

TO GRIP OR NOT TO GRIP: AN EXPERIMENTAL APPROACH FOR UNDERSTANDING THE USE OF PREHENSILE AREAS IN MOUSTERIAN TOOLS

Agarrar o no agarrar: una aproximación experimental para comprender el uso de áreas prensiles en útiles Musterienses

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ABSTRACT

The existence of a more or less complex handling technology with the lithic tools during the Lower and Middle Paleolithic is an interesting topic for understanding aspects of the human behavior during these periods. In this work we present a preliminary experimental evaluation of the possible functionality of prehensile area in some of the most representative lithic types of the Mousterian assemblages (dorsal elements and levallois *chapeau de gendarme* proximal area), in which the morphological comparative analysis of imprints and prehensile tool areas, is compared by 3D analysis procedures. Preliminary results indicate that there is a close relationship between the digital grasp morphologie and the prehensile area of some Mousterian techno-types. We also discussed the relevance and significance of these provisional conclusions in the context of hunter gather communities.

Key words: Mousterian; experimental archaeology; lithic tools; gripping; hafting; 3D.

RESUMEN

La existencia de una tecnología más o menos compleja en el manejo de los útiles líticos durante el Paleolítico Inferior y Medio es una clave interesante para conocer, en todas sus facetas, a los grupos humanos de estos periodos. En este trabajos presentamos una

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evaluación experimental de carácter preliminar sobre el posible funcionamiento de las áreas prensiles de algunos de los tipos líticos más representativos de los conjuntos musterienses (elementos de dorso y talones Levallois de *chapeau de gendarme*) en la que el análisis morfológico de improntas en masillas y en útiles líticos se compara mediante procedimientos de análisis 3D. Los resultados preliminares indican que existe una estrecha relación entre las morfologías de presión digital y las áreas prensiles de algunos tecno-tipos musterienses. Igualmente discutimos qué significado pueden tener estas conclusiones provisionales.

Palabras clave: musteriense; arqueología experimental; útiles líticos; agarre; empuñadura; 3D.

INTRODUCTION

Lithic tools are the most frequent and representative cultural expression of the human cultural evolution. In Pleistocene archaeological sites, frequently lithics are the only recognizable remains, and their study from different perspectives is the only way to approach past human behavior.

Among the lithic studies, the technological perspective has conceived lithic tools as a complex combination and interrelation of components. E. Boëda redefines the term 'tool' as an object consisting of three different and related parts (figure 2) - *partie préhensée, partie transmettrice* and *partie transformative*- (Boëda 2013; Frick and Herkert 2014) related with the concept of techno-functional units -*unités techno-fonctionnelles* (UTF)- (Boëda 1997). According to Boëda (2013 pp. 40-46), a tool has sense when a particular action operates in combination with three components: the tool itself, the mode of operation and the energy applied in the action. The final composition of the tool depends on cultural and functional variables that determine a wide variety of hafting models (figure 1).

Thus, the tools are structured into different (techno-) functional entities: a handle or prehensile area, the transformation part which corresponds to the active edge, and the transmitting part conceived as an intermediate section that drives the force from the handle to the transformation part (Boëda 1991, 1997, 2013; Lepot 1993).

In order to understand the technological process, it became of great importance the analysis of the morpho-potential properties of the prehensile areas of the lithic, final

products. In the present research we present a preliminary evaluation of some specific tool in which a direct hand handling procedure seem to have been applied. Implications about its significance are also discussed.

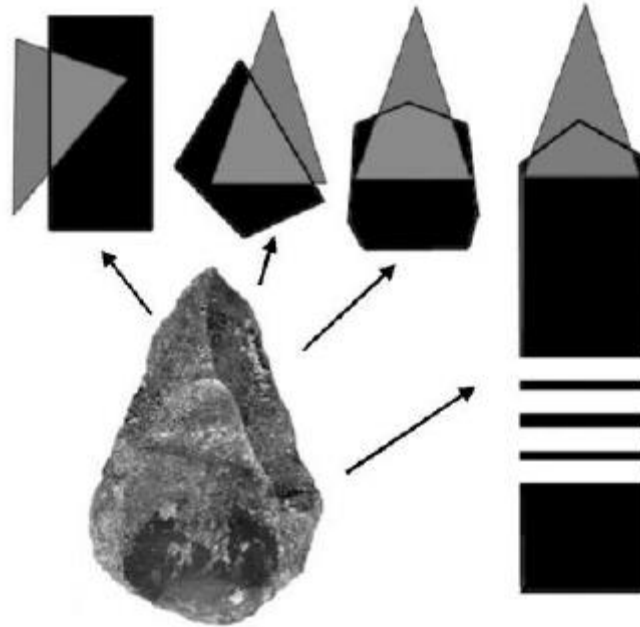


Figure 1. Examples of hafting possibilities of a Levallois point after Bonilauri 2010 (in Boëda 2013 fig. 7, p. 42)

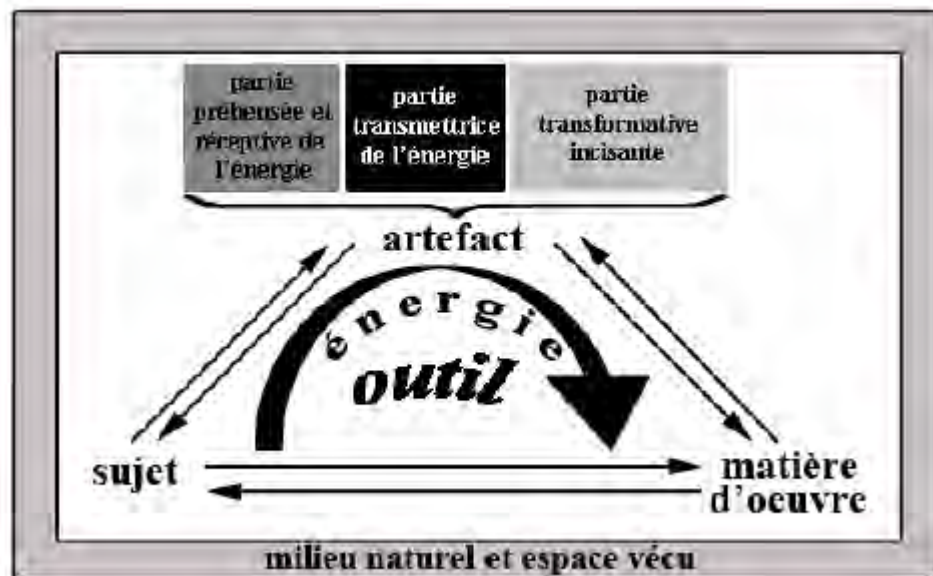


Figure 21. Examples of hafting possibilities of a Levallois point after Bonilauri 2010 (in Boëda 2013 fig. 7, pag 42)

In our study we will consider two main technotypes of the Middle Paleolithic in order to evaluate the character of the prehensile areas through a comparison between fixed

hafting and handling methods, and hand/finger gripping. We will also overview several handling methods to evaluate the potential use of each one in our case studies.

Hafting methods during Middle Paleolithic have been proposed on the basis of archaeological records from several Middle Paleolithic sites attesting the presence of different types of bitumen or glue products (Boëda et al. 1999; Koller et al. 2001; Grünberg 2002; Pawlik and Thissen 2011, Zipkin et al. 2014, etc.). In those cases, the existence of a handle (wood or organic materials) looks to have been aimed at increasing the efficiency of the tool.

However, hand use must have been frequently applied. We can hypothesize this option due to stress conditions, occasional uses, or cultural habits. The morphology of the prehensile area could affect the efficiency of the transmission of force during use (Boëda 2013) and, consequently, the specific products of human groups.

THE STUDY SAMPLE

In this work, we pay special attention to some flake or tool morphologies and platform types that present a high degree of standardization in the Mousterian technical tradition. The first one is the *chapeau de gendarme* butt (figure 3 A). Defined by Bordes (1947), it presents a regular morphology both in plan and section, usually explained by the necessity to provide an accurate location of the impact during the knapping process: “the profile of this very distinctive butt should be looked at face-on; while this type of butt is common in Levallois *débitage* (for a good, preferential impact point), it occurs during every period, irrespective of the methods applied” (Inizan et al. 1999 pp.134). As stated by the authors, the creation of this morphology is not restricted to the Middle Paleolithic period. However, is extremely frequent within the Neanderthals productions.

It is one of the most representative morphological criteria present in the canonical Levallois production, and at the same time ensures the effectiveness of the percussion contact in precise parts of the core. However, for knapping accuracy, a convex surface is needed only on the horizontal surface of the core entering in contact with the hammer, while convexity along the perimeter of it is not necessary (the transversal section of the proximal part of the resulting product). The existence of this particular morphology must be also explained by some other reasons (cultural, functional, etc.).

The second classical type in Mousterian production is the *couteau à dos* (backed knife), that is a *débordante* flake with a cutting edge opposite to the prepared or not,

cortical back (Bordes 1961). The knife is frequently produced by the “orange slices” system or by backed flakes series, with a particular slightly twisted longitudinal profile, as the results of the presence of negatives in the dorsal surface, and a bulb in the ventral one (figure 3b).

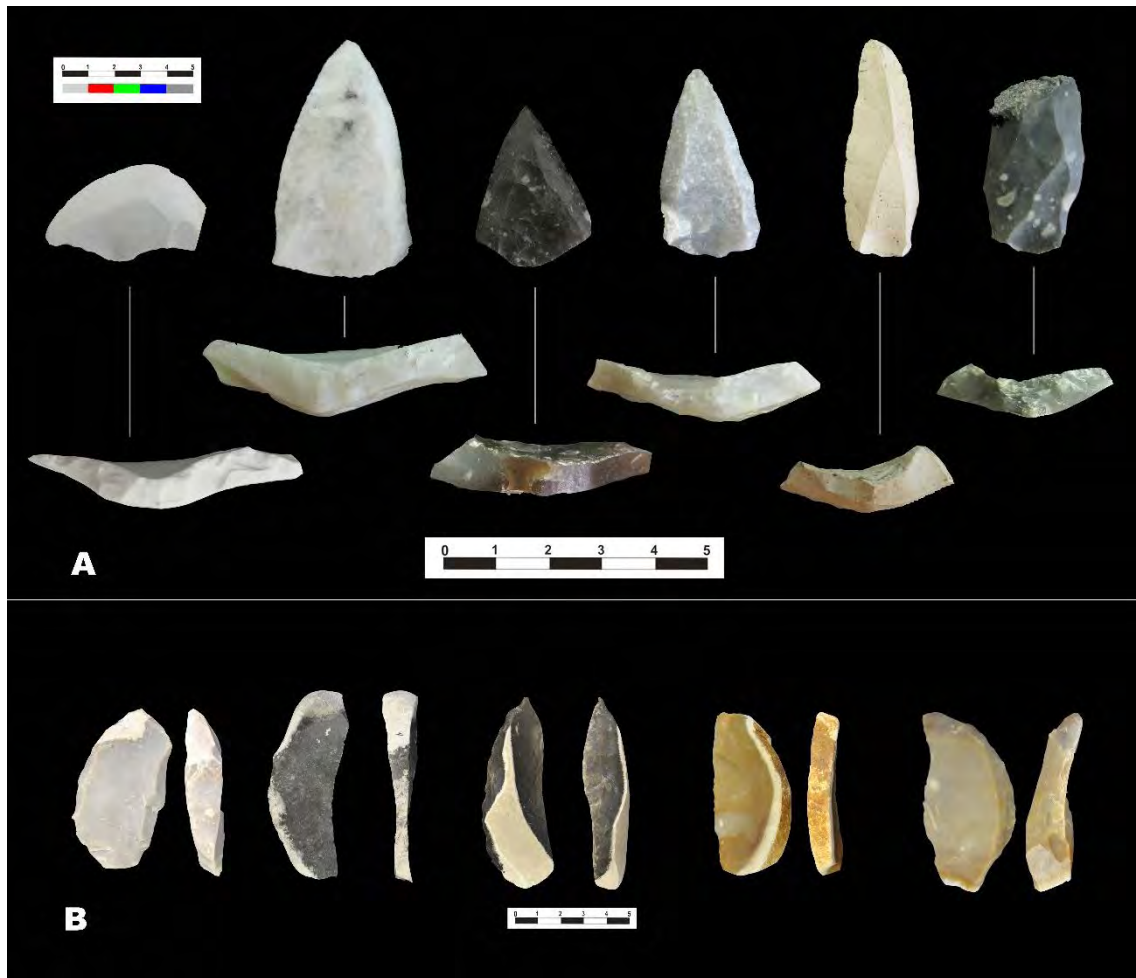


Figure 3. Experimental collection of replicas. A. levallois products with a classic chapeau de gendarme platform. B. backed knives.

Our contribution does not pretend to present an exhaustive study of the whole Mousterian collection, but to open an experimental perspective for a better understanding of the manipulative technologies of Neanderthal communities.

TOOL HANDLES AND METHODS TO USE LITHIC TOOLS

Several handle methods have been documented in the ethnographic and archaeological record. Some of them are also used in our everyday life. The first consist in a two opposite vector direction system, in which two fingers, wood sections or other materials are applied in order to include the lithic element between them (figure 4, A1).

The cohesion of the shafts is produced by adhesives, ties, strings and/or by the composite character of the wood piece and the hand pressure (figure 4, A2).

Possible variations of this system consist in the application of three force vectors (two opposites and one lateral, figure 4, B), or in a multiple vector force application (figure 4, C1, C2, C3 and C4). In some cases the hafting is reinforced by using hides or strings in different locations of the tool. The gripping system could also be produced by the inclusion of fibers or tendons in the lithic tools by adding different types of glues or adhesives (figure 4, C1). The handle is produced by the inclusion of numerous layers of fibers and by gripping this mass. The result is a multiple force vector application system. The main inconvenience of this method is the limitation in the effective length of the handle.

It is also possible to standardize a wood or bone handle by curving the support into a specific morphology that can be easily adapted to the prehensile UTF of the lithic tool. The dimension of the lithic object is essential in order to obtain the maximum benefit developing the functional action, and to avoid the concurrence of ineffective parts of the tool (Carrion Santafé 2003). Examples of use of three force vectors are usually applied in opposite and perpendicular directions with or without cordages (figure 5, D1, D2 and D3).

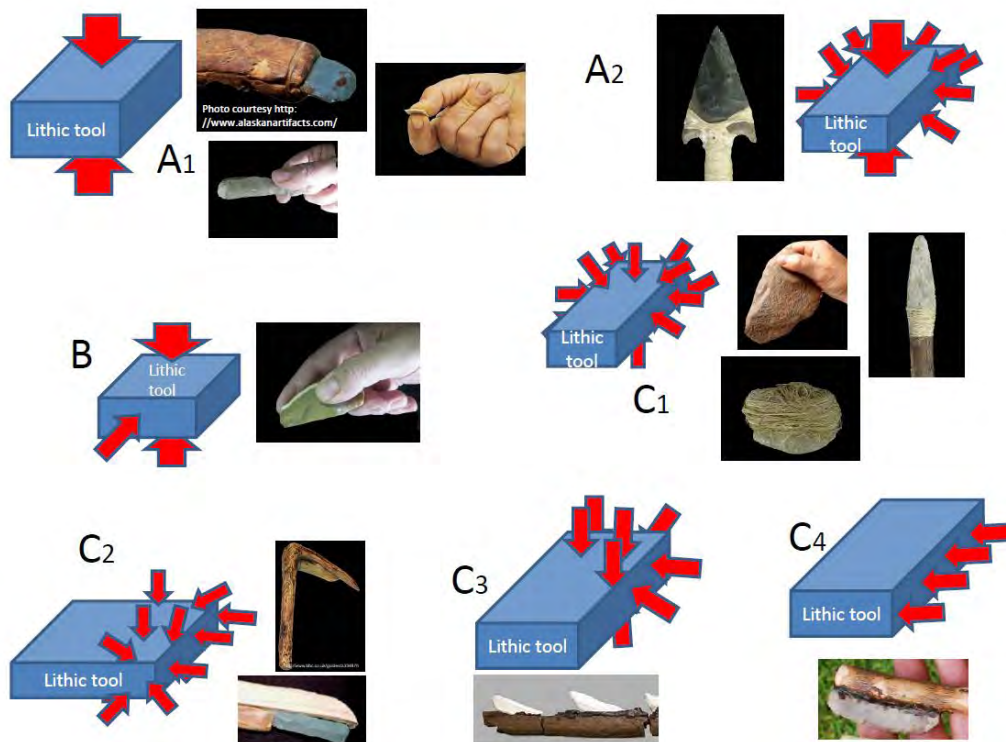


Figure 4. Gripping and hafting lithic tools systems. A. Two opposite vectors B. Three opposite and lateral vectors C. Multiple vector with variants.

Another variation is the case of the production of sockets or cavities in the stick or the support by taking advantage of a vector reaction force produce by the socket during the activity (figure 5, E1 and E2). A variation consists in a perpendicular orientation of the socket (figure 5, E3). A lateral two force reactions could also be applied by using particular shaft morphologies (figure 5, G1 and G2).

Finally, exists the triple gripping, in which aspects such as volume and morphology of the prehensile UTF of the lithic implement are essential. The relation of these attributes with the fingers or wood/bone gripping procedure strongly influences the efficacy of the tool use (figure 5, F).

In summary, there are several ways in which lithic tools could be handling and/or hafted. The simplification shows several prehensile models: the opposite vector or clamp system, the tripod system, the cover system, half cover with or without stop, the opposite resistance system, the hole systems, the ring or multiple rings systems, the back with or without stop systems, diagonal systems, etc. (figures 4 and 5). The use of glues, strings, fibers or simply hand gripping do not essentially change the vector compositions and thus, the prehensile UTF morphology needed for each one.

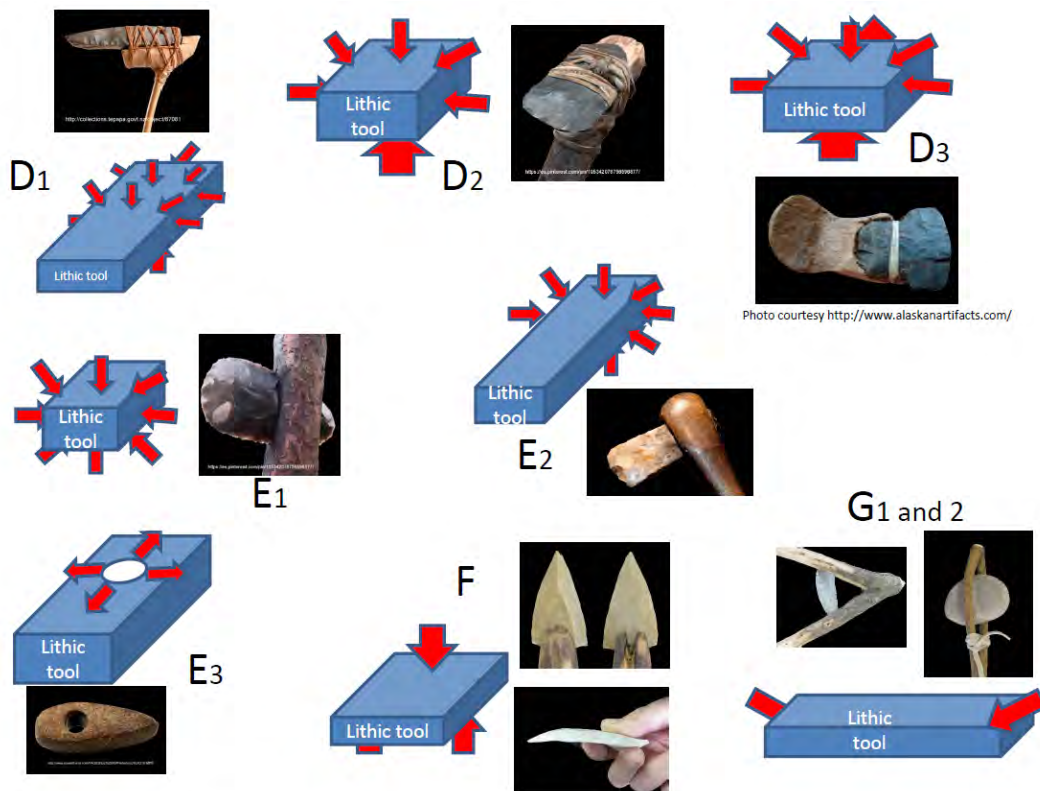


Figure 5. Gripping and hafting lithic tools systems. D. multiple vector with a main opposite one. E. Ring vectors with variants F. triple gripping vectors. G. Two opposite lateral vectors.

EVALUATION OF COSTS (COST OF HANDLING AND USE EFFECTIVENESS)

There is no doubt about the importance of using handles or the use of a correct gripping system in relation with effectiveness and average production. The analysis of the prehensile UTF could provide a better analysis of the global human productivity. The problem is to evaluate what is better in terms of efficiency: to invest more efforts in producing a handle for a better final effectiveness, or, on the contrary, to avoid the production of handles (saving this invest of time and resources) although effectiveness in force application decreases.

The cost of using fixed armatures or handles (wood, bone, etc.) is arithmetic and even exponential due to the fact that Middle Paleolithic tools present multiple dimensional scales of the same morphology that need a single handle or a particular adaptation in each case. However, the application of handles always increases the efficiency of the tool. Experimental logic indicates that by gripping the tool with the hand, the volume and morphology of the prehensile UTF determine the working efficiency. In general, the more volume of the UTF is present in the tool, the bigger productiveness is obtained. Morphology is also important, as attested in the case of Quina sidescrapers whose supports are morphologically predetermined by specific *débitage* systems (Turq 1989; Bourguignon 1997). The adaptation of handles to the prehensile areas of these tools is quite complicate due to the triangular morphology of the back (Baena Preysler and Carrión Santafé 2010). The direct hand use of this volume seems to be the best (figure 4 and 5) in particular when de prehensile morphologies of the Quina sidescrapers presents a wide variation (Carrión Santafé 2003). Furthermore, variable small tools seem to have been used for detailed activities during the Middle (Rios Garaizar 2012) and probably even the Lower Paleolithic (Mazza et al. 2006; Alperson-Afil and Goren-Inbar 2016). The question that arises is if the adhesive technology is present during the Lower Paleolithic, because in the contrary the finger/hand griping could be deduced.

The direct use of the lithic tool by hand gripping provides a more versatile way to hold and use variable morphologies. The use of medium and small flakes implies the adaptation of the UTF to the griping mode. The relevant question is if the prehensile part is conceived and designed in a general predetermined way. Is it predetermined as well as the *transformative* and *transmitive* parts? Does the prehensile area of the tool have a standardized morphology in order to improve the gripping procedures?

APPROACHING PREHENSILE MORPHOLOGIES IN MOUSTERIAN PRODUCTS USING 3D ANALYSIS.

The use of 3D technologies in lithic studies is not a recent subject (BIBLIO).topic. Several approaches have revealed the potentiality of its application (Grosman et al 2008). In this research we analyze the proximal area of Middle Paleolithic final products comparing it with the prehensile area of the hand gripping morphology obtained by negatives in molds. The analysis is based on the comparative analysis of the distances of the prehensile areas between lithic Mousterian morphologies and the gripping mold scans. We have produced different negative molds of finger gripping in modelling clay for a standard “natural backed knife” gripping (figure 6A) and a standard “Levallois flake” gripping (figure 6B). After that, we selected the proximal area of typical Levallois products: “Pucheuil”, Levallois flakes and Levallois points (Bordes 1961; Geneste 1985, 1988; Delagnes and Ropars 1996), and the prehensile area of standard natural backed knives (*couteau à dos naturel*). We scanned both the negative molds and the standard lithic tools in models of points with a high resolution 3D scan. We used a NextEngin 3D Portable Scanner with macro option, seven to eight rotations, and 10Ka points per square inches (HD quality) (figure 7 A and B).

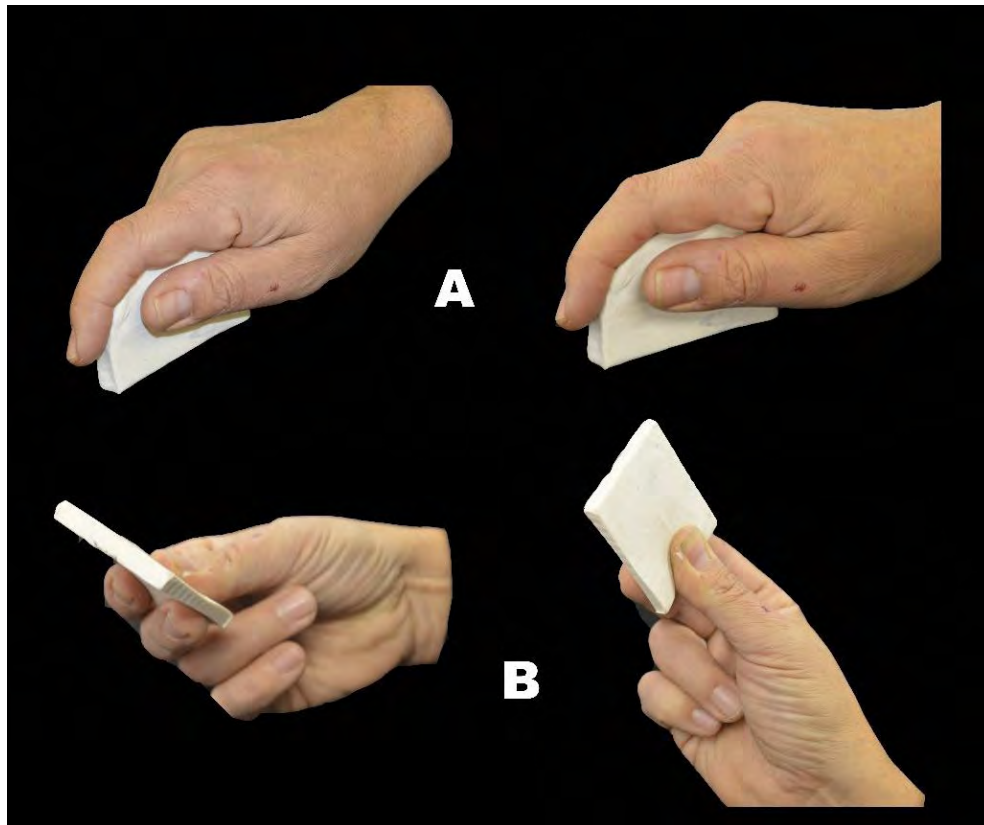


Figure 6. Creation of imprints in modelling clay by strong gripping. A. Backed Knife B. levallois flake

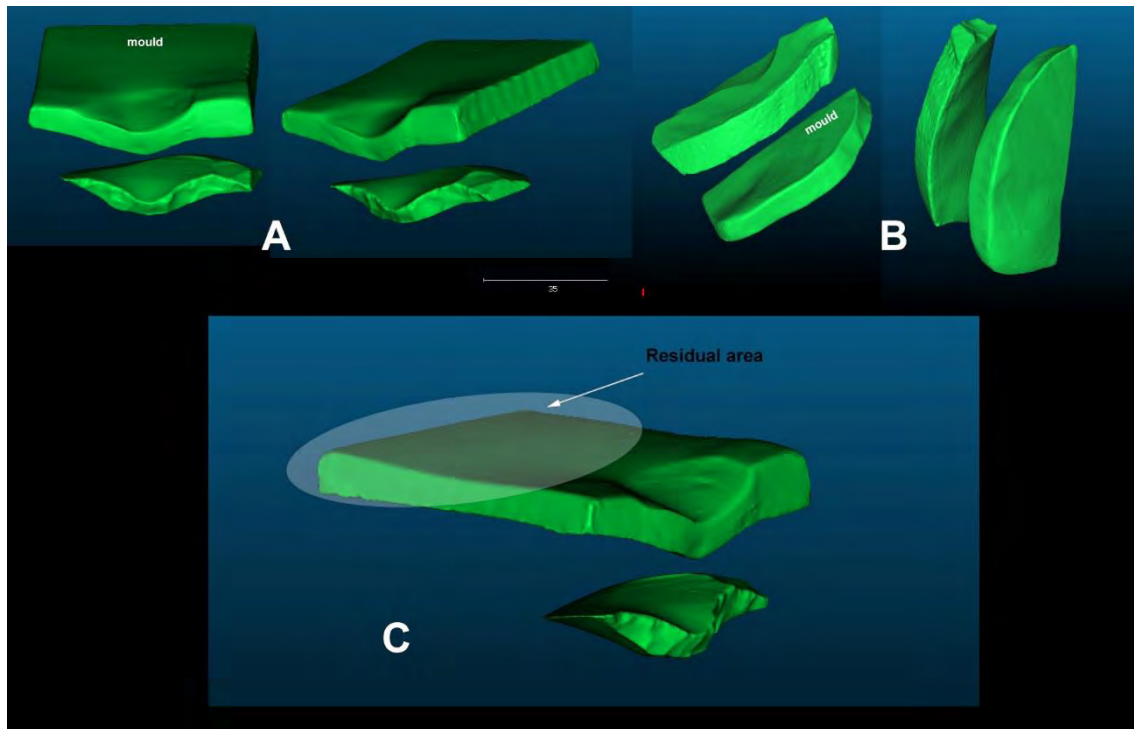


Figure 7. Three dimensional scanned models in comparison with the lithic tools. A. Levallois. B. Backed knife. C. Residual areas not consider in the 3D scanned molds.

The analysis is based on the comparative resources of the software Cloudcompare V2 version 2.8 beta (<http://www.cloudcompare.org> License: GNU GPL, General Public Licence). We applied the command “distance compare” that computes distance differences between two or more 3D point or mesh models. The analysis comprises several steps in order to optimize and standardize the comparative analysis, and produces graphical and statistical results that evaluate the differences between them. We have used a standard modelling clay cube to obtain the fingers gripping imprints. This procedure will leave important residual areas with a high degree of distance differences. For this reason, for the distance model calculating we only selected the areas with the minimal distance differences avoiding residual areas (figure 7 C).

The computing procedure includes the following steps:

- 1) Scan the experimental lithic replica and the finger negative molds.
- 2) Adapt both 3D models for a latter reference.
- 3) Coarse and fine reference of the models.
- 4) Compute cloud/mesh or cloud/cloud distance model.
- 5) Exclude the residual areas by splitting the distance model.

6) Build the interpolated model of minimal distance in close areas of both models.

We try to reduce the RMS error to the minimum. However, the existence of several differences between the clay standard mold and the lithic tool (for example in distal or lateral part) introduces non representative values in marginal areas. For this reason, we limit our statistical analysis to a descriptive presentation of values distributions in the selected ranges and to a visual representation of the common closest distance models. In both cases, the graphics measures represent decimeters.

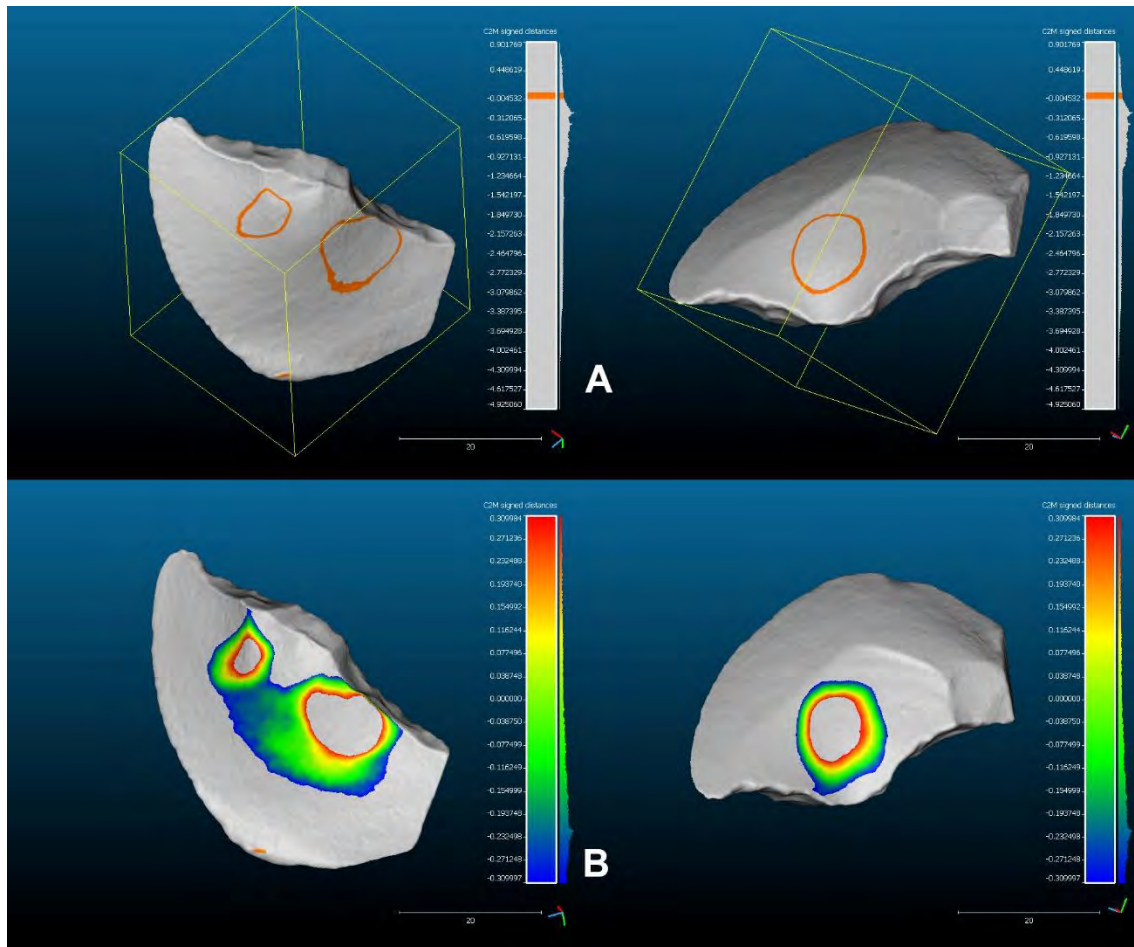


Figure 8. Short distances models in the levallois “Pucheuil” example. A. Lower than 1 mm. B. Lower than 3 mm. C. Distribution of contact areas in the lower than 3 mm range.

Results for the *chapeau de gendarme* prehensile morphology show a perfect adaptation of the three holding system (figure 7 A), since the existence of minimal distances (lower than 1 mm and lower than 3 mm) match in both models in three points (figure 8 A and B, respectively). However, the existence of a gradual range of distances in the generated “interpolated distance model”, suggest that the use of rigid contact points (that could be the example of a wood shaft) do not provide enough contact surface for a correct gripping. On the contrary, the application of a soft material (as is the case of

fingers) provides a better grip contact. The correlation between the finger gripping system and the tool morphology matches perfectly with very clear and concentrated short distance common areas (figure 8 A and B; figure 9 A, B and C).

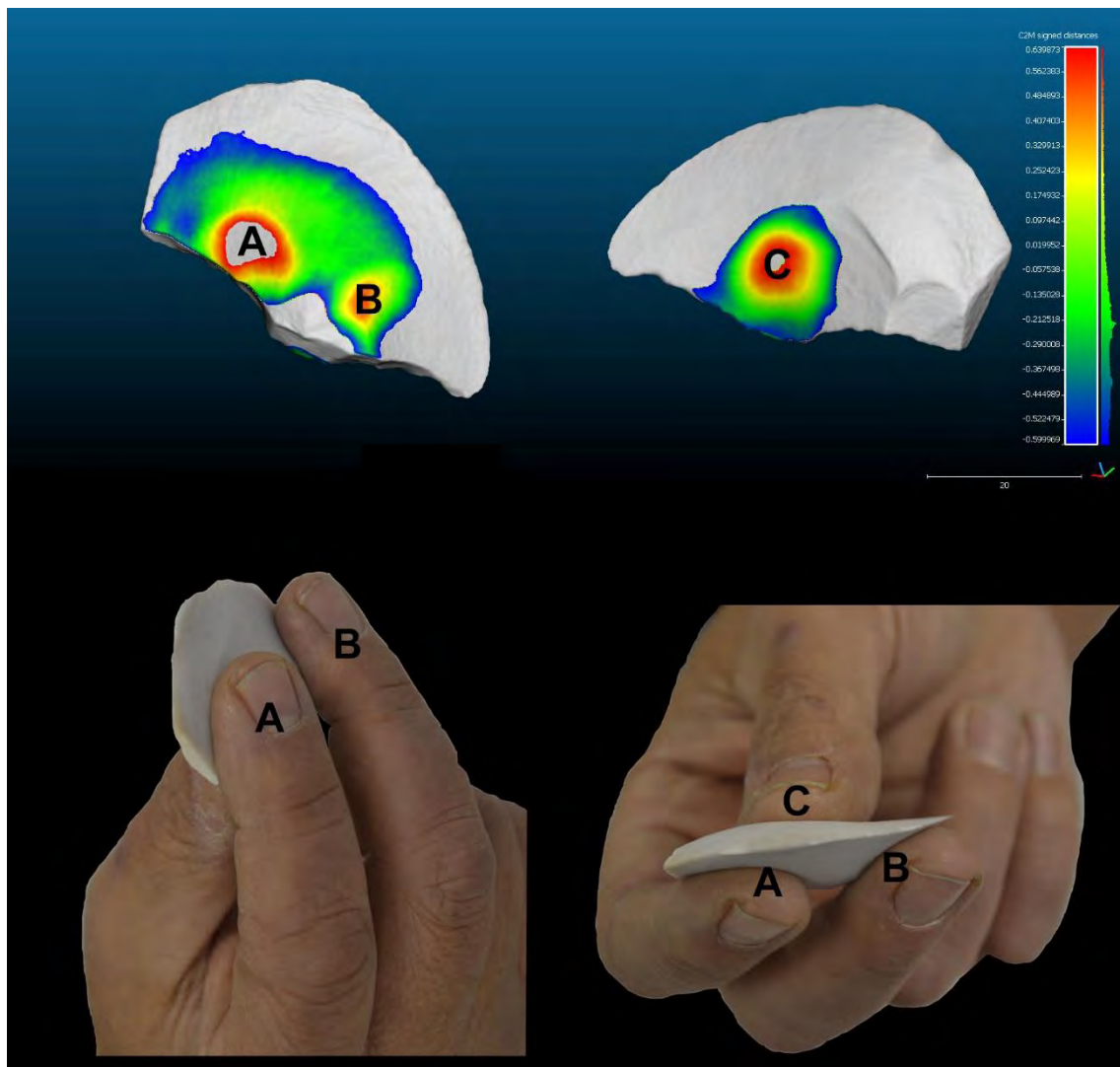


Figure 9. Comparison between gripping contact areas and the distance comparative model in the levallois example.

In the case of the backed knife, (figure 7 B; figure 10 and figure 11) the distribution of contact areas has a lower correspondence between the lithic and the modelling clay reproductions. This is caused by the higher variability of tools morphology. However, the main contact parts correspond in both knife models (figure 10 A, B and C). Short distances distribution (lower than 1 mm and lower than 3 mm) are more concentrated and clear in the case of the Levallois, probably due to the existence of a higher contact surface in the backed knife (that introduces a bigger contact variability). But in both models, there is a high correspondence between all the “touching” areas (figures 8 and 11 distributions). With a higher range distances the common surface areas

do not significantly change in location, circumstance that could confirm the correspondence of the contact areas between both models in the two examples (figure 11 A and B).

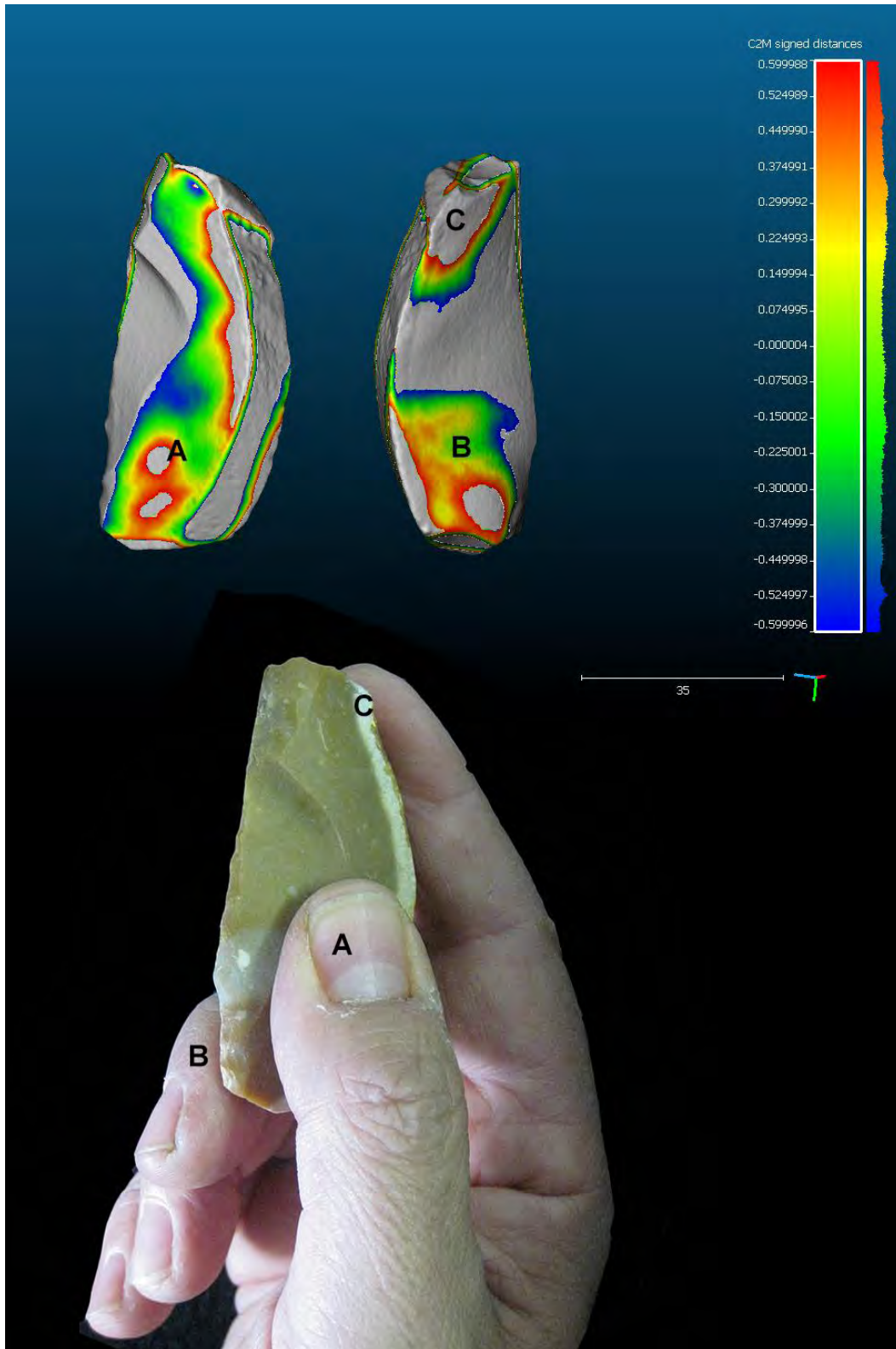


Figure 10. Comparison between gripping contact areas and the distance comparative model in the backed knife example

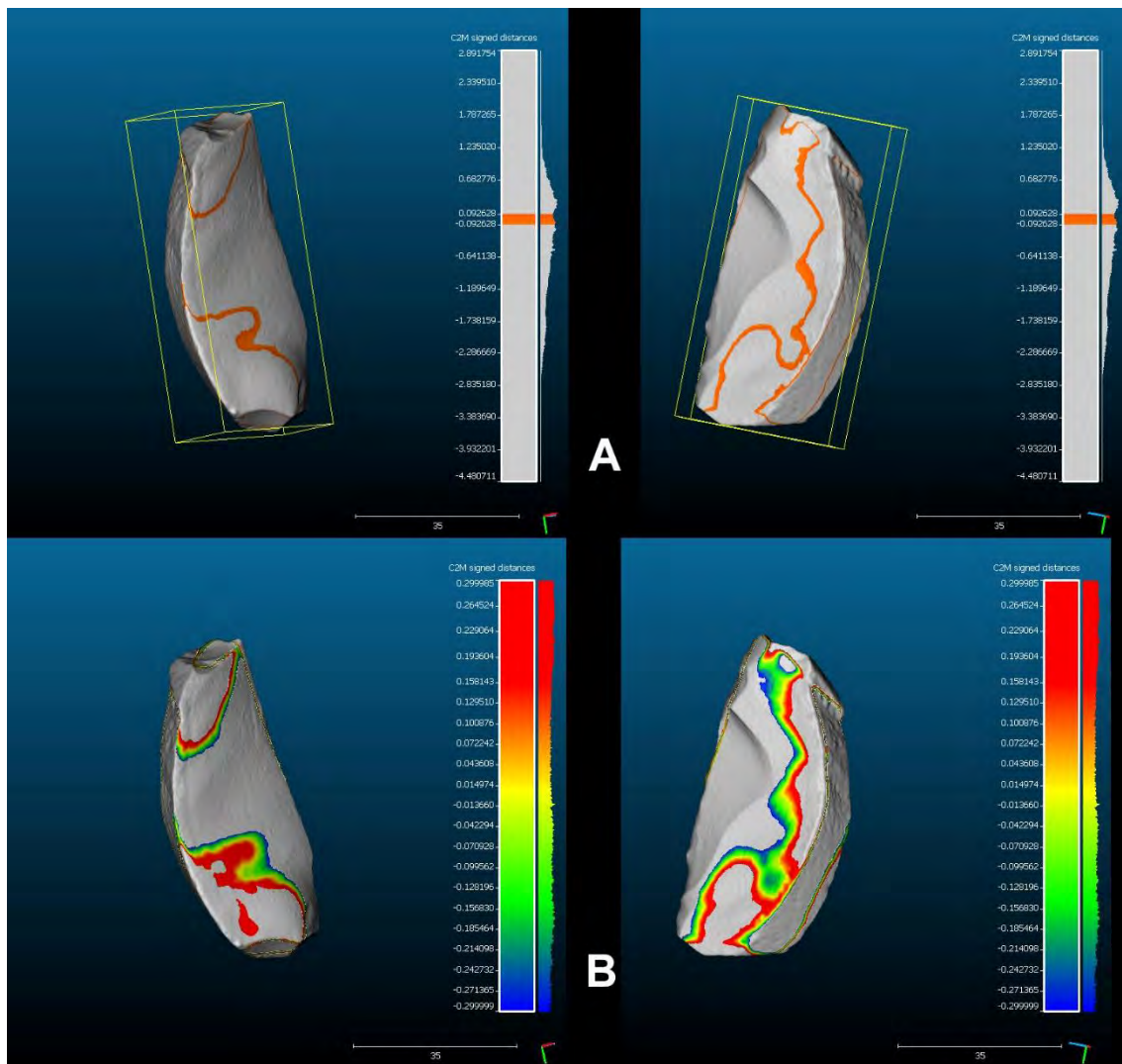


Figure 11. . Short distances models in the backed Knife example. A. Lower than 1 mm. B. Lower than 3 mm. C. Distribution of contact areas in the lower than 3 mm range.

CONCLUSIONS

Without a detailed functional analysis in a complete archaeological sample, our conclusions could only be understood as a working hypothesis. Deeper morphological and functional studies could support our preliminary suggestions. However, the comparative analysis of the hand gripping negatives with the standard prehensile morphology of indicative tool types, indicates that there is a coincidence. These results could indicate the possible existence of a planning in the creation of morphologies in the final products. Hand gripping and tool morphology correlation could also indicate the existence of predetermined prehensile methods for some of the Mousterian tools.

These conclusions might question preliminary inferences obtained from traceological and residues analyses that suggest a generalized use of fixed handles by

applying glues and/or birch tar (Boëda et al 1999; Koller et al. 2001; Grünberg 2002; Mazza et al. 2006; Galván et al. 2008; Rios 2010; Rots 2010; Lazuén, 2012, Alperson-Afil and Goren-Inbar 2016). Our preliminary results suggest that the manual prehension (in our study three fingers) is quite similar to the natural proximal morphology of some Levallois and other discoid products. The presence of residues of birch pitch and impact damage in several Middle Paleolithic tools demonstrate the use of fixed handles in addition with different types of glues but in the case of *chapeau de gendarme* platform and the backed knives, the application of a triple finger gripping method seems to be the best and faster way to manipulate this specific tool morphology (figure 5 F). The variation of the proximal morphology and dimensions matches better with a hand clamping system than a fixed or hafted one. We should bear in mind that variability has been registered as common feature of the Mousterian tools (Rios Garaizar 2016, Romagnoli et al. 2015) and multiple tool use expressions could be found. In our case studies, morphological similarities between three fingers negatives and the proximal UTF prehensile area seem to indicate that the finger/hand gripping must have been the most versatile way to use these lithic implements.

Predetermination is one of main hallmarks of the Mousterian productive “philosophy”. Much has been written about final Mousterian products programming (Boëda, 1988) and even about the teleological organization of the global production (Bourguignon et al. 2004) defined as ramification. The existence of a predefinition of the morphology of the prehensile areas in relation with the gripping modes increases the predetermined conceptual character of the Mousterian production far away from a stochastic tool conception. If so, then Neanderthals could have had a strict tool conception that could have been important socioeconomic consequences.

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