BIFACE FORM AND STRUCTURED BEHAVIOUR IN THE ACHEULEAN

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"Homo erectus of 700,000 years ago had a geometrically accurate sense of proportion and could impose this on stone in the external world…mathematical transformations were being performed"

(Gowlett 1983: 185)

ABSTRACT

According to some perspectives, the standardised nature of biface forms and the rule-governed nature of biface discard reflect a highly structured and static adaptation. Furthermore, it has also been suggested that the Acheulean represents a period of over a million years in which technological and social development were in relative stasis due to social limitations. In this paper we explore the possibility that this apparently static and highly conformable adaptation may have represented a crucial pre-linguistic phase in which humans became adept at engaging with, reacting to and manipulating an early semiotic environment. We also present evidence which suggests that, in addition to symmetry, there may have been an underlying preference for the manufacture of bifaces with proportions conforming to the 'Golden Section'. The possibility that bifacial tool form and structured archaeological signatures might have combined to produce a self-organising effect on early human land-use behaviour is explored. These behaviours, we argue, formed through simple feedback mechanisms which led to the ordered transformation of artefact scatters over time. We suggest that the apparent homogeneity of Acheulean technology might therefore signal a cognitive phase in which material culture played a semiotic role prior to the development of language.

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INTRODUCTION

For the purposes of this paper the Acheulean is defined as Palaeolithic industries in which bifaces and other large cutting tools form a variable component. These industries span Africa, Europe and Asia and persist in a recognisable form from their first appearance around 1.7 million years ago (Dominguez-Rodrigo *et al*. 2001; Roche 1995) until less than 50 thousand years ago. Within this broad definition there is large variation, both in the degree to which bifaces comprise the overall tool kit and in the morphology of the bifaces themselves. What is remarkable is that this variation never seems to lead to sustained technological evolution or innovation over the immense spatial and temporal scales that the tradition encompasses:

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Acheulean signatures are relatively uniform in their range of variation across the spatial and temporal distribution of the phenomenon (Gamble 1999). Patterning in biface form has been characterised as something of a 'random walk' for much of the Acheulean (Isaac 1977), distinct perhaps from the later emergence of innovative and regionally stylistic lithic industries after 500 thousand years ago (Wynn & Tierson 1990). This apparent conservatism in technological innovation is undoubtedly explained in part by both the adaptive success of large cutting tools in general and the relatively limited number of form outcomes which can possibly emerge from the process of bifacial manufacture. Others have suggested that the technology reflects highly routinised patterns of knowledge transmission embedded within groups which either exhibited strong patterns of social learning and self replication (Mithen 1996a), or were of a size unlikely to sustain innovation (Shennan 2001).

Bifaces, and other large cutting tools, present other paradoxes. The tool form itself often displays such attention to detail in terms of symmetry and form that they appear over-engineered for the range of simple functional tasks envisaged. The finesse, exactitude and apparent aesthetic sense worked into what are essentially meat knives continues to demand an adequate explanation, an explanation which might throw some light onto the fundamental relationship between form and function in the material culture of early humans. Conversely, explanations of biface form must adequately take account of assemblages which contain large numbers of poorly standardised or 'non-classic' forms, which seem to argue against strong mental templates or patterns of social learning (McNabb *et al*. 2004; Ashton & McNabb 1994). The challenges to our understanding of the cognitive development of *Homo* presented by Acheulean technology are compelling enough to offer the possibility that insights into the origins of modern human behaviour might lie at the heart of any explanation of the phenomenon.

In this paper we wish to present preliminary results from the analysis of standardisation in biface form. We show some compelling results which appear to show a broad agreement between biface shape and the 'Golden Section', a ratio controversially claimed to have particularly aesthetic properties. Whilst at an early stage of analysis, we wish to share these initial, speculative, observations. We explore the possibility that standardised proportions, in addition to symmetry, may have been an important component of the 'mental template' underpinning biface manufacture in the Acheulean. That these ratios, and perhaps the quality of symmetry itself, might have been cued by proportions found commonly in nature, perhaps suggests that early *Homo* possessed a rudimentary aesthetic sense, echoes of which might still be preserved in classical definitions of beauty. We go on to examine the possible roles bifaces and other large cutting tools may have played in human landuse, individual identity and social cohesion during this period. In particular we build on the earlier modelling of land-use patterns in the Acheulean (Pope 2002) to examine the potential semiotic role bifaces may have played as part of highly structured artefact signatures in the Acheulean.

SYMMETRY AND AESTHETICS IN THE ACHEULEAN

It has previously been suggested that hominins throughout the Lower Palaeolithic may have demonstrated a clear appreciation of form in the manufacture of bifaces (McPherron 2000). It is perhaps now generally accepted that bifaces were finished forms resulting from intentional, deliberate reduction strategies (e.g. Gowlett 1984, 1995; Ashton & White 2003) and not simply the outcomes of standardised flake production sequences (Davidson & Noble 1993) or as flake dispensers (Potts 1989). The concept of 'mental templates', at least in part guiding reduction strategy, is now an important component of explanations for biface form. Whilst the concept of a mental template is often employed in a vague manner, and must be considered only as part of a complex suite of factors which include raw material quality (Jones 1994), individual idiosyncrasies (Ashton & White 2003) and cultural/social influences (Wenban-Smith 2006), evidence is emerging from our own analysis which may indicate that clear aesthetic preferences may have been guiding biface manufacture for significant parts of the Acheulean record.

One of the baselines for judging the potential importance of aesthetics in biface production is symmetry, which has long been recognised as an imposed and apparently non-functional aspect of the biface mental template. While the possibility that symmetry imparted some kind of functional advantage is currently being tested through on-going research (Machin *et al.* 2007), the characteristic of symmetry has been invoked as indicating that bifaces may have played a role in courtship display (Kohn & Mithen 1999). Examples from Elveden (Ashton & White 2003) and Boxgrove (Figure 1) show that overall tool symmetry was of immense importance to particular individuals. In both cases, the tool maker was at pains to preserve symmetry by purposely replicating mistakes or flaws unavoidably present on one side of the biface with careful knapping on the other. In the illustrated example from Boxgrove (Roberts *et al.* in prep.), a constriction in the original parent nodule, visible through cortex left remaining on the tool, may have been incorporated into the overall axis of symmetry of the finished tool. This kind of evidence, although based on isolated individual examples, does suggest that symmetry was an intended outcome from the start and that natural symmetry could be appreciated in the parent material, enhanced and built into the overall form of the tool itself. Symmetry, whether viewed in terms of its mass production and repetition throughout the Acheulean or in the context of more individual examples of craftsmanship, continues to remain unaccounted for. However, there are other remarkably standardised similarities in other aspects of biface form which may help to elucidate the significance of symmetry.

By itself, the apparent trend within parts of the Acheulean, at both site and regional scales, of producing broadly standardised and symmetrical tools offers little more than the tantalising possibility that a shared sense of aesthetic appreciation was at work. Yet it has been previously suggested that there are remarkable levels of standardisation in the overall proportions of biface shape. For example, in commenting upon plots for biface length and width data from Acheulean assemblages, McPherron noted that the results are:

"...Remarkable for the degree of similarity displayed among these handaxe assemblages. Assemblages from across the Old World and throughout much of the Pleistocene all tightly cluster on a single line. What this suggests is that there is an underlying factor that affects handaxe shape in some fundamental way"

(McPherron 1999: 668–669)

One possibility is that the trend towards standardisation may signal a shared mental template leading to proportions inherently preferred by archaic *Homo* being imposed in tool manufacture. We have found two quantitative relationships which may support this general observation. These emerged from the apparently serendipitous outcome of broad comparisons we were drawing between Boxgrove bifaces and other Acheulean assemblages. It was established that preferred biface shapes for key assemblages from both Kilombe (Gowlett 1978, 1982a) and from an initial sample of Boxgrove's waterhole site both produced average length to breadth ratios of 0.62. Furthermore, it was noted that this specific ratio equated closely to a proportion widely claimed to occur in art and nature. The Golden Section or

Golden Ratio, often represented by the Greek letter Phi, has been controversially claimed at various times to have aesthetic qualities and has been the subject of much discussion from its possible formalisation in Pythagorean mathematics to its clear role in Euclidean geometry (Herz-Fischler 1998; Livio 2002). It has the value of 1.61803398…and, remarkably, its square (2.61803398…) is obtained by adding 1 and its reciprocal (0.61803398…) by subtracting 1. The Golden Section is given by dividing a straight line into two parts so that the ratio of the total length to the longer part is equal to the ratio of the longer part to the shorter part. So, from Figure 2a, we can write:

$XY/XZ = XZ/ZY = 1.61803398\ldots$

or taking reciprocals,

$XZ/XY = ZY/XZ = 0.61803398\ldots.$

Figure 1: A sense of symmetry. Biface from Boxgrove Q1/B manufactured to incorporate an irregularity in the parent nodule into the main axis of tool symmetry.

The Golden Rectangle (Figure 2b) has been described, although never convincingly proved, as the rectangle which has the most aesthetically harmonious proportions. It is defined by a Length/Breadth ratio of 1.618…or its reciprocal 0.618…. There have been many claims for its influence in paintings, architecture and various other branches of the arts (Scruton 1979). These claims are highly controversial (Markowski 1992; Končeni 2003) being in the most part easy to disprove (e.g. The Great Pyramid, The Parthenon) or else the product of very conscious employment by classically influenced artists (e.g. Corbusier). The situation has become confused recently with many unsubstantiated claims for finding the ratio Phi throughout western art and architecture.

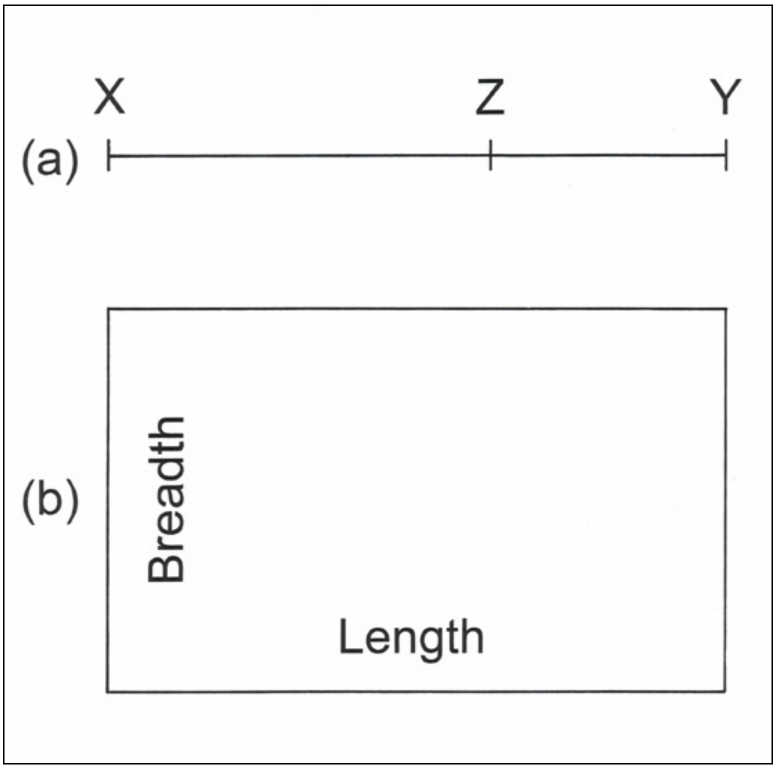

Figure 2: The proportions of the Golden Ratio and the Golden Rectangle

More rigorous and less controversial research has focussed on the widespread occurrence of Phi in natural structures. Pertinently Phi is a ratio which repeatedly occurs throughout elements in the natural world visible and accessible to early humans, having been identified in mollusc shell proportions, flower head structures, the branching of trees, and features of the human body. Occurrences of Phi, beyond direct human perception and therefore the scope of this paper, have been documented in the fields of astrophysics and non-linear mathematics (Livio 2002).

In this initial study we focus on two of the most commonly used indicators in the analysis of biface shape: the ratios for breadth/length and butt length/tip length (Figure 3). These indicators define the overall plan view of the tool. Mean values of these ratios were calculated from a seminal and universally accessible database (Marshall *et al*. 2002) that provides measurements for 1,297 complete bifacial stone tools from sites dated to periods throughout the Lower Palaeolithic up to about 300,000 BP. These bifaces, mostly handaxes, were randomly selected from a total of 17 key sites located in Africa, England and Israel (Table 1). The majority were made from quartzite (734) or flint (306), but 15 other raw material types are also represented.

The mean breadth/length and butt length/tip length ratios for the entire sample were found to be 0.6233 and 0.6237 respectively. The corresponding 99% confidence intervals were 0.616–0.630 and 0.607–0.640, both of which encompass 0.61803 and fall well within tolerances for the acceptance range for Phi established by Markowski (1992). In the case of the artefacts themselves this range of variation translates as average tolerances of only a few millimetres on each measurement.

This pattern has been independently considered before in the analysis of two specific assemblages. Gowlett, in his early analysis of biface morphology from Kilombe stated:

"Most remarkable of all is that the fitted lines, and mean values closely match the proportion of the Golden Section (c. 0.62: More precisely 0.6285/1) favoured in classical art and architecture for all the Kilombe examples."

(Gowlett 1982: 104)

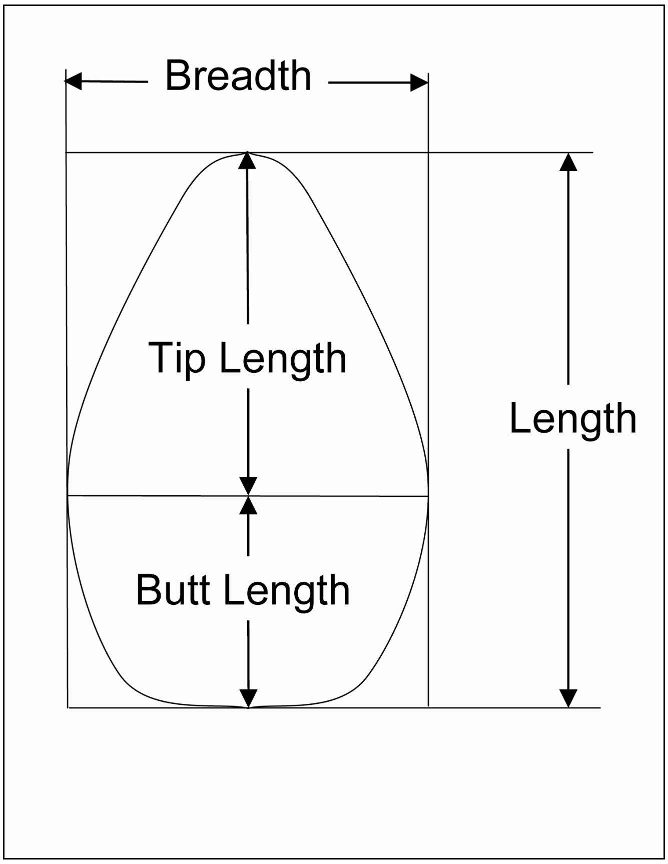

Figure 3: Principle biface measurements studied

More recently Le Tensorer, in explaining the apparent strong preference for similar length/breadth ratios for bifaces from the Nadaouiyeh site, has gone as far as to suggest that a particular aesthetic preference, informed by the Golden Section, directed biface manufacture (Le Tensorer 2006). That a concept of aesthetic preference influenced tool making behaviour across evolutionary time scales is far from being established by the above data. We do however feel it is an exciting and controversial hypothesis to pursue. We are now engaged in trying to establish whether, at a wider level, a preference for particular proportions can be substantiated within biface assemblages once factors such as raw material constraints, resharpening and other functional factors have been accounted for. As a preliminary attempt to test these findings against an independently collected data set, average breadth/length ratios were calculated for the biface assemblages presented by Shannon McPherron in his discussion of the mental capacities of early *Homo* (McPherron 2000). A total of 148 assemblages comprising over 8,000 bifaces from across the Acheulean record of Europe, Africa, the Near East and India produced an overall average B/L ratio of 0.612, confirming an overall agreement between average biface proportions and the 'Golden Section'.

Ref. No.	*Site*	*Country*	*Artefacts in Sample*
1	Amanzi Springs	South Africa	54
2	Bowman's Lodge	England	2
3	Boxgrove	England	94
4	Broom Pits	England	1
5	Cape Hangklip	South Africa	92
6	Cuxton	England	42
7	DeBeers Floors	South Africa	4
8	Doornlaagte	South Africa	18
9	Elandsfontein	South Africa	156
10	Kimberley Townlands	South Africa	7
11	Montagu Cave	South Africa	157
12	Olduvai Gorge	Tanzania	220
13	Pniel 6	South Africa	25
14	Sidi-Abderrahman	Morocco	228
15	Sussannahkop	South Africa	1
16	Tabun	Israel	187
17	Warren Hill	England	9

Table 1: Details of complete bifaces (n=1,297) taken from the Marshall Database (2002)

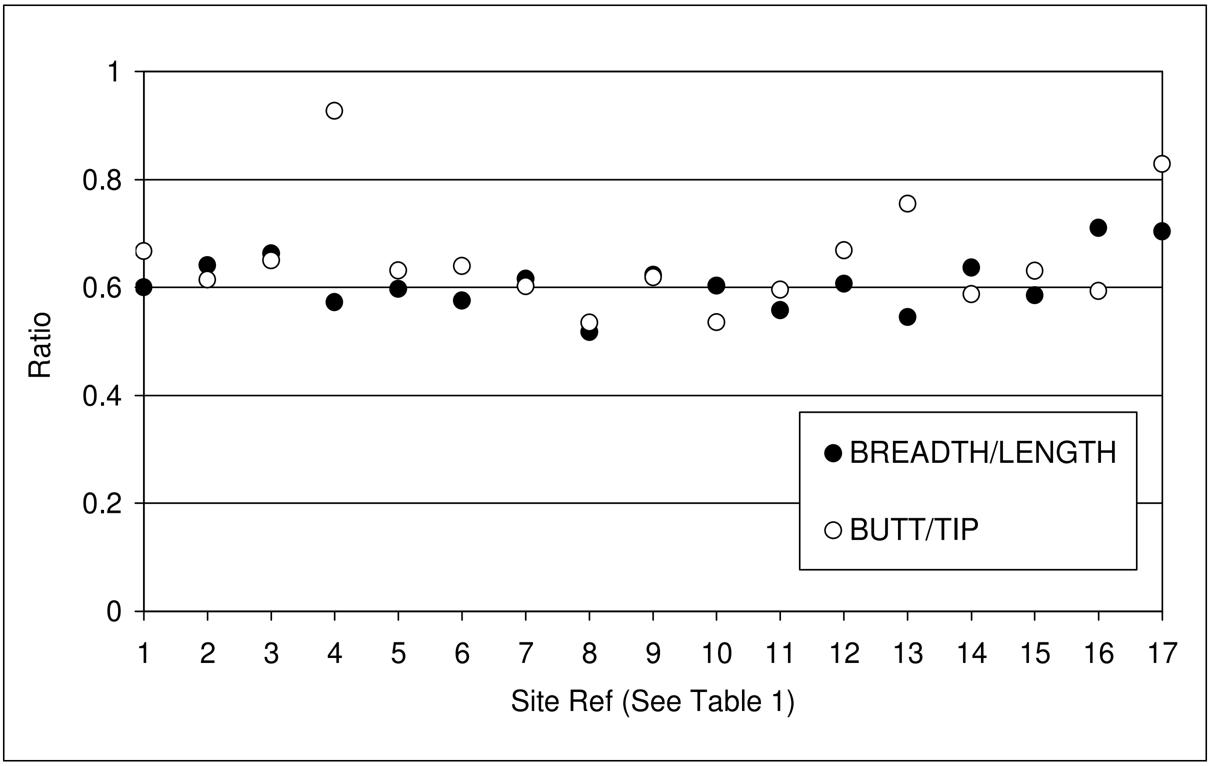

Figure 4: Mean breadth/length and butt length/tip length ratios by site

CONSIDERING INDIVIDUAL EXPRESSION IN THE ACHEULEAN

In presenting the above data, it has been our aim to simply draw attention to the apparent conformity in average biface shape throughout the Acheulean and suggest that aesthetic rules, underpinned by the possible evolutionary significance of Phi, may lie behind the phenomenon. Further work now needs to be undertaken to both replicate these results and to look carefully at both inter-assemblage variation and variation in conformity to Phi between different sites. Only once the rigor of the relationship has been tested and variation accounted for can we go on to discuss its significance in detail. Yet this does not preclude a more general consideration of the relationship between standardised aesthetics, wider rule systems in the Acheulean and the apparent presence of highly individualistic reduction sequences in the archaeological record.

It is important to remember that each individual tool had its own reduction history, could have been produced through a multi-location chaîne opératoire and was the outcome of negotiation on the part of the knapper between a mental template, raw material quality and landscape context (Pope 2002). Yet just as overall symmetry appears to have been maintained if at all possible in the course of these negotiations, shape and proportion appear to emerge as the product of similar negotiations between preferred mental templates, raw material limitations and contingent needs. For example, if McPherron is correct in suggesting that bifaces went through morphological shifts during successive phases of reduction (McPherron 1999) and maintaining standardised proportions was as important to *Homo ergaster* and Archaic *Homo sapiens* as maintaining symmetry, we would expect to find some measurable compensation in the allometric relationships between conformity to these 'aesthetic' ratios and either biface size, elongation or refinement. These might be similar in nature to the allometric relationships already established by Crompton & Gowlett (1993).

We are also becoming increasingly aware that, despite compelling evidence to show that mental templates underpinned biface form throughout the Acheulean, the tools themselves were also the product of clear spatial/temporal styles (Wynn & Tierson 1990; Wenban-Smith 2006) and the idiosyncratic knapping traits of individuals (Ashton & White 2003). Cultural influences are perhaps hinted at in the restrictive spatial and temporal presence of tool types such as twisted ovates, ficrons and bout coupés; variations which do not seem to be dependant on raw material variability. It is interesting to note that these forms occur in Britain after MIS 12, perhaps reflecting a changing role for bifacial technology, part of wider cognitive, social or linguistic developments. Yet, exploring the role of the individual as part of the earlier, less fluid and more monolithic Acheulean technologies is more elusive. As we have already seen, even a characteristic as routinised and rule-governed as symmetry can be arrived at in a very individual and unstructured way (Figure 1). Similarly, the pairing of bifaces documented by Ashton & White (2003) from Foxhall Road appears to show stylistic affinities linked to the knapping skill and might possibly be showing style in the knapping techniques of particular knappers. In passing, we can add evidence for two similar pairings of tools from Boxgrove: in each case the bifaces were located in isolation and exhibit remarkable levels of similarity in terms of raw material, form and size (Figure 5). Figure 5a shows two bifaces from the upper Unit 4c horizon at GTP17, above the level of the more widely known horse butchery site. The two tools shown in Figure 5b were both recovered from a small isolated patch of Unit 4c at the Q1/B site. These tools were found adjacent to each other and again display a remarkable degree of technological similarity. When examining edge flaking patterns on these pairs, they exhibit almost identical patterns of flaking on each edge (Russel *in prep.*). Such hints at individual styles working within a prolonged and fluid chaîne opératoire should always temper our understanding of the Acheulean record in the face of so much compelling evidence for its otherwise highly structured, constrained and conformable nature.

a)

b)

Figure 5: Pairings of bifaces from Boxgrove. a) From the upper palaeosol horizon at GTP17. b) From Unit 4c at Q1/B.

DISCUSSION: BIFACE FORM, STRUCTURED DISCARD AND THE SEMIOTICS OF ARTEFACT SCATTERS

Both in previous presentation of land-use data from Boxgrove (Pope 2002; Pope & Roberts 2005) and in the current discussion of biface form we are suggesting human behaviour throughout much of the Acheulean (up to at least 500 kya) was underpinned by some very basic rule systems and characteristics (Gowlett 1996). These rule systems led to both structured patterns of artefact discard within the landscape and highly consistent biface forms which seem to show a standardised mental template which favoured symmetry and proportion. Examples of highly routinised patterns of behaviour appear to be a real feature of the archaeological record of both early *Homo* and archaic *Homo sapiens*. Artefact caching, operating on simple feedback mechanisms of transport and discard, has been suggested for the Olduvai accumulations (Schick 1992), and the production of particular tool forms such as twisted ovates rely on demonstrably mechanical systems of rotation (White 1998b). We would see both the formation of biface-rich assemblages and the production of tool forms which tightly conform to a standardised aesthetic as two complementary examples of highly structured behaviour in the Early and Middle Pleistocene.

We would like to suggest that these routinised, structured behaviours could be seen as essentially stigmergic in nature. Stigmergy is a concept, derived from the terms stigma (Greek for sign) and ergon (action), developed in biology to describe the self-organising effects of pheromones on insect social systems to account for the highly complex and decentralised rule systems which seem to govern them (Grasse 1959). It is a concept which is currently useful in studies of modern robotics and artificial intelligence studies to account for self-organising systems of information, such as the internet. Indeed it has been claimed that the internet is the first truly stigmergic communication medium for humans; we would disagree.

The evidence from Boxgrove and other key Acheulean localities offers a tantalising possibility: that once occupation became established within a region, artefact spreads might have acted to both cue and spatially organise subsequent behaviour at particular locales. Simple behavioural feedback could lead to productive areas developing a particular signature which would perhaps trigger further activity leaving an ever-increasingly amplified signal, which in turn would exercise a larger trigger. Within this system the contextualised discard of bifaces, as a visible and clearly humanly-made artefact might have further enhanced and amplified the trigger signal. From this perspective tools could, if discarded contextually within stigmergic systems, fulfil key semiotic roles beyond simple technological function. Tools, fulfilling this semiotic role in even a passive manner, are a clear early example of human ‘extension’ through technology, facilitating a means of extending the self beyond the confines of the body itself and communication beyond the primate legacy of attenuated site-lines and hearing range (Wrangham 1979).

We have argued previously (Pope 2002) that structured discard in this manner may have enabled pre-modern humans to effect a ‘release from proximity’ (Rodseth & Wrangham 1991) prior to the acquisition of language. Perhaps in investigating the nature of rule systems underpinning tool manufacture and discard within the context of stigmergic information systems we might usefully elucidate the mechanisms through which this was achieved. For example, the form of a biface itself, defined by visible reflective planes shaped to incorporate both symmetry and arresting proportions, could not be better designed to catch the attention of a human group scouting an unfamiliar region. With a simple rule system in place, precluding the discard of finely made bifaces at single-episode sites, the inevitable amplification of triggering signals would be enhanced at sites which routinely provided game intercept opportunities, fresh water or other resources. Structured discard of this nature does appear to have its origins within the Oldowan, as shown by coherent differential tool discard patterns (Blumenschine & Masao 1991), localised concentrations of material (Potts 1988) and the overall scatters and patches configuration of the record within Early Pleistocene localities (Isaac 1981; Roebroeks *et al*. 1992). Yet we would argue it is within the Acheulean that stigmergic systems emerged, in which standardised biface form and discard rule systems effected an amplification of behavioural cueing by artefact concentrations. It is however important to remember that these routinised behaviours were enacted by individual participants who were actively negotiating tool function, raw material limitations, individual styles and perhaps cultural affinities within the chaîne opératoire.

From such a perspective, the apparent coherence of the Acheulean might be better seen as stemming from its success as part of a cognitive and social adaptation which allowed the exploitation of large landscapes and group fragmentation prior to the development of language. Within this it might also be possible to see the step-change in technological diversity after MIS 12, as expressed in Northern Europe through aspects of variation such as the Clactonian, twisted bifaces, ficrons, large tools and Levallois (Wenban-Smith 2006; Wynn 2003), as perhaps reflecting a crucial shift in cognitive gear. It may be no coincidence that at this point there appears also to be an increase in the relative size of the human neocortex at this time, which may relate to an increase in social group size (Dunbar 1993). The commensurate amount of grooming time required to maintain social relationships at this point alone indicates the likely emergence of language (Dunbar 2003), a threshold which we would argue led beyond the highly structured and stigmergic systems of *Homo erectus* and the Acheulean and into more modern modes of human behaviour.

CONCLUSION

We recognise ourselves as an essentially semiotic species able to negotiate in both geographical and social space through cues, triggers and structures often embodied in constructed human space and visual stimuli. Anatomically Modern Humans have perhaps uniquely combined this facility with vocalisation to develop a capacity for fully grammatical language, the emergence of which has been sometimes seen as the critical rubicon in the development of fully human behaviour. We would like to suggest that the focus hitherto on the evolutionary development of language might be premature without a fuller consideration of earlier capacities for non-verbal communication. It might be possible that we are overlooking the potential semiotic role artefact scatters may have played in our pre-linguistic cognitive and social development. Our ability to decode material culture as we encounter it in space is something we take for granted, yet to afford archaic *Homo sapiens* similar abilities is an aspect of early human behaviour something largely unconsidered to date. It raises the possibility that archaic *Homo* was preconditioned for the development of language because they already inhabited a semiotic environment rich in highly contextualised social and ecological information which they were adept at decoding on a daily basis.

As Palaeolithic archaeologists we are only too aware of the arresting, indelible and compelling nature of bifaces and biface clusters in a very ancient archaeological record. We would suggest that the Acheulean record is highly distinctive and structured in this manner for a clear reason; that it provided a coherent framework for behavioural cueing, personal extension and social cohesion at landscape scales. We are therefore pursuing the possibility that it was the successful and uniquely stigmergic nature of these Acheulean frameworks, intimately reliant on standardisation to work effectively, which led to the apparent stasis in technological development during the million years of the Acheulean. It is here we have now turned our attention, examining the possibility that structured behaviour patterns, including an emergent sense of proportion and symmetry, engendered and allowed the successful development of semiotic patterns of cognition which eventually gave rise to our modern symbolic and linguistic capabilities.

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