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The Acheulean Handaxe Technological Persistence: A Case of Preferred Cultural Conservatism?

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One of the unsolved 'paradoxes' in prehistoric archaeology is that of the gap between the considerable advances in human biological and cultural evolution during the Lower Palaeolithic period, and the over one million years of 'stagnation' of the Acheulean handaxe. Most of the research on this topic has focused on innovation – why it was delayed or failed to take place – while overlooking the fact that innovation had occurred in many other fields during the same period. We suggest that practical, social, and adaptive mechanisms were in force in certain areas of human behaviour and led to enhanced innovation, while conservatism was preferred in handaxe technology and use. In this study we emphasise the dependency of Acheulean groups on calories obtained from large mammals, and especially megafauna, as well as the central role of handaxes in processing large carcasses. It is our contention that the handaxe's role in Acheulean adaptation was pivotal and it thus became fixed in human society, probably through the psychological bias towards majority imitation, which subsequently became a social norm or tradition. In brief, we suggest that the technological persistence of the Acheulean handaxe played an adaptive role that was based on a preferred cultural conservatism and led to the successful survival of Lower Palaeolithic populations over hundreds of thousands of years in the Old World.

Keywords: Acheulean, Palaeolithic, handaxe, stagnation, innovation, conservatism, learning

In modern culture, innovation is conceived as a key feature in the human struggle to survive, develop, and prosper. Innovation is associated with modernism and progress and is usually perceived as the antithesis of religious, social, or organisational conservatism. The layman sees innovation as integral to adaptation and survival and might consider that evolution prefers innovation over conservatism. In reality, however, since innovation is a conscious action, whereas natural mutation and selection are random, innovation does not necessarily promote survival. In practical terms, when measuring evolutionary success in the survival time of species, the most successful species are the conservative 'living fossils' such as the horseshoe crab or Cycas plant, which have not changed morphologically for over 100 Mya (Mayr 2001, 195, 287). On the other hand, mutations that supposedly represent innovation often do not survive the test of natural selection. The catchphrase of the advocates of evolutionary punctuated equilibrium theory, Eldredge and Gould, is 'stasis is data' (1972), meaning that the 'usual fate of most species is stasis' (Mayr 1992). We suggest that this basic notion may be applicable in the case of Acheulean handaxe technology: ie, a preferred stasis with no evolutionary drive for innovation.

The research in Palaeolithic archaeology suffers from a similar conceptual bias towards innovation. One of the unsolved phenomena is that of the gap between the considerable transformations in human biology and culture during the Lower Palaeolithic, and the impression of stagnation of the Acheulean handaxe (1.8/1.6–0.4/0.25 Mya – depending on regional differences). Much of the literature deals with the causes of this apparent stagnation, focusing on the seeming lack of creativity and innovation in Lower Palaeolithic times (eg, Elias 2012; Mithen 1998; Renfrew & Morley 2009). In general, such studies fail to address the dissonance between the handaxe's

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apparent stagnation and the advances in other areas (including the use of fire, expansion into new territories, the development of predetermined blank production and the Levallois method, big game hunting, and a protein and fat-based diet). We may ask why the suggested mechanisms behind this seeming stagnation did not similarly apply to hinder the concomitant transformations that did take place. One possible explanation is that the handaxe 'stagnation' had an adaptive advantage – a direct functional edge and/or social tradition/norm that evolved around its manufacture and use. Our study develops the notion that cultural conservatism (Gould 1977; Sharon *et al.* 2011) may have been a preferred adaptive strategy and a key reason for the persistence observed in Lower Palaeolithic handaxe use in the Old World.

In general, Acheulean lithic technology is characterised by the production and use of flakes and flakes shaped as tools. However, its hallmark is considered to be the Acheulean handaxe (see Gowlett 2013; Pope *et al.* 2006; Machin 2009; Sharon 2010; but also Barkai 2009) (Fig. 1). Handaxes are, in most cases, relatively large items (most commonly 10 cm or longer and a few cm thick; however smaller items also feature), shaped by extensive bifacial knapping that reflects manual dexterity, symmetry, and, in some cases, prolonged life cycles (Lycett & Gowlett 2008; Machin 2009; Sharon 2010). Such bifaces are usually used as a *fossil directeur* for the Acheulean cultural complex, regardless of the fact that modern research strongly indicates the variability and complexity of Acheulean lithic technologies (eg, Agam *et al.* 2015; Bar Yosef 2006; Dennell 2009; Hosfield 2008; Gowlett 2011; Lycett & Gowlett 2008).

The present study begins with a survey of views regarding the handaxe technological 'stagnation', the consequent debate, and advances in other fields. Theories are then presented regarding the causes of this so-called stagnation or slow development. The last section presents our hypothesis that preferred cultural conservatism, based on the functional role of the handaxe in processing carcasses of large game, was the major cause of 'stagnation' and persistence. This preferred conservatism was reinforced by knowledge transmission mechanisms that enabled handaxe production and use to become a social norm and a key feature in the survival and prosperity of humans during the Lower Palaeolithic.

THE ACHEULEAN HANDAXE – A CASE OF TECHNOLOGICAL PERSISTENCE?

The handaxe is recognised as the hallmark of the Acheulean cultural complex for three main reasons: its wide geographic distribution; its continuous presence throughout the Acheulean (1.8/1.6–0.25 Mya in Africa and the Levant); and its persistent morphology and production technology. These characteristics have earned the handaxe the sobriquet 'the Swiss Army knife of the Palaeolithic'. Various views concerning the level of technological stagnation or of change are often derived from the research terminology: stasis, stagnation, conservatism, slow change, monotony, and so forth. Each of these terms has its distinct nuance and thus represents a different level of 'freedom' in interpretation. While this article focuses on the continued persistence of the handaxe in the Acheulean cultural complex, some noticeable lithic innovations, such as prepared core technologies (eg, Adler *et al.* 2014; Nowell & White 2010) and the production of small flakes by means of recycling (eg, Agam *et al.* 2015; Shimelmitz 2015) also took place alongside the tool's apparent stagnation. These innovations, however, were not as geographically and chronologically widespread as the persistence of the handaxe. The following views relate to handaxe persistence and its bearing on Acheulean technology and culture.

The differing views on the issue can be divided into two schools: those that perceive stasis and those that emphasise a slow change. The terminology used to define the Acheulean technology by members of the first group include: 'conservative' (Scarre 2009, 95); 'behavioral conservatism' (Klein 1999, 337); 'essentially unchanged' (Gamble 2007, 221); 'rigid conformity' and 'conservatism' (Bar-Yosef 2006, 483); 'essential ideas were handed over from tool-maker to tool-maker over an exceptionally long period' (Lycett & Gowlett 2008, 309). Pope *et al.* (2006, 54–5) reached a similar conclusion regarding the symmetry and aesthetic form of the handaxe. Other scholars present data from specific sites, employing similar terminology such as: 'definite conservatism' (Gesher Benot Ya'akov, Israel: Sharon *et al.* 2011, 395); 'remarkably strong intra-assemblage uniformity … strong rules or conventions in technological operations' (Awash region, Ethiopia: Schick & Clark 2003, 26); 'uniformity … is consistent with a pattern of strong conventions held across Acheulean society' (Hunsgi and Baichbal Valleys and Isampur Quarry, India: Petraglia *et al.* 2005, 208).

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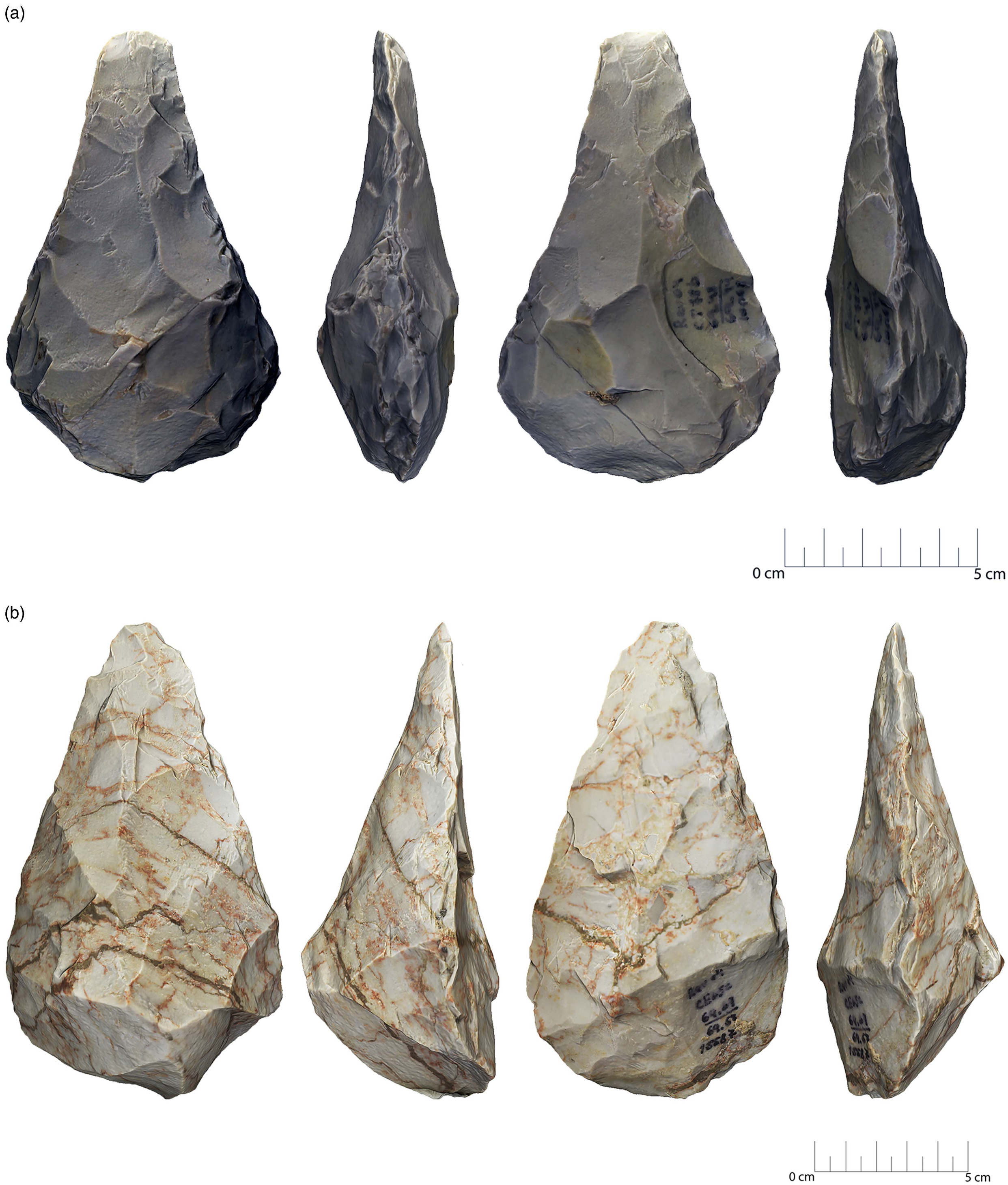

Fig.1.
Examples of Acheulean flint bifaces from the Revadim site, Israel

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The second school of thought, which acknowledges the existence of variability, includes Nowell and White, who contend that although the convention concerning the '… technological conservatism of unparalleled magnitude, a million years of stasis usually attributed to the limited cognitive and linguistic abilities of the hominins involved' (2010, 70), this misidentified stagnation is the result of analytical shortcomings. These researchers contend that handaxe variation can be detected at the global, regional (eg, in UK – see also a recent study by Bridgland and White (2015) suggesting chorological changes reflected in biface assemblages) and site levels (such as Boxgrove). They also state that the innovation and adoption of the handaxe itself was substantial (and flexible) enough to support transformations in the life history of Acheulean hominins. Inventiveness is suggested to have produced variations on a theme in the Acheulean, as in the case of the 'prepared cores' at Gesher Benot Ya'akov, Cagny La Garenne, France, and other sites, but these were relatively local (Nowell & White 2010, 73). It is generally assumed that a threshold – demographic, cognitive, physiological, social, or a combination thereof – had to be passed in order to make the next local 'invention' a global innovation (see also Hopkinson *et al.* 2013).

Hosfield (2008, 15) suggests that the gap between the 'sheer longevity and overall morphological stability of the Acheulean handaxe' and behavioural variability and flexibility found in other aspects of hominin life is due to differences in research resolution. He suggests that the morphological stability of handaxes is not a reflection of behavioural stability, but is due to problems with the identification of handaxe variability. Other researchers who seek to explain the Acheulean industry variance still begin from the assumption of stasis (Machin 2009, 36). Based on the same assumption, Hopkinson and White (2005, 23–5) engage with the role of the individual in creating the variance/stagnation in the Acheulean handaxe industry. Somel *et al.* (2013, 113) present an account of human brain evolution and employ the phrase 'limited progress' to describe the Acheulean technology.

McNabb *et al.* (2004) argue that the reason for diversity among handaxes should be attributed to the stylistic choices of the individuals who made them. McNabb and Cole (2015) recently employed orders of intentionality as a measure of cognitive evolution in order to suggest that what we observe today is basically variability, appearing within long periods of apparent stasis.

In conclusion, some perceive the Acheulean technological stagnation to be represented by a single tool type – the handaxe – that consistently appears both chronologically and geographically. Within this 'stagnation', variations exist in its manufacture and use at different sites and in different periods. For our case, including all its variations, the handaxe was sustained as the same 'tool category' (similar, in a way, to the modern hammer, axe, knife, or chopstick, which retain the same basic shape and function, albeit with many variations) for a prolonged time span, and we refer here to this continuity as 'stagnation'.

TRANSFORMATION IN OTHER AREAS OF HUMAN BEHAVIOUR

Unlike the suggested 'stagnation' in handaxe technology, the Acheulean cultural complex features a variety of transformations in other fields. Before presenting some of these in brief, it is worth noting that at least two different human groups were producing and using handaxes: *Homo ergaster/erectus* and *Homo heidelbergensis*, and that *Neanderthals* continued to make bifaces in late Middle Palaeolithic Europe (however, we should keep in mind that the jury is out regarding the variability within the genus *Homo*; see for instance Schwartz & Tattersall 2015). Machin (2009) surveyed several changes in Hominin characteristics between 1.8 Mya and 500 Kya, such as the increase in body size, brain size, and encephalisation; the development of communication and social complexity; changes in life history (longer periods of childhood and adolescence); social organisation; and strategies for procuring raw materials and food provisioning. Regarding food, Machin emphasises the rising place of meat in the diet and the transition from scavenging to hunting; a suggestion that has been recently strongly reinforced (Domínguez-Rodrigo & Pickering 2017). The need for lengthy parental supervision might have led to monogamy, the division of labour between man and woman, intra-group changes, and the promotion of social learning (Machin 2009, 38–40; Nowell & White 2010, 74–6). Regarding human cognitive abilities as reflected in the findings at Gesher Benot Ya'akov, Goren-Inbar (2011) argues that inventions undoubtedly occurred in the Lower Palaeolithic: eg, the use of the soft hammer for shaping handaxes and the early appearance of the

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Levallois method (or prepared core technologies) that flourished later in the Middle Palaeolithic. Regarding the dissonance between these developments and handaxe stagnation', Goren-Inbar further contends that 'These innovations, together with the creativity expressed in the full control of fire and its uses, clearly negate the notion of stagnation and/or stasis' (2011, 1045).

Dennell (2009, 335) emphasises the transition to big game hunting in the Lower Palaeolithic and Klein (1999, 343–60) reviews transformations in human behaviour during the Lower Palaeolithic and the changes in various areas such as the use of fire, non-lithic tools, and the types of animals hunted. Nowell and White (2010) argue that significant changes in human life history occurred in the Middle Pleistocene, such as increased geographic dispersion, and meat eating. The migration from Africa to Asia and Europe required abilities that enabled adaptation to diverse environmental and climatic conditions. Finally, the basic question remains: How can we explain the gap between the range of biological, social, and technological transformations and the 'stagnation' in handaxe technology?

POSSIBLE CAUSES FOR ACHEULEAN HANDAXE TECHNOLOGICAL 'STAGNATION' & THE LACK OF INNOVATION

Scholars combine various fields of research (human cognition, knowledge and information transmission, social learning, and demographic variables such as group size, composition, and distribution) to explain the apparent technological 'stagnation' in question. We contend here that the fundamental flaw in these theories is that if they hold true for the handaxe, then they are assumed to hold true for other transformations as well.

Recently, Corbey *et al.* (2016) suggested that handaxe persistence in time and space is better explained not only by cultural and social reasons but partly by genetic inheritance. Moncel *et al.* (2016) somewhat follow this line of thinking, suggesting that the explanation for the combination of wide geographic distribution and the diversity of the handaxe lies in convergent evolution. In our view, such explanations need to be better supported and argued, and for the time being we therefore focus on functional–behavioural–cultural propositions. The persistence in handaxe shape and technology is, according to Mithen (1996), the result of technological information transmission, mainly via imitation mechanisms. Given the complexities of handaxe manufacture, a more advanced learning mechanism known as 'guided learning' may have also been involved. Shipton and Neilsen (2015) argue that the 'unparalleled homogeneity of the Acheulean' is due to over-imitation and shared intentionality. Recent studies have identified the presence of inexperienced knappers in specific 'knowledge transmission grounds' at Palaeolithic sites. These learning grounds may reflect the presence of knappers in the process of learning as well as learning transmission mechanisms at such sites (Assaf *et al.* 2015 and references within; Tehrani & Riede 2008).

Lycett and Gowlett (2008) contend that four models of cultural transmission can be taken into account: parent to offspring; teacher/leader to a number of individuals; numerous individuals to one individual; and peer learning. Each of these supports a different rate of innovation, dissemination, and consolidation. They further suggest that the low rate of innovation during the Lower Palaeolithic seems to be related to the parent-to-offspring model, although this method predicts inter-group variance that is not clearly observed in lithic findings of the period. A model of knowledge transmission from many individuals to one predicts a relatively low rate of innovation and greater variation between groups. Lycett and Gowlett (2008) further suggest this model as suited to the Acheulean evidence. Stout (2011) argues that another factor in the innovation rate equation is that of the rise of technological complexity. As technological complexity increases, it creates the likelihood for more combinations to arise based on the existing variance, some of which will become the next innovations. He contends that sufficient complexity can be detected already in the Lower Palaeolithic, supporting the innovation of 'pre-Levallois' cores and knapping with a soft hammer to produce refined handaxes at 0.5 Mya (Stout 2011). It should be noted that yet another mechanism for conveying information in social learning is that of conservatism transmission, which researchers of the Acheulean tend to ignore as a possible explanation for the handaxe paradox. Recent studies from the field of primatology also emphasise the explanatory potential of an approach focused on conservatism and functional fixedness (Gruber 2016; Wrangham *et al.* 2016). In the following we discuss the 'conservatism transmission' concept in greater detail.

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Several approaches have been presented for reconstructing learning mechanisms in the Lower Palaeolithic. Their common theme is that relative technological stagnation is due to the low rate of innovation for reasons associated with learning ability and group size. None of the approaches suggests the possibility that the persistence could be due to a conscious and adaptive preference to produce the same tool type for generations.

Another view of preferred conservatism comes from studies of human life history. Nowell and White (2010) argue that significant changes in human life history took place during the Middle Pleistocene. The rising place of meat and fat in the human diet is most likely related to the increased dependence on hunting, the adoption and use of fire, the reduction in gut size, the 20–60% expansion of brain size, and the increase in body size. All of these transformations are interrelated, though the sequence of cause and effect is far from being understood. The increased brain size led to the birth of helpless infants (relative to other mammals), which in turn led to extended infancy and longer puberty, as well as extended life expectancy long after menopause. To explain the relative technological 'stagnation', Nowell and White (2010) distinguish between innovation – such as the adoption of the handaxe that marks the transition to the Acheulean – and inventiveness – a lesser degree of a novelty, such as variations in handaxe manufacture. How can we explain these processes according to the changes in human life history? Human life history is divided into five phases: infancy, childhood, juvenile, adolescence, and adulthood. Of these, childhood and adolescence are unique to the human species. Childhood has two important advantages: first, it allows the mother to stop breastfeeding and reduces the interval between births; and second – and of greater importance in our case – childhood allows 4 years of learning social behaviour. Adolescence provides the additional years of development that are essential for technological learning, experimentation, social integration, language acquisition, and other cultural transformations. The researchers suggest that *Homo erectus* childhood was shorter than that of Modern humans, which would have resulted in an imprinting of the handaxe 'idea' during the child's early learning process from his 'ultra conservative' parents (Nowell & White 2010, 76). Nowell and White, however, do not indicate why the parents were so conservative. Instead, they ask, is it possible that a short childhood in a relatively small group, with a limited number of associates with whom one could learn and experiment, could have harmed the option to create real innovation?

Somel *et al.* (2013) support the importance of long childhood. Referring to data on the rate of production of proteins in the brain due to different genes, they contend that the process of creating synapses (synaptogenesis) in the frontal cortex, the quantity of which has a major effect on the brain's plasticity, takes place primarily between the ages of 3½ and 10. This period is the 'window of opportunity' in which many human cognitive abilities are developed. In chimpanzees and macaque monkeys this period is limited to a few months only. From the suggested Early Palaeolithic short childhood, the effect we can deduce regarding human cognitive ability is that of its possible bearing on a limited scope of innovation (Somel *et al.* 2013, 124). The biological perspective sheds light on the relative 'stagnation' in handaxe technology. On the attempt to ascribe the slow change in the form of tools to conformity caused by the early stage of cortical organisation, Bar-Yosef (2006, 483) writes that the explanation based on 'predetermined solutions embedded in the technical "mind" of [the] individual who conformed to the social context of society' is more applicable than the one based on brain development.

Demographic studies indicate that a clear link can be identified between the dynamics of culture – the stability of traditions and the development of variance within them – and demographic processes such as population size, composition, and distribution (Steele & Shennan 2009), although others, such as Vaesen *et al.* (2016) argue that population size does not explain past changes in cultural complexity. Richerson *et al.* (2009) maintain that if we assume that the development of practical novelties is a rare event, then the rate of innovations should be relatively limited in small populations. In such populations, practical innovations will disappear randomly due to the problem of information transmission. In relatively large populations there are more potential inventors, and the chance of incidental loss of innovation is relatively small. Premo and Kuhn (2010) assert that the stability of Lower Palaeolithic technology is not related to human limited cognitive ability, as other scholars claim, but is derived, rather, from the high extinction rate of small social groups that characterised this period. Nevertheless, the question remains: Why did extinctions limit transformations only in lithic technology and not in the other described technologies and life-history characteristics?

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In summary, we have reviewed a variety of explanations, some mutually supportive, others mutually contradictory, for the handaxe 'stagnation' phenomenon. The basic problem with this variety of explanations is that they present theories that are considered to be valid in principle in other fields in which transformation and innovation occurred, such as the emergence of the Levallois method or the use of fire. Why, then, should the handaxe phenomenon be considered to differ from other fields of human behaviour? What was so unique to it or its use that led to its persistence for more than a million years?

PREFERRED CONSERVATISM AS A MAJOR DRIVE TOWARDS TECHNOLOGICAL PERSISTENCE

Here we engage with conservatism on two levels: the practical function of the handaxe; and the cognitive-social mechanism that entrenched the production and use of handaxes as a prolonged tradition. The term conservatism does not imply that humans resisted change; rather, it suggests that in this specific realm change was not perceived as an essential adaptive element. Conservatism, both social and biological, proves itself when the environment is reasonably stable and change is unnecessary. Under these circumstances the drive for innovation is relatively low and the modes of action that have proven themselves have an advantage over those that have not yet stood the test of time. Conservatism does not have to be expressed in all aspects of life. Many examples of conservatism concurrent with innovation are known (Lucas 2005, 83), and this may well be the case here. Such a state of affairs may be due to several reasons:

- Technological development in one field and not in another. For example, information technology compared to the relative 'stagnation' of internal combustion engine technology.
- The drive for adaptation in a particular field compared to relatively constant conditions in other fields. For example, the development of sophisticated weapons compared to the relative stagnation of rifle and hand grenade technologies.
- Fields in which conservatism is based on deep foundations compared to those in which it is not. For example, the conservatism of social or religious norms and codes compared to the innovative use of technology. This phenomenon is particularly prevalent in traditional and religious societies.

The Acheulean handaxe might fall under one of these categories. However, the specific question remains as to what were those areas of life in which the handaxe had an advantage? The solution may lie in one or a combination of two alternatives:

- The handaxe itself was functionally important, so its production and use gave a direct evolutionary/adaptive advantage over a very long period of time.
- For various reasons the manufacture and use of handaxes became a social norm (probably related to the first alternative), and the tendency to imitate the majority and/or to punish deviators preserved the norm for millennia.

Lycett (2015) categorises selective biases that may act on artefact variation as 'content biases' (functional bias and aesthetic bias), 'contextual biases' (model-based biases based on prestige, success, similarity, etc), and frequency-based biases (conformity, saturation, and rarity). Here we suggest that conservatism was adopted and preferred due to a combination of biases that slowly shifted from functional (and aesthetic) preferences to conformity, as will be elaborated upon below.

THE FUNCTIONAL BASIS FOR CULTURAL CONSERVATISM – THE ROLE OF THE HANDAXE IN MEGAFAUNA PROCESSING

Most scholars would agree, we believe, that the available functional, technological, and experimental evidence suggests that the primary use of Lower Palaeolithic handaxes, as well as Middle Palaeolithic bifaces, lay in processing animal carcasses (eg, Claud *et al.* 2009; Claud 2008; 2012; Jones 1980; Keeley 1980,160–70; Machin *et al.* 2007; Mitchell 1996; Solodenko *et al.* 2015). It is true that in some cases handaxes were used in other tasks than in solely assisting the extraction of calories from different game taxa (eg, Domínguez-Rodrigo *et al.* 2001) and, thus, some see the handaxe as a multipurpose tool. However, the bulk of the available data indicates not only the repeated archaeological association of handaxes and processed animal parts, but also the efficiency and suitability of handaxes in skinning, cutting, defleshing, and dismembering carcasses, and in particular carcasses of large game taxa (eg, Jones 1980; 1981;1994; Key & Lycett 2015; 2016). It is also true that while handaxes are present at many Lower Palaeolithic sites associated with elephant and other

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large taxa remains, some multi- as well as single elephant carcass sites lack handaxes altogether (see Slodenko *et al*. 2015 for details).

We do not discuss here a possible explanation for handaxes not having been found at those sites, and we do not claim that the only possible way of processing a large animal carcass was by using a handaxe. We do, however, offer an hypothesis regarding the repeated association of handaxes and very large game at Lower Palaeolithic sites in the Old World, coupled with the dependency of Palaeolithic humans on animal meat and fat (eg, Ben-Dor *et al*. 2011; 2016; Domínguez-Rodrigo & Pickering 2017; Zink & Lieberman 2016), and the intriguing production of handaxes made from elephant limb bones (Zutuvski & Barkai 2016 for details). While it is generally accepted that meat fueled the physiological developments in *Homo erectus* populations (eg, Aiello & Wheeler 1995; Domínguez-Rodrigo *et al*. 2014; Pontzer *et al*. 2016), we suggest that greater emphasis should be placed on the role of fat and the significance of animals capable of supplying large quantities of fat year round (Ben-Dor *et al*. 2011; 2016). Elephants and mammoths are such animals, and thus we argue that the dependency of early humans on the caloric contribution of fat and meat, in addition to plant-based calories (eg, Melamed *et al*. 2016), led to the preference for procuring calories from elephants and mammoths, when available. Other large prey (rhinoceros, hippopotamus, wild cattle, and wild horse) are also important contributors of fat and meat, and these taxa were of course regularly exploited by early humans as well. However, no animal matched the extraordinary package of fat and meat as that to be found in the elephant and mammoth. Smaller taxa such as deer and gazelles, among the ungulates, as well as tortoises, rabbits, and birds, were also a source of calories whenever possible, but again none of these matches the ideal food package represented by the proboscidea.

Skinning, cutting, defleshing, and dismembering elephants and mammoths is a tedious and demanding task (eg, Gingerich & Stanford 2016). The presence of proboscidea remains bearing cut marks at Palaeolithic sites (see Slodenko *et al*. 2015 for details) as well as the butchered elephant skull from the site of Gesher Benot Ya'aqov, associated with many handaxes (Goren-Inbar *et al*. 1994), supports our contention regarding the link between Lower Palaeolithic humans, elephants, and handaxes. The same holds true for a biface bearing fat residue from the Acheulean site of Revadim, Israel (Slodenko *et al*. 2015). The presence of butchered elephant/mammoth remains at many Palaeolithic sites worldwide (eg, Agam and Barkai 2016; Blasco *et al*. 2013; Germonpré *et al*. 2008; Iakovleva *et al*. 2012; Kufel-Diakowska *et al*. 2016; Rabinovich *et al*. 2012; Smith 2015) suggests that elephants played a major role in the early human diet and adaptation (but see Lupo & Schmitt 2016 and Smith 2015). Direct evidence of proboscidean consumption is also provided by isotopic studies, indicating a significant dependence upon mammoths by early humans in Europe (e.g. Bocherens 2011; Bocherens *et al*. 2015; Naito *et al*. 2016).

The importance of proboscideans in the Palaeolithic diet is further stressed through cases in which selected elephant body parts were carried into Palaeolithic caves (eg, Blasco *et al*. 2013; Germonpré *et al*. 2014; Zhang *et al*. 2010), implying their high nutritional value (especially regarding elephant heads, see Agam and Barkai 2016), along with the social and symbolic roles that certainly could have accompanied such an activity. We do not delve here into the question of whether proboscideans were procured by hunting, scavenging, or both, but suggest in brief that, in our opinion (Agam and Barkai submitted), relevant archaeological, ethnographic, and ethno-historic evidence points in favor of hunting as a relevant elephant/mammoth procurement strategy. The scope of this article does not allow us also to engage with the ways in which Palaeolithic groups dealt with this enormous 'food package', but we hope to be able to develop this line of inquiry elsewhere.

We suggest that handaxes were efficient and effective tools in processing large carcasses, enabling the removal of large quantities of fat and meat and the separation of body parts in order to manipulate and transport them. The handaxe allows the application of considerable force and leverage during cutting and dismembering, and its continuous and mostly curved and sharp working edge is ideal for massive and intensive meat and fat processing tasks (eg, Key & Lycett 2015; 2016) (Fig. 2). Moreover, handaxes could be re-honed in order to prolong the use of the tool for continuous operations, such as the processing of very large game (eg, Claud 2012). We thus see the handaxe as the primary tool that assisted butchery during Lower Palaeolithic times, and in particular the processing of large game such as the elephant. The intriguing production of handaxes made of elephant

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Fig. 2.
An experiment in using flint handaxes in butchering operations (courtesy of Ruth Blasco and Jordi Rosell)

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bones might serve as another clue, emphasising the possible role of these components within the cosmology of the groups that used stone handaxes in their preparation for the consumption of elephants (see Zutuvski & Barkai 2016). Last but not least is the chronological and geographical connection between elephants/mammoths and handaxes. We suggest that these two go hand in hand, and that when megafauna no longer comprised part of the diet, handaxes/bifaces ceased to be produced and used. It is our contention that the central role of handaxes and large game in Lower Palaeolithic adaptation is of pivotal significance, and that it is the role of handaxes in processing these large 'food packages' that ensured their long service during Lower Palaeolithic times.

Within the framework of our hypothesis, it is interesting to recall Bar-Yosef's suggestion that, considering the variety of difficulties encountered by humans as they spread from Africa to Asia and Europe, it is not surprising that the handaxe – as a useful and effective tool specifically employed for cutting raw meat – persisted over such a long period: 'It is against this background that we should view the conservation of knapping techniques and the retention of tool morphotypes like the bifaces that served, like Swiss Army Knives, as multi-purpose tools, and were undoubtedly essential in chopping meat into small pieces consumed (and digested) raw' (Bar Yosef 2006, 490).

HANDAXE VARIABILITY: 'INSIDE THE BOX' MODIFICATIONS

'Variability' and 'variation' are the major terms used by those who subscribe to the view of a dynamic and variable process over that of 'stagnation' in handaxe persistence during Palaeolithic times. A recent publication of several handaxe assemblages from a Lower Palaeolithic site in Syria offers a good example of the scale of variability in handaxe production during different Acheulean human occupations (Jagher 2016). Consistent with our proposal of functional-based conservatism, we refer to the recent understanding that function is not substantially affected by morphological variation.

McNabb and Cole (2015) argue that handaxe variability reflects situational/local symmetry and refinement and that no gradual slope of advancement can be seen in Acheulean material culture. They propose the term 'variable equilibrium' to describe the phenomenon of variability within long periods of apparent stasis.

Key and Lycett (2016) conducted a large-scale experiment in handaxe cutting efficiency (n = 500 handaxes) and stated that variability in size and shape does not necessarily have a strong impact on the cutting effectiveness.

In a recent experiment focusing on the role of copying variance in handaxe form, Schillinger *et al.* (2016) argue that what seems to be cultural-based artefact variability may not result from an 'intent' or 'mental template' but from behavioural differences among individual artisans that over time developed into 'visibly distinct traditions'.

In another recent study on the role of micro-evolutionary processes in handaxe variation, while taking into account factors of raw material, copying errors, and their relationship to mechanisms of social learning, Lycett *et al.* (2015) contend that handaxe variation was probably both generated and constrained by those opposing factors. We concur with these ideas, with the addition of the social factors.

FUNCTION LEADS THE WAY TO A NEW SOCIAL NORM

In this section we review a list of possible reasons that might have led to the transformation of the original functional role of the handaxe (including its variation) into a dual role, combining the practical with the social.

Sharon (2008) studied the impact of raw material on Acheulean large flake production and suggested that the phenomenon that we define as 'stasis' – a similar form regardless of the original shape, size, and type of raw material – in fact reflects inventiveness and resourcefulness. The conclusion to be drawn from these data is that raw material availability, type, shape, and technological constraints were not the primary factors dictating the characteristics of handaxes. This leads to the possibility that the main consideration guiding the Acheulean knapper was a functional and/or cultural preference. Experimental knapping also supports the notion that early humans had a preconception of the desired end product of the reduction sequence (Eren *et al.* 2014).

Another functional realm of the handaxe was suggested by Kohn and Mithen (1999), who contended that handaxes might have played a role in Lower Palaeolithic mating systems by demonstrating the overall cognitive, physical, and mental competency of males in order to be selected by females for gene exchange. Such a mechanism would have led to

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preferred cultural conservatism. We may be dealing here with the conservatism of a social code that developed in human society through many generations of mate selection based on handaxe production and use (following the Handicap Principle), and eventually manifested in the framework of technological conservatism. It is of interest to note that Lower Palaeolithic quarries and workshops in Isampur, India: '… presents tentative evidence for shared intentions and cooperation in biface manufacture' (Shipton 2013, 63 and references within). Ethnographic studies too reveal that large-scale quarrying activity might be characterised by cooperation (eg, Burton 1984; Hampton 1999, 226–32, 256–62).

We suggest that handaxe production might have been a form of preferred social activity, replaced by later stone tool making methods and technologies (Levallois, blades, etc), storytelling around the campfire, rituals, and other mechanisms. The mechanism of handaxe production might explain its enduring persistence. Hunting big game, aside from its major contribution to diet and survival, is also viewed as a preferred male social activity (eg, Speth 2010 and references therein). Handaxe production may be another example of male 'display' and technological 'gadgetry' based on the functional necessity of this item in the extraction of calories from big game (see Hawkes *et al*. 2014 and references within).

Machin touches upon the basic human cognitive tendency for aesthetics. Aesthetic objects generate emotional and intellectual pleasure (Machin 2009, 48), and symmetrical handaxes may have had a combined aesthetic and functional advantage (Machin *et al.* 2007). Gowlett (2011) argues that a constant proportion in Acheulean handaxes, in many cases the 0.61/1 ratio or the 'golden ratio' (the proportion preferred in the natural world, including an aesthetic measure by humans), testifies to the deep roots of this human trait. He also suggests that the difficult to achieve elongation that characterises 5–10% of the handaxes from 1.75 Mya, is the outcome of both functionality and symbolic value (Gowlett 2013). This argument can be added to the preferred mate selection and preferred social activity hypotheses, with particular shape/size perhaps constituting personal and/or group markers.

In some specific and interesting cases 'imitations' of the typical stone handaxes were made from elephant limb bones (see Zutovski & Barkai 2016 for an updated account). This remarkable Acheulean trait combined two of the most fundamental elements found at many Lower Palaeolithic sites: namely, large game and bifaces – and may express a cosmological connection between Acheulean subsistence and lifeways, closing an ontological circle by producing bone handaxes from the remains of elephants that might have been processed using stone handaxes.

Assuming that the handaxe had one or more of the above-mentioned functions, in addition to its practical role in processing animal carcasses, we need to explore the learning/knowledge transmission mechanism that cemented its central role in human adaptation during the Lower Palaeolithic.

Studies in cognitive psychology on the type of social learning called 'conservatism transmission' – an adaptive mechanism aimed at acquiring knowledge by observing the behaviour of others and the mental state that underlies their behaviour – offer a possible explanation. Henrich and Boyd (1998) suggested that the psychological bias to 'acquire' behaviour, which is common to most members of a group ('following the herd'), has an advantage over social solitary learning in a wide range of situations. One possible consequence of this learning/transmission mechanism is the creation of long-term boundaries between groups. This type of learning/transmission mechanism can explain the persistence of certain human behaviours in a particular group, including the production and use of a specific technology. On the other hand, the possible creation of boundaries between groups might impede the wider inter-group transmission of knowledge. In the case of the handaxe, the combination of long-term persistence and wide geographic distribution suggests that this mechanism does not provide an appropriate explanation. However, one cannot rule out the possibility that the emphasis in research on exclusively identifying the Acheulean culture with handaxes has led to less attention being paid to Lower Palaeolithic sites devoid of handaxes (eg, Bizat Ruhama in Israel, Grand Dolina in Atapuerca, and the Clactonian in Britain, see Zaidner *et al*. 2010; García-Medrano *et al*. 2015 and Mithen 1996, respectively). Thus future research may prove that the pattern of greater Acheulean variability or 'sub-cultures' actually fits the model presented above.

Tehrani and Riede (2008), who claim that stone knapping was too complex to be transferred through imitation, emphasise the role played by active teaching. Based on ethnographically documented traditions, including weaving, stone-knapping, and foraging, they state that teaching has been an important mechanism

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in material culture transmission since at least the Lower Palaeolithic. They also argue that, through teaching, highly complex forms can be expected to survive for very long periods since both the donors and the recipients actively collaborate in knowledge transfer. We strongly believe that such a scenario is applicable for the Acheulean handaxes, as most scholars agree its production could not be transmitted by imitation only.

The following human traits enhance conformity and conservatism and should be taken into account in this discussion:

1. Strong reciprocity: 'A strong reciprocator is predisposed to cooperate with others and punish non-cooperators, even when this behavior cannot be justified in terms of self-interest, extended kinship, or reciprocal altruism' (Gintis 2000);
2. Homophily: The tendency for individuals to associate and bond with others like themselves (Flynn *et al.* 2010);
3. The need for closure (NFC), which reflects an aversion to ambiguity and uncertainty as well as a preference for firm, definitive answers to questions (Kruglanski & Webster 1996). Persons with high NFC are more motivated to reach agreement with their peers and are more disturbed by violations of social norms (Flynn *et al.* 2010);
4. The chameleon effect: the unconscious mimicry of the postures, mannerisms, facial expressions, and other behaviours of one's interaction partners, such that one's behaviour passively and unintentionally transforms to match that of others in one's social environment. The chameleon effect might have played a role in human evolution by allowing individuals to maintain harmonious relationships with fellow group members (Chartrand & Bargh 1999; see also Lakin *et al.* 2003).

An examination of the conservativeness/flexibility of 47 cultural traits in 277 African societies revealed that the traits affecting family structure and kinship had demonstrated a high degree of conservation over generations. These traits, transmitted by family members, indicate that cultural transmission in the family is the most conservative mechanism (Guglielmino *et al.* 1995). The dominance of vertical transmission was also observed in North American Native Peoples, where learning from group members was a more important process than learning from members of other groups (Mathew & Perreault 2015). Traits that require the expertise of a specialised mode of subsistence were also found to be vertically transmitted in Austronesian cultures (Mace & Jordan 2011). In sum, these data reflect the substantial support for preferred cultural conservatism.

A direct correlation exists between the bias towards conservatism and evolving 'traditions' in a variety of animals, such as birds, rodents, and Japanese Macaque monkeys (for a review see Jablonka & Lamb 2005, 155–91), and thus the transmission of human culture is much more elaborated than those of chimpanzees. As for human material culture, Eerkens and Lipo (2007) argue that employing the conservatism transmission approach explains many phenomena in the archeological record. Claidière and Whiten (2012) link sociological research to the study of animal behaviour. They divided the issue of conformity into two sub-issues: information/knowledge conformity (for acquiring non-social information in order to gain an adaptive edge in new environments); and normative conformity (for acquiring social information in order to facilitate cooperative relationships with other members of the group). Conformity and punishment evolved concomitantly in large groups and enabled improved inter-group cooperation because conformity reduces variance, which is the basis of disagreement, and at the same time it supports punishment. Punishment, in turn, protects the group from deviations and gives conformists an advantage over 'independent' imitators (Boyd & Richardson 1992; Guzman *et al.* 2007). It should be noted that a willingness of societies to risk costly punishment has been observed around the globe (Henrich *et al.* 2006). It is generally accepted that norms provide an evolutionary advantage to individuals (Kameda *et al.* 2005). A study of norm enforcement in Ju/'hoansi hunter-gatherers revealed that norms are obeyed, and the imposition of penalties on violators occurs even when such costly behaviour cannot be explained by immediate preferences. Wiessner (2005) suggests that one of the motives for this is the need to maintain 'industrial peace' in the social group. Punishment of norm violators is a mechanism for maintaining social cohesion and is central in hunter-gatherer societies. Regarding Acheulean handaxe persistence, we suggest that the bias to imitate majority behaviour that then evolved into social norms may provide a plausible explanation.

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THE HANDAXE & THE CHOPSTICK – A TEST-CASE FOR PREFERRED CULTURAL CONSERVATISM BASED ON FUNCTION, LEADING TO THE CREATION OF A SOCIAL NORM

In his book *Chopsticks: A cultural and culinary history,* Wang (2015) describes in depth a phenomenon not so very different to what we have just described concerning the handaxe. Forty-two bone sticks found in Neolithic Longqiuzhuang ruins in present-day Gaoyou, Jiangssu, dated to 6600–5500 BCE, are believed by some scholars to be the earliest recorded chopsticks, although others suggest that they were used as hairpins (Wang 2015, 16–17). It was only in the Bronze Age, or during the Shang dynasty (*c.* 1600–1046 BCE), that the Chinese began using chopsticks to prepare and eat food. Bronze pieces found at two sites in southern China (Anhui) and south-west China (Yunnan) may have been originally employed in cooking – stirring and mixing, and only later on in feeding. The earliest ivory chopsticks were found in Changyang, Hubei, dated to the Zhou period (1045–256 BCE). The spoon was the primary eating implement in ancient China, but due to the broad appeal and increasing variety of floured-wheat foods, it lost its primacy across China to the chopsticks. Later on, the spreading influence of the Tang culture in Asia extended the use of chopsticks to the north (Mongolian pastureland), north-east, and east (Korean Peninsula and the Japanese islands) and south (the Indochina Peninsula). 'A chopsticks cultural sphere thus began to take shape, albeit with discernible variation in time and space' (Wang 2015, 66). Was the 'Handaxe cultural sphere' the first of many later similar phenomena?

Wang goes on to describe how chopsticks were (and still are) used as popular wedding gifts and in wedding ceremonies, and in celebrating happy occasions like birthdays and sad ones like funerals. The Japanese call the utensil 'the sticks for one's life', for chopsticks are, for the Japanese as well as for other Asians, a symbol of life. As part of acquiring cultural meaning, chopsticks, usually made of bamboo or cheap wood, are sometimes also made of rare and expensive materials (depending on geography) such as gold, silver, copper, rhinoceros horn, deer antler, ivory, ebony, mahogany, and the most precious one – jade (Wang 2015, 120–43). Chopstick design also varies in length (18–33 cm in Tang China), the shape of the top (rounded or four-sided), 'two-ended' vs 'one-ended', and more (Wang 2015, 77–84). Altogether, we suggest that the phenomenon described in the case of chopsticks has some parallels with that of the handaxe – a tool that was originally developed to best fit an essential function but which over time gained social and cultural meanings, resulting in a basic shape that persisted over long periods, combined with multiple variations in size, material, and level of finish.

CONCLUSIONS

The unresolved issue of the technological persistence of the Acheulean handaxe has been intensively discussed in the literature for many years, employing a variety of research methodologies. The vast majority of studies on this topic focus on innovation – the reasons for its absence or delay – while ignoring the fact that the suggested mechanisms behind this seeming 'stagnation' should have similarly hindered the concomitant transformations that did take place. Here, we explored a different possible explanation for this seeming paradox, and suggest that different trajectories of social, and behavioural transformations characterise Palaeolithic societies for over a million years. In some fields of human behaviour, where advantage was gained, innovations evolved and spread, while in other fields, such as handaxe technology, conservatism was preferred. We suggest that the handaxe played a dual function in the Lower Palaeolithic period. On the one hand, it served as an essential working tool mainly for butchery and dismemberment of large animal carcasses, and occasionally also for other tasks such as woodworking. On the other hand, producing handaxes acquired a social meaning that was based as some kind of norm. Taken together, the handaxe was the flagship of Acheulean adaptation and way of life. In the changing world of Acheulean hunter-gatherers, it became the anchor of successful adaptation, the key to maintaining the Acheulean mode of existence. By focusing on preferred cultural conservatism and following a safe, familiar, path of survival, Lower Palaeolithic hominins stuck to the handaxe for over one million years through a particular style of knowledge transmission and strict behavioural and practical norms. We argue that this handaxe conservatism enabled change and transformation to be initiated, assimilated, and adopted in other trajectories of behaviour and lithic technology. Had the handaxe not maintained equilibrium with the Acheulean pace of change and prevented the mode of adaptation from 'running too

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fast', real stagnation might have occurred. Based on elements borrowed from the fields of conservatism, transmission, and social learning, we argue that the persistence of the Acheulean handaxe, far from being evidence of stagnation, instead reflects a slow and safe method of adaptation that accepted innovations while ensuring group existence. Perceived thus, we suggest that the handaxe became a fixed feature in human society in the Lower Palaeolithic, probably due to the psychological bias for majority imitation that subsequently became a social norm. It is important that modern cognitive biases that 'sanctify' innovation do not impede our ability to analyse our predecessors' considerations that have led to the successful survival of the human race.

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RÉSUMÉ

Le hachereau acheuléen persistance technologique: Un cas de préférence du conservatisme culturel? de Meir Finkel et Ran Barkai

L'un des 'paradoxes' non résolus de l'archéologie préhistorique est l'écart entre les considérables avancées dans l'évolution humaine biologique et culturelle au cours de la période du paléolithique inférieur et le million et quelques d'années de 'stagnation' du hachereau herculéen. La plupart des recherches sur ce sujet se sont concentrées sur l'innovation: pourquoi a-t-elle été retardée ou a-t-elle échoué à se mettre en place, tout en négligeant le fait que des innovations avaient eu lieu dans bien d'autres domaines au cours de la même période. Nous proposons que des mécanismes pratiques, sociaux et d'adaptation étaient présents dans certaines secteurs du comportement humain et conduisaient à une innovation rehaussée tandis que le conservatisme avait la faveur en matière de technologie et d'usage du hachereau. Dans cette étude nous insistons sur la dépendance des groupes acheuléens sur les calories provenant des gros mammifères, en particulier de la mégafaune, ainsi que le rôle central des hachereaux dans la transformation des grosses carcasses. C'est notre point de vue que le rôle du hachereau dans l'adaptation acheuléenne était primordial et il s'en est trouvé fixé dans la société humaine probablement à travers un penchant psychologique vers une imitation de la majorité, ce qui est devenu par la suite une norme ou une tradition sociale. En bref, nous proposons que la persistance technologique du hachereau acheuléen a joué un rôle d'adaptation qui reposait sur une préférence pour un conservatisme culturel et a conduit au succès de leur survie les populations du paléolithique inférieur sur des centaines de milliers d'années dans l'Ancien Monde.

ZUSSAMENFASSUNG

Die technologische Beständigkeit des Faustkeils des Acheuléen: Ein Fall bevorzugten kulturellen Konservatismus? von Meir Finkel und Ran Barkai

Eines der ungelösten „Paradoxe" der prähistorischen Archäologie ist das der Kluft zwischen den erheblichen Fortschritten der menschlichen biologischen und kulturellen Evolution während des Altpaläolithikums und der mehr als eine Million Jahre dauernden „Stagnation" des Acheuléen-Faustkeils. Meist fokussierte die Forschung auf die Frage der Innovation – warum sie sich verzögerte oder gar nicht erst stattfand –, während die Tatsache übersehen wurde, dass in der gleichen Epoche in vielen anderen Bereichen Innovationen auftraten. Wir schlussfolgern deshalb, dass praktische, soziale und adaptive Mechanismen in bestimmten Bereichen menschlichen Verhaltens in Kraft waren und zu erhöhter Innovation führten, während in der Faustkeiltechnologie und seiner Nutzung ein Konservatismus bevorzugt wurde. In dieser Untersuchung stellen wir die Abhängigkeit der Menschengruppen des Acheuléen von Kalorien, die sie von Großsäugern erlangten, heraus, insbesondere von Megafauna, sowie die zentrale Rolle von Faustkeilen in der Verarbeitung großer Tierkörper. Es ist unsere Überzeugung, dass die Rolle des Faustkeils für die Adaption während des Acheuléen entscheidend war und er deshalb in der menschlichen Gesellschaft festgeschrieben wurde, möglicherweise durch eine psychologische Neigung zur Majoritäts-Imitation,woraus nach und nach eine soziale Norm oder Tradition wurde. Kurz gesagt gehen wir davon aus, dass die technologische Beständigkeit des Faustkeils des Acheuléen eine adaptive Rolle spielte, die auf einem bevorzugten kulturellen Konservatismus basierte und zum erfolgreichen Überleben altpaläolithischer Gruppen während hunderttausender Jahre in der Alten Welt führte.

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RESUMEN

La persistencia tecnológica de los bifaces achelenses: ¿un caso de conservadurismo cultural? por Meir Finkel y Ran Barkai

Una de las paradojas sin resolver en arqueología prehistórica es el lapso temporal existente entre los considerables avances en evolución biológica y cultural durante el Paleolítico Inferior, y el 'estancamiento' durante más de un millón de años de los bifaces achelenses. La mayor parte de la investigación relacionada con este aspecto se ha centrado en la innovación -porqué se retrasó o no se llevó a cabo- mientras se ignora el hecho de que estas innovaciones se produjeron en muchos otros campos durante el mismo período. Nosotros sugerimos que los mecanismos prácticos, sociales y adaptativos estuvieron vigentes en ciertas áreas del comportamiento humano y condujeron a una mayor innovación, mientras que el conservadurismo se impuso en la tecnología y uso de los bifaces. En este estudio destacamos la dependencia de los grupos achelenses de las calorías obtenidas de los grandes mamíferos, especialmente la megafauna, así como el papel central de los bifaces en el procesado de las grandes carcasas. Siguiendo esta línea argumental, el papel del bifaz achelense en los procesos de adaptación fue fundamental y, por tanto, quedó fijado en la sociedad, probablemente en el ámbito psicológico a través de la imitación, llegando posteriormente a convertirse en una norma o tradición social. En resumen, sugerimos que la persistencia tecnológica de las hachas achelenses jugó un rol adaptativo basado en un conservadurismo cultural y condujo a la supervivencia de las poblaciones del Paleolítico Inferior durante cientos de miles de años en el Viejo Mundo.

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