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THE ORIGINS OF BONE TOOL TECHNOLOGIES: CONCLUSIONS AND FUTURE DIRECTIONS

The origins of bone tool technology lie with the use of bones in lithic manufacture and maintenance. Such behaviour extends as far back as a half million years, if not earlier, and continued until as recent as 5000 years ago. This volume examines in great detail the circumstances of these origins, particularly how these bone tools were integrated into the entire suite of emerging Palaeolithic technologies and how these cumulative innovations influenced hominin lifeways.

The "Retouching the Palaeolithic" conference on which this volume is based was organized around four interconnected themes related to the use of bones and other osseous materials in lithic production: 1) Identification, methodology and terminology; 2) Form and function; 3) Time and space; and 4) Associated archaeology and human behaviour. These themes are woven throughout the individual papers in this volume, with significant attention paid to the archaeological contexts in which these bone tools have been recovered. From these themes, a coherent methodology for the analysis of these bone tools has emerged, together with a set of experimental protocols to verify or reject interpretations of these artefacts; the various pits and scores on these bone tools have been considered in relation to a range of possible functions to determine their role(s) within the overall lithic *chaîne operatoire*; local and regional chronologies for the use of these bone tools have been improved; and most importantly, the complete archaeological contexts in which these bone tools were recovered, including the associated lithic industries and faunal assemblages, have been scrutinized to reveal economic decisions and organisational strategies of Palaeolithic populations.

Identification, methodology and terminology

Exploring the origins of bone tool technologies hinges on the accurate identification of pits, scores, and other markings on bones and other osseous materials related to lithic manufacture and maintenance. We must adhere to strict scientific standards of identification in order to trace the development of this technology over time, beginning with the oldest Palaeolithic faunal assemblages up to the more recent Mesolithic and Neolithic periods. Images and descriptions of these artefacts have been available for decades, but manuals and reference works dedicated to various bone surface modifications provide little coverage on the specific markings to define bone tools used in lithic manufacture. Only with the publication of *Retouchoirs, Compresseurs, Percuteurs…Os à Impressions et Éraillures* (Patou-Mathis, 2002) did such guidelines become available for the standardized identification of these bone tools. This collection of papers published under the sponsorship of the *Commission de nomenclature sur l'industrie de l'os préhistorique (Société* *préhistorique française)*, remains enormously influential and has been referenced extensively by all the contributors to this present volume. This synthesis of *retouchoirs, compresseurs* and *percuteurs* from the European Palaeolithic represented the culmination of research by numerous scholars extending back to the turn of the 20th century, and significant developments have been achieved since 2002.

Toward an updated set of guidelines for identification and methodology, Mozota (2018) chronicles the history of archaeological and experimental research on bone retouchers and similar bone tools and provides a much needed anthology of the different classification schemes employed by various researchers to define specific "use traces" on bones related to lithic manufacture and maintenance. Mozota's meticulous review charts the "approximate equivalences" across various terminologies, which seeks to clarify any unintended discrepancies encountered with the translation of original French terms to English. Along the way, Mozota also details the historical developments of experimental studies, and with a nod to the future, outlines a methodological approach to guide archaeological interpretation toward more quantitative, explanatory, and verifiable results. This inferential framework is a critical component of formulating and testing hypotheses about the behavioural significance of the use of bone tool technologies during the Palaeolithic.

In regards to methodology, the individual contributors to this volume drew from a wide range of existing qualitative and quantitative procedures as a basis for their analyses. Together with the various methodologies prescribed in Patou-Mathis (2002), nearly every author converged on the conventions and protocols outlined by Mallye et al. (2012). These simple methods of recording the orientation, location, distribution and morphology of use traces have proven beneficial to the standardization of basic observational data. We strongly support the continued use this methodology for describing these various bone tools.

Much of this volume deals with pits, scores and other marks left on bone surfaces indicative of stone tool manufacture and maintenance. Recognition of this type of damage has grown steadily over the past decades, and archaeological case studies often interpret the damage as the result of retouching the edges of stone tools. Consequently, the bones on which these marks are found have been termed "retouchers", from the original French word *retouchoir.* This is the preferred terminology used throughout this volume, and we agree with the individual authors in their interpretation of these artefacts, but we caution that the use of the term "retoucher" carries with it a specific definition, together with an inferred mode of use and singular function. In simple terms, a "retoucher" is a percussion implement that is struck against a lithic tool (or flake) thereby resharpening or reshaping its edge. Ungulate limb bone shaft fragments were the preferred raw material for retouchers throughout much of the Palaeolithic period, but we emphasize that retouchers cannot be identified by the form of the bone or bone fragment itself; rather, it is the diagnostic pits, scores, and other marks left on the bone's surface by a lithic edge that positively identifies a bone as a retoucher. But, not all bones or other osseous materials bearing these types of marks are created equally. Characteristic pits and scores can be imparted by varying degrees of force, by percussors (*percuteur* in French) or other hammer-like implements. Compressors (*compresseurs* in French) work by applying pressure to the lithic edge. Bone anvils (*enclumes* in French) used in a passive manner may also bear marks related to various lithic knapping activities. Thus, the appropriate terminology should be dictated by the motion involved in utilization, whether active or passive, and technique applied, whether through percussion or pressure. In a broad sense, "retoucher" has become a catch-all term for bones with marks resulting from the manufacture and maintenance of stone tools, regardless of its use in an active or passive manner, through percussion or pressure, or otherwise. We argue that this generalization obscures the variability in use and function of these bone tools. Furthermore, in archaeological examples, the motions (active or passive) and techniques (percussion or pressure) involved must be inferred based on the characteristics of individual or groups of pits and scores. Even with decades of experimental studies, the distinction between pits and scores created through different motions and technique is not entirely clear. Thus, the term "retoucher" has come to be used somewhat imprecisely, similar to the use of the term "scraper" in lithic studies. A "scraper" is truly a scraper only if its use-wear indicates its usage in scraping tasks. Likewise, a "retoucher" can only be defined as such if it preserves surface modifications resulting from shaping the edge of a lithic tool by percussion. For the sake of clarity, the continued use of term should be accompanied by a qualifier: retoucher *sensu lato* to describe the broader category of bone tools used in lithic production, including retouchers, precussors, compressors, etc.; and retoucher *sensu stricto* for actual bone retouchers used for shaping a lithic edge by percussion.

As a synonym for bone retoucher *sensu lato*, we suggest the reuse of the French phrase "os à impressions et à éraillures", shortened to "os à impressions", to describe the entire class of bone tools bearing pits, scores, and other marks related to lithic manufacture and maintenance; Daujeard et al. (2018) also advocate for the use of the general term "impressions et éraillures" to describe these marks (see also Patou-Mathis, 2002). "Os à impressions" loosely translates to "bones with impressions", but we prefer to use the original French phrase to avoid any confusion or loss of meaning through translation. This phrase offers a neutral description of the bone tools, without ascribing specific functions, and can be used synonymously with the phrase "minimally modified bone artefacts" (Villa and d'Errico, 2001) or "bone expediency tools" (see Lyman, 1984). In the broadest sense, the key element of this terminology relates directly to the pits, scores, and other marks ("impressions") on the bone surfaces imparted during lithic production. These marks may be indicative of how the tool was used (motion and technique) and for what function (retoucher, percussor, hammer, compressor, anvil, etc.), the specifics of which must be made explicit based on contextual and experimental data.

Form and function

Equating form and function could be used a means to link various "os à impressions" with specific elements of associated lithic assemblages at archaeological sites, thus placing these bone tools within the lithic *chaîne operatoire*. However, it is apparent that the gross morphology of the bone tool has little interpretive bearing on the function of the tool. Flat or convex surfaces are common, and the tools must be of a minimum size to be useful, but other morphological features are quite variable. Therefore, we contend that the individual pits, scores, and other "impressions" must serve as the defining feature of these tools, not the form of the tool itself or the anatomical element from which it is derived.

Throughout the Palaeolithic, a vast majority of faunal remains with pits, scores, or pieces of embedded lithic material originated from ungulate long bone shaft fragments of various dimensions and from small to very large animals. Overall, the selection of materials for such tools seems to have occurred on a rather *ad hoc* basis. It can be reasoned that the smaller and thinner examples functioned as more light-duty retouchers, while the larger, thicker specimens and complete bones were used as percussors or hammers. This does appear to be the case with the complete and fragmentary equid metapodials from Schöningen 13II-4 described by Hutson et al. (2018), but those bones also show evidence of use in multiple tasks related to lithic manufacture and maintenance. Other bones, such as ribs, limb epiphyses, and phalanges, in addition to teeth, ivory, and antler, are also known to have been used in lithic manufacture. As these more rarely used source materials were often recovered alongside large accumulations of bone refuse, the intentional selection of alternative osseous remains may imply functions different from that of long bone shaft fragments used as retouchers. This is likely the case with a variety of antler fragments interpreted as pressure and punch tools from the Mesolithic of northern (David and Pelegrin, 2009; David and Sørensen, 2016) and southeastern Europe (Vitezović, 2018). Apart from these few exceptions, the functions of the bone tools in question can only be determined through analysis of the use traces.

Several authors have suggested that compressors used in pressure tasks may display short linear impressions, sometimes with secondary striations, as well as an increased occurrence of scaled use areas, whereas percussion traces on retouchers are characterized by long linear impressions, sometimes with internal scaling, abundant punctiform or trihedral impressions, and less frequent scaled use areas (e.g., Rigaud, 1977; Ahern et al. 2004; David and Pelegrin, 2009; Mozota 2013). Costamagno et al. (2018) outlines a system to differentiate retoucher types based on use area characteristics and features of individual marks, but these classifications are quite specific to bone retouchers used in the production and maintenance of Quina scrapers at Les Pradelles, France. Thus, despite the collective body of experimental research on bones used in the manufacture and maintenance of lithic tools, there are no universally applicable links between particular tasks or functions and specific categories of use traces (see Mozota, 2018). Variables such as anatomical element, bone freshness, bone density, type of lithic raw material, lithic tool type, duration of use, and user experience, to name just a few, are important in the creation of use traces, but have received only little experimental inquiry on an individual basis. Furthermore, different combinations of these and other variables have not been fully evaluated, nor has overprinting of different types of lithic manufacture and maintenance tasks. These lines of experimental research are ripe for further investigation, and, after rigorous testing, would provide valuable insight into the spectrum of utility for these bone tools.

Time and space

Matters of temporal and geographic scale are important in discussing the origin and development of bone tool technologies. Whereas two possible bone hammers from Bed II at Olduvai Gorge, Tanzania (Backwell and d'Errico, 2004), point to a very early origin of bones used as tools in Africa more than one million years ago, similar implements used in the manufacture and maintenance of lithic tools only re-appear in sub-Saharan contexts at 75,000 years ago in South Africa (Henshilwood et al., 2001; d'Errico and Henshilwood, 2007). On the other hand, the use of bone retouchers and similar tools in Europe appeared around 500,000 years ago at Boxgrove, UK, during the Lower Palaeolithic (e.g., Roberts and Parfitt, 1999) and survived until at least Neolithic times (e.g., Taute, 1965). These osseous technologies were integrated into a multitude of local and regional lithic industries, and were not only shared among both *Homo heidelbergensis* and *Homo neanderthalensis*, but also persisted through the replacement of Neanderthals by anatomically modern humans *(Homo sapiens)* in Europe. In this regard, Europe and the adjacent Levant is presently the only region where the development of these technologies over time and space can be studied in great detail.

The corpus of works in this volume comprises regional syntheses, temporal overviews, and site-specific depictions of bone tool use covering much of Europe and the Levant from 400,000 to roughly 5000 years ago. Northern and southern France are particularly rich in Palaeolithic sites with bone retouchers (Costamagno et al., 2018; Daujeard et al., 2018; Sévêque and Auguste, 2018). Spanish sites are not featured in this volume, but the use of bone retouchers on the Iberian Peninsula spans the entire Palaeolithic period (e.g., Mozota, 2009; Rosell et al., 2015; Moigne et al., 2016; Tejero et al., 2016). To the north in Belgium, research through museum collections has revealed a trove of bone tools dating from the Middle Palaeolithic (Abrams, 2018). Continued work on these collections is likely to yield even more bone tools from older and younger periods. In Germany, bone retoucher use is well-studied from the Swabian Jura in the south (Toniato et al., 2018) and extends deep into the Middle Pleistocene with the metapodial hammers and other bone tools from Schöningen on the northern Plains (Hutson et al., 2018). The Italian peninsula, particularly in the Alpine north, contains numerous archaeological sites with bone retouchers (Jequier et al., 2018; Thun

Hohenstein et al., 2018). Further to the east, tools made from a variety of osseous materials span from at least the Middle Palaeolithic in Czech Republic (Neruda and Lázničková-Galetová, 2018) to the Neolithic in the Balkan Peninsula (Vitezović, 2018). In the adjacent Levant region, evidence suggests the potential for a longstanding tradition of bone retoucher use covering the entire Palaeolithic period (Rosell et al., 2018; Yeshurun et al., 2018).

Altogether, the works presented here offer a wide-ranging view of bone retoucher use across time and space. We have focussed mainly on Europe and the Levant, but similar technologies are known from nearly every corner of the globe. And yet, this is merely a glimpse of the potentially unknown temporal and spatial distribution of bones, antlers, ivory, teeth, and the like, used in the manufacture and maintenance of lithic tools. Continued investigations of existing collections, not just in Europe, but globally, will undoubtedly yield a more clear view of the origins and development of bone tool technologies. Building upon a more complete temporal and geographic continuum, we may refine our ideas about the technological, behavioural, and cultural significance of bone tools use, as well as formulate equally important explanations for the absence of such technology

Associated archaeology and human behaviour

The most important and lasting outcomes of this volume are the conclusions drawn about the significance of bone tool technologies for the study of human behavioural evolution. Examining both the lithic and faunal assemblages associated with these tools, together with their depositional settings, provide a holistic view of the economic decisions and organisational strategies of Palaeolithic peoples. In this respect, we can use this class of bone tools as a medium to explore the biological, behavioural and ecological dynamics of technological innovation.

With the keynote paper, Davidson (2018) revisits the question of language origins and the potential importance of bone tool technology for understanding modern human cognition. Davidson theorizes on the affordances brought about by the development of bone tool technology and how we may arrive at a better understanding of hominin niche construction and adaptation through analyses bone tools within the archaeological record. In this way, tool use, language, and cognition become intimately entwined as driving factors behind hominin behavioural evolution.

While the bulk of bone retouchers are known from Palaeolithic contexts in Europe, the oldest examples of bone tool technology presented in this volume come from the Lower Pleistocene in the Levant, at Qesem Cave in Israel, dating to perhaps 400,000 years ago. Here, Rosell et al. (2018) describe a series of bone retouchers attributed to the Acheulo-Yabrudian Cultural Complex used in the production and maintenance of Quina and demi-Quina scrapers for hide-working activities within the cave.

Beyond Qesem Cave, bone retouchers were thought to be absent from the Levant region. Based on the findings of Yeshurun et al. (2018) from Ahmarian / Aurignacian deposits at Manot Cave, Israel, the use of retouchers in the Levant now extends to the early Upper Palaeolithic. Owing to the long hiatus between the use of retouchers at Qesem and Manot, bone retouchers may not have been a permanent feature of local tool-kits, but an imported cultural tradition, together with other Aurignacian technologies. Equally possible, and perhaps even more encouraging for future studies, is that bone retouchers are simply an (as yet) unrecognized phenomenon in the rich faunal record of the Levant.

Another rare occurrence, or perhaps underreported, are the metapodial hammers from the Schöningen 13II-4 "Spear Horizon" in Germany presented by Hutson et al. (2018). The Middle Pleistocene hominins inhabiting the Schöningen lakeshore environment, armed with their wooden spears, used horse metapodials for breaking bones and in lithic maintenance. No hammerstones have been reported from the "Spear Horizon" or other nearby sites; thus, it seems bone hammers replaced hammerstones for a variety of tasks, a behaviour that is unique to Schöningen.

Moving to southern Germany, Toniato et al. (2018) continue a long tradition of research in the Swabian Jura with a review of retouchers from five Middle and Upper Palaeolithic archaeological sites. This comparative study details the prevalence of bone retouchers made from limb shaft fragments during the Middle Pleistocene, which were succeeded by a broader range of skeletal parts used as tools during the Aurignacian, and eventually replaced by stone pebble tool retouchers during the Gravettian. The Swabian Jura is well known for its many sites with personal ornaments and portable art objects made from a variety of osseous materials, and continuing work is revealing that objects made from bone were also an integral part of the human technological repertoire well into the Upper Palaeolithic.

France has a long history of archaeological research on "os à impressions", and Daujeard et al. (2018) offer a reappraisal of bone retoucher use in southeastern France, from the Lower and Middle Palaeolithic. Bone retouchers at the oldest sites (MIS 11) are rare, but their frequency grows during MIS 9 and 7, and become very prevalent in deposits associated with MIS 5. At these more recent sites, there does not appear to be a single factor that governs the presence/absence or abundance/rarity of retouchers in southeastern France, but is likely tied to a combination of scraper production, mobility strategies of the tool-kit, and the types of activities performed in and around the site.

Sévêque and Auguste (2018) take a similar comparative approach with bone retouchers from a number of Lower and Middle Palaeolithic sites in northern France. As is apparent in southeastern France, the presence of bone retouchers in the north is multi-factorial, and cannot be explained in relation to the production of specific tools or site function alone.

In what is one of the largest collections of bone retouchers from a single site, Costamagno et al. (2018) detail 408 bone retouchers from Middle Palaeolithic deposits at Les Pradelles in southwest France. This remarkable series of bone retouchers is associated with Quina Mousterian lithic technology and the secondary processing of a large number of reindeer. The abundance of bone retouchers made from the bones of reindeer carcasses transported back to the site indicates their vital nature at task-specific butchery sites. Bone retouchers actually outnumber Quina scrapers at the site, suggesting that a many of the lithic tools were exported for use at nearby locations. Altogether, the holistic view of bone retoucher use at Les Pradelles shows that the exploitation of animals for subsistence and as a source for raw materials was well integrated into the system of lithic production.

To the north in Belgium, Abrams (2018) highlights the need for the continued study of museum collections with the documentation of 535 bone retouchers from 14 recent and historic excavations of Middle Palaeolithic sites. Preference for bone tool raw material mirrors that of the most common large mammalian ungulates, but the rare cave bear and Neanderthal bones were also used as tools. The *chaîne opératoire* determined for the production of four conjoining retouchers made from a cave bear femur suggests a certain degree of predetermined form.

On the Italian peninsula, bone retouchers and similar tools are not particularly numerous, but Thun Hohenstein et al. (2018) discuss 79 tools from two Middle Palaeolithic cave sites in the pre-Alpine north. The bones selected for use were limb bone shaft of medium- to large-sized ungulates, which are the most abundant remains from the sites. This pattern is duplicated at most sites with bone retouchers and marks the selection of bones from the remains of recently butchered animal carcasses or from debris littering the sites.

Jequier et al. (2018) also studied the retouchers from two north Italian sites. Retouchers associated with large Quina scrapers are larger, thicker, more intensively used, and the pits and scores are heavily impressed in the bone. This appears to be an intentional selection of the most robust skeletal elements available for production of Quina scrapers. Another interesting point raised during this study is that scraping marks associated with the pits and scores produced by retouch may not be related to the preparation of the bone surface or the removal of the periosteum, but rather the preparation of the margins of the lithic blank prior to retouch.

Remaining in the Middle Palaeolithic, but moving east to the Czech Republic, Neruda and Lázničková-Galetová (2018) describe two unique retouchers made of mammoth ivory from Micoquian layers at Kůlna Cave. As compared to the earlier deposits, the Micoquian records a shift in the relationship between mammoths and Neanderthals in terms of subsistence and the use of ivory as tools.

Finally, Vitezović (2018) rounds out the volume with a review of retouching tools from the Mesolithic and Neolithic in southeastern Europe. While Palaeolithic bone retouchers and similar tools are quite simple and required little modification before use, this trend did not continue into the Mesolithic and Neolithic. Tools from these later periods were rarely unworked, *ad hoc* fragments of bone and antler, but intentionally shaped, heavily curated, and highly prized items. Antler appears to be the preferred raw material, mostly used for pressure flaking or as punch tools.

From these pages, a more clear view on the origins and development of bone tool technology is emerging. The early use of bone in the manufacture and maintenance of stone tools constituted a conceptual transformation of bone refuse to bone as an exploitable raw material. Whether we can equate this phenomenon with the modern concepts of recycling, reuse, repurposing, or something similar is a topic for debate, but the more important matter is that around 500,000 years ago, and probably earlier, Palaeolithic hominins began to view the living world around them differently. Animals once exploited only for their meat and other edible parts also contained bone and other hard, osseous materials suitable for modifying stone. Fresh bone, and even-semi-dry bone, has certain elastic properties that may have offered an advantage over stone when sharpening the edge of a tool, and it is clear that these properties were known to Palaeolithic hominins.

The means of acquiring bone, antler, ivory, teeth, etc., for maintaining lithic tool-kits have consequences for Palaeolithic hominin mobility. One reliable source of these materials would have been from carcasses killed directly by hominins. There is evidence from even the earliest sites that bone retouchers and percussors were fashioned from the bones of recently dead animals during the butchery process. While cutting meat from an animal carcass, the cutting edge of a tool becomes dull; thereafter, a bone is selected from among the debris, the surface of the bone and the lithic edge are prepared, and then the bone is used to rework the dulled tool. These short sequences of events are recorded in the butchered and utilised bones. At other sites, there is evidence that some bones used as retouchers were selected from the remains of a previously butchered animal carcass. This is common at habitation sites, such as caves, where bones accumulated over repeated visits. Open-air hunting and butchery sites also include bone refuse used as retouchers. Such locations with readily available and abundant bone for use as tools would have been an important resource on the landscape, further affecting the reoccupation of habitation sites and the reuse of butchery sites. When viewing animals in this technological sense, as a source of raw material, hominins become somewhat less reliant on stone and perhaps less tethered to known sources of lithic raw material. In some contexts, bones may have been transported across the landscape for use in an array of lithic maintenance tasks. Over time, retouching tools made from bone, and especially antler, became a common feature of an increasingly mobile tool-kit. Even the ill-fated Ötzi, who died atop the Tyrolean Alps some 5000 years ago, kept with him an antler retoucher or pressure flaker to sharpen his flint dagger and arrowheads, despite also carrying a bronze axe.

Future directions

This volume builds on more than a century of research on the influence of bone tool technologies for the study of human behavioural evolution. The last major compilation of papers specific to bone retouchers and the like, *Retouchoirs, Compresseurs, Percuteurs…Os à Impressions et Éraillures* (Patou-Mathis, 2002), left an indelible mark on the field and stimulated a renewed interest in Palaeolithic bone tool technologies. Since that publication, great strides have been made in the conceptual, methodological, and technical study of these tools. The works presented here reflect that progress, with the optimism to inspire future studies on the origins and development of bone tool technologies.

An important point moving forward is to not lose sight of the importance of bone retouchers and similar tools when discussing prehistoric technology. These tools, once relegated as mere curiosities and often overlooked, can now be regarded as critical components of many archaeological assemblages and should no longer be considered rare or unusual; nor should we restrict our expectations of where these artefacts ought to be found to their current geographic and temporal distributions. The absence of these tools from a site, region, or time period can be just as informative as their presence and should be noted together with other taphonomic features of faunal assemblages. At sites where organic preservation is an issue, we may be able to indirectly infer the use of bone retouchers through features in the lithic assemblages. In other cases, their complete absence provides an interesting contrast in terms of site function and organizational strategies. Above all, it is essential to consider the presence and absence of bone retouchers in conjunction with lithic knapping strategies and the treatment of animal carcasses, as some activities appear to have been reliant on the extensive use of retouchers, such as the Quina method to produce tools used in processing animal hides (e.g., Costamagno et al., 2018). In this respect, we need to look beyond the individual bone tool for answers to broader questions about hominin behaviour; we must take a holistic view of the complete archaeological record to trace the origins, development, and significance of bone tool technologies.

All of this begins by acquainting the next generation of researchers with the existence of bone retouchers and similar osseous technologies and incorporating current methods for identification of these tools into regular zooarchaeological instruction. We add to that a call to renew or continue investigation of museum collections in order to fill in the supposed temporal and geographical gaps in our understanding of bone tool technologies.

Once bone tools have been identified, we must take advantage of the most up-to-date digital imaging technologies to record the impressions, or marks, on the bone surfaces. Modern digital microscopes, scanners, and other three-dimensional imaging technologies capture high-resolution surface topographies of a variety of materials, including bone and other osseous materials, allowing for individual marks to be studied in great detail with powerful image analysis software. These techniques will become invaluable tools for identifying different types of marks at the micro- and macroscopic levels, and will lead to a better understanding of how different measurable characteristics of marks may equate to different functions. While these machines and software may be costly (although there are open-source software options), the entire field of archaeology has become increasingly reliant on virtual methods of data collection, and a failure to adopt these new methods of analysis would be a missed opportunity for progress.

We conclude with a call for more rigorous experimental programmes to clarify the spectrum of utility for bone retouchers and similar tools. Important in this regard are scientifically structured experiments to address specific research questions and to test hypotheses. These experiments (together with new imaging technologies) can help move beyond the simple identification of bone tools and begin to address larger questions regarding the functional, logistical, and behavioural contexts for these implements during the Palaeolithic and into the Neolithic.

Looking to the future, it is important to keep in mind that these tool-making tools are more than just prehistoric artefacts. They represent a novel approach to better understand technology and innovation, features that are ingrained in what it means to be human.

Acknowledgements

We thank all of the authors that contributed to this volume, the participants of the "Retouching the Palaeolithic" conference, reviewers, and colleague who provide insight into the study of bone tool technologies. We would also like to recognize Nicole Viehöver for her diligent work in the production of this volume.

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