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Supplementary Materials for

Bow-and-arrow technology of the first modern humans in Europe 54,000 years ago at Mandrin, France

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Supplementary Text

Supplementary Note 1. Origins of mechanical delivery systems

The emergence of the Upper Paleolithic (UP) is perceived as a critical moment, related throughout Eurasia with a cultural remodeling and replacement of indigenous Neanderthal societies (*4, 7, 69*). This global extinction of a population that was, for Europe, the only hominin representative for ~250 ka, remains an unresolved question and the archaeological inference is of global implication. The contemporaneous arrival of the ABMH in these territories suggests the a relationship between these two processes, even if they were surely much more complex than a simple biological and cultural replacement of archaic societies by biologically and culturally modern populations (*4, 7, 69*).

Stone technologies represent, for prehistorians, the most complete source of archaeological documentation. Regarding the issue of lithic points, it is fundamental to clearly distinguish different technical entities. It has been precisely demonstrated, at least since the work of François Bordes (see refs. *5-7, 30,* and references therein), that pointed flakes, Levallois points, and Mousterian points correspond to very different technical entities. Thus, flakes with a pointed morphology can arise from any debitage and do not necessarily correspond to any technical intention on the part of a knapper. Any debitage thus can randomly produce a fraction of more or less pointed blanks and whose "pointy" character is both relative and subjective. Mousterian points are flakes of any kind and any form whose morphology is produced by secondary retouching to give them an acuminate end. Levallois points are, on the contrary, perfectly symmetrical pointed blanks produced intentionally by the setting up of specifically organized debitages with the goal of obtaining them. In this paper the notion and term 'point' corresponds to the strict and precise definition of advanced Levallois, that is to say of blanks whose specific morphology is voluntarily produced by the knapper using specifically oriented debitage towards their production.

Lithic technologies show strong divergences between MP and UP technical structures. Much has been written around these topics, and the accumulation of archaeological evidence shows that a development of 'stone point' technologies across Europe may indeed have played a fundamental role in these socio-structural changes, throughout the so-called 'transitional industries' (*1, 6, 70-73*). The full UP represents a further technological step, enabling a central role toward stone armatures, based on the production of light microlithic technologies (*1-3, 12, 74*). Older projectile technologies may have emerged in South Africa where bone points and some stone tools of the Middle Stone Age present ballistic properties and Diagnostic Impact Fractures (DIFs) that may be indicative of their use in mechanical delivery systems, as arrow tips or barbs (*33, 36-39, 61, 75-87*).

In Eurasia, when evidence for weapons in the MP are found, the ballistic features of these heavy points relate them directly to hand-thrown or thrusted weapons that could not be involved in any mechanical delivery systems (*20, 21, 88*). Such features are shared throughout the MP stone weapon context thus far known throughout Eurasia (*21*).

Supplementary Note 2. Grotte Mandrin Layer E lithic technology

Layer E yielded 2267 lithic elements. Flints were directly flaked in the cave as shown by the representation of all technological phases, from flaking initiation to the discard of end-products after use, including cores and categories of sub-products (*4*). The lithic system is entirely oriented on the production of regular stone points, technologically obtained after laminar phases.

Quantitatively, blades, bladelets, and a variety of points represent 75.1% of all blanks. These points are produced out of raw materials selected from both local and distant Cretaceous flint sources, respectively located within a radius of 5 to 10 km, and 20 to 35 km, from the opposite bank of the Rhône River, potentially for their excellent flaking properties (*6, 7*). Secondary modifications to produce typological tools are only sparsely represented with 162 retouched elements, thus slightly more than 7% of all blanks (Table S5), a low representation that is consistent with the technological logic of these productions that induced a high control of the initial morphology of the points.

Points were obtained through a technological process organized in two phases. The first phase is based on laminar technology, initiated by a crested blade extraction and followed by unipolar blade production that configures the core geometry to extract technologically well-defined points during the second technical phase. Micro/nanopoints are based on the (re)knapping of different categories of blanks: cortical flakes, blades, or points. Their phases of production are also based on a first step focused on the extraction of crested bladelets and/or bladelets that configure the core before the extraction of the micro/nanopoint. The fact that these microlithic points are obtained from the secondary flaking of different categories of blanks induce that points and micro/nanopoints represent, technically, two different populations. The micro/nanopoints are not obtained in the last phases of the productions of points but from strictly distinct processes. Two categories of points can then clearly be differentiated, with larger points from 30 to 60 mm maximum length (thus 71.8% of the points) and microlithic points below 30 mm maximum length (78.7% of the micropoints) that can reach a centimeter in maximum length (Fig. 1 & S1). These two distinct processes have been called Blade/Points (BP) and Bladelet/Micropoints (BM). BP and BM are both based on a strictly unipolar convergent exploitation. BM is a technical microlithic transposition of the BP system, but exploiting flake-cores and based on an alternation between tiny bladelets, that configure the core geometry, followed by the extraction of regular tiny points. Most of the Mandrin E bladelets show a general triangular morphology resulting from this unipolar convergent process. These micro-productions are based on a secondary flaking of byproducts (cortical flakes and large blades) deriving from the largest points' production.

Considering the chronology of this context at 54 ka, microlithic and technically standardized points represent a strong specificity of the Mandrin E technologies. Micropoints and bladelets represent in total 578 elements, thus more than a quarter (26.6%) of all blanks from this layer. 170 of these light points are below 30 mm in maximum length, and 39 of them are clustered between 16 and 8 mm.

In total, 882 points of all size come from this layer. This point population includes different technical realities, from acute blanks, presenting a flat butt, coming from the first phases of these productions, to very regular points showing a strict axial symmetry and a classic reversed Y-shape. The latter present a finely facetted butt and most often a maximum thickness between 3 to 6 mm (88.3%, Fig. S1-1c). Their maximum width is grouped between 16 and 25 mm for 60.7%

of them (Fig. S1b). Micropoints generally have no more than 2 to 3 mm maximum thickness (74.3%, Fig. S1c), with a maximum width from 6 to 15 mm (75.3%, Fig. S1b).

These measurements are remarkably clustered for a technology that shapes the points' morphology during the flaking process, with no secondary modifications, thus illustrating a deliberate technical control focused on thin and regular points, with a certain degree of technical standardization. These points are perfectly straight and homogeneously rectilinear.

The Mandrin E process of stone point morphological predetermination obeys a standard comparable in many ways with Levallois technologies, due to the discontinuous rhythm of exploitation (*6, 7*). However, the core geometry and its exploitation process do not present links with Levallois cores (*89*). Such a notion of predetermination is comparable with those employed in Levallois flaking standards, yet with a very different core geometry and control. Classic Levallois cores are defined as articulated by two different surfaces, the one exploited to obtain the Levallois blanks (flaking surface), separated by a peripheral hinge of the exploitable volume of the core (reserve surface), thus giving the Levallois cores their specific structure. The stone points from Mandrin E are obtained from a very distinct process. Cores do not present a peripheral hinge and are not subdivided between a flaking and reserve surface. Flaking begins with a first phase focused on obtaining blades. This laminar production can be initiated by the conception of a crest on the core, followed by its extraction (crested blade), or by the exploitation of a natural dihedral elongated surface. The first blade extraction initiates a sub-peripheric –volumetric- laminar debitage with a strictly unipolar exploitation. This unipolarity is always present, whatever the raw materials and their specific natural morphologies. During this first process, lateral blades overpass the lateral blanks of the core, determining its morphology in a triangular shape that will allow the final obtaining of points. This was the ultimate aim of the predetermination, and this discontinuous rhythm of exploitation (between blades and points) that traces a link between these debitages and Levallois flaking (*90*). A comparable discontinuous rhythm is also here applied on Kostienki flaking (*90*) (flaking on the upper surface of a flake, from a proximal or distal truncation), based on a different core geometry and on the exploitation of a core-flake. These flaking procedures are non-compatible with the common Levallois variability, as such defined, and largely accepted (*89, 90*).

Laminar productions unrelated with the Point technical system are attested by several large blades, for which the *by-products* from their making are not attested at the Mandrin site. These laminar productions are mainly represented by very regular and large medial blade sections, some of which have been secondarily flaked (as burins, or Kostienki cores). Some bladelets may also have been obtained independently of the BM concept, as shown by cores involved exclusively in obtaining bladelets. These debitages share a common unipolar convergent exploitation, to obtain straight and regular bladelets with a general triangular shape.

Micro/nanopoints technology

These productions are not obtained from the reduction of the BP system. As so these productions are, technically, strictly distinct of the BP productions. According to the Kolmogorov-Smirnov non-parametric test of normality, Dks= 0.872 > critical value 0.071 (for n=361 at the $\alpha = 0.05$ threshold, the critical value is 0.071), therefore the null hypothesis H0 is rejected. At the 5% significance level, it cannot be stated that the width of the points and micro/nanopoints of Mandrin E follow the normal distribution (Figure S1, n°2).

Out of 182 cores, 112 belong to a secondary exploitation of a blank (cortical flake, blade) to obtain microlithic elements. Close to ~1/3 of these cores (n=36) are of the Kostienki type (90), exploiting the upper surface of a blank after a proximal truncation. Micro/nanopoints were also obtained from more classic burin-cores, flaking the lateral side of a blank. Burin-cores and Kostienki are sometimes conjunctly realized on the same (micro) core-flake, flaking both the upper and the lateral edges of the blank. Burin flaking is commonly initiated by a crested-bladelet extraction followed by a bladelet phase.

All flaking appears to have been conducted by a direct percussion with a hard hammer (*e.g.* quartzite pebbles).

Elements of typology

Typological tools are dominated (n=95/162; 58.6%) by UP categories. Some of these points are secondarily thinned and regularly (re)appointed, mainly by a direct retouch (n=28), but also by tiny ventral modifications, giving what we call '*Soyons Points'* that constitute one of the main typological categories of the Neronian (Table S5). Some of these regular pointings are based on opposing retouch, ventral on one side, and direct on the opposite flank. Typological burins are here considered those that are not considered as cores, when extraction was restricted to a few burin spalls defining a potentially functional chisel-like dihedral surface. Two chamfered pieces, plus a spall belonging to such distal secondary thinning are recorded on the distal end of blades.

Proximal thinning is attested on 6 elements, applied by proximal truncations limited to the butt and bulb extractions by ventral or bifacial secondary thinning. However, as for the secondary retouches, secondary thinning remains rare, a general tendency thus must be related to the overall highly technical standardization of this material. Points are generally perfectly straight and show a homogeneous thickness, limited to 4 to 6 mm. Even their proximal end, butt and bulb that represent the thicker part of a blank, are restricted to this 4 to 6 mm maximum thickness. In this particular technical context, their proximal thickness and morphology do not represent any constraint in a distally hafted mode. Our own experimental replications were efficiently directly hafted at the distal end of shafts, without proximal thinning. These proximal thinnings probably concern a local morphological regularization only episodically applied. Secondary blank modifications, both retouch and thinning, appear only episodically and are of thus limited implication in the global morphological modification of these elements. Finally, a proximal point presenting two proximal notches may be related with a specific hafting mode; but such proximal modifications are not representative of the norm of the collection.

End-scrapers are mainly made from blades, and in one case on a point. Two borers were also realized on the distal end of a point. These tools show that some of the points were at least episodically (n=3/882 points and fragments) involved in more domestic activities. Such categories of activity appear however mostly as the by-products that record most of the secondary retouches. This category of secondary retouch is generally limited to discrete modifications of cutting edges. Three of these tools are very specific. They are very large scrapers, each ~17 cm long. These three tools are all very similar, presenting a sharp and regular cutting edge heavily transformed. These heavy tools are made from non-local Cretaceous flints, with excellent knapping properties, and deriving from the opposite bank of the Rhône River, some 25 km away. No byproducts or rejuvenating flakes related with these tools are attested at the site and they were most likely imported pre-flaked to the shelter. Two of these samples are made from a selected cup-shaped material deriving from natural cryoclastic fragmentation.

Supplementary Note 3. Use-wear Analysis, method, experimental and archaeological results

Methods

All the elements, whether finished products or technical waste, were analyzed by naked-eye observation, whatever their technical categories, Levallois points, flakes, blades, bladelets, or indeterminate blanks. This step allowed us to select elements that could show traces of use. Among the 2267 pieces, 852 pieces were observed, at low magnification macroscopically, and for those whose conservation allowed it (n=692), at high magnification microscopically.

Of the 353 pieces without any patina, 95 have a gloss visible to the naked eye. A microscopic test was carried out on a selection of objects in this category and confirmed the systematic presence of a category 3 (strong) glossy sheen uniformly covering the surface of the piece. These were then systematically removed from the sample that was to be analyzed microscopically. While to the naked eye there was nothing to suggest the presence of a taphonomic gloss on the rest of the sample, an analysis at high magnification showed that 93 (out of 258) of the pieces, not patinated and apparently without any trace of gloss, were covered with the same homogeneous and brilliant texture, of lesser intensity, but nevertheless expressed on the whole of their surface, including the edges and ventral faces, sometimes accompanied by isolated spots of extreme brilliance. Differentiating this "pseudo-polish" from true micropolish of wear was not an easy task. Only about forty pieces could record possible microscopic traces, but the origin of these has been interpreted with certain reservations.

Accumulation of DIFs method

The term "projectile" is used here exclusively in its restrictive meaning of propelled weapons, whether they are hand-thrown or by a mechanically assisted propulsion using a spear-thrower or bow. We agree with the fact that the accumulation of FIDs on the same piece reinforces the hypothesis as to its use as a weapon element (*58, 65, 66*), but by excluding from the weapon function any element carrying a single DIF, the qualitative aspect loses its relevance here in favor of a purely quantitative character. This also implies that the accumulation of several criteria, not very relevant, can lead to a positive diagnosis by their only combination. This quantitative approach must then be counterbalanced by the qualitative value of the diagnostic criteria analyzed. It should be noted that in the experimental context, a large proportion of the impacted armatures only register a single DIF (43.6% of the projectiles in the *Initiarc* program). Furthermore, given that the presence of mastic linked to the fitting strongly limits the formation of MLITs on the armature elements, or that characteristic hafting traces, without an educated and experienced eye, are easily confused with simple use traces, one cannot exclude from the weapon function any part recording only one character if its qualitative value is judged to be highly diagnostic.

This method of analysis by combination of diagnostic characters makes it possible, by prioritizing them, to have a notably more precise vision of the place of functional characters considered discriminating within a lithic industry (Fig. 4B). The accumulation of several characteristics allows us to specify the degree of reliability or certainty as to the use of the observed pieces as armatures. For this purpose we consider four main categories that can be conceived as grouping functional indications ranging from the most diagnostic, category 1, to the most generic or weakly relevant features, category 4.

The characteristics retained, within these 4 categories, are all the traces related to a high kinetic energy impact (fractures, spin-offs, removals, MLIT). All the pieces marked with DIFs fall, depending on their quantity, into the first 3 categories (Cat1, 2 and 3) and on some occasions into a subcategory of the fourth category (Cat4p1). Those that record characteristics potentially related to a use as a weapon (likely complex fracture) are to be considered as category 4 weapons.

Taphonomic specificities are obviously to be considered on a case-by-case basis. Some traces may be due to alterations rather than use. Microscopic traces materialized in the form of striations may reflect friction in the archaeological soil rather than brief contact with a prey skeleton. The location of the striations is important in this case, but not diagnostic. This is why a trace must imperatively be defined by its nature and not only by its location.

Initiarc Experimental program

The *Initiarc* experimental program consisted of 301 pieces (blanks, blades, and points) used in two operating modes: non-percussion versus percussion motions.

Non-percussion actions. Un A total of 184 anthropogenic movements (multidirectional, longitudinal, transverse, and rotational) and 35 taphonomic actions (trampling, fracturing, knapping accident, reworking, transport) were performed (*8*). Within domestic activities, 70 pieces were used for cutting, incising, grooving, and sawing; 87 were used for scraping, plucking or softening, one shard was used for skin piercing, and 26 were used for butchery activities (disarticulation, fleshing, skinning, evisceration). The actions implemented, as well as the materials that could have been used within the archaeological series studied, were respected within our own experimental process. The materials involved were wood, antler, bone, skin, meat, and fish . The wood, antler, and bone were scraped, sawn, incised and grooved, in both a fresh and dry state. Meat was processed in a fresh state during butchering activities. The processing of skin was divided into several stages. The defleshing was followed by the preparation of the skins for drying, some were oiled or ashed and others were left in their natural state. Once dry, the skins were scraped and, for one of them, cut into strips which were then softened.

Parameters such as the state of the worked material (fresh, dry, or rewetted), hardness, flexibility, texture, or the fat content for working with soft animal materials, which have a considerable influence on the types of traces, were taken into account in these experiments (*53, 67*).

The amount of time a tool was used was precisely recorded in order to control the parameters of polish formation between them and to compare them with the other materials worked. In this experimental program, the tools were held bare-handed or with the aid of leather straps or covers.

All the pieces of in the sample were viewed with a binocular magnifying glass (Leica MZ 6, Olympus SZ-PT) and a microscope (Olympus BH2-UMA and Leica DMR).

Percussion actions. We replicated 82 Mandrin E points and micropoints, similar to those archaeologically observed: 73 to be used as projectiles (50 arrows and 23 spear-thrower-darts) and 9 to be used as thrusting spears (Fig. S3 & S4). These points were made from the same raw materials and the same archaeo-technological production systems. Shafts were mainly made of red dogwood (*Cornus sanguinea*), but also in common bulrush (*Typha latifolia*), wild rose (*Rosa* *canina*) and buddleja (*Buddleja davidii).* These points were hafted with diverse hafting methods (notch, shoulder-and-slot haft), with mastic (beeswax, rosin, and ochre) or hide glue and natural tendon lashing (Fig. S2). The points were tested by Christian Trubert (experimental archaeologist) against two goat (*Capra aegagrus hircus*) carcasses hung intact on a wooden frame. The smallest points were propelled by bow from 5 to 8 meters, or as dart tips propelled by spear-thrower from 3 to 5 meters. The larger points were on spears that were thrusted by hand into the carcasses. Arrows were shot with a traditional bow made from hazel wood tightened to between 35 to 40 pounds. The archer position was perpendicular to the animal flank for most of the shots, but also laterally oriented, from the back, or at the front to enable different penetration angles in the prey. Whatever the propulsion method, the shots principally targeted the upper part of the animal (thoracic area), where the main vital organs of the prey are located. These experiments demonstrated the effectiveness of these points in these categories of weaponry.

After the shooting phases, the carcasses were meticulously skinned and eviscerated in collaboration with Toomaï Boucherat (UMR 7269, CNRS). Each fragment of flint lodged in the animal was recovered and placed in a separate zip-lock bag. Armatures were previously numbered in ink and were immediately cataloged after extraction from the carcasses, recording and describing their anatomical localization, and photographed. A few lithic fragments could not be directly related with a specific shot. These were independently labeled and drawn to ensure capturing all experimental data.

Projectile experimental results

During an experimental shooting session, the development of DIFs was not systematic, whether the lithic armature is mounted at the end of arrows, darts or hand-cast, even when they violently and frontally impact a target (*9, 10*). The same is true for the formation of MLIT, the development of which is the result of a complex process related to the brevity, but also the intensity, of the contact of the armature with its target allowing, in a rather exceptional manner, the development of this category of traces.

A total of 114 shots were performed with 82 experimental weapon tips (73 projectiles (bow/spear-thrower) and 9 thrusting/hand-cast weapons; Fig. S3). 84.7% of the weapon tips delivered via mechanical propulsion, bow or spear-thrower, were damaged; 70.1% of the sample was fractured and 8.3% had no trace. Despite the precautions taken during the shooting sessions (cover under the animal) and the complete dismemberment of the animal after each session, 5 points (6.9%) could not be recovered. In 92% of the cases, the projectile reached the target, one landed in the soil, and another hit and bounced off a tree. Some of these weapons were shot up to 5 times until a breakage appeared. In 2 cases the shaft broke before the point could record any breakage. Finally, two points came off the shaft when reaching the prey. Damaged armatures represent 85.4% of the total (70/82); the remaining 8.5% (7/82) show no sign of damage.

In terms of penetration, there was a notable difference in the degree of penetration between arrows and darts (Fig. S4). Arrows tended to penetrate the animal much deeper than darts; most darts generally penetrated 15-25 cm deep, rarely reaching 33 cm deep and never exceeding it (83.3% arrows vs. 16.7% darts > 30 cm deep). Some arrows penetrated 51 cm, with more than 10 of the arrows passing through the animal and exiting on the opposite side of the target. The hand-cast spears rarely penetrated the epidermis, and when penetration was greater, it rarely reached 15 cm in depth (n=2).

Slightly more than 70% of the armatures were found (n=67/81) fractured into 86 elements. Unexpectedly, the most frequently found parts were the incomplete elements (34.3%). Seven points that remained hafted after shooting were fractured at the limit of their hafting zone, keeping their proximal parts inside the shaft. The mesial and mesio-distal parts were mostly found inside the animal (17.9%). The distal ends were only rarely found (2/67).

Although the acute end of a point is the first area to contact the target, the cutting edges play a critical role in allowing the weapon to penetrate. Regardless of the mode of propulsion (bow or spear-thrower), the damaged areas were identical.

After being used, the armatures recorded 5 different types of fractures, simultaneous axial or lateral spin-off, and 3 types of removals (Figs. 4 & S5). The main DIFs observed in these experiments are fractures with extensions, most often terminating in a step. We note that this type of termination is more frequently observed on arrowheads (31%) than on dart tips (24%) although the difference in proportion between the two is not significant (Z test: 13/42 vs 5/21). The same is true for the feather terminating bending fracture, which is observed on only 4.8% of darts (vs. 19% on arrows). For hinge terminating, they are just behind feather terminating, but unlike feather endings, they are evenly distributed among the projectiles. Clear fractures are also numerous, but here, almost systematically associated with a simultaneous axial or lateral spin-off (20/24). Nearly half of the sample has lateral removals affecting the cutting edges of the projectiles (47.2%). The endings of the spin-off and removals appearing on the edges of the projectiles are most often hinge terminating.

The projectile points record traces that are both numerous and highly variable. However, not all of them are diagnostic of their function as a weapon. Nevertheless, it is important to note the high proportion of DIFs that appear on elements used as arrowheads or dart tips. Of the 73 points used as mechanically propelled projectiles, 40 are impacted, accounting for 138 DIFs. Slightly more than 50% of the traces affecting the pieces used in these three experimental shooting programs can be considered diagnostic of impact (n=71/138). These DIFs are notably better represented on arrowheads (36.5%) than on dart tips (14.6%).

The development of several DIFs is a common phenomenon, with 41% of points recording two (category 2 weapon) but the presence of at least 3 DIFs is however quite exceptional (15.4%) (category 1 weapon). For 43.6% of the experimental projectiles only one DIF was recorded (category 3 weapon). It should be noted fracturing is far from ubiquitous and that even when fired several times, an experimental weapon tip may not fracture nor record any DIFs. The number of shots fired does not necessarily influence the formation of DIFs or the accumulation of these traces on the same element. Knowing that impact traces are not formed systematically at the moment of impact and that the recording of a DIF represents, in itself, a discriminating indication as having functioned as a mechanically propelled projectile, the accumulation of 3 or even 4 DIFs represents a rather exceptional configuration, ensuring a strong diagnosis and a high degree of reliability in the determination of the object's use.

The different mechanical propulsion systems do not seem to play a central role in the process of formation and accumulation of DIFs on a weapon tip, as this process seems to be mainly induced by the material encountered by the weapon in the prey or in its environment (bone, muscle, wood, soil, etc.).

Experimental taphonomic

To distinguish a specifically diagnostic impact fracture (complex fracture) from a non-diagnostic fracture (simple fracture), a potential diagnostic impact fracture (likely complex fracture) or a taphonomic fracture, an experimental program was conducted, like many research and experimental programs before (*9-22, 55-57, 59-62, 91-93*).

Attempts at taphonomic reconstruction consisted of reproducing the traces left by trampling, fracturing pieces by hard percussion or dropping pieces on the ground at a height of about 1.5 meters. A sample of 35 pieces was dedicated to different activities. Ten points of different sizes were transported inside the same leather bag for several months in order to observe the tribological reactions, both macroscopic and microscopic, induced by the contact between flints. To understand the traces left by trampling, two pouches filled with sediment of different grain sizes (pebbly and sandy) were placed in an area of high traffic within the Mandrin shelter. Each pouch contained four flint points, previously photographed, and trampled continuously for two months by a group of about ten people. Macroscopically damaged edges were found to be those with angles no greater than 25 degrees. Edges with more moderate or even steep angles showed no damage. Removals are never continuously distributed and are commonly isolated from each other. Microscopically, numerous linear traces have been observed, often within particularly bright polishes. Their orientation can be organized, the striations being parallel to each other, or totally disordered. The spots of "polish" are rarely located along the edges but on the protruding parts, the ribs, or the bulb. Nine pieces were fractured with blocks. Blocks were dropped on the lithic objects at a height of 2 to 2.5 meters. During the knapping of experimental points or during a retouching phase, eight elements were accidentally fractured, preserved, and analyzed.

Archaeological results

DIFs

This use-wear analysis demonstrated a special DIF distribution following the technical categories (points, micro/nanopoints, and bladelets; Fig. 3). DIFs never appear on blades, flakes, or microflakes of comparable thickness and length as the points. Flakes and blades exclusively record 'simple fractures', common breakage of various origins and that represent non-diagnostic fractures for weaponry determination.

Among the 852 pieces analyzed, 287 pieces show bending fractures (simple, complex, or likely complex) and/or spin-offs, counting both distal and proximal fracture. A percussive action mode was identified on 196 of them.

Thus, even though experiments show that proximal fractures also affect lithic weapons, such fractures are not evidently diagnostic of a weapon use. For this, specific attention was focused on fractures affecting the distal end of a blank. Despite this, categories of proximal fractures provide pertinent additional information on artifacts presenting DIFs on their distal end.

Among the 196 points with evidence of percussion actions, 71 pieces were impacted. The accumulation of DIFs brings us to a total of 131 DIFs (Figs. 7-8). We are here restricted to damages affecting the distal end of the points. The tiny removals and micro-spin-offs that often accompanied DIFs are not included in the counting. Their presence offers precious information about hafting mode for example.

The accumulated method shows that the points marked with at least 3 DIFS are not frequent (n=9), those marked with two DIFs do not represent more than 1/5th of the weapons (n=15), but those recording only one DIF are particularly numerous, concerning more than two thirds of the impacted points (n=47) (Fig. 6A). The difference in proportion between category 3 and categories 1 and 2 is highly significant (Z-test: Cat1: 6/39 vs. 9/71; Cat2: 16/39 vs. 15/71; Cat3: 17/39 vs. 47/71).

The combinatorial study carried out on the experimental projectiles makes it possible to illustrate that mechanical propulsion (using a bow or a spear-thrower) does not necessarily generate impact traces. The apical part of the experimental projectile tips is rarely devoid of wear marks, but even during a particularly violent impact the tip may not register any DIFs (circa 50% of the sample). Of the 39 experimental armatures impacted, 15.4% (6/39) show up to 3 DIFs. Archaeologically, 12.7% of the impacted points (9/71) belong to this same category 1. These proportions, tested with the Z-test, show no significant difference within this category, whereas within categories 2 and 3, differences in proportions discernible by combination categories between archaeological and experimental prove to be statistically significant (Z-test: 8/71 vs 47/71 between Cat 1 and Cat 3 and 15/71 vs 47/71 between Cat 2 and Cat 3) (Fig. 6B). All the pieces placed within category 4 were interpreted as probable weapon elements (n=78) including those showing DIFs, here downgraded for qualitative reasons. The status of weapon and potential weapon then concerns, all categories taken together, nearly a third of the Mandrin E points (29.9%), which were therefore used, with varying degrees of certainty, in hunting or warfare activities.

For micro/nanopoints, languet lengths vary from 1.5 to 5 mm long, from 2 to 3 mm long for bladelets, and from 2 to 12 mm long for points. This means that for some of the nanopoints considered here, a 5 mm languet covers more than 30% of the full length of the point, thus representing a particularly large trace.

Microscopic criteria distinguishing lithic involvement in weapons use is rare. The main example is represented by the Microscopic Linear Impact Trace (MLIT), which results from a friction from the spin-off removed from the distal end of an armature during the impact and that cross off the surface. Experiments show that such microscopic DIFs concern only a low fraction of the weapon tips and are also rarely documented in archaeological contexts (*13, 15, 16, 63*). When appearing, such micropolish is very different from those classically encountered in use-wear analysis on experimental pieces used as knives and scrapers involved in categories of domestic activities (working meat, bone, hide, etc.) producing a systematic formation of a specific micropolish (Fig. S5). As mentioned above, chemical alterations limited a micro polish analysis, but at least one micro-wear trace can safely be interpreted, by its location and orientation, as a MLIT. This MLIT is located on the distal end of a tiny (16 mm long) and regular nanopoint presenting a snap distal fracture and several small spin-offs (Fig. 7, n°16). Thus, in total 130 macro fractures plus one MLIT represent here a minimal number of unambiguous DIF (15.5% considered by MNI; Table S1).

These DIF proportions are here but a minimal counting. Indeed, 108 artifacts (19.4%) also present a 'likely complex fracture' (*12, 13, 94*) that may be related with their use as weapons (Fig. S6). However, one must bear in mind that when, as for Mandrin E, DIFs are widely attested and strictly distributed in specific technical categories, such scars (probable DIFs) are likely to be considered as resulting from weapon use (but are not included herein). Complex and likely complex fractures concern 29.9% of the Mandrin E points and 79.5% within the micro-nanopoints. In parallel, these elements do not record any traces related to domestic functions. Finally, 131 fractures are undiagnostic.

For the larger points context, DIFs have a larger ratio on those presenting a secondary modification. Out of 56 retouched points, 13 indicate a DIF, thus concerning some 23.2% of the retouched points (Fig. 7, n° 6, 8, 12, 14, & 15). These secondary modifications of the points represent slight regularizations of their distal end, sometimes by ventral retouch (Soyons Points). These points could be called 'pointed-points', a modification that may represent a resharpening or a discrete improvement of their tip. On these elements DIFs appear only subsequently on the retouches. In one specific case a DIF was modified by a secondary retouch, meaning that the point was first broken during weapon-use, and afterward resharpened (Fig. 7, n°14).

The different fragments show that the hafting process strongly influences the location of the fracture. Our experiments employed points that were mostly axially hafted on the distal end of a shaft. On such hafting processes, fractures preferentially affect the distal end of the point. When numerous fractures appear on a point, they commonly affect both the distal end and its proximal part at the precise limit of the hafting zone. Lateral damage was only attested by lateral spin-offs, which mainly appear when the weapon had a direct contact with bone (commonly ribs and scapula).

The functional analysis of the last five Mousterian levels of the sequence (B2, B3, C1, C2 and F), excluding Mandrin E, records 24 pieces with DIFs. Out of a total of 9096 blanks, the recognized weapons are quite exceptional (0.26%). On the other hand, it can be noted that 13.6% of the points from these five assemblages are related to the function of armament (24/176 points). It seems that in these Neanderthal societies of the Middle Paleolithic, weapons were not made ubiquitously from any available pointed support but were made exclusively from certain technical categories. In the 4 upper levels (PNII, layers B and C), the weapons are made from unretouched, heteromorphic large Levallois points. During the PNI (layer D), armatures are only attested on pseudo-Levallois points and, rarely, on some Levallois points. In the Mousterian of the Rhodanian Quina type, the rare finely pointed Mousterian points are the only elements used for weapons. In the Neronian, all weapons are made from raw or very finely (re)pointed points. The parts of small to very small module (micro/nanopoints) being exclusively armatures. Putting the *H. sapiens* technologies of Layer E into perspective against the Neanderthal layers of this late Middle Paleolithic sequence (overlying layers B, C, D and underlying layer F) shows occupations that are generally poor in points, but within which the production of points is mainly for the creation of weapons.

Supplementary Note 4. About delivery systems

Point width

If for some researchers it seems particularly delicate, in an archaeological context, to recognize a mode of projectile propulsion based on a generic morphometric study of lithic points (*9, 17*), others propose different formulas considered as discriminating between arrowheads, dart tips, or hand-cast points (*24, 28, 95*). There is, however, in the case of elements that have been demonstrated to be projectile points, the possibility of concluding that the maximum width of a point is in strict interdependence with the diameter of its shaft. This strict constraint regarding the configuration of the hafting at the tip thus becomes an archaeologically diagnostic criterion for documenting and directly reconstructing the original morphology of a complete weapon (its length, weight, etc.). A small point of 10 mm width, mounted at the end of a shaft, thus directly informs us of the use of a shaft with a very reduced diameter, up to 10 mm maximum (*26*). This constraint has direct implications for discerning possible modes of propulsion. As demonstrated experimentally herein, the only means of propulsion with a strength sufficient to ensure the weapon's efficacy, for weapons where the width of the shaft is less than 10 mm, is exclusively and unconditionally the bow.

The diameter of the shafts used for the experimental points was between 5 and 20 mm. Since a shaft doesn't have the same diameter along its entire length, the measures were always taken at the widest point and are therefore maxima (Fig. S4). For any point of width <10 mm, the maximum diameter of the shafts is between 5 - 11 mm. For points between 10 and 20 mm wide, the shafts are between 6 and 18 mm in diameter. Greater than 20 mm wide, the points are mounted on shafts ranging from 6 to 20 mm. Except for one, all the points turned out to be wider than their shafts by 1 to 2 mm. A total of 36 points were selected to be positioned on shafts ranging from 6 to 13 mm wide. The diameter of the shafts never exceeds the width of their lithic tips and have, for many of them, a much smaller diameter. Points that are 11 mm wide, for example, were all mounted on shafts ranging from 6 to 9 mm. While experimentally we can see wide arrow tips (25 mm) mounted on narrow shafts (12 mm in diameter), smaller points (width less than or equal to 10 mm), on the other hand, can not in any case be associated with large shafts. Considering that for a projectile to be efficient, and therefore effective, its shaft cannot exceed the width of its axially mounted tip, the narrower a point is, the smaller the diameter of its shaft. These will then have to compensate for their low kinetic energy by means of adequate propulsion providing sufficient speed to be able to become a powerful piercing weapon. The largest point width is therefore not necessarily associated with the largest shafts, but conversely a narrow point cannot be effective if the fundamental principle of tip / shaft association within which the tips exceed more or less widely each side, allowing laceration of the skin for better penetration, is not respected.

In our experimental program, no point less than or equal to 10 mm wide could be used other than as an arrow tip. Propulsion attempts with the spear-thrower all failed, even after compensating the narrowness of the shaft by a longer length and thus increased overall weight of the weapon. After several consecutive failures, the shafts of these spears were reduced in size and reused with the bow. All then reached and penetrated the target.

TCSA Statistics

Mandrin E micro/nanopoints show statistically significantly lower TCSA values than Shea's ethnographic arrowheads (*20, 21*). This feature is of major importance, for the main ballistic difficulty remains in the higher TCSA value in order to distinguish between spear-thrower and bow delivery systems. Both TCSA and statistics show that, in terms of TCSA, there exists a more pronounced difference between the Mandrin E points and micro/nanopoints than between the Shea test ethnographic samples of spear-thrower-dart-tips and arrowheads (Fig. 9, Tables 1 & S2). It is important to underline that this ethnographic sample does not present the lower TCSA limit for arrowheads, but average sizes of 118 ethnographic arrowheads from the Thomas collection from the *American Museum of Natural History*. Much smaller arrowheads are ethnographically and archaeologically documented (*20*).

TCSA values place Mandrin point categories within the spear-thrower range and micro/nanopoints distinctively in the bow and arrow range (Tables S2 & S3). From these TCSA values, none of the Mandrin point categories would be linked to handheld spears. These ballistic traits are consistent with technical features distinguishing the Mandrin points in two categories and with functional analysis showing an unexpectedly high representation of DIFs illustrating violent axial impacts on tiny points. Finally, it is also convergent with the morphological features of these regular and tiny points that constrain their hafting to a shaft having a maximal diameter below 10 mm for some 40% of the micro/nanopoints, a crucial ballistic step which mechanically limits such narrow and tiny points again, strictly within the bow delivery system (*28, 31*).

Descriptive statistics were calculated for all variables and specifically for points' TCSA: 1) average and standard deviation (SD), and 2) medians and quartiles (indicators of central tendency and more robust dispersions that must be preferred for small samples). Due to the non-normality of studied distributions (as determined using the Kolmogorov-Smirnov or Shapiro-Wilk tests as required by the available number of artifacts), non-parametric Kruskal-Wallis tests were used to compare measures of different independent variables, and Wilcoxon tests in case of two independent variables. All tests use 0.05 as the alpha level for statistical significance unless stated otherwise. To remedy any eventual problem due to the multiplicity of tests, we applied the False Discovery Rate (FDR) correction involving two by two comparisons (*96*). Statistical analyses were performed with SAS® v9.3, RStudio, and PAST 3.1 software.

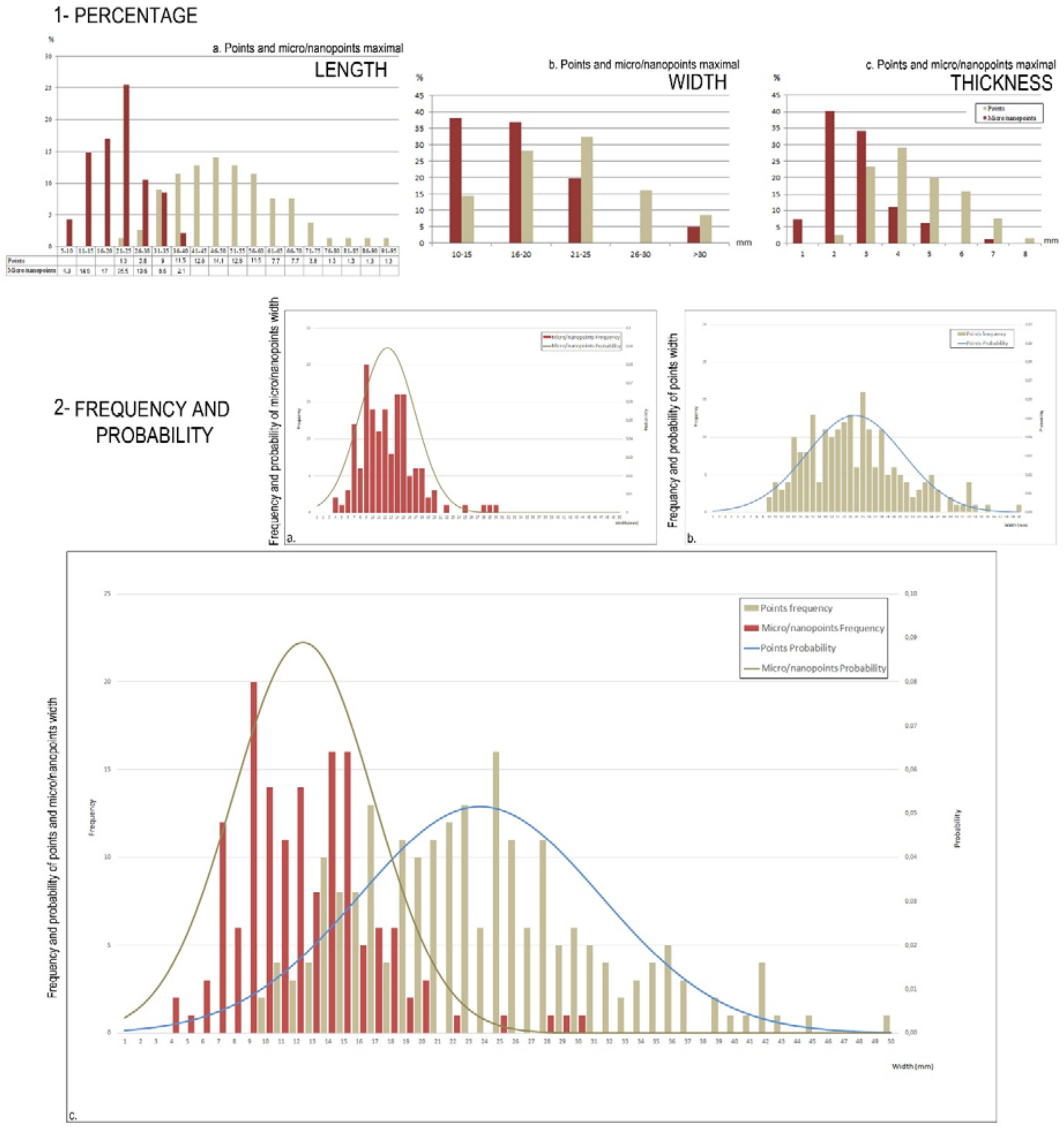
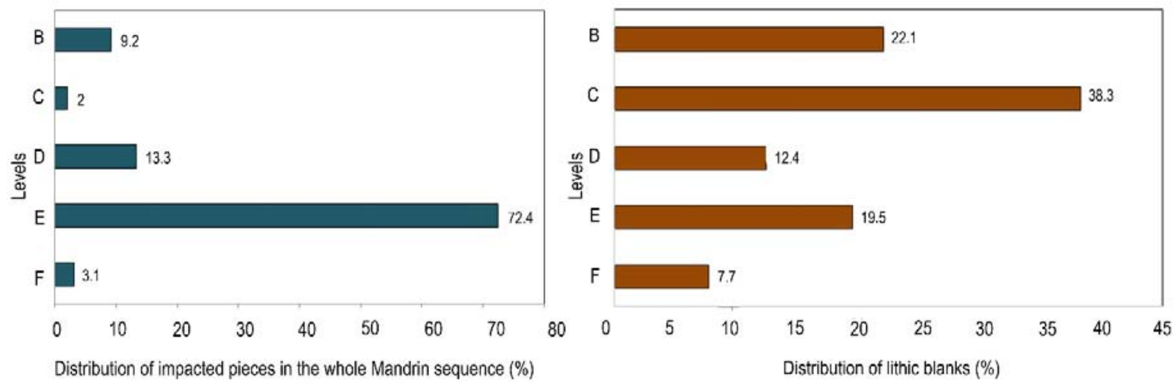


Figure S1. Mandrin E point and micro/nanopoint dimensions. 1. Percentage. a, Maximum length in % of points and micro/nanopoints; b, points' and micro/nanopoints' maximum width in %; c, points' and micro/nanopoints' maximum thickness. 2. Frequency and probability histogram of point and micro/nanopoint widths and Gauss curve*. a, micro/nanopoints; b, points; c, point and micro/nanopoints.



Level	Attribution	Chronology	Total number of blanks* -n-	Total number of points** -n-	Proportion of points -%-	Analyzed sample -n-	Impacted pieces (DIFs) -n-	Impacted pieces type	Weapon type	References
B2, B3, C1 and C2	PN II	~42 ka	8172	161	2.0	158	21	Lev. point	Spear and/or Thrusting spear	97, own data
D	PN I	~49-50 ka	1743	516	29.6	128	13	ppL	Spear and/or Thrusting spear	97, own data
E	Neronian	~54 ka	2267	882	38.9	2267	71	Point cf Lev.	Arrow, Spear and/or Thusting spear	90, 97 own data
F	Rhodanian Quina	~54 ka	924	15	1.6	924	3	Moust. Point	Thrusting spear	97, own data

* by blanks, we mean all lithic elements except fragments, debris, pebbles and cores

**Levallois, Levalloisian, Mousterian, pseudo-Levallois points,

Mandrin (Levels B-F). Functional analyses of the MP layers before and after Layer E

Figure S2. Mandrin. Distribution of all DIFs and of all the lithic blanks in the sequence by layer (B to F).

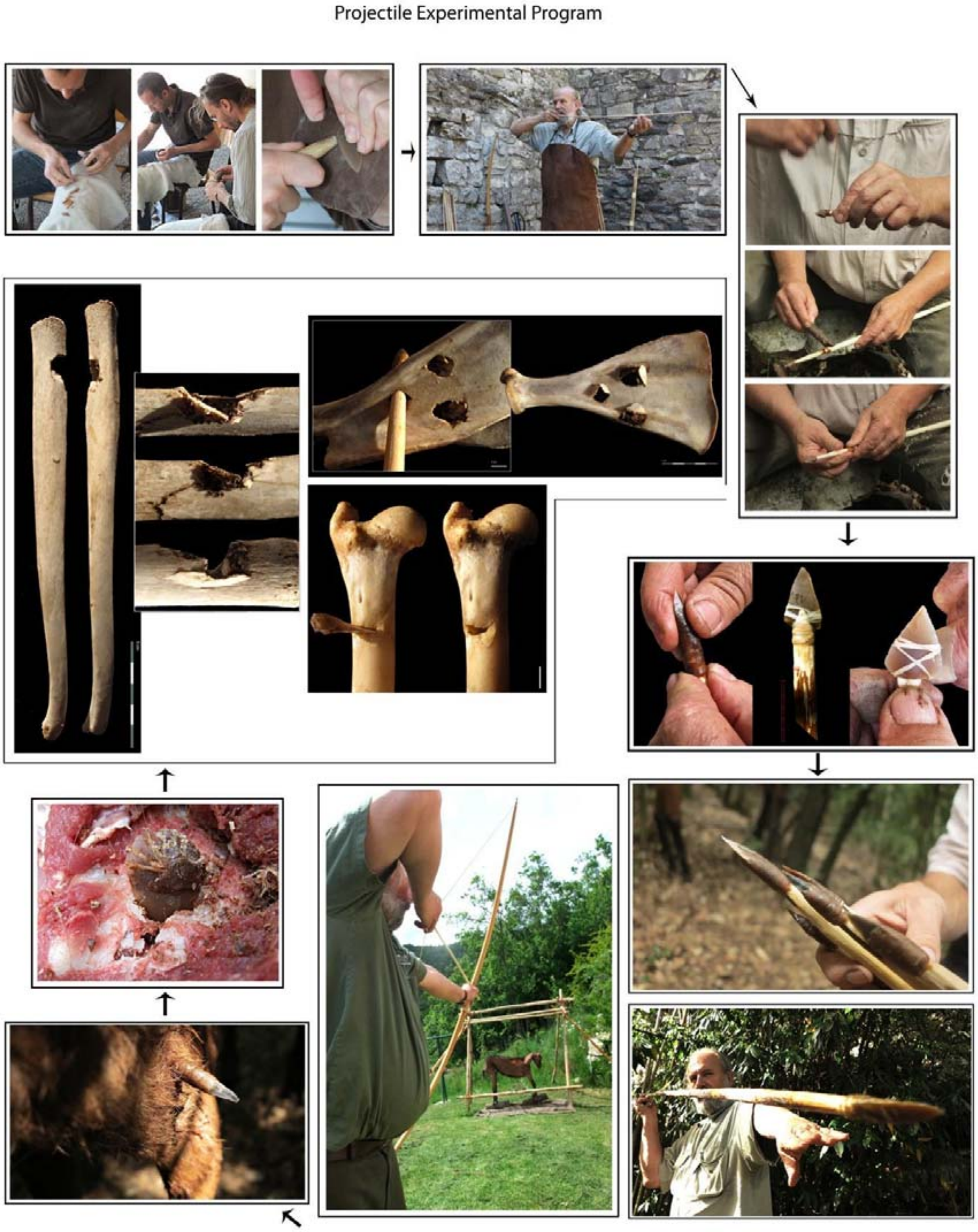


Figure S3. *Initiarc* experimental program. Session of knapping - Projectile mounting -Shooting experiment on goat (*Capra aegagrus hircus*) carcasses via bow, spear-thrower, and thrusting - Arrows crossed through the *Capra*; arrowhead planted in between two ribs; impacts on scapula and right femur.

1-

		Min	Max
ARROWS (n=52)	Arrowhead's weight (g)	0.35	10.2
	Arrowhead's length (mm)	11	55
	Arrowhead's width (mm)	7	27
	Arrowhead's thick (mm)	2	9
	TCSA (mm²)	9	99
	Shaft diameter (mm)	5	12
	Arrow's weight (g)	14.4	72
	Arrow's length (cm)	65	146
SPEAR-THROWER-AND-DART (n=23)	Dart's weight (g)	2.2	8.2
	Dart's length (mm)	29	72
	Dart's width (mm)	10	31
	Dart's thick (mm)	3	9
	TCSA (mm²)	20	87.6
	Shaft diameter (mm)	10	14
	Spear's weight (g)	180	302.2
	Spear's length (cm)	124	237
HANDHELD SPEARS (n=9)	Thrusting spear tip's weight (g)	12.1	20.1
	Thrusting spear tip's length (mm)	52	69
	Thrusting spear tip's width (mm)	18	42
	Thrusting spear tip's thick (mm)	8	14
	TCSA (mm²)	72	222
	Shaft diameter (mm)	18	20
	Thrusting spear's weight (g)	352.5	494.4
	Thrusting spear's length (cm)	152	261

2-

Arrow

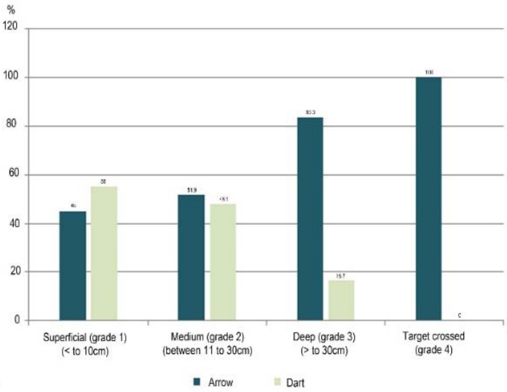
Arrowheads				*Arrow*		
Length (mm)	Width (mm)	Thickness (mm)	*Weight (g)*	*Length (cm)*	*Overall weight (g)*	*TCSA*
21	10	3	0.35	109	44.75	10
19	10	2	0.41	103	66.15	10
17	13	2	0.42	103.5	69.2	13
15	12	2	0.45	87	45.45	12
17	11	3	0.45	107	72.3	16.5
11	11	2	0.48	104.5	76.6	11
27	11	3	0.55	67.7	19.26	16.5
17	13	2	0.56	113	65.4	13
23	12	3	0.58	100.5	63.42	18
17	12	4	0.58	121	72.07	24
22	9	3	0.66	103.5	57.2	13.5
24	11	4	0.87	109	60.9	22
38	9	3	0.9	104	43.4	13.5
32	15	3	0.98	99	62.3	22.5
25	7	2	0.98	105	56.2	7
17	15	3	1.1	92	43	9
24	17	3	1.1	83.5	34.2	25.5
26	14	4	1.18	110	76.14	28
28	11	3	1.2	117	63.2	16.5
27	8	3	1.2	65	14.4	**12**
34	11	3	1.2	109	61	16.5
21	9	3	1.2	112	54.2	13.5
37	27	3	1.2	121	66.2	40.5
25	17	4	1.4	115	59.6	34
31	14	4	1.4	107	59.2	28
27	12	3	1.8	113.5	64.76	18
27	12	3	1.9	90	85.57	**18**
28	15	4	2.1	65.7	23.6	30
30	17	5	2.3	99.5	38.9	42.5
28	22	3	2.43	65	19.29	33
36	16	3	2.5	124	63	24
36	13	5	2.5	105	48.5	32.5
32	20	3	2.5	94.5	43.6	30
35	19	5	2.8	102.5	36.5	47.5
44	16	4	3.4	87.5	40.1	32
48	20	5	3.5	110	64.3	50
46	15	5	3.7	104	44.5	37.5
40	13	5	3.8	87.5	42.1	32.5
34	24	5	4.2	93	27.2	60
44	20	4	4.3	106.3	48.8	40
42	14	4	4.7	143	71	28
41	25	4	5.1	82	35.3	50
43	24	4	5.5	81.2	24.2	48
51	17	7	5.6	79.2	30.8	59.5
53	22	5	6	90	35.3	55
54	17	6	6.2	146	72	51
42	25	5	9	95.2	47	62.5
49	22	9	10	96.2	53.5	99
55	25	7	10.2	97.8	56	87.5

Spear-thrower-and-dart

Spear-thrower dart tips				*Dart*		
Length (mm)	Width (mm)	Thickness (mm)	*Weight (g)*	*Length (cm)*	*Overall weight (g)*	*TCSA*
72	10	4	2.2	133.5	283.3	20
29	21	5	2.8	130.2	292.4	52.5
34	17	7	3.5	131	283.3	59.5
39	15	3	3.8	135	292.5	22.5
40	21	5	4.2	124	283.2	52.5
51	21	4	4.3	133	290.5	**42**
39	22	3	4.3	132	294.4	33
60	19	3	4.7	132	285.3	28.5
67	13	4	4.7	132	287.4	26
41	22	4	4.9	131.5	289.7	44
42	20	5	5.1	131.5	299.3	50
17	25	7	5.1	131	299.5	87.5
33	31	4	5.2	131	302.2	62
49	17	7	5.3	132	295.2	59.5
56	22	6	5.7	234	197	66
64	17	9	6	133.5	299.4	76.5
59	23	7	6.1	237	199	80.5
41	21	4	6.1	133	297.5	42
63	24	5	6.2	170.5	180	60
46	**23**	**7**	6.3	131.5	284.8	80.5
59	21	6	6.5	133	287.7	63
51	25	6	8.2	188.5	183	75

Handheld weapons

Thrusting spears tips				*Thrusting spears*		
Length (mm)	Width (mm)	Thickness (mm)	*Weight (g)*	*Length (cm)*	*Overall weight (g)*	*TCSA*
52	18	8	12.1	152	352.5	72
53	30	14	12.9	261	451.2	210
56	33	9	13.4	163	395.4	148.5
54	42	9	13.9	164	365.5	189
69	27	9	14.1	155.5	378.6	121.5
66	37	12	14.4	260	494.4	222
64	34	10	15.6	232	473.2	170
60	33	10	15.8	240	452	165
59	32	11	20.1	180.5	431.1	176



3-

4-

	Arrows		Darts	
Armature Width (mm)	***Shaft diameter (mm)***	***Pieces (n)***	***Shaft diameter (mm)***	***Pieces (n)***
< to 10	between 5 and 11	10	N/A	0
Between 10 and 20	between 6 and 13	36	between 10 and 14	7
> to 20	between 6 and 12	6	etween 10 and 14	16

Figure S4. ***Initiarc* experimental program.** 1- Weights, diameters, lengths, and TCSA values according to type of experimental weapon. 2-, Morphometric data (tips length, width, thickness, and weight/ projectile length/ projectile weight, TCSA) of the three types of experimental weapons. 3- Degree of penetration of experimental projectiles. 4- Relationship between armature's width and shaft diameter depending on the two different types of experimental weapons.

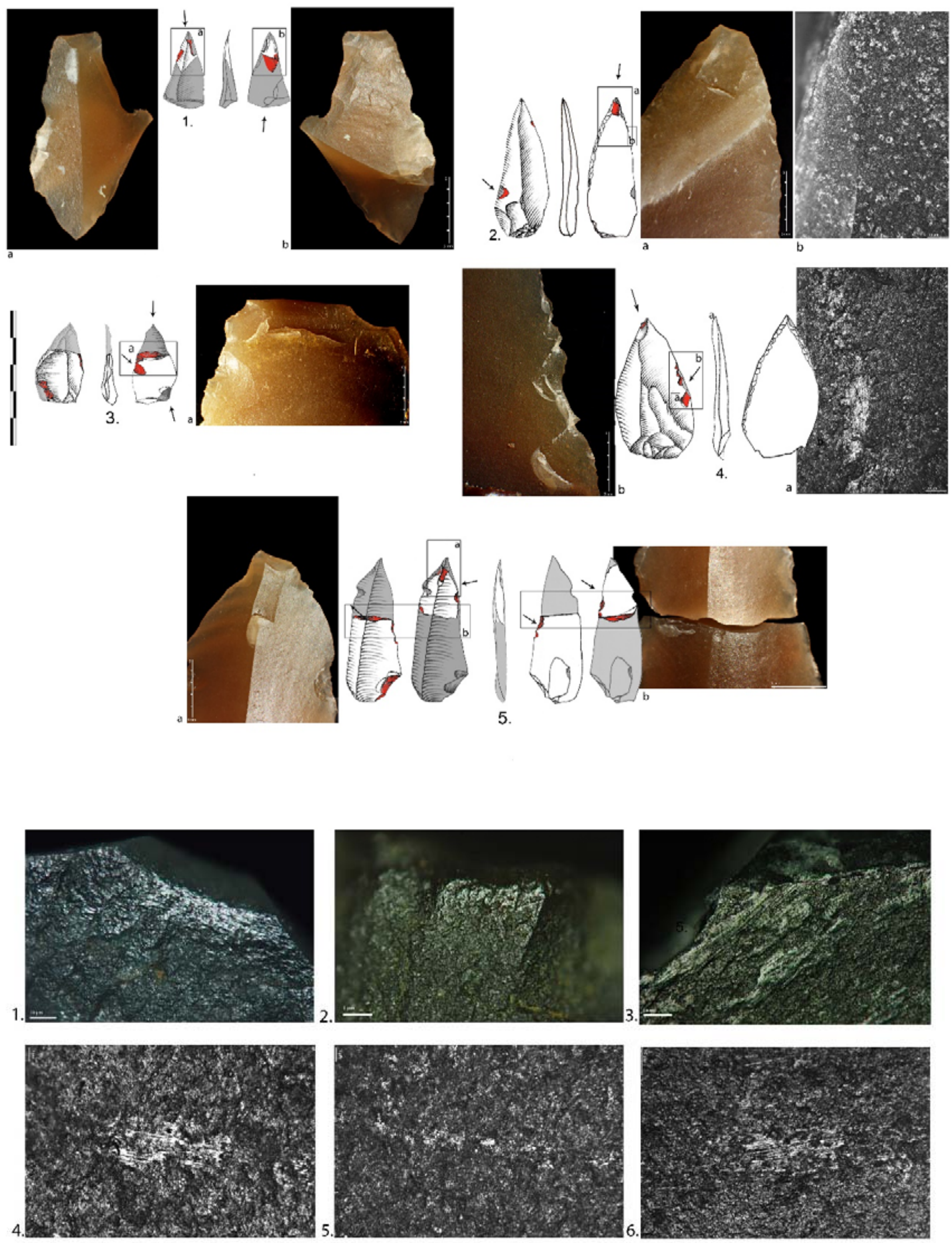


Figure S5. ***Initiarc* experimental program.** Macro use-wear analysis of the projectiles after shots – 1-3, Experimental arrowheads and 4-5, dart tips with DIFs: drawings before (gray) and after (white) *shooting*. Experimental micropolish and MLIT. 1-3, micropolish due to non-percussive action. 1, fresh vegetable wood incision; 2, Scraping dry skin 3, Cutting fresh bone. 4-6, MLIT due to percussive action (*Initiarc* experimental projectiles).

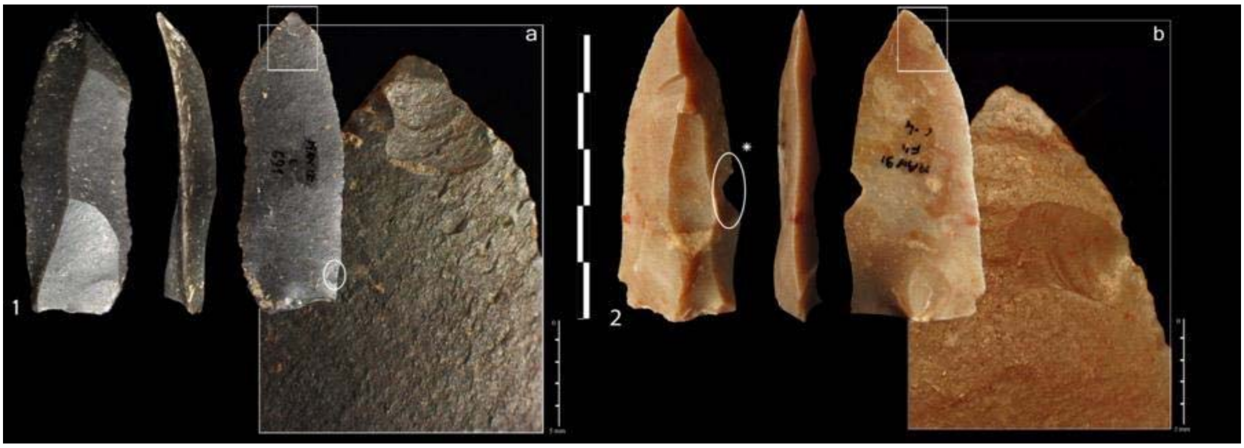


Figure S6. Mandrin E. Points with likely complex fractures. 1, appointed point; a, facial removal (4mm). 2, point; b, lateral removal (5mm). *Lateral removals relating to a percussion action.

Mandrin E	*Points*	*Micropoints*	*Nanopoints*	*Total*
Observed pieces	697	153	46	***896****
MNI observed	247	53	30	***330***
Impacted pieces	33	25	13	***71***
DIFs	67	47	17	***131***
MNI Impacted pieces	24	16	11	***51***
% MNI impacted	9.7	30.2	36.7	***15.5***

Table S1. Mandrin E. Categories of points in the usewear analysis, fracture locations, 1DIF distribution and proportion by technical categories (*882 points and 14 indeterminate blanks).

THRUSTING SPEAR TIPS	n	Min	Max	Mean (SD)	Median [IIQ]	*p-value*
Experimental Thrusting/Hand-cast (21, own data)	36	50	392	165.8 [80.7]	148.5 [123.0-189]	0.468, p>0.05
Experimental Thrusting/Stabbing spear tips (38)	47	46	406	153.9(61.7)	143.5 [119.5-169]	
All experimental Thrusting spear tips	*83*	*46*	*406*	*159.2(70.5)*	*147.5 [121.4-180.5]*	

DART TIPS/LIGHTWEIGHT JAVELIN	n	Min	Max	Mean (SD)	Median [IIQ]	*Experimental Dart tips (Initiarc)*	*Ethnographic Dart tips (21)*	*Ethnographic Dart tips (23)*
Experimental lightweight Javelin (22, 38)	29	47.5	216	89.72 (39.7)	75 [63-104]	0.0001,p<0.05	0.0001,p<0.05	4.444e-12,p<0.05
Experimental Dart tips (own data)	23	20	87.5	52.8(20)	52.8 [37.5-64.5]	~	0.317, p>0.05	2.485e-13, p<0.05
Ethnographic Dart tips (21)	40	20.3	94.3	57.9(18)	60.3 [44.7-69.2]	0.317, p>0.05	~	2.2e-16, p<0.05
Ethnographic Dart tips (23)	103	66.6	488.4	240.02(101.5)	240.7 [172.3-315.2]	2.485e-13, p<0.05	2.2e-16, p<0.05	~

ARROWHEADS	n	Min	Max	Mean (SD)	Median [IIQ]	*Experimental Arrowheads (Initiarc)*	*Poisoned bone arrowheads (36-38)*
Ethnographic Arrowheads (21)	118	7.9	145.8	32.53(20)	29.87	0.2423, p>0.05	p<2.2e-16, p<0.05
Experimental Arrowheads (own data)	50	7	99	30.82(20)	28.0 [16.5-40.5]	~	2.019e-13, p<0.05
Poisoned bone arrowheads (36-38)	126	5	25	12.1 (4.4)	13 [8-13]	2.019e-13, p<0.05	~

p>0.05 pas de différence statistique significative

p<0.05 différence statistique significative

Table S2. Individualization of TCSA values by experimental and ethnographic weapon category.

	Mean (SD)	Vs Poisoned bone arrowheads
Poisoned bone arrowheads (36-38)	**12.1(4.4)**	~
Ethnographic Arrowheads (21)	32.53(20)	p<2.2e-16, p<0,05
Experimental Arrowheads (own data)	30.82(20)	p=2.019e-13, p<0.05
Mandrin micropoints (own data)	22.28(15.8)	p=6.701e-10, p<0.05
Mandrin nanopoints (own data)	15.77(12.9)	p=0.1321, p>0.05

Table S3. Mean, (SD,d) and statistical significance between TCSA of ethnographic and experimental arrowheads, Mandrin micro- and nanopoints, vs. poisoned bone arrowheads.

	>	**Mandrin E points Mean**	>
Mean (mm²)	Ethno. Dart tips (21)	**Points**	Exp. Dart tips *(Initiarc)*
	57.9	**56.3**	52.8
	Ethno. Arrowheads (21)	**Micropoints**	Ethno. Poisoned arrowheads (36-38)
	32.53	**22.28**	12.1
	Expe. Arrowheads *(Initiarc)*	**Nanopoints**	Ethno. Poisoned arrowheads (36-38)
	30.82	**15.77**	12.1

Table S4. Place of Mandrin E points' TCSA Means between ethnographic and experimental data.

	Flake	*Blade*	*Point*	*Micropoint*	*Indet.*	*Total*
Pointed			27	1		***28***
Burin	6	9			6	***21***
End-Scrapper		6	1		5	***12***
Soyons			11			***11***
Soyons atyp.		2	7			***9***
Prox. Troncated and thinning		2	3			***6***
Borer			2			***2***
Chamfered		2				***2***
Backed	1		2			***3***
Raclette					1	***1***
Total UP group	***7***	***21***	***53***	***1***	***13***	***95***
Secondary lateral retouch	22	3	3	5	25	***58***
Notch/denticulate	2			1	6	***9***
Total MP group	***24***	***3***	***3***	***6***	***31***	***67***
Total	31	24	56	7	44	***162***

Table S5. Mandrin E. Typological tools by technical categories.

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