The elements of design form in Acheulian bifaces: modes, modalities, rules and language

J. A. J. Gowlett

British Academy Centenary Research Project,
SACE, The Hartley Building,
University of Liverpool,
Liverpool L69 3GS, UK

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Abstract

Acheulian bifaces are multivariate objects, in which a set of variables were controlled by the manufacturers and users, constrained by basic needs and necessities. In any set of Acheulian bifaces, variation of shape and size is pronounced and obvious. Part of this is in simple variables such as length, which often approximate to a normal distribution. Other variation gives the appearance of internal structure within the set, such that if all variables were measured and plotted in multivariate space, there would be clusters of preferred forms, with gaps between them. Aware of such variety, archaeologists have usually dealt with it by segmenting the variation, according to arbitrary distinctions. Such "types" or "subtypes" have the advantage of uniformity across sites, but the disadvantage of being a projection from the modern mind. To explore natural variation, it is necessary to isolate the most important "true" variables, and from them to explore preferred design targets, bearing in (modern) mind that we have a limited idea of how tightly "bounded" these were in the ancient mind. This paper relies chiefly on East African material – Kilombe, Kariandusi – for its examples, coupled with some use of North African and European material, together relevant to the Middle East. Using results of cluster analyses and PCA (Principal Components Analysis), it explores the nature of variation, and argues that a limited series of "imperatives" best explains the way in which the makers of Acheulian bifaces arrived at working solutions to problems involving the handling of several variables.

Introduction

Almost any artifact is multivariate – it can be made only through an instruction set that encompasses the set of variables. Hence early artifacts tell us (perhaps incidentally) about the abilities of early humans in managing such variables. It can be argued that such variable sets might be linked with language emergence (Gowlett, 1996), and that the difficulties of processing entailed in managing several variables together may correspond loosely with those involved in handling levels of intentionality. Modern human intelligence is marked by the ability to operate at several levels of intentionality, apparently as a byproduct of operating in large social groups (e.g., Dunbar, 1993; 1996; 1998).

This paper considers "what" bifaces are at a deep level, arguing that they inform us richly about the nature of abstraction and its origins, and that they inform us too about the difficult relation between human knowledge "in theory" and knowledge "in practice", and about the interface between function and style.

The idea of form is crucial – almost every archaeologist will start from the intuitive position that they know what a biface *is* – even if they then proceed to argue that bifaces are not products of an intended design. Here, however, we encounter a problem, reflected in archaeology in a traditional dichotomy of form studies and function studies. Some emphasize the form and its abstract concepts. Others can see no need for such form to be intended by early humans, and emphasize the role of function, arguing its ability to generate form as a side-effect or epi-phenomenon.

Allometry studies are one example of an attempt to relate form and function (Crompton and Gowlett, 1993; Gowlett et al., 2000), among various new developments. The interplay of approaches can help us to get further away from this traditional dichotomy of form studies and function studies. In general, there are two complementary approaches to bifaces: the one to work from the past objects in description and exploration, and the other to work into the problem from everything that we know about human and animal cognition and performance in the present.

Background

Although bifaces have been recognized for some 200 years, it is through the last fifty years that they have been described in measuring systems. The first of these, e.g., that of Bordes, appeared in the 1950s. In major contributions of the 1960s, Roe through his diagrams emphasized for the first time the field of variation that is normal in any biface set (Roe, 1964; 1968). Glynn Isaac was particularly concerned with whether, within such a field, there were genuine subtypes, that is, favored target zones of design (Isaac, 1977). He suggested that tests could be made for the presence of modes, an approach taken up by Gowlett (1988). Although believing that there were such modes, Isaac (1968; 1977) also drew attention to the large numbers of “nonstandard” bifaces that do not appear to be classic types to the modern eye, and he considered the problems of interpreting these. He noted the possibilities of strong mode and weak modalities, as also discussed by White (this volume). The “other bifaces” were recognized on numbers of African sites, including Olduvai and Karari as the oldest; their presence on European sites has been highlighted much more recently (Ashton and McNabb, 1994). Like Gilead (1970), Isaac was also concerned with size variation and its meaning, noting the tendency for bifaces to decrease in size through time, and correspondingly to change in shape (Isaac, 1977; McPherron, 2000).

My own work emphasized the importance of size transformations, in demonstrating cognitive/processing abilities. The ability to project the same design at different scales was stressed, as was its relevance as a precondition for the practice of artistic and mathematical abilities as expressed in modern humans at much later dates (Gowlett, 1982; 1984). Subsequently Crompton and Gowlett (1993) showed in allometry studies that there are systematic shape shifts in bifaces according to size. These have such an effect that doubling the length of a biface – which according to geometric principles should raise the mass of an object by a factor of 8 –

in practice raises it only 5 times. This principle is widespread in bifaces across Africa (Gowlett et al., 2000).

Such findings raise the question of how rules might operate in biface production. The studies show that biface manufacture cannot be governed by a simple fixed “mental template”, since this would yield neither the fields of variation within a dataset, nor the local variations observed from site to site and even within sites. (Although I am regularly cited as a supporter of the “mental template”, I have argued that the term calls to mind an *idée fixe* too fixed!) Elsewhere it has been argued that a better term is “instruction set”, or set of parameters, but this still leaves the question of how many of them there are and how they are managed by the brain (i.e., were managed by the brain of *Homo erectus:* Gowlett, 1996). This is a good point to acknowledge the explorations of Wynn (e.g., 1985) in terms of defining and explaining geometric elements in psychological terms, and of McPherron (2000) in exploring pattern at a more general level. McPherron finds and examines pattern but is cautious about interpreting it in higher-order terms, in effect emphasizing the need to separate more deterministic aspects from those of design, in explanations that embrace different factors (McPherron, this volume).

Data

This paper is based largely on material from East African sites aged ~1 ma but, to gain some geographic and age range for testing its principles, extends to use of North African material from the STIC site at Casablanca (Biberson, 1961; Raynal and Texier, 1989; Raynal et al., 1995) and material from the recent excavations at Beeches Pit in Suffolk, UK, aged about 0.4 ma (Gowlett et al., 1998; in press; Gowlett, in press; Hallos, 2004; 2005).

The idea of retrimming is sometimes advanced to account for part of biface form. The dataset is chosen so as to address clearly the issue of trimming. For example, the STIC assemblage from Casablanca has very similar dimensions to bifaces of Kilombe and Kariandusi, but is based in large part on cobble blanks. The position of remaining cortex gives particular lessons, and also illustrates clearly the limited extent of trimming (Figure 1). Kilombe specimens also frequently preserve the form of a large flake blank, and a previous study comparing Kilombe specimens retaining large areas of cortex with those that are heavily trimmed showed very little difference in their respective dimensions (Gowlett, 1996). This is not to say that such trimming is not an important factor in some assemblages, merely that it appears to occur to a limited extent in contexts such as these where raw material was plentiful.

The issues of modes and fields of variation are certainly relevant to sites such as Gesher Benot Ya‘aqov and ‘Ubeidiya (Goren-Inbar and Saragusti, 1996; Goren-Inbar et al., 2000; Bar-Yosef and Goren-Inbar, 1993), which show different ranges of output and different uses of raw materials (Belfer-Cohen and Goren-Inbar, 1994).

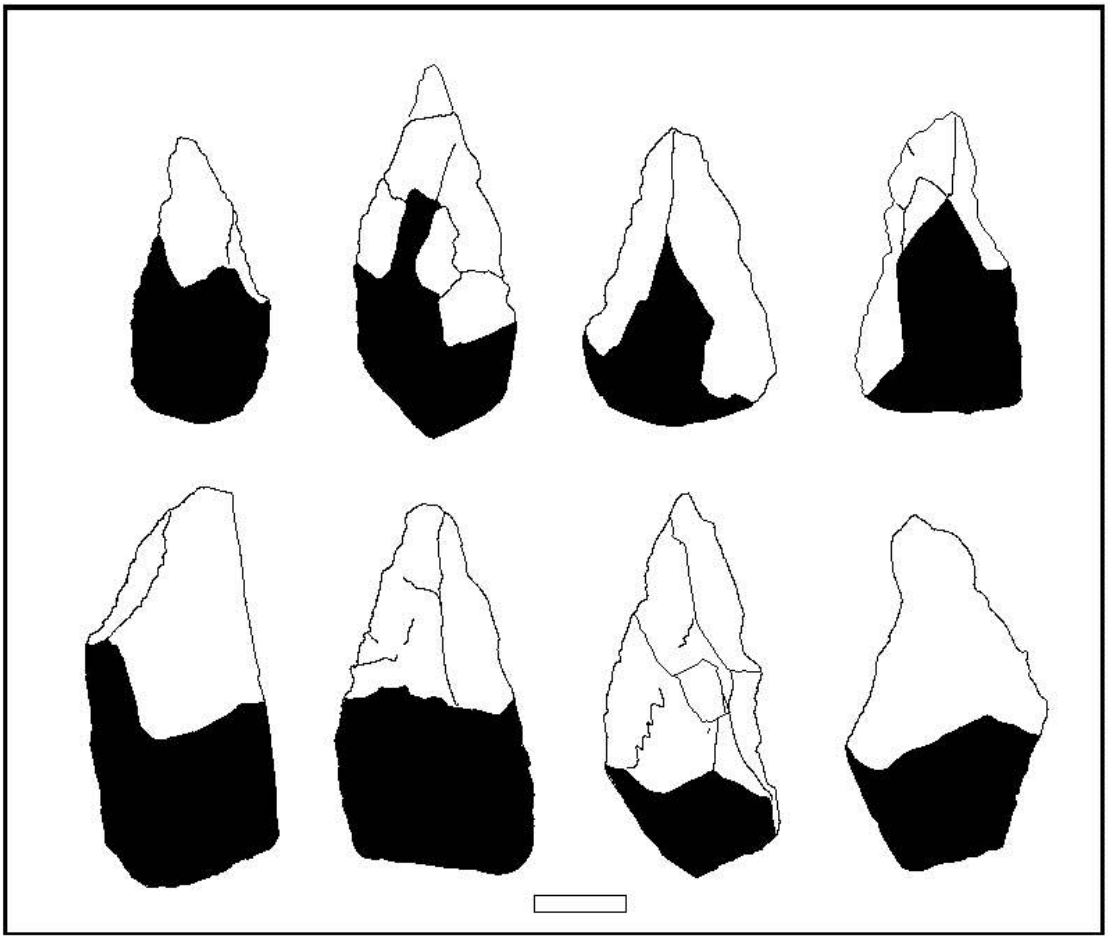

Figure 1: Bifaces from STIC, Casablanca,made on cobble blanks and retaining cortical butts, 5 cm scale.

Emerging questions

Can we isolate the key driving concepts, whatever they were, that underlie biface manufacture? Did early humans possess formal geometric concepts? How did they handle the multivariate processing load imposed by the concepts that are undoubtedly necessary for biface production?

As the idea of an overt geometry causes problems, it may be best to consider first an analogous situation, in which a chimpanzee (not possessing language, but in a cultural context of simple technology) makes an ant-dipping stick and then fishes for ants. First, there comes the perceived need, to do the fishing for food; then selection of a suitable stem; then its preparation for use. The chimpanzee must have an overview of the process, and it must in some way operate according to rules and through a process of testing (cf. McGrew, 1992; Byrne, 1996). It must have a knowledge of (say) appropriate length, but can we here distinguish, or is it meaningful to distinguish, between practical knowledge (based on cultural tradition and experience) and a more abstract concept of length?

It is important now to see that this is not simply a philosophical problem of “what is an abstraction” (an old debate; cf. L. A.White’s complaint about Kroeber’s notion of abstraction in culture: papers in White, 1987). Psychologists in varied studies note that there is a system of short-term working memory, involving subcomponents that are apparently capable of providing both assistance to one another and interference with one another (e.g., Pearson et al., 1999): the visuospatial sketchpad and the phonological loop. Here, in introducing these and their relevance, one might note that a) the visuospatial sketchpad must have evolved earlier, and in some sense must be shared by many species, especially primates engaged in carrying through complex routines; b) the phonological loop must evolve with language, would be helpful for describing geometric concepts, and possibly would assist in reducing cognitive load in some complex tasks.

In a recent paper Wynn and Coolidge (2004) discuss some other aspects of working memory, relating to possible differences between Neanderthals and modern humans. Alongside these components of mind, other scholars, with reference to modern human classification capabilities, note a hybrid system of “fuzzy sets” and precise rule systems (e.g., Pinker, 1999). These too provide opportunities to explore continuities between animal and human minds. Biface groups embrace large variations and as a whole can be seen as a sort of fuzzy set. They do, however, sometimes embrace some precise rules (e.g., decision: work this edge to a straight line).

The aim here, following the chimpanzee example, is to work from a notion that driving needs are expressed initially in a combination of procedural and declarative aspects, which I will describe here as “imperatives”. Each is a rule-set corresponding to a perceived need (and somewhat paralleling the name of “primitives” used in artificial intelligence programming). (The choice reflects the difficulty of language in issues relating to the origins of language.)

The imperatives argument does not represent a simple instruction set, such as might tell a computer-controlled machine to render the form of a biface (mindless execution). The imperatives in effect lay the skeleton for what is needed; they dictate the geometric solutions that are possible, and which must then be delivered through a technical procedure. These parts must be tied together through a certain amount of looping; it is part of the technical procedure of implementation that a multivariate handling of variables must be managed. All this represents the solving of 3D problems in real time, but one of the simplifications for early humans, which we tend to take for granted, is that separation of planes allows 2D solutions (discussed further below).

The imperatives argument

The argument to be developed here starts from the point that any manufactured tool is by definition multivariate. In the simplest form it starts as a “lump” in the hand, and from that point it acquires characteristics that are variables. We know, from cognitive science, that the mind builds up or holds internal appreciations of objects in similar ways. As an illustration, a full change of state takes around 400 milliseconds to realize; but in becoming aware of a person, humans require further time to analyze and recognize the individual, taking around 800 milliseconds. In general some hundreds of milliseconds are required for changes of state, with attentional deficits or interferences between tasks being characteristic in human processing (Raymond, 2001; Arnell, 2001).

The essence of tool *making* is that the maker finds ways of projecting such recognized qualities or variables into the material. This would be the case for the chimpanzee making an ant-dipping stick, which must have certain properties, which can only be found be testing possibly suitable tool blanks (twigs) against a kind of mental visualization. Where there is a cultural tradition, there *has* to be a kind of duality, in which the inner artifacts of the mind parallel their external counterparts.

How many variables are involved? This is the key question both for understanding the Acheulian artifact, and for gaining any lessons about early human cognition. The studies mentioned above have depended on archaeologists assigning variables intuitively; in the interests of achieving comprehensive description, they have tended to work towards using larger and larger numbers of variables, organized in formal geometric schemes. As Crompton and Gowlett (1993) noted, it is not always easy to distinguish between true variables and those that are constructs of analysis – thus Breadth seems a true variable, but "Breadth at the middle" (BM) need not be.

Although formal schemes employ large numbers of variables, observers tend to see these as overstudy, departing from reality. It seems likely, simply from the difficulties that modern humans have in handling several variables at the same time, that the "true" number of variables would actually be quite small, and that to an extent they might well be handled sequentially in the manufacturing process.

On these grounds, it would seem likely that multivariate objects would be "packaged" around only a few basic principles, to make up an effective instruction set. In the case of bifaces/large cutting tools, I would argue that the following "imperatives" are the basic necessities:

Glob-butt

This is the starting point – a "glob" that is held in common, e.g., with the Oldowan chopper, and which in a handaxe is the conservative butt zone, varying relatively little between biface categories and sizes. It need have no set shape in itself, but embraces the concept of "centered mass" (3D centre of gravity) that is crucial in the intuitive appreciation of any artifact.

Forward extension

This is the dominating principle that distinguishes the Acheulian from the Oldowan; key points in it are the provision of leverage through forward extension, and the weighting of the distribution, so that the butt-mass balances out the extension, which must therefore be thinner if longer.

Support for working edge

The purpose of the extension is to provide support for working edges, which are varied in possibility (Figure 2). Various working edges are possible, but whichever has been selected for implementation, the extension must offer support to them in relation to the butt, affecting the nature of the connecting geometry.

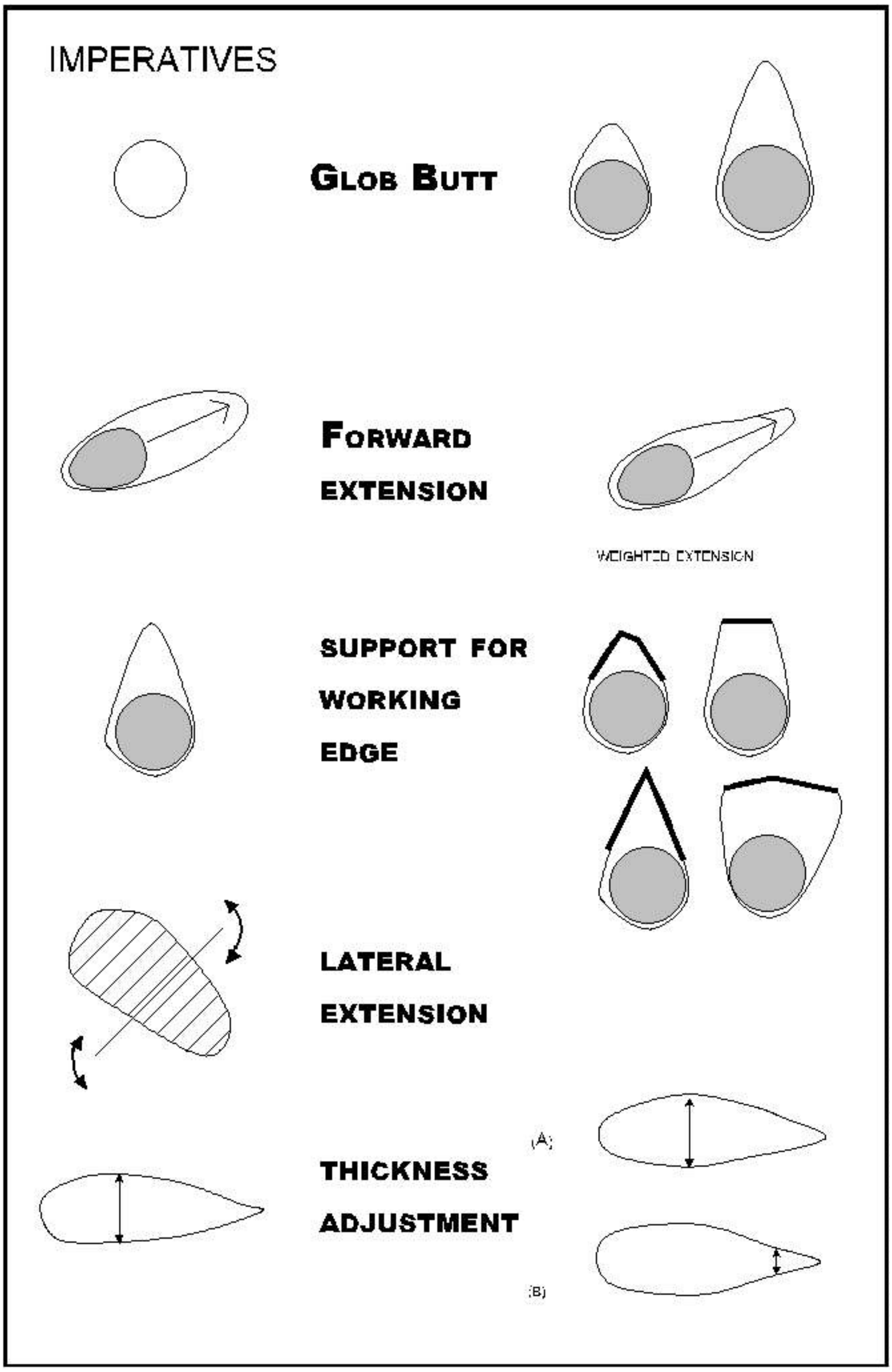

Figure 2: Imperatives: the basic series argued for in this paper.

Lateral extension (planeness)
The purpose of lateral extension, usually worked around a major plane, is to offer resistance to torsion and to give support to long working edges.

Thickness adjustment
Thickness adjustment allows the general mass to be tuned without affecting most other features (such as "footprint"), but also allows adjustment of working edge angle. There can be a conflict between these two needs, and they should perhaps be seen as two related imperatives: a) thickness adjustment to control mass and b) thickness adjustment to control edge angle.

Skewness
This is commonly seen in bifaces and might be summarized as a working response to the needs of handedness.

This limited set of imperatives may well be enough to account for most of the basic form (and forms) of bifaces. "Knock-on" factors may well generate most of the rest of the instruction set, but implementation might well require additional conceptual elements – the point at which one might consider whether there are genuine subdesigns that may introduce further imperatives. Skewness is a borderline case, probably a response made in relation to demands imposed by handedness. Other components may be regarded as invoking particular subroutines. At a certain stage the maker might concentrate on preparing a particular "edge" and this might be regarded as entailing a call for a particular set of stored knowledge.

A point about the imperatives is that each embraces simple concepts, encountered in the world; they need not (perhaps) be conceived in abstract geometric terms, but they do have implications of geometry.

The reality of some of these principles can be tested, in particular circumstances.

Butt
For a start, the mean weight of core tools in the Oldowan at Olduvai was ca. 0.5 kg over a long period (Leakey, 1971). The mean weight of many biface sets in Africa is similar.

Oldowan core-artifacts are not completely globular, but they suggest a starting point of compactness. Relative to these, the Acheulian shape transformation is clearly achieved by forward extension from a butt area that can be seen as conservative (Crompton and Gowlett, 1993).

Is this butt a reality? Allometry studies have shown that the variables concerned with the butt vary less than others and with a negative allometry, such that small bifaces have a relatively large, thick butt zone, and large ones a relatively smaller, thinner one (Crompton and Gowlett, 1993). More conclusive, and highly illuminating, are those cases where bifaces are made from cobble blanks. Normally, interpreting working edges objectively can be difficult, particularly as manufacturers would usually work around the entire circumference of a blank. It is however possible to turn to special cases in which biface sets were worked on cobble blanks. In these, such as STIC Casablanca, the maker chooses how much of the circumference to work, and thus gives an opinion as to where pre-existing form is more desirable than altered form. The pattern of such specimens clearly illustrates the importance of and extent of the butt (Figure 1).

Extension

Extension is also plain in such specimens: this long axis can even be seen as the key concept of the "classic" biface. Generally, however, it seems that it must be "weighted extension" in which the compact butt balances the longer thinner working extension (Figure 2): Crompton and Gowlett (1993) found a contrasting allometry of butt thickness and tip thickness, such that in larger bifaces there would be a tendency to keep weight towards the butt of the handaxe, minimizing the weight of the extended tip.

Edge support

The working edge or edges must be the basic necessity of a working tool, but various configurations are possible (Figure 2). There is not necessarily continuity between these various options. The selected option may dictate form all the way back to the butt – edge length and edge angle would seem to be the major determinant of variability in a biface, apart from size-related factors. Thus the imperative for a butt with appropriate mass, and the imperative for a particular edge, would need to be put together through interpolated form.

Lateral extension

Lateral extension (i.e the extent of stretching out the specimen from side to side) might be thought to be simply a consequence of the last observations, but the overall width of bifaces appears to vary much less than the lateral extension of working edges. Thus other influences appear to keep the biface to an overall width that is highly related to length (nor is mass the explanation, since this can be more easily controlled through varying thickness). The point of maximum breadth moves forward allometrically in large bifaces, but generally remains fairly far back. These points emphasize a probable need to reduce torsion effects by keeping the maximum width accessible to hand control.

Thickness profile

Thickness profile is of particular interest, because there are signs of two conflicting imperatives – first, to control overall mass by selecting the appropriate thickness; second, to control tip thickness and working edge angle through a locally focused thickness adjustment. Principal components analysis (see below) and allometry studies both indicate a tension that was usually resolved through increased thinning near the tip.

Principal components analysis is a useful tool for considering some of these aspects of variation. In the PCA of Kilombe it is very noticeable how little of tip variance (TA) is accounted for in the first two principal components – it may well be a true variable considered separately by the maker (Figure 3).

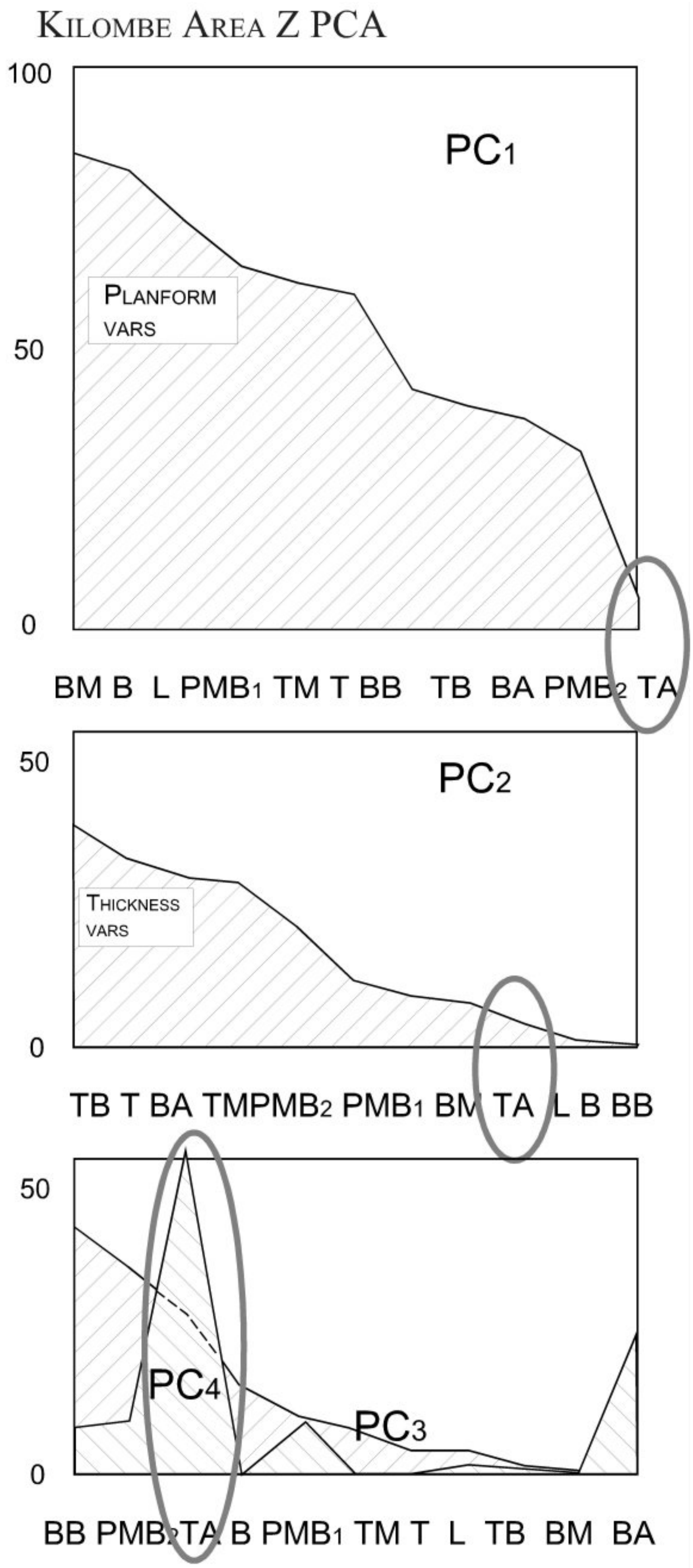

Figure 3: Principal Components (PCA) for Kilombe Area Z. TA (thickness near tip) is seen to be strongly dissociated from other thickness measures, with low loadings in PC1 and PC2, but high loadings in PC3 and PC4. (A similar pattern is seen in bifaces from Kalambo Falls A6: cf Gowlett et al. 2000).

PCA can be seen as a tool for determining where the variance lies in a biface, and what aspects of it are related. It does not disentangle things that co-vary. Generally PC1 reflects size variation and is interesting for showing which elements tend to vary geometrically with size change (mainly major dimensions of planform), and which have axes of variation that do not relate to size (mainly the thickness variables, dominating in component 2). The value of PCA is that it establishes real continuity across variables rather arbitrarily chosen by archaeologists – by objective algorithm it pools the variables if they contain the same information, and separates them if they do not. Hence the importance of the clear separation of TA, hardly represented in the first two components, and tending in other biface sets to generate its own component.

Variable handling and transforming abilities

The ability to project a design at different sizes (transformation) is impressive, but the PCA example would suggest that this task, although one key to later artistic and mathematical transformations, is not itself the most computationally intense. Adjustment of other variables, as required by the particular size, would seem a more demanding task, especially if several variables must be handled at once.

Apart from general reasoning, both the PCA and allometry analyses pick out elements of deep pattern in bifaces, suggesting that at least several variables interact, perhaps the ~6 imperatives argued for here, perhaps more. Anyone arguing for fewer would need to find convincing alternative explanations for the systematic PCA and allometry results.

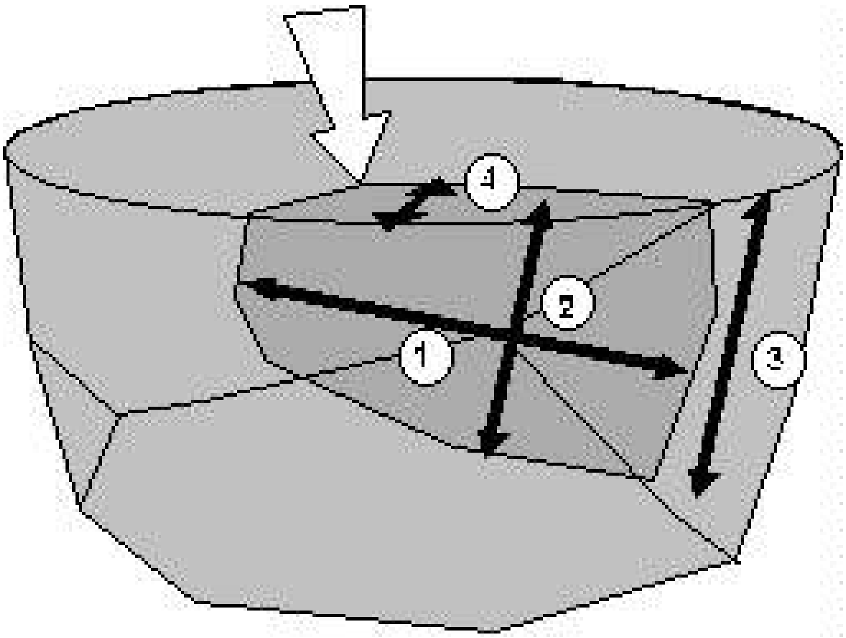

Figure 4: Control of several variables on a core, indicating the potential that a maker has to adjust these "in the mind's eye" before finally choosing the thickness parameter and releasing the flake.

Figure 4 illustrates the possibility of a maker achieving a position of being able to control for several variables, without being involved in heavy computation. As in many other human tasks, preparation achieves that position, and this argues for seeing the concept of core preparation at an early date. As argued long ago (Gowlett, 1984), the maker needs to see the outline of the blank "in the mind's eye" – i.e., to be able to use a visuospatial sketchpad, or even a series of them related like the still frames making up a film. If the core surface is correctly curved, the initial control will operate over length, breadth and potential edge conformation; with these held constant, the control then moves to thickness, which can be freely adjusted as platform depth (4 in Figure 4).

Such activities would seem to encourage the separation of planes. The potential for that may stem from the natural configuration of stone flakes, but it should also be noted that in the normal process of vision the human eye makes 2D images on the retina, then combining them through neural processing to gain a 3D image. The brain may thus have some predisposition to revert to 2D concepts, through a kind of mental "reverse engineering".

Modes and modalities

Among bifaces, various subtypes are noticeable to the modern mind – the question is, were they recognizable to ancient minds, seen as separate categories? Isaac's (1977) discussion showed the difficulties of this view, as many early artifacts seemed not to conform with particular design targets. In theory the parameter of length could have a single mode, but another variable, say thickness, could be bimodal, perhaps because there was more than one design target, or for some other reason. The mode of a distribution is taken here conventionally, simply as the point or interval with the highest frequency of a value. The search for modality, then, precedes the interpretation of modes. Cluster analysis offers one approach to picking out modes in a field of variation. An early application at Kilombe picked out rather general variation that might correspond with "classic" Acheulian vs. Developed Oldowan bifaces, or even with one-handed and two-handed use groups, but it did not distinguish morphological modes of handaxes and cleavers. A recent study uses Wishart's Density Analysis and succeeds in picking out small groups of very similar bifaces (Gowlett, 2005; Wishart, 1999). The geographic expression of these groups was tested, with the finding that in many cases most members of a group would lie close together on the ground.

The imperatives approach may provide some explanation for such a pattern of variation. Arguably, at any moment, a maker is influenced by a set of needs. In effect a pointer is moved to one place within the field of variation – in theory any point within that field. Hence, overall, the continuous variation and the absence of strong modalities within it. One individual maker of tools, however, may in similar circumstances be subject to similar imperatives, and reproduce the same solution a number of times over, as is perhaps the case with the small Kilombe groups. Intriguingly, these small clusters often differ most from the main population in thickness rather than footprint (Gowlett, 2005).

Beeches Pit

The analyses discussed here have relied on large sets of data, cumulatively representing something like the total range of biface output from certain past populations. In contrast, recent excavations at Beeches Pit, Suffolk, UK, have yielded a very small number of bifaces (Figure 5), in particular contexts (Gowlett et al., in press). How can these supplement the information of the large series?

They emphasize the nature of individual decisions within group norms. First, in the hearth area of AH, a cleaver about 14 cm long was probably broken during retrimming. It is an average specimen, near the centre of any distribution, but its form is dominated by its need to have the cleaver edge (produced by tranchet blow). As discussed above, the cleaver edge is less than the breadth of the piece. Nearby, a roughout shows the effort to manufacture a similar specimen, traceable in a refit series of nearly 30 flakes (Gowlett et al., 1998, in press; Hallos, 2004; 2005). It was abandoned before completion because of a flaw in the flint, but the point to make here is that the knapping could have continued for several more strikes (and as a core this could have yielded numerous additional flakes). It was abandoned because the knapper could see that it failed the test to become the desired biface. Then there is a small lopsided specimen, in which the need for a useful edge clearly outweighed the need for fine symmetrical shape. Likewise, a thick tabular piece, the heaviest specimen, has a good edge, but is not made in a complete biface form.

Figure 5: The bifaces of Beeches Pit, Suffolk, UK, 5 cm scale.

Twenty meters away, and perhaps thousands of years later, two small bifaces found together show the need for small size and delicate edging. They cannot be confused with the other bifaces – they are several times lighter. They represent different choices (and would merit a separate discussion). At that moment, on that channel bank, the makers were preoccupied not with using the abundant local flint to make something big, but with some particular needs that led to a particular solution.

Discussion: the imperative approach

The imperative approach represents a conscious effort to seek out some true or natural variables governing biface form and variation, at least as hypothesis. It seems able to resolve some of the problems highlighted by various authors from Isaac onwards. The central point is that the biface is a multivariate object, and that its conception and manufacture therefore impose a heavy cognitive load, perhaps especially on short-term working memory. The "imperatives" are primary needs that cannot be implemented independently, but only by reference to the others – hence the link with levels of intentionality.

Previously I have argued against the notion of template as being too hard and fast, and talked of "instruction sets". With an instruction set a computer could generate the form of a biface mindlessly. If imperatives get closer to mapping the number of true variables and how they interact, they also hint at the need for integrating or smoothing abilities to bring them together in a final package. It is in this combining stage that there is the need for geometric and transforming abilities.

The progress comes through understanding that in talking of "elements of design form" one need not talk *initially* about a sort of geometric form, but rather about a set of imperatives or pressing needs that must be balanced or traded off to get a solution. This behavior, responding to need, is likely to demand the handling of geometric concepts in the realization (packaging) of a solution.

These "secondary" elements, such as straight lines and flowing curves, are provided not (initially) for aesthetics, but because they provide the simplest solutions. Apparently, however, it is this very pressure for simple solutions that encourages certain decouplings of "concepts", which we can begin to see as elements of design form. We could say that "thickness" is handled separately from "footprint", as a number of studies show, partly because this aids in adjusting mass, partly because it aids in setting edge angle, and partly because these elements fit well within the reduction process (and perhaps also, because of transferred knowledge from other, possibly wooden, tool forms).

The effect, though, is that the 2D major plane is handled rather separately from the third axis, and that this may be another means of reducing cognitive load. Such behavior then leads to the effect being "imprinted" in the cultural tradition. We hesitate to say "also in the human brain", but it is a fact that brain hardware has changed during our period, that language has evolved, and that the phonological loop of short-term working memory has emerged.

The imperatives also help to explain symmetry. Balance is important or even crucial in the use of an artifact, and excess mass in any inappropriate direction creates unwanted turning moments. Symmetry restricts these to the desired extension and anti-torsion properties, eliminating other conflicting tendencies.

As argued above, the imperatives also help to address questions of the field of variation recognized by Roe, and the puzzle tackled by Isaac, on whether there were true "design modes" within the field. Isaac pointed out the difference from modern artifacts in the proportion of early artifacts that are not standardized and resist "typing". Each time an individual embarks on making an Acheulian large cutting tool, he/she is in effect moving a pointer to a particular position within the possible size-shape variation. The decisions involve weighting some or all of the imperatives, not necessarily at the same time. Decisions relating to raw material need to be taken early on, but others arrive at the final position only towards the end of the process.

These observations relate to standardization issues discussed recently, for example by McNabb et al. (2004). Those authors interpret high and low standardization as reflecting strong or weak cultural tradition. An alternative view is that the whole repertoire of biface making is always in cultural memory, but that the positions of "pointers" are determined by the relative weighting of basic imperatives in the particular context. The views need not be incompatible, because cultural views may well influence the limits of tool-making in a particular situation. In the nature of culture it follows that even individual traits can be an element of strong or weak tradition in a particular society.

The archaeologist might see particular modes (and recognizable standardization around them) if the set of local imperatives (and the tool blank availability) coincided in pointing again and again to the same solution. In fact, the nature and extent of the gross field of variation is so similar in many assemblages that it illustrates rather well how they do not all coincide. Nevertheless, subgroups of very similar specimens as isolated at Kilombe may well indicate that an individual at a moment may repeatedly aim for and hit the same target (Gowlett, 2005). The field of variation may also be limited in certain ways, so that for example the specimens of Gesher Benot Ya'aqov, which closely resemble African series made on lava blanks, do not include a continuum of thick pick-like specimens, although these could have been made from the available raw material.

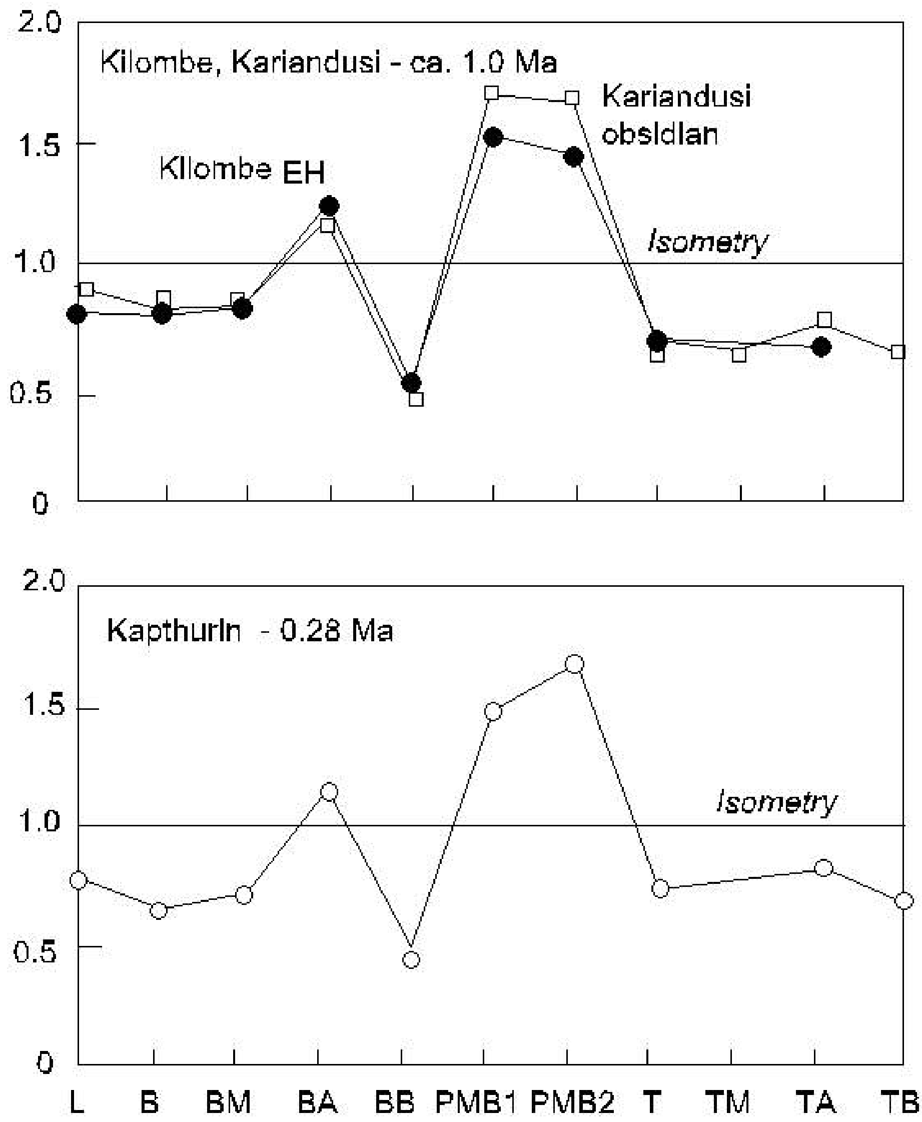

Figure 6: Allometry profiles from biface sets show that deep-seated patterns operated through very long periods of time. Those for early sites at Kilombe and Kariandusi (dated 1 million) are replicated virtually exactly by the far later series at Kapthurin (ca. 280,000). This is the more remarkable because the Kapthurin specimens are made by full Levallois technique (refs in text).

Language

Models about the origins of language vary widely. Arguments that are now being aired tend to place language earlier, perhaps around 0.5 ma (Dunbar, 1996 etc.), in contrast with other views that place it within the last ~150,000 ka. If the earlier dates are correct, the Acheulian, and the bifaces or large cutting tools in particular, provide the best structured evidence of human activity through the crucial period, both in the form of the tools, and their movements within landscape. A most striking element in this picture is the continuity of deep pattern through an immense period indicated by allometry studies. Figure 6 shows almost identical allometry pattern in the early bifaces from Kilombe and Kariandusi, and in the far later series from Kapthurin made by Levallois technique (Gowlett and Crompton, 1994; Gowlett, 1999; McBrearty, 1999; Deino and McBrearty, 2002). Do the rule systems explored here indicate any connection with language? Perhaps the strongest evidence, though requiring much deeper exploration, is that multivariate operations generate a high cognitive load, and that emerging geometrical ideas could possibly serve to reduce that load, as is hinted at in interactions between the visuospatial sketchpad and phonological loop for modern humans. Arguably, then, the geometric elements represent concepts which would have a selective advantage, partly for offering working solutions, and partly for allowing easier mental handling and social transmission of complex ideas.

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