. brecciated remnant of a site fill entirely of MP age and where the notion of later intrusions is an oxymoron—the association of this material with the Neandertals is, literally, rock-solid.

The symbolic implications of body painting and of the ornamental use of pigment-stained and perforated marine shells are uncontroversial in UP and later prehistoric contexts but, as shown by the evidence from Africa, the Near East and now Iberia, both behaviors first occur in the MP/MSA. Their emergence in two continents, among two different lineages and, in the time scale of human evolution, at about the same time, is inconsistent with cognitive-genetic explanations and implies that these innovations were fulfilling a need—aiding in the personal or social identification of people—that did not exist in the preceding two million years of human evolution.

Our findings therefore support models of the emergence of behavioral modernity as caused by technological progress, demographic increase, and social complexification and show that there is no biunivocal correlation between "modern" anatomy and "modern" behavior (13, 36–38). This much is also implied by the North African beads, which are from a time when the region was inhabited by the Dar-es-Soltan people, who, anatomically, were nonmodern (39, 40). Where the personal ornaments of the Châtelperronian and coeval "transitional" cultures of Europe are concerned, a final corollary of our results is that Neandertal authorship is the null hypothesis.

Materials and Methods

Archeological excavation was by natural stratigraphic units and used 3D piece-plotting. Description of the reference profiles followed geoarcheological criteria, accounting for stratigraphic, sedimentary, and diagenetic features to differentiate units and group them, on the basis of the observed discontinuities, into complexes (formally, allostratigraphic units). Dating was carried out by the radiocarbon method, on samples of shells, at Aviones, and charcoal, using both the ABA and ABOx-SC methods, at Antón. Nondestructive elemental analysis of pigment residues on shells from both sites was carried out by X-Ray Fluorescence and Energy Dispersive Spectroscopy and compound analysis by micro-Raman spectroscopy. The mineralogical composition of the colorant lumps from Aviones was established by X-Ray Diffraction. Assessment of the origin and nature of perforations in the bivalve shells from Aviones and later prehistoric sites of the region was based on visual and microscopic inspection of the surfaces, with reference to systematically collected modern beach thanatocenoses of the same species. For additional details on materials and methods, see SI Appendix.

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