Handaxes: Products of Sexual Selection?

Why were handaxes made and why was their shape symmetrical and regular? These and many other questions are considered here, in a paper tackling hominid social behaviour and sexual selection.

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Introduction: unanswered questions about handaxes

Handaxes are bifacially manufactured stone artefacts, predominantly pointed or ovate in shape. Along with cleavers, which have a wide, straight edge at right angles to the major axis of the artefact, handaxes are also known as 'bifaces'. Such artefacts first appear in the archaeological record 1.4 million years ago (Asfaw et al. 1992) and then continue as a pervasive element of that record for more than one mil-lion years. Handaxes are associated with a range of hominid species, including those assigned to Homo ergaster, H. erectus, and H. heidelbergensis.

Many thousands of handaxes have been excavated from sites in Africa, Europe and Asia, and then subjected to detailed metrical studies (e.g. Isaac 1977; Roe 1981; 1994; Villa 1983; Wynn & Tierson 1990). Archaeologists have undertaken microwear analysis, detailed refitting of debitage and experimental studies concerned with manufacture and use (e.g. Keeley 1980; Jones 1980; 1994; Bergman & Roberts 1988; Austin 1994; Mitchell 1996). Handaxes have also been at the centre of research regarding the evolution of human intelligence (e.g. Wynn 1979; 1989; 1993; 1995; Mithen 1996; Kohn 1999). Recent studies have challenged notions of chronological patterning for handaxe types, and placed emphasis on raw material and func-tion, rather than culture and style, when ex-plaining handaxe morphology (e.g. Ashton & Mckabb 1994; Callow 1994; Bosinski 1996; Roberts et al. 1996; White 1998). There has also been more emphasis on handaxe variability, stressing how artefacts range from the classic, highly symmetrical bifaces to non-classic or atypical bifaces, which lack a clearly imposed form (Ashton & McNabb 1994).

In spite of this extensive body of research, five fundamental questions remain unanswered:

1. Why are handaxes so pervasive in the archaeological record?
2. Why are they often found in such prolific numbers at individual sites?
3. Why was time invested in making these artefacts when less extensively retouched artefacts, or even plain unretouched flakes, are suitable for tasks such as butchery, woodworking and the other activities for which handaxes were used?
4. What was the value of imposing high degrees of symmetry on so many handaxes?

5. How can one explain the handaxe ‘oddities’, especially the ‘giant’ handaxes? Examples include those from Furze Platt and Shrub Hill in England, both of which appear much too unwieldy for use (Wymer 1968; 1983; Roe 1981). Roe’s (1994: 207) description of an assemblage of quartzite handaxes from the site of FLK in the Masek beds at Olduvai Gorge includes ‘dramatic objects’ c. 28 cm long.

Archaeologists’ attempts to address such questions have focused on the role of handaxes in hunting or butchering animals, or tasks such as digging, cutting wood or processing plants. Interpretations range from multi-purpose arte-facts (Keeley 1980) to throwing implements (O’Brien 1981; Calvin 1993). We think that this overwhelming concern with hominid interaction with the natural world has constrained the development of satisfactory answers to the above questions. We concur with Gamble (1997: 108) that handaxes were also part of a ‘social technology’, and with White (1998: 32) that the ‘apparent over-sophistication’ of many bifaces for tasks such as butchery may well reflect some ‘historically accrued social significance’. But we wish to go further than these generalizations by making a specific proposition: handaxes were products of sexual selection and as such were integral to the processes of mate choice within socially complex and competitive groups.

Sexual selection in human evolution

Miller (1997) provides a comprehensive review of sexual selection in human evolution, including origins, historical development and current applications. In essence, sexual selection con-cerns mate choice: those individuals who possess characteristics which are attractive to members of the oppos3'te sex will be chosen as reproductive partners; if those characteristics have some genetic basis they will flourish in future generations. Ideas about sexual selection fall into two main schools of thought. 'Indicator' theory includes Zahavi's 'handicap principle' (Zahavi 1975; Zahavi & Zahavi 1997) which maintains that traits indicating 'good genes may be selected precisely because the possession of the indicator trait imposes a cost. The tail-fan of the peacock is the classic example of a handicap which functions as an indicator and is sexually selected. As Miller (1997) explains, peacocks with drab tails get eaten more often by predators; hence the quality of the tail appears to correlate with an ability to escape from predation and when choosing a mate, peahens use the tail as an indicator of this ability. Even without such a correlation, peacock fans may be sending a message attractive to females: 'despite this elaborate tail fan I am able to maintain myself in a healthy condition: I am so good at finding food, fighting parasites, and avoiding predators that I can afford to commit a significant proportion of my resources to growing this tail fan'. The most important feature of such indicators is that they must be costly to possess; if not, they can be too easily faked.

A second school of thought puts greater emphasis on aesthetic displays, such as Fisher's (1930) 'runaway process'. As Miller (1997: 96) explains: "Aesthetic displays play on the perceptual biases of receivers to attract attention, provoke excitement, and increase willingness to mate ... The perceptual biases open to manipulation can arise in two, often complementary, ways. They may already exist as latent preferences — side effects of previous evolutionary processes, reflecting basic psychological effects, general principles of perception. or perceptual adaptations to particular environments — and they may co-evolve with courtship traits they prefer, through Fisher's runaway process." Selection for indicators and aesthetic displays are both well-established and complementary evolutionary processes. essential for an under-standing of the morphology and behaviour of many animal species. Miller argues that they are of critical importance for understanding human physiology, behaviour and cognition.

Several features of human bodies appear to derive from the mate choice criteria used by our male and female ancestors and should be described as products of sexual selection (Buss 1994). Among these are the male penis, large by comparison with those of other primates, and females' breasts and buttocks, which appear to have undergone sexual elaboration through mate choice by males. Miller (1993; 1997) has argued that the creative intelligence of the human mind is also a product of sexual selection.

We have summarized the nature of sexual selection with such brevity because of the excellence of Miller's (1997) review and the numerous other publications that have recently described the nature of sexual selection in human evolution (e.g. Buss 1994; Ridley 1993; Wright 1994). While Miller has suggested that a wide range of modern human behaviours, such as song, humour and the use of a large vocabulary, are related to courtship display. we wish to propose a specific candidate from the hominid archaeological record: handaxes. We will argue that by considering these artefacts in terms both of Zahavi's handicap principle and the notion of aesthetic displays, solutions to those baffling questions about handaxes will be forthcoming. First, we must briefly highlight these questions by explaining the costs involved in handaxe manufacture.

Making and using handaxes in a social context

Manufacture and function

Manufacture of a fine symmetrical handaxe requires appropriate raw materials — stone and suitable hammers (of bone, antler and stone). Time and energy costs vary, depending upon local environment and mobility pattern, and in many situations, raw material acquisition may have been the most costly part of the handaxe's manufacture. Once the raw material was secured, a range of different knapping actions were required, most of which were applied by working the artefact in a bifacial manner (Inzian et al 1992; Pelegrin 1993; Schick & Toth 1993: 237A5).

First, relatively large cortical flakes must be removed, requiring use of a hard hammer. When the approximate shape has been created, other types of flakes are detached, notably thinning flakes, which travel across the surface of the artefact. These are struck with an antler, bone or wooden hammer at quite different angles, and with different degrees of force, to those initial hard hammer removals. To detach the thinning flakes, preparatory flakes may need to be removed to create a striking platform. Throughout the manufacturing process, the edge of the artefact may need to be slightly ground to remove irregularities that might otherwise deflect the force of the strike.

In light of the required planning of knapping actions (Gowlett 1984), mental rotations (Wynn 1989) and the range of hammers and striking methods, there can be little doubt that in the majority of artefacts a specific symmetrical form was imposed, even though raw materials may have constrained the options available and influenced the result (Ashton & McNabb 1994; White 1998). handaxes were general-purpose artefacts; their functions are likely to have included the butchery of animals, cutting wood, slicing meat and chopping vegetables. Direct evidence, however, is quite scarce. There are a few cases where microwear studies have been undertaken, such as on artefacts from Koobi Fora in Africa (Keeley & Toth 1981) and at Hoxue in England (Keeley 1980). Both samples showed a range of wear traces, indicating they had been used for a variety of tasks. Experimental work appears to confirm this, as handaxes are clearly effective for a range of activities (Jones 1980; 1981; Schick & Toth 1993: 258–60; Mitchell 1996). It has been suggested that handaxes may also have functioned as a source of flakes, having been carried around the landscape as curated artefacts (Hayden 1979; Jones 1994), or as implements for throwing at game (Calvin 1993).

The dilemma archaeologists face is that while the imposed symmetrical forms often allow the artefacts to sit comfortably in the hand, they do not appear to provide sufficient degrees of improvement over plain flakes or choppers to justify that extra investment: animals can be butchered, sticks sharpened, and plants chopped by tools requiring far less time and skill to make. The fine trimming flakes found on so many artefacts appear quite unnecessary for these activities. The presence of an imposed symmetry beyond functional requirements, and a measure of the extent of extra investment to achieve that, has recently been demonstrated by Barker (1998). She used an extensive experimental knapping programme (employing the knapping skills of John Lord) to make a care-ful documentation of the degree of symmetry at various stages of handaxe production, both prior to and after a stage when the artefact was accepted as being functionally optimal. Comparison with the degree of symmetry found on artefacts from several English Palaeolithic sites demonstrated that these had had an excessive level of symmetry imposed.

The social context

Handaxes were made by a variety of hominid types in numerous different geographical areas with different resources, the social context of manufacture and use is likely to have been variable. Nevertheless there may have been shared features arising from the common attributes of large brains, habitual bipedalism, and significant meat eating. As Aiello & Dunbar (1993; Dunbar 1993) have argued, large brains imply large groups. We suspect that these groups were highly competitive, requiring individuals to adopt a range of Machiavellian social tactics to survive and prosper (cf. Byrne & Whiten 1988; Whiten & Byrne 1997). Even chimpanzees, with 50% of Early Homo brain size at most, live in socially complex societies in which friendships and alliances are constantly being adjusted (de Waal 1982). It seems likely that handaxe-making hominids would have had an advanced 'theory of mind' (Mithen 1996; in press) and that deceptive behaviours would have been rife within their societies.

Large brains are metabolically expensive organs (Aiello & Wheeler 1995) which need a high-quality diet requiring substantial meat consumption. Its acquisition required cooperation through hunting or scavenging, and this dependency on animal carcasses probably favoured large groups, with opportunities for food sharing and/or tolerated theft. Another factor for larger groups was the reduced risk from carnivore predation in Pleistocene environments (Mithen 1994).

A third shared feature is likely to be considerable competition between males for mates. Among primates substantial sexual dimorphism is related to a polygynous mating system in which large males frequently gain control of a harem. Australopithecines had a high degree of sexual dimorphism, and they are likely to have had a similar mating system (McHenry 1994; 1996), although there was apparently a reduction of sexual dimorphism in Homo ergaster. This reduction might suggest a shift to a monogamous mating system. However, we concur with Aiello (1996: 91 A; Power & Aiello 1997) that this is not necessarily the case, since the reduction in sexual dimorphism relates to an increase in female body size, explained by (terrestrial) adaptation to open environments. Biomechanical constraints on maximum body size are likely to have inhibited an equivalent increase in male body size (McHenry 1994). In spite of the lack of marked sexual dimorphism in the Homo species associated with handaxe manufacture, we doubt that it reflects a reduction of inter-male competition for mates. Like O'Connell et al. (1999) we do not think that the increased reproductive costs of H. ergaster females resulting from increased body size, brain size and infant dependency were offset by male provisioning. Support for pregnant or nursing females is likely to have derived principally from female kin alliances (i.e. the 'grand-mothering' hypothesis, Hawkes et al. 1997). As we will discuss below, monogamous mating systems with substantial male provisioning of females would emerge later in human evolu-tion, and indeed may be associated with the end of the Acheulian (Foley & Lee 1989; 1991).

Handaxes as reliable indicators

We propose that handaxes functioned not just to butcher animals or process plants but as Zahavian handicaps, indicating ‘good genes’. Those hominids (male or female, see below) who were able to make tine symmetrical hand-axes may have been preferentially chosen by the opposite sex as mates. Just as a peacock’s tail may reliably indicate its ‘success’, so might the manufacture of a fine symmetrical handaxe have been a reliable indicator of the hominid’s ability to secure food, find shelter, escape from predation and compete successfully within the social group. Such hominids would have been attractive mates, their abilities indicating ‘good genes’.

Critical to this argument is the wide range of variability found in artefacts categorized as handaxes (Ashton & McNabb 1994) which is essential for selection. Axes range from classic, symmetrical forms to non-classic asymmetrical handaxes which lack continuous surface.

Whereas the peacock’s tail growth is involuntary, a hominid chose how much handicap to incur when making stone artefacts. For example, a flake might be chosen for food acquisition, but handaxe-making might be considered if hominids of the opposite sex were present. The degree of refinement could be adjusted according to the balance of priorities, and the individual’s capacities, representing a development of the process known as ‘strategic choice’ handicap.

We propose that handaxes acted as reliable indicators for four specific dimensions of fitness: resource location abilities, planning ability, good health and capacity to monitor other individuals within the group.

Knowledge of resource distribution

The ability to make a fine symmetrical handaxe shows environmental knowledge, because such artefacts require high-quality raw material. Knowledge of good-quality stone locations would imply an ability to locate sources of good-quality plants, carcasses, shelters and water. The ability to comprehend and exploit resource locations in the environment would be attractive in a hominid mate, as an indication of heritable perceptual and cognitive skills.

Executing plans and good health

Classic handaxes were difficult to make (Gowlett 1984; Wynn 1989). They required the ability to conceive and successfully execute a plan, and to modify it continually as contingencies arose, such as unexpected flaws in the material and mis-hits; as well as persistence and determination. Handaxe production would have been a 'test of character', indicating behavioural disposition to potential mates. Effective handaxe production could be a reliable indicator of health, strength, good eyesight and coordination, whereas poor knapping might represent the opposite.

Social awareness

In order to avoid deception or social disadvantages and maintain status, a hominid would need to monitor the behaviour of others, whilst engaged in axe-making.

Handaxes as aesthetic displays

Artefacts of a symmetrical form may have been particularly attractive to members of the opposite sex because of an evolved perceptual bias toward symmetry. Symmetrical objects would attract attention because our visual systems, like... many ... animals, ... are exquisitely sensitive to patterns with a vertical axis of symmetry' (Dennett 1991: 179). The symmetry of handaxes may have 'play[ed] on the percep-tual biases of receivers to attract attention, provoke excitement, and increase willingness to mate' (Miller 1997: 96).

These biases for symmetry may relate directly to mate choice itself, as bodily and facial symmetry could indicate good genes. Symmetry abounds in the morphology of living things, since single genes control the development of features on both sides of an organism. High levels of symmetry are rare, and the presence of genetic mutations, pathogens or stress during development may lead to the presence of asymmetries in bilaterally distributed features (Parsons 1992). In consequence the degree of symmetry is a good indicator of the degree of genetic and physical health of an individual. The relationship between 'good genes' and symmetry has been established in several species (Mailer 1988; 1990; 1992; Manning & Chamberlain 1993; Manning & Hartley 1991; Goss 1983; Parsons 1992).

These studies assume that females select males both on the traits such as tail lengths and on the degree of symmetry (Manning & Hartley 1991). This certainly appears to be the case for modern humans, where both men and women make substantial use of the degree of symmetry in the faces and bodies of those of the opposite sex when selecting reproductive partners. Thornhill & Gangestad (1994; 1996) have measured men's 'fluctuating asymmetry' and examined how this is related to several measures of reproductive success. 'Fluctuating asymmetry' means the measurable difference in a range of characteristics between the right and left side of the body, from which an index is calculated for the degree of bilateral asymmetry for each subject. Women, they argue, seek mates with low degrees of asymmetry as this is an in-dicator of 'good genes'. Highly 'symmetrical' men were found to be more facially attractive and to be sexually more successful. These traits suggested potential for reproductive success.

Although we are cautious about the specific arguments put forward by Thornhill & Gangestad, it seems very likely that the males and females of all hominid species would have also used symmetry as a cue when selecting mates.

The makers of handaxes, we argue, were simply tapping into this perceptual bias, making artefacts that caught the attention of, and were most probably attractive to, members of the opposite sex.

The problem of cheating and handaxe abundance

As indicators of 'good genes' and exploiters of perceptual biases, we see handaxes as similar to the ornaments (e.g. plumage, canine teeth, antlers) of other species. But there is, of course, one fundamental difference: a handaxe is not attached to a body, and hence a set of genes. This creates a major problem for the signal receivers: the sender of the signal may be a cheat. Without effective counter-measures, an individual could avoid the costs of making a handaxe by acquiring one, through theft or collection, of a quality beyond the cheat's own abilities.

One of the most puzzling features of hand-axes in the archaeological record is their great abundance at Acheulian sites (e.g. Isaac 1977; Roe 1981; Wymer 1983), where many appear to be in pristine condition. At Boxgrove, not one of the excavated handaxes shows signs of macroscopic damage (Roberts et al. 1997), and whilst functional accounts struggle with this evidence, it fits the handicap model perfectly. Our theory, where observation by a potential mate of handaxe production is the important factor, explains why handaxes were discarded shortly after being made.

Which sex made handaxes?

Handaxes have traditionally been associated with the male activities of hunting or scavenging. Data on tool use and manufacture in chimpanzees, however, suggest that handaxe-making skills are often transmitted by adult females to their offspring (Dennell 1994). Our sexual selection theory has implications for sex bias in manufacture, and the sex which invests most in reproduction will be the one which chooses mates more carefully (Trivers 1972). Males tend towards display, so conspicuously impractical handaxes were most likely made by males, whilst females would make less refined, more practical handaxes.

The cultural development of the Acheulian

The archaeological record of East Africa (especially from Olduvai Gorge) documents the emergence of handaxes via the proto-bifaces of the Developed Oldowan (Leakey 1971). These artefacts show the use of bifacial knapping but lack the form of classic handaxes. We suspect these proto-bifaces were simply an improvement over Oldowan choppers in terms of the efficient use of raw material and production of butchery tools. Bifacial knapping unintentionally produces some degree of symmetry in an artefact: once such proto-bifaces were in existence, they became caught up in the game of sexual selection. The transition to handaxe manufacture was also a social transition in the socially complex and competitive societies of large-brained hominids. It established a new mechanism for mate choice according to cognitive criteria.

The result is that during the Early Palaeolithic there were two technologies. One was a 'social' technology, the handaxes, related principally to the social world. The other was a 'functional' technology related to the natural world and comprising artefacts such as cores and retouched flakes, used for plant processing, woodworking and animal butchering. Many functional tools may have been made from organic materials, as illustrated by the spears from Schoningen (Thieme 1997). Whilst handaxes were rarely used for such functional activities, they nevertheless could be used for functional tasks, most notably animal butchery.

The dual-component nature of Early Palaeolithic technology in the Old World is reflected in the variable presence of handaxes in lithic assemblages. Some areas and temporal periods contain only a pebble/flake technology (Wymer 1988; 102–33; Roebroeks et at 1992). A classic example is the record from southern Eng-land, once classified into two industries, the Acheulian (with handaxes) and the Clactonian (without) (e.g. Wymer 1974), but now shown as a continuum of variability in the relative frequency of handaxes (Ashton & McNabb 1992; Ashton et al. 1994; Mithen 1994; Roberts of a'. 1996). As McNabb & Ashton (1995) have explained, the core/flake technology in handaxe-poor/absent 'Clactonian' assemblages is the same as in handaxerich Acheulian assemblages.

The dual-component is what we should expect, if our theory of handaxes as sexually selected artefacts is correct. Once competitive social conditions in mate choice were relaxed, handaxes — most notably those of a classic form — would disappear due to their high cost of manufacture. Many assemblages which either lack or have low frequencies of handaxes were produced in wooded environments (Wymer 1988; Valoch

1984; Svoboda 1992; Gamble 1992: 571). Hominid group size would be relatively low in woodlands where predator risk was low, and food available in small parcels. These social conditions might offer insufficient opportunities for social learning and maintaining the technical knowledge for handaxe manufacture (Mithen 1994). Equally, mate choice and mate attraction may not have been such competitive undertakings, so it was no longer worth incurring the costs of making handaxes. The variable presence of handaxes in Early Palaeolithic assemblages is, we suspect, a direct reflection of both variable sexual selection pressure and the degrees of inter-male competition arising from the variation in hominid socio-ecology throughout the Old World.

The end of the Acheulian

Changes in sexual selection criteria, we sug-gest, caused the Acheulian to break down. This transformation was driven by the increased costs of reproduction incurred by females as a result of the relatively rapid increase in brain size associated with the appearance of archaic Homo sapiens (Aiello & Wheeler 1995; Knight of 0'. 1995). The degree of brain enlargement between 600,000 and 250,000 years ago resulted in modern brain sizes (Ruff et at 1997), which imposed such costs upon reproducing females that they could no longer maintain their own foraging strategies or rely on support from female kin alliances. To raise their larger-brained and slower-maturing offspring, females now needed males to provide them with reliable supplies of food, especially meat, with its high energy yield. They were now concerned about their relationships with their mates, not just the quality of their mates' genes, and their mate-choice criteria shifted accordingly; towards those males who were most reliable in the provision of resources. In response, males made their artefacts according to the demands of functional efficiency, developing varied toolkits as a result. Consequently we see the development of Levallois technology for producing good-quality blanks, and the appearance of spears with stone points.

Summary

This paper proposes a radical new interpretation of handaxes which we hope contributes to solving the questions about them that have baffled archaeologists for many years. In our view, handaxes were products of sexual selection: they were used as reliable indicators of a potential mate's quality by those of the opposite sex. Those individuals who made fine symmetrical handaxes were preferentially selected, as the handaxes indicated that they had 'good genes' — genes for high degrees of physical health and intellect. The degree of handicap incurred by the handaxe maker, through the time spent on knapping it or through making an impractical artefact, was itself an indicator of fitness. It could be varied according to the 'tactical choice' of the knapper. In addition, such handaxes played upon the perceptual biases of the hominid's evolved psychology.

As a consequence, cultural traditions of handaxe manufacture flourished during the Pleistocene in the period between the emergence of large, socially complex societies and prior to a significant change in social relations between the sexes arising from greater dependency by females on male provisioning.

To conclude, we offer our answers to the five questions we posed above:

1. Handaxes are pervasive in the archaeological record because throughout the Pleistocene hominids frequently lived in large, socially complex and competitive societies in which sexual selection pressures and inter-male competition for mates were intense;

2. Handaxes are often found in abundant numbers at individual sites because, to fulfil their social function, members of the opposite sex had to witness the act of handaxe manufacture;

3. Greater time and effort was invested in handaxe manufacture than appears necessary for the adequate accomplishment of utilitarian tasks such as animal butchery, because handaxes also functioned in the social domain as indicators of health and intelligence and as aesthetic displays;

4. Handaxes were symmetrical because knappers exploited the perceptual biases of an evolved psychology that was attracted towards symmetry;

5. The handaxe oddities — those which appear too large, or which may have additional features such as embedded fossils — are readily explained as particularly

elaborate social displays. We concur with Wymer (1968: 225) that the Furze Platt giant handaxe was made by a hominid wishing to display knapping skill, and we suspect that the maker was male. We also agree with Roe's (1994: 207) comment regarding the 'dramatic' quartzite handaxes from FLK at Olduvai Gorge: 'one cannot but feel that a highly accomplished knapper, in full control of a difficult raw material, was aiming at a preferred size and shape'. But we.also cannot but feel that the knapper was engaging in a social display when making that artefact.

A complete explanation for the form and distribution of handaxes in the archaeological record will require many factors to be invoked. The nature and distribution of raw materials was no doubt a major influence on their form, and handaxes were clearly efficient butchery implements. But, unless we also understand how handaxes functioned within the social domain, we will only ever gain a partial understanding of these most enigmatic of prehistoric artefacts.

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