An "aesthetic" explanation for the symmetry of Acheulian handaxes : some neuropsychological insights.

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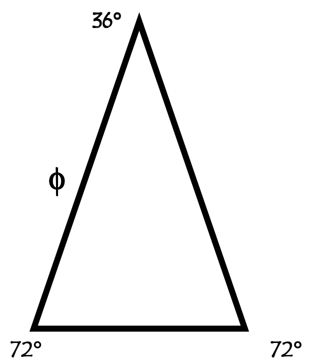
There has been much discussion as to the significance of the refined symmetries that typify late Acheulian handaxes. Some investigators argue that this symmetry goes far beyond the functional requirements of a tool and may therefore be informative as to the cognitive outlook of those responsible for the end product (Wynn 2002). It certainly appears to be the case that these tools show a preference for symmetry absent in earlier Acheulian examples (Saragusti and Sharon 1998). One of the features of symmetry in later handaxes is their uniformity across wide geographical locations and throughout a considerable period of time. Conservatism of this order continues to perplex commentators who, for the most part, have tended to account for this homogeny in terms of functional demands or raw materials (Machin et al 2007; McPherron 2000; White 1998). However, as the symmetry of late Acheulian tools purportedly goes beyond functional requirements (Wymer 1982) it is assumed something about cognitive and cultural determinants may be involved. Whether this is the case, however, remains controversial. Here, I present evidence showing how the increasing preference for symmetry may have arisen from an "aesthetic" bias on the part of hominins that led to the making of congruent profiles of late Acheulian bifaces.

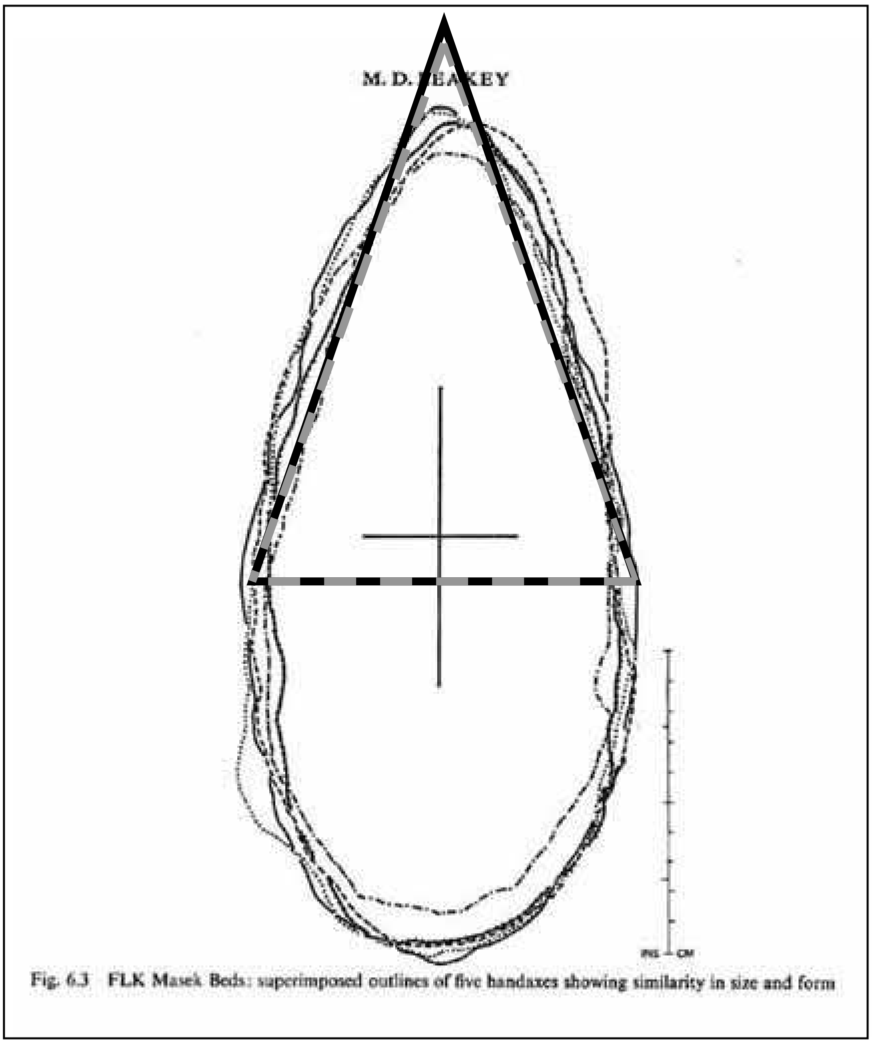
Despite the sensationalism and controversy that has surrounded what has been termed the golden section [ϕ], the consensus amongst those who have taken a scientific interest in the subject seems to be that there may be something genuine to the effect. In other words, when confounding variables are controlled, there still seems to be a preference for the underlying proportions that lead to shapes based on the golden section. A review (Green 1995) of the many serious attempts to pin down the phenomenon came to the conclusion that the effect is indeed real. A more recent study reinforces this view by showing how the effect can be isolated and is therefore liable to objective scientific scrutiny (Russell 2000).

By dividing a straight line into the proportions of the golden section (approximately equal to 0.618) a golden rectangle (not to be confused with Aristotle's golden mean) or phi can be produced Interestingly, Green (1950) has shown how the golden section can also be used to produce the golden triangle. The shape of the golden triangle is determined by the three angles pertaining, as shown below in Figure 1. This is derived from a regular pentagon by extending the sides so that they intersect with each other – each point of the resulting pentagram thereby produces an isosceles golden triangle. Such a triangle has within it copious examples of the golden section. For example, the ratio of each of its diagonals to the base line is ϕ. The golden section is also found in the component angles of the triangle as the cosine of 36° is $\phi/2$, and the cosine of 72° is $\phi/2$, and a unique property of the Golden Triangle is that it can be divided into smaller Golden Triangles (Livio 2002).

Figure 1. The Golden Triangle.



Given that the Golden Triangle is based on the golden section and there seems to be a psychological preference for this shape, how might this relate to the symmetry of late Acheulian tools? From the perspective of Acheulian handaxes, there seems to be a particular profile that is especially ubiquitous – an ovate-like outline that Leaky and Roe (1994) have drawn attention to, also referred to as the "tear drop" shape (Figure 2). Leakey and Roe's example is particularly apt because it shows how five Acheulian tools seem to conform to a particular shape profile.



Key: Continuous black line = triangle created by connecting widest points of axe to form base-line with converging uprights meeting at the tool's apex.
Broken grey line = Golden Triangle

Figure 2. Golden Triangle superimposed on Leakey and Roe's (1994: fig. 6.3) illustration showing how the averaged triangle based on the five handaxe outlines is virtually the same shape as the surperimposed golden triangle. Leakey and Roe comment that "FLK Masek Beds: superimposed outlines of five handaxes showing similarity in size and form. Four found together, the fifth 10 feet away. All about 27 cm in length." The elongated ovate shape. is a characteristic of Acheulian tools of the Later Acheulian period. (Illustration © Leakey, M. D. and Roe, D.A. (1994). *Olduvai Gorge. Vol. 5*. Fig. 6.3. Cambridge: Cambridge University Press.)

If one were to draw a line connecting the two widest side-points of any such tool, this produces the base of a triangle of which the point is formed by following the contour of the converging sides towards the tip of the tool. By superimposing the Golden Triangle (Figure 1) onto such an outline (as in Figure 2) one immediately sees how the angles and lines of the Golden Triangle closely match.

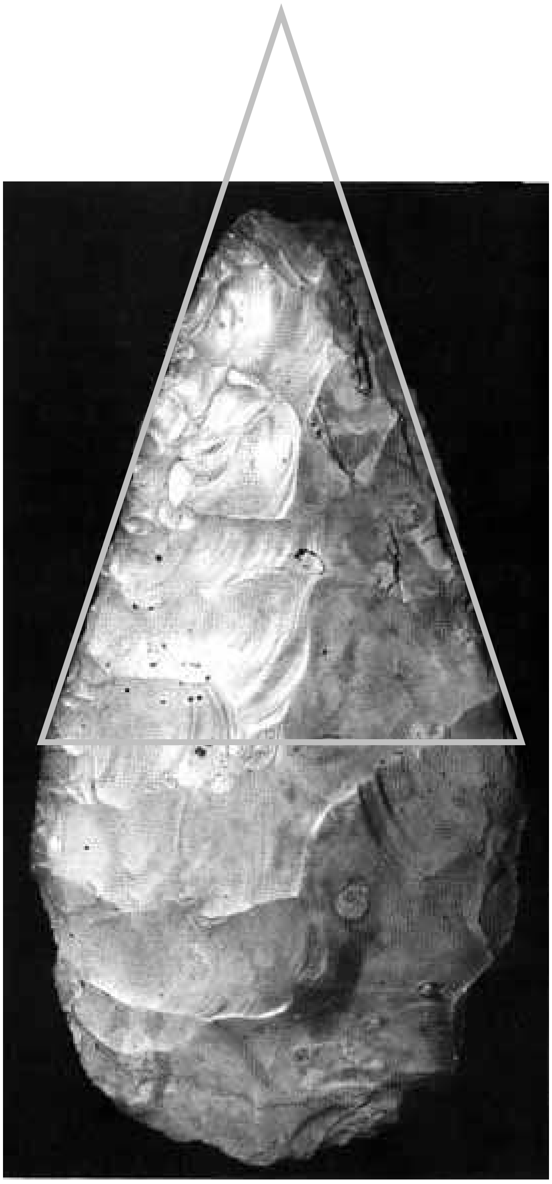


Figure 3. Golden Triangle superimposed on giant Acheulian hand-axe. Acheulian industry, Furze Platt, Maidenhead, England. Length: 39.5 cm or 15.6 inches; weight 7.5 pounds. The Furze Platt industry belongs to the Pointed Cordiform Group and dates to c. 300,000 BP. Photo © Wymer, J. (1982). The palaeolithic age. New York: St. Martin's. Plate XIII (Photograph: reproduced courtesy of the Trustees of the British Museum of Natural History).

Figure 4. The Elandsfontein hand-axe with superimposed golden triangle showing correspondence. Taken from: http://antiquity.ac.uk./ProjGall/marshall.images/fig5.jpg>

Acheulian handaxes, such as Furze Platt (Figure 3) and Elandsfontein, South Africa (Figure 4) also demonstrate the same striking correspondence. The Furze Platt object is particularly important because the large dimensions are thought to preclude functionality suggesting that shape itself might have become the main focus of concern (Kohen and Mithen 1999). Similarly, Wymer (1982 p. 103-104) points out that many perplexing facts about handaxes are inexplicable from a utilitarian perspective e.g., "the large, magnificently made handaxes which seem too good or too heavy to use." Yet, despite this impracticality, these examples still conform to the proportions of the Golden Triangle. Handaxes that are too large and wieldy to have a practical function thus present a unique opportunity to test the hypothesis regarding the Golden Triangle. The prediction would be that such tools would demonstrate greater statistically significance in conforming the Golden Triangle than would be the case for handaxes of a more functional size.

Given that stone tools are difficult to manufacture, we should expect to find widespread differences in shape according to the material used, yet, except for local variations (Gowlett, 2006), this seems not to be the case (Sharon, 2007). In this respect, "tear drop" Acheulian handaxes from other sites betray a similar correspondence (see Marshal, Gamble and Roe's Data Base). Interestingly, Gowlett (1993) has shown how the length to breadth ratio of Acheulian tools tends to be preserved despite large differences in size. Could the appearance, longevity, and universality of symmetrical handaxes be accounted for by the preference for the golden section as manifest in the Golden Triangle? The close correspondence does seem to be more than a co-incidence. A strong claim would be to propose that this shape is derived, and uniquely predicated, on an aesthetically-defined predisposition for the golden section. A weaker claim would be to propose that although the basic shape may have been initially dependent on functional considerations, the later refinements were dictated by the preference for the golden section. The null hypothesis is that no relationship exists between the symmetry of Acheulian handaxes and the Golden Triangle.

Gowlett's (1982;1993) finding of a surprisingly standardised length to width ratio, despite disparities in size, is a proportion that also conforms to the golden section (see Figure 5). This has been interpreted as the "same design at different scales" which, although it might be based on a "mental template," is subject to instruction sets and procedural factors that give rise to local variations (Gowlett 2006). that, nevertheless, cluster around a "modal shape" (McPherron 2006, p.274) Gowlett's analysis (1982), however, merely noted the correspondence of the golden section to Acheulian tools. The present analysis, on the other hand, while offering data to support Gowlett's findings, shows how applying the Golden Triangle to the profile of Acheulian handaxes can also be revealing. Interestingly, McPherron while critical of Gowlett's interpretation as to why this standardisation exists, unwittingly demonstrated how the regression line that charts the average length to width proportions for African, European, Indian and Near Eastern Acheulian assemblages(see McPherron 2000, Fig.2), also closely coincides with the proportions of the Golden Triangle.

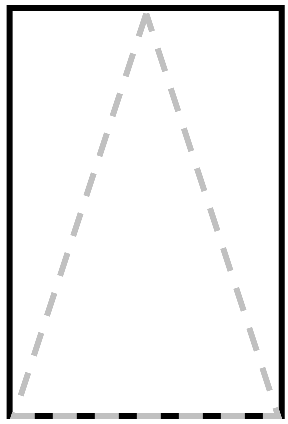


Figure 5. Gowlett's (1993) averaged rectangle based on width to length ratio taken from a wide sample of different sized Acheulian handaxes from Kilombe, Kenya showing close correspondence to the Golden Triangle. The same dimension conform to McPherron's (2000) data from a range of diverse sites.

SYMMETRY IN THE BRAIN

A logarithmic spiral can be obtained from the proportions of the Golden Triangle (Livio 2002). Such spirals are frequent in nature because they appear to be an efficient and economic means by which growth occurs e.g., sea shells. Growth patterns, therefore, exploit the golden section because this is one of the most parsimonious and efficient ways by which such things as cells can fit together (the same applies to crystals). The golden section thus seems to be common in natural forms. The cognitive imperatives contained in neural pathways and circuits may well have been dependent on such dynamics at micro and macro levels with generalised processing patterns emerging as a consequence, thereby directing the preference for particular kinds of symmetries. On a more cautionary note, however, there have been numerous claims as to the relevance of the Golden Section in relation to different areas of concern many of which have been found to be spurious (examples in Livio 2002) mainly because those making such claims have not taken the trouble to disconfirm their assertions by way of concerted efforts at falsification or the parameters chosen have been arbitrarily selected in order to prove the case. The hypothesis presented in this paper, however, that symmetrical Acheulian handaxes betray a close correspondence to the Golden Triangle can easily be verified or falsified in the light of further empirical investigation

The golden section may also be related to issues of symmetry. Kohn and Mithen (1999) suggest that the prodigious symmetry of Acheulian handaxes might be accounted for by sexual selection. Interestingly, most biologically important objects, such as predator or prey, are also symmetrical (Moller 1992; Johnstone 1994; Grammer and Thornhill 1994). More fundamentally, sensitivity to symmetry may have evolved because it is crucial for discriminating living organisms from inanimate objects. In fact, symmetry seems to act as an early warning system that directs the visual system to further scrutinise an object until full recognition has occurred (Ramachandran and Hirstein 1999; Tyler 1998). Experiments with functional fMRI imaging (Tyler 2002) have demonstrated that humans are able to accurately discern symmetrical objects in less than a twentieth of a second and the eye is particularly fast at discerning objects with vertical mirror symmetry, suggesting that this ability is hard-wired. The detection of symmetry, as Julesz (1981) has established, is therefore virtually automatic in that it precedes attention - the probable explanation for this resides in the fact that symmetry could be a characteristic of an advancing predator. And once symmetry has been detected, the eye will then only track those parts of the object that have not yet been assimilated (Locher and Nodine 1987).

It appears then that the visual brain is especially responsive to symmetry suggesting that this preference may derive from enduring evolutionary factors Hodgson n.d). Fundamentally, it has been established that the human brain contains neurones specifically tuned to symmetry in an area known as the medial occipital gyrus (MOG). This reflects the fact that other areas, such as the primary visual cortex, although at a more basic level of processing, are also preferentially tuned to particular features - in this case vertical and horizontal lines - to the extent that humans have a raised sensitivity to such lines because these are preferentially represented in the early visual area (Dragoi et al 2001). The reason for this is to be found in the fact that the natural visual array has implicit within it more horizontal and vertical lines than any other orientation. The evolution of the visual brain has therefore "picked up" on this tendency to the extent that it has become embedded in the underlying neurophysiology that has consequences for perceptual awareness. It may be that because the golden section is such a common feature pertaining to natural forms that the brain has also similarly picked up on this fact to the extent that the proportion is instantiated into the neural mechanisms involved.

Interestingly, one of the main ways by which visual information is thought to be processed involves the interpolation of the tuning curves of neurones. For example, and again at the level of the primary visual cortex, each neurone encodes for a particular orientation of line and it is the pooling of the tuning curves for each line that leads to access of the full suite of lines as perceived. The same procedure will be enacted as one climbs the visual hierarchy including at the level of the MOG at adjacent areas such as the lateral occipital area (LO). At this level there may be a limited number of symmetrical forms, encoded in view-dependent neural mechanisms, which, through a similar process of cross-referencing key views, are capable of accessing the full array of symmetrical forms (Tarr and Bülthoff 1998). One way to validate these fundamentals would be to predict that, when viewing a Golden Triangle, the MOG and LO of an individual undergoing a brain scan would be more active than when viewing symmetrical forms that do not conform to this configuration.

This hypothesis is supported by the fact that the perception of symmetry is something that seems to be inborn and develops early, even among young children from isolated communities that have no previous training or exposure to illustrations of abstract symmetrical forms (Dahaene et al 2006). In fact, Dahaene and co-workers found that core geometric concepts are part of basic human cognitive development shared by young children the world over. This study concluded that a sophisticated analysis of shape appears to be a heritage common to humans. Such factors may well have been appropriated by the increasing ability of *Homo erectus* to assimilate the "what" (involved with recognising objects by way of the "mental image") and "where/how" brain pathways (involved with manipulating objects in 3D by way of procedural memory) leading to better eye-hand coordination for the making of more efficient, evenly-shaped tools (Hodgson 2005). This accords with Saragusti and Sharon's (1998) findings of a gradual propensity towards more refined symmetry in such tools as a function of time.

The object of this paper has been to bring attention to the correspondence that may exist between the shape of Acheulian bifaces and the Golden Triangle. The hypothesis that such a correspondence does exist is empirically testable in that the dimensions of the Golden Triangle can be applied to a wider selection of samples with more accurate measuring techniques especially with the benefit of modern statistical methods. The prediction would be, if not a large share, then a considerable number (above chance) of "tear-drop" handaxes from the late Acheulian would conform to the shape of the Golden Triangle. Moreover, as indicated, large functionally-redundant Acheulian handaxes are predicted to especially correspond to the proportions of the Golden Triangle. A positive correlation however would not imply that archaic humans had a consciously derived aesthetic-sense that led to symmetrical tools, rather certain generalised perceptual principles necessary for the recognition of objects may have served to tacitly bias preferences.

Similarly, the notion of Gowlett (1993) and Frolov (1978a; 1978 b; 1979a) that some basic mathematical ability in terms of an intentionally-produced Euclidean geometry existed in those producing Acheulian tools, needs to be tempered by similar reservations. This ability was more than likely restricted to an implicit awareness of basic aspects of geometry mediated by the way that the visual/spatial areas of the brain process such information rather than anything more elaborate. This would explain the universality of symmetry based on the Golden Triangle in that this proclivity was mediated by enduring contingencies closely aligned to the functioning of the visual brain. Those citing variations in the symmetry of Acheulian tools as a sign of incipient cultural factors or a function of knapping processes, it should be noted, also admit that there is a striking standardisation to be found in Acheulian handaxes (e.g., McPherron 2000).

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