Man and environment in the Palaeolithic
H. Ullrich (ed.), E.R.A.U.L. 62, 1995, Liège, pp. 29-42.

Psychological worlds within and without: Human-environment relations in early parts of the Palaeolithic

John A.J. Gowlett*

Abstract
In seeking to build up a picture of human evolution, we use abilities which have themselves evolved, and which are unique to human beings. As a matter of scientific epistemology we can benefit from examining those abilities to see how they condition our view of the past; at the same time we can seek to document their emergence, using archaeological and fossil evidence.
My paper examines the way in which we label time and entities, and the difficulties which we have in modelling change when hampered by poor sampling. It then reviews psychological approaches which can be used for evaluating early archaeological evidence. It finishes by drawing examples from the record, considering the ancient environments in which we map hominid activity, and weighing the alternative interpretations of controversial evidence. Special consideration is given to questions of raw material transport and its significance, and to sequences of operations. The paper addresses the question: *How important should 'deliberateness' or 'intentionality' be in our assessment of the capabilities of early hominids?*

Key words: Early hominids, raw materials, artefacts, routines, intentionality, classification

Introduction

When we look at pages in a book, or at people in a room, we think we see the reality. Human senses are so good at interpreting signals from the world outside, that they create it a new inside. It takes something of a trick to illustrate their fallibility, as in an optical illusion, or the refraction of light between water and air (Fig. 1). This effectiveness of the senses can be seen as a product of natural selection: creatures need to be comfortable in their environment; as far as possible we have come to operate as a 'clear system', in which we are only aware of a minute fraction of the processing which goes on: we are aware of our hands which the brain needs to control, but not of the brain itself.

It is clear, however, that modern humans, and perhaps living apes, have achieved far more insight into this environment than have other species, through the extent of their internal processing.

Here, then, we have a peculiar aspect of animal-environment relations which can be investigated only for human beings, because of the existence of the archaeological record - and yet archaeology often passes over these possibilities. My basic question is 'how can we trace in evolutionary terms the origins of the abilities which allow us to investigate our own past?'

Why should we even have these abilities, and what are they? I intend to amplify here two themes which I have touched on before (Gowlett 1984), summed up in two apposite sayings - that of the evolutionary biologist B. Rensch, that the great victories of evolution are brain victories (Rensch 1959); and that of the pioneering neurologist Sherrington that the 'mind pilots the organism' (Sherrington 1940). Both of these are entirely consonant with recent views of cognitive science (e.g. Sacerdoti 1977; Gregory & Zangwill 1987; Hoc 1988).

* Prof.Dr. John A.J. Gowlett, Department of Archaeology, University of Liverpool, The Hartley Building, P.O. Box 147, Liverpool L69 3BX, U.K.

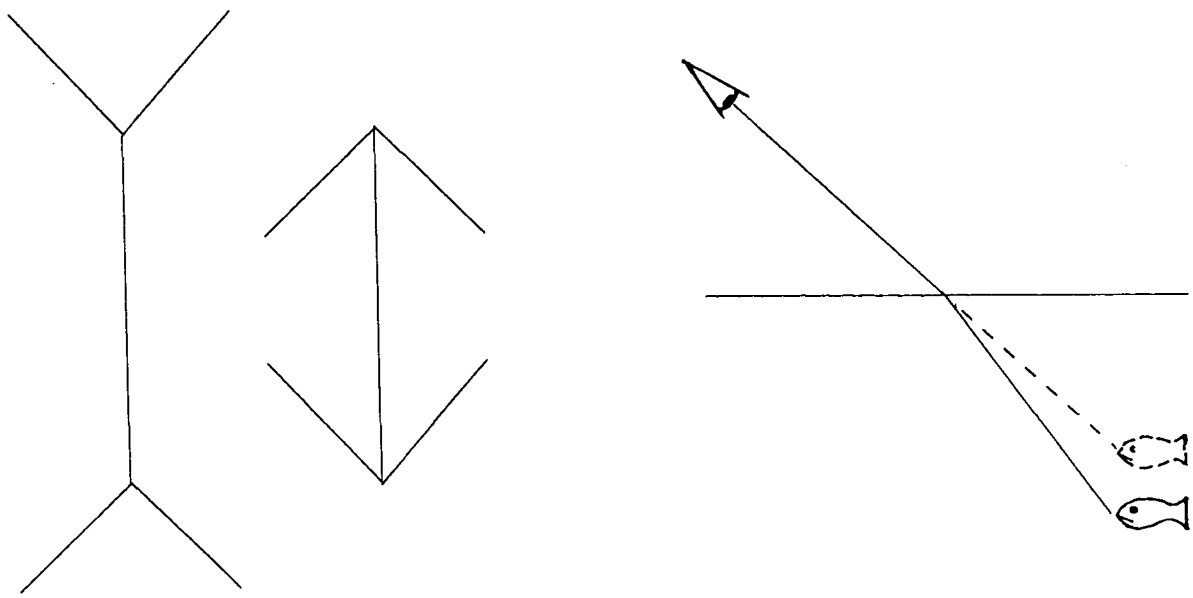

Fig. 1. Illustrations of the fallibility of the senses serve to stress their normal reliability: optical illusion (left); refraction (right).
The left figure shows an illusion which is a function of the brain's processing; the right, an effect caused by external physical reality. Archaeological classification is faced with the challenge of distinguishing similarly between effects which it creates itself, and real discontinuities in archaeological material.

Human abilities

Three of our senses - sight, hearing and touch - combine to recreate an internal world that mirrors the external world, to the extent that our perceived external world is internal. In particular we have, compared with other animals:
(1) extended scope of visual processing,
(2) hearing linked to brain processes which can interpret language,
(3) a tactile sense greatly interlinked with manipulation and the visual field.

These senses are deeply involved in the processing of data drawn from the environment: yet apart from input and output the major role is that of the brain itself in filtering the vast datasets which are available to be taken in. This elimination of the extraneous can be summarised as concentration - possibly one of the principal evolutionary needs leading towards the enlarged human brain (Holloway 1969). At any rate the brain achieves through the senses the datasets which serve as the basis of its simulations; and our academic abilities are amongst those which depend on such processing.

Little of this should now be seen as controversial, since we live in an age of data-processing: but we can only look for the origins of such abilities, if we have some agreement as to their present importance.

Curiously, through our lack of awareness of much of what our brains do, we are often unaware of their advantages - and this extends to many views held in the social sciences. Yet one can easily give an example relating to environment. Our contact with the external environment is discontinuous - in international science we may see a colleague today, then maybe not for three years. One role of the mind is to model across such gaps in the environment. We process, we simulate: we anticipate the continued activity of our colleagues. Across the whole animal world one might assert that the higher the level of internal simulation the greater the potential advantage for the owner of the brain.

Nevertheless, this is an area of varied opinions in the social sciences, and though the great majority of scientists dealing with the brain accept its great information-processing role, some workers are hesitant to project this back into the past. In this we can now say quite categorically that they are wrong. The bee makes mental maps; input of a cat's visual field is mapped thirteen times in the cortex for processing. Quite certainly the common ancestor of chimpanzees and humans had a brain far more complex than these.

Scientific epistemology

In seeking to build up a picture of human evolution, we use these abilities which have themselves evolved, and which are unique to human beings. As a matter of scientific epistemology we can benefit from examining those abilities to see how they condition our view of the past.

By way of illustration I refer to an analogy used by Eddington (1939): to evaluate what we catch, we must first examine the mesh of the net. His concern as a physicist was to look at the mesh of available technique. My concern goes a step further: as science is performed by human beings, the ultimate mesh is made by and dimensioned by human abilities which have evolved. Hence we have good reasons to explore them.

Classification: an example of human abilities and their limits

Classification has always been a basic part of biological and archaeological science, and I take it here as an example of the application of certain abilities of modern humans. We can examine particularly our tendency to impose labels and then, once they are assigned, to believe in them. Science needs to build up systems of classification, but these often become so fixed that we hesitate to question them. At worst this is 'False concretisation' (Craik 1943), but it must have its advantages. Arguably it is the other side of the coin provided by abstract nouns, a powerful tool of analysis, a part of our academic environment which may be encouraged by the nature of language itself. We are unlikely to do good palaeoanthropology unless we both examine the effects of such tendencies explicitly (an aspect of theory-building), and also seek evolutionary explanations for the origins of those same tendencies.

In the framework of palaeoanthropology and evolutionary theory one may emphasise that we use quite different and partly incompatible systems for classifying archaeology and hominids. In archaeology there is a basic system going back to the nineteenth century of 'cutting the cake', or pigeon-holing. It allows us Lower/Middle/Upper Palaeolithic in Eurasia, or Early/Middle/Later Stone Age in Africa. But thereafter we are free to subdivide as necessary, guided by but not ruled by attempts at codes (e.g. recommendations in Bishop & Clark 1967). We impose grand entities such as technocomplexes or traditions (cf Clarke 1968), because we have found that 'culture' in the sense of 'a culture' is too small or poorly-defined for the Palaeolithic record. The 'fuzzy' nature of these entities has been noted by Gamble (1986): if they work it is largely because of the lack of absolute formality. At the lowest level of the hierarchy an archaeologist is free to make up a plethora of small local phases which may roughly correspond with 'cultures'.

In contrast for biology the Linnaean system, devised by the eighteenth century Swedish scholar, and amplified by succeeding generations of biologists, imposes the concepts of genus, species and subspecies. We have very little freedom to rework this - who will follow ? Although there are problems in making definitions, the system works with absolute formality. It was constructed by pre-evolutionary science for classifying present-day life, but has been imposed on the past, making a need for agreed rules of temporal discrimination as well as the original spatial discrimination of taxa. Yet this system has structural limitations which impose a mesh on the data - and all too often this gains no explicit recognition within a particular sub-discipline. Where there is the set of genus/species/subspecies, then unless it is accepted plainly that these are merely 'working definitions' (cf Huxley 1963), then a set of transitions from genus to genus, species to species, and subspecies to subspecies, is automatically imposed. The transitions may gain undue importance since terminology itself gives the appearance of periods of gradual change or stasis, separated by bursts of rapid change. Of course, Darwin's idea of gradual evolutionary change has been much challenged in recent years, but it has also become plain that the newer ideas of punctuated equilibrium, or of cladistics, cannot be accepted uncritically (e.g. papers in Bendall 1983, especially Ayala 1983; Trinkaus 1990).

Perhaps the chief danger is that instead of starting by testing whether these discontinuities are realities, we may commence by simply searching for them. Or we hope that through a process of accommodation the notional transitions will come to coincide with real discontinuities. But what if in a particular area of biology - say human evolution - there are not three suitable discontinuities to make transitions or boundaries?

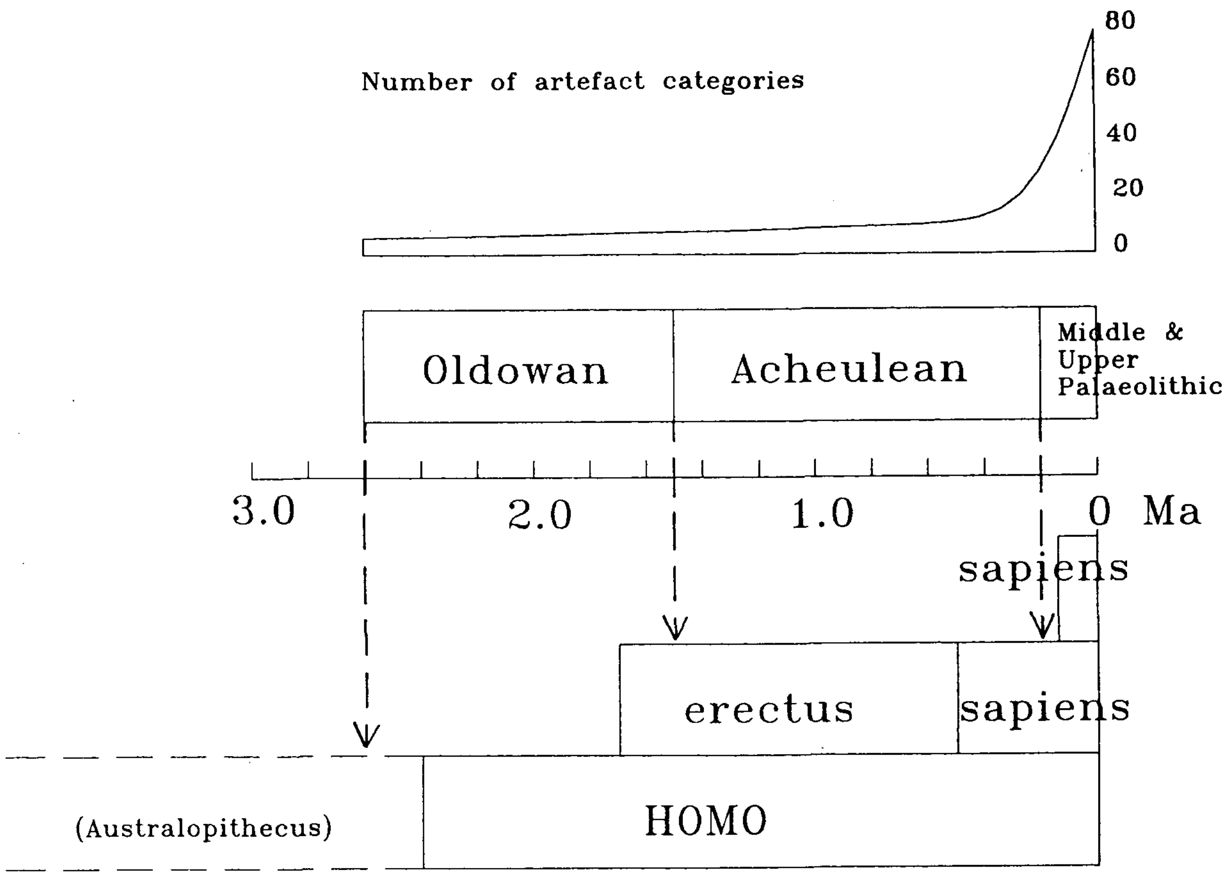

Fig. 2. Classification boundaries in hominid evolution and the archaeological record.

The difficulties can be illustrated through looking at a concordance of the two systems of archaeological and biological classification (Fig. 2). This shows an apparent mismatch of the junctions or transitions between archaeology and hominid palaeontology - that is, changes of archaeological tradition do not appear to coincide with changes of hominid species.

The Acheulean, for example, appears later than *Homo erectus*; but it continues after the disappearance of *Homo erectus*. The Middle Palaeolithic or Middle Stone Age begins long after the first appearance of *Homo sapiens*, but continues until anatomically modern humans are present.

At least two possible explanations can be offered for this series of mismatches:
(1) that cultural progress follows some time after biological change;
(2) that some of these boundaries are essentially artificial - imposed by the demands of a classificatory system.

The first option seems very neat, but is perhaps too good to be entirely true. Some workers have suggested an analogy with computer hardware and software: once the new hardware is developed, new software opportunities gradually develop (cf papers in Mellars & Stringer 1989). This argument holds best for the Middle Palaeolithic/Upper Palaeolithic transition, where cultural change is clearly more rapid than biological change. On the other hand, in evolution in general it has been argued that behavioural change precedes physical change (Huxley 1963): animals have some behavioural flexibility allowing them to take new opportunities; natural selection then acts to improve the adaptation. The second option therefore remains equally possible. For example, the persistence of the Acheulean across the *Homo erectus/Homo sapiens* transition may well show that it is a false boundary.

In the 1960s there was a yearning for improved definitions (e.g. Bishop & Clark 1967), but now we seem happier to inhabit the shattered shell of old terminology, admitting that it is roofless. I suggest, however, that in palaeoanthropology we should aim to be more explicit both in exploring and expressing the limits of our classificatory abilities, and in applying objective tests to

the results. In relation to modern humans I venture to summarise the following points:
(1) We are good at labels, poor on dynamics. Statics tend to win over dynamics in our verbal analyses, since - as here - we often apply abstract nouns; we are probably worst at integrating the two.
(2) We can comprehend interactions of two variables, or three, but cannot handle multivariate systems. Nevertheless, it is plain that in palaeoanthropology we are almost always dealing with multivariate data.
(3) We often behave as if our task is to find every past fact to make a complete record. But it cannot be: even if the data were available, we would not have time to relive the past. So an understanding of our sampling is crucial, beyond the common observation that it is poor and biased.

I have deliberately highlighted the discrepancies between the frameworks of archaeology and hominid palaeontology. One must also note important sampling differences. The number of complete crania is very small indeed from about 1.3 million to 0.3 million years ago. Yet during this period archaeological traces become common - there is ten or a hundred times more material than represents the Oldowan. Computer simulations provide valuable information about possible population characteristics (Wobst 1974; Steele in press), and in principle might be used to investigate the likely effects of our limited sampling.

Psychological approaches to the past

One might accept my points about modern abilities without believing that we can easily chart their emergence in the past; can they be documented? Language has often been the focal point of study, but in the view of various authors, myself included, this labelling system is extremely difficult to document by archaeological means (e.g. Gowlett 1990; Wynn 1993; Graves in press). In fossil evidence this is a matter for palaeoanatomists (e.g. Falk 1993; Holloway 1969; Tobias 1981; Lieberman 1989; Deacon 1992) but there seems no full consensus in their views. One difficulty is that category formation is present in other animals (Leach 1970), and so demonstrating their presence in the archaeological record does not prove language. Some of our colleagues feel that the presence of symbols might demonstrate language - and it is debatable whether there is any symbolic component in early artefacts (for reviews of the arguments see Chase 1991 and Duff et al. 1992) - but there is evidence that both chimpanzees and other animals have an internal comprehension of symbols (e.g. Adrian 1950; Savage-Rumbaugh 1986).

The sequencing, modelling system, in contrast, may indeed be revealed in technology, and in the relations of technology and physical environ-ment.

It is therefore my aim to explore the Lower Palaeolithic evidence.

Psychological approaches provide a means of such documentation. They have a long history, for example in the work of Schmidt (1936), drawn to my attention by Kenneth Oakley, who himself made contributions in this field (e.g. Oakley 1981). Schmidt's work is inevitably outmoded, but it still manages to anticipate post-processual archaeology's concern with the viewpoint of the observer: 'We civilized men, with our logical concepts, live in a world of reality; this has its own rigid sense of cause and effect, which inhibits unfettered fancy'. For our consciousness is alert, and distinguishes with sober reason, between the real and the ideal, between the external form and the mental image.'

His point is to underline our difficulties in looking into the minds of past times and other societies, and the language is surprisingly modern. External form and mental image can both be explored by various psychological approaches. These include the information-processing approach of modern cognitive psychology, or the tenets of Piaget's developmental psychology. Wynn has used the latter to explore questions of form (e.g. Wynn 1985). I have aimed to use sequencing models, as established by Miller et al. (1960), and developed further in artificial intelligence modelling (e.g. Sacerdoti 1977; Hoc 1988). These methods leave gaps in our understanding of form representation, and various other approaches are possible (e.g. Goren-Inbar 1988).

The basis of all such work is that decision points in operations can be mapped out in space and time. The complexities of planning have been summarised in ever more sophisticated models, starting from the TOTE (test-operate-test-exit) loops of Miller et al. 1960. French scholars often prefer to follow the concepts of Leroi-Gourhan embodied in operational chains (e.g. Boeda et al. 1990), although this concentrates on ethnological description rather than an analysis of decision points.

The essential point is that if we have datasets which relate to past events generated by humans in an environment - we can chart decision paths. There is every incentive to go on seeking out such material through new fieldwork, for if we do not have solid datasets, it seems to me that we can do very little.

Human-environment relations in the Lower Palaeolithic

The modelling of human/hominid environment relations is one area that can take into account mental knowledge and processing, and is one where data on the ground may be good enough to produce substantive results.

There are two conventional approaches:
(1) Homebase/site catchment studies, which are developments of central place ideas (e.g. Higgs 1972).
(2) Landscape approaches, outlined for the lower Pleistocene by Isaac and for the Holocene in Foley's approach to off-site archaeology (Isaac 1981; Foley 1977).

The underlying models are essentially geographic or space-oriented. They include time only insofar as it is a limit, as in Higgs' models, where 10 km is a practical maximum travel distance for people returning to a home base on a daily basis. Time-depth is however an important aspect to investigate (Gowlett 1984).

Now, following critiques from Binford (e.g. 1981) or McGrew (1993), if we reject home bases for early humans, it would follow that we lack the information to discriminate homebase/landscape models. But, we do have information which allows us to look at management of energy, selectivity and choice. These can be demonstrated from examples. In these, early artefacts or technology can be seen as an energy lens applied to the environment. There would be great rewards for using effective artefacts, in that there would be real penalties for using ineffective ones.

Admitting that some old goals of Lower Palaeolithic archaeology - i.e. reconstructing life in and around putative campsites - are difficult to follow at present, I aim now simply to look at evidence of selectivity, sequencing and economy.

Transport of materials

It has become conventional to distinguish between Oldowan and Acheulean industries in assessments, although the only sharp difference is the incorporation of large cutting tools or bifaces in the latter.

The Oldowan represents the simplest and oldest industries. Although it may last for a million years it is represented from very few sites. Even so there are now a variety of views about it (Isaac 1984, 1986; Leakey 1971; Roche 1980; Schick & Toth 1993; Toth 1985). The Acheulean which follows the Oldowan has been less favoured in study but may offer a better handle on many of these questions simply because of the greater quantity of material and the increased signs of design form (Crompton & Gowlett 1993; Wynn 1993; Toth & Schick 1993). The Acheulean represents about 55% of the total duration of our technological record, and is largely associated with *Homo erectus*, but it is not exclusive to that species, nor *Homo erectus* to it.

Both the Oldowan and Acheulean demonstrate the transport of raw materials. The question is, does this indubitably show hominid planning on the timescale required for the journeys? One challenge comes from McGrew (e.g. 1993), who notes that chimpanzees can move material across a landscape in additive small journeys.

The best documented cases of Oldowan raw material transport are from Olduvai, where distances of 3km - 12 km have been established (Leakey 1971; Hay 1976; Fig. 3). This gives us a time dimension of transport of up to 2 hours. East Turkana also provides instances of raw material onto flood plains of the ancient lake, distances of up to 20 km (Harris & Herbich 1978). Hay (1976) observes that almost any site which has large numbers of artefacts includes a few exotic pieces carried in from a great distance. Leakey (1971) has shown also a great deal of raw material selection in Olduvai Bed I, where quartz/-quartzite was usually preferred for small tools on flakes, and lava cores evidently had some value in themselves, because they had been transported away from the flakes which had been produced from them.

Transport distances have too often been ignored for the Acheulean, though an excellent late example shows that at Arago in France, towards the end of this epoch, artefacts were being transported systematically for distances of up to 30 km (Wilson 1988). Small finished tools amount to the highest proportion of exotics (over 30%), indicating the importance of selection.

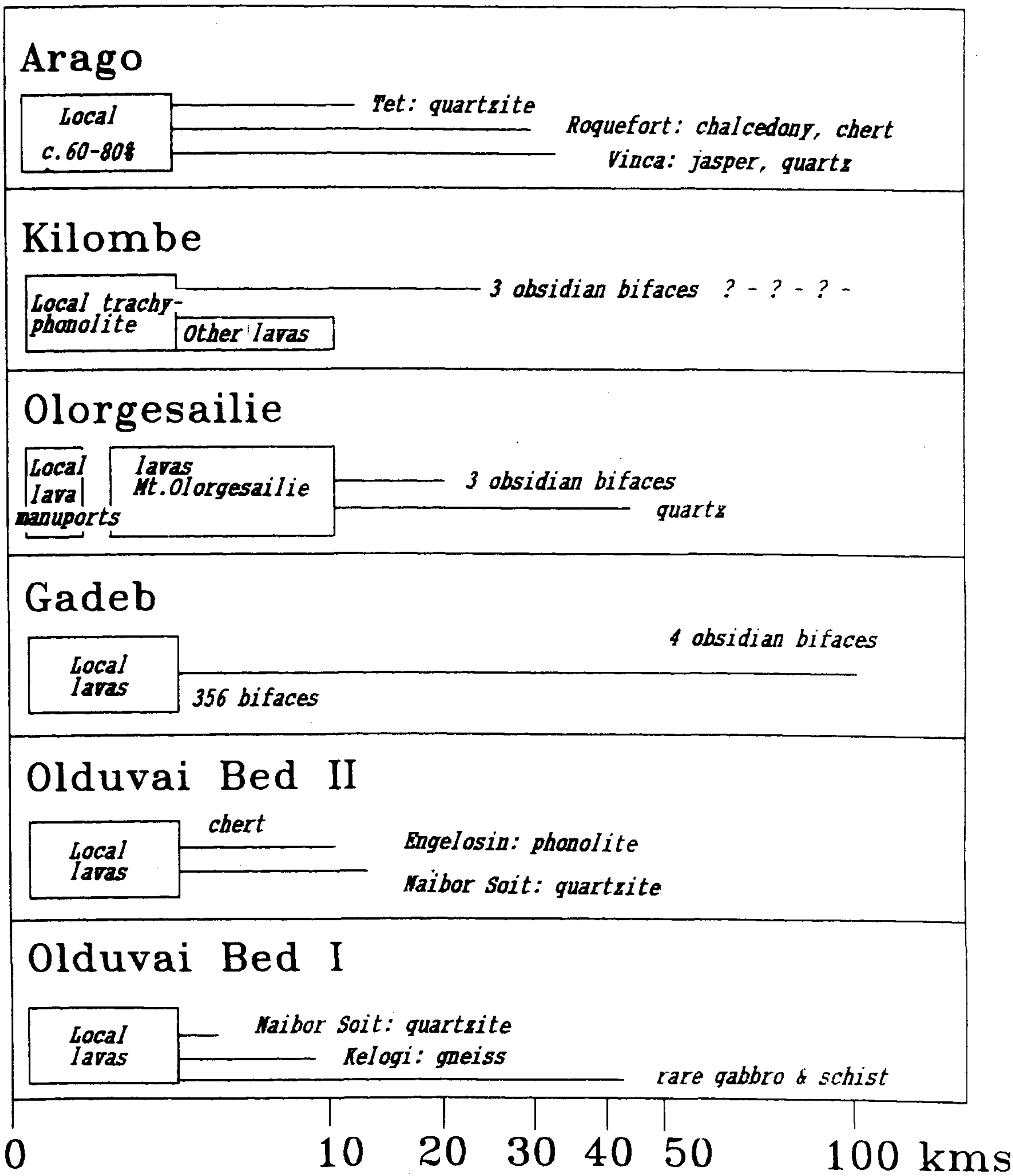

Fig. 3. Transport of raw materials in the Lower Palaeolithic: some site examples..

Occasional long distance transport is also well-documented for the earlier Acheulean, for example at Olorgesailie, where Isaac (1977) notes occurrences of quartz brought over 40 km. Most biface material comes from lavas of Mount Olorgesailie, about 10 km away, but a local vesicular lava found about 1 km away was utilised for cobbles or manuports.

One of the most interesting cases occurs at Gadeb in eastern Ethiopia. Here, several obsidian bifaces appear which document a transport distance of over 100 km from the Rift Valley (Clark 1980). There were five of these among 290 bifaces made of local materials. This evidence may support the idea that bifaces were general purpose artefacts, held in hand perhaps for days of travel, and then abandoned when the owner arrived at a new site and had access to new materials. Far later examples of raw material transport, such as Pincevent, would suggest this possibility (Leroi-Gourhan & Brezillon 1972).

All together there is considerable documentation to Hay's observation, that early hominids knew their material well. Isaac came to the same conclusion in his paper 'the first geologists' (Isaac 1978). There may however be a duality in what we are seeing: relatively short distance transport (up to 15 km) of considerable quantities of material specifically for use on a site; and far longer distance transport 'tool-in-hand', where the main purpose is to be equipped for a journey, and the contribution of the material to the site of arrival is incidental.

If so, a simple home-base model does not easily encompass this, particularly not if worked with travel-distance examples from later hunter-gatherers, whose home range is often far less than 100 km across. Yellen, however, has demonstrated how life-time ranges of members of the Dobe can be much larger than the range of their immediate band - reckoned in distances of 100-200 km rather than 30 or 40 km (Yellen 1977).

I would conclude from this that:
(1) one may need to envisage mental maps encompassing 100 km for early *Homo erectus*;
(2) such evidence makes it difficult to support the idea of concentrations formed 'without intention' on a 'just so' basis.

The combination of long-distance transport and careful selection both of raw material and elements for transport indicates hominids who knew their environment precisely. It also implies considerable conceptualisation of time-depth on their part: probably running to at least two days. One may acknowledge that other animals disperse over equally large distances, but the tie to artefacts demonstrates among hominid levels of planning which we could only postulate for other animals. The constant evidence of selection is the best counter to arguments such as those put by McGrew (1993) that hominid transport may not have been intentional.

Our evidence preserves only stone, but it seems likely that early hominids were engaged in other sequences of actions which had to be scheduled alongside raw material transport. Here the advantage of successful sequencing can be stressed, because the energetic costs of faulty sequencing can easily be seen.

Artefact manufacture

Archaeology can provide documentation of routines within sites as well as on landscapes. In assessing earliest artefacts there are two principal points of view: that of Wynn & McGrew (1989), which sees the artefacts as on the level of ape tool making; and a view of greater complexity, which has been argued by for example Schick & Toth (1993), Bilsborough (1992), Roche (1980) and Gowlett (1984, 1986). A view taking artefacts as a genetically controlled species characteristic (Binford 1989) is much more difficult to support, since any comparative study of the higher primates shows increased plasticity of behaviour rather than genetic control. Indeed Ingold (1993) criticises recent work by biologists which fails to recognise the flexibility of culturally controlled behaviour.

Closer examination of the work listed above shows a divergence of views in detail about the design content of early artefacts. I have discussed this elsewhere (Gowlett 1982, 1984, 1990; cf Crompton & Gowlett 1993) and treat the issues only in outline here. The status of form is critical, and Schmidt's (1936) view of the Acheulean provides a baseline:

'For the first time eye and hand gained the mastery over stone, the most important material for artefacts... The early Palaeolithic artificer went to work like a sculptor, who has in his mind a conception of the complete form of his creation. By well-calculated blows he released the form, in the rough, from a fragment of rock or from a flint nodule. A second operation shaped it symmetrically, by retouching the surface; and a third, by flaking the border, gave it a sharply-defined edge.'

This is a view shared by most of the authors mentioned, but disputed by for example Davidson & Noble (1993). Metrical studies, e.g. Roe (1964, 1968), Wynn & Tierson (1990) or Crompton & Gowlett (1993) all echo Schmidt in seeing a mastery of form in the Acheulean, now thought to begin about 1.4 million years ago (e.g. Asfaw et al. 1992).

My paper of 1984 emphasised two concepts in relation to form: the procedural template and a template of morphology. Support for this separation is provided by Hoc (1988), for whom a plan is a schematic and/or hierarchical representation whose function is to guide activity, and who distinguishes declarative (or static relational structures) and procedural plans. Although the design content varies, both major Oldowan and Acheulean sites preserve evidence of guiding plans. Artefact-making and -using routines are embedded in the stuff of life, which is why nearly every site provides us with loose ends - evidence of blanks brought in, or perhaps of completed tools carried away. Multi-step routines are evidence of concentration on a particular task, maintained through time.

A major question which requires more work is the status of 'categories' in early artefacts (Isaac 1977; Gowlett 1988). Establishing the existence of numbers of categories seems unlikely to inform us about language, but it can tell us about thought processes: roughly, we can ask, what kind of instruction set is required to store the whole of the information embodied in an Oldowan or Acheulean industry ? It would seem that it must entail numbers of categories of pieces with 'bestowed meaning' (White 1962). Probably a chimpanzee, recognising an abandoned termite-fishing stick for what it is, would be exhibiting similar categorisation. In such categories we can probably see the origins of our own classifying abilities which we use academically.

Some thoughts about intentionality

I am using the word 'intentionality' here in its conventional sense, rather than the specialised one of philosophy. In current debates there seem to be two principal views about early hominid activities:
(1) that hominids plan what they are about to do, on a timescale of hours or even days;
(2) that things happen in 'just so' fashion, i.e. concentrations form, because of accumulations of sequences of unplanned events.

Wrangham (1974) gives us an example of unintentional leadership in chimpanzees. When a dominant individual decides to move in search of other resources, or seasonally, its companions tend to follow.

Thus the second view argues that to ascribe intentionality is to go beyond the evidence. But quite apart from the fact that chimpanzees exhibit intentionality in much of what they do, this is to ascribe everything to trial and error. It implies that early hominids could learn nothing from the errors.

I argue that technology, like brain, is expensive, so that there will be strong selection pressures for effective decision making - whether over shape or raw material. Once a technological threshold has been crossed, and the creature is committed to tools, such distinctions are magnified: the costs of not knowing the environment well enough become greater. The greater territories which were exploited by hominids compared with apes -as shown by the raw material transport - would have demanded an efficient use of resources.

Conclusions

My conclusions are mainly about energy. First, let us return to the initial points: brain victories and piloting the organism. Both show brain being used, at a price which can be paid - i.e. benefits in energy acquisition justify the expense of carrying and fuelling the brain.

We might dispute the objectivity of Rensch's observation - what is victory? But there is no objective doubt that more complex brains have emerged. We can measure this evolution in relation to time, by numbers of neurons or axons, or by size or energy consumption. To present a satisfactory explanation, we must of course be able to justify how it is that some organisms survive with smaller and less adequate brains. The answer is surely that past trajectories govern both the selective pressures that an animal is under, and what it can now do. The brains of simple organisms must be adequate to their environments. How then can we justify the very expensive human brain, that uses so much energy? I can think of two solutions:
(1) that it is necessitated by an environment which is largely the human social environment - no other animal has this;
(2) that it pays for itself by the energy that it saves - it models the environment so well that it permits energy saving decisions.

Since the time of Kohler we have known that chimpanzees have 'insight' that can solve problems by thinking - with immediate benefits (Kohler 1925). To experiment in the head is cheaper than to experiment in actuality. I see no discrepancy that the chimpanzee can be used to make this point - it too has a large brain, as well as being our close relative. But humans have travelled further, with these abilities probably developing in a feedback loop (Tobias 1981). I have tried to give some definite examples of their brain processing and transformations. The benefits of this brain work are readily apparent, but it leaves major questions.

Especially, did these enhanced abilities arise gradually and steadily since *Homo habilis* and the earliest technology, or did they arise in a sudden crescendo in the last hundred thousand years ? At one level we have uncertainty because of the difference between capacity and expression (I may...but I choose not to; cf Mellars & Stringer 1989). In another way I would argue that there is evidence for a steady increase from early times, and in pushing archaeology towards science, we seek its better documentation, preferably on a measurable basis.

Hominids have changed far more than their close relatives the apes. It is not entirely plain whether this reflects greater selective pressures, or environments where greater evolutionary distance can be travelled in search of new solutions. Perhaps the second entails the first. Either way, in the environmental relations of early hominids we can be reasonably sure that there will be powerful measures of selection aiming to reduce costs in energetic terms. In technology these may well be represented as rule-systems. One can map out complexity in the rule systems so as to show the sophistication of the early hominids, but perhaps more convincing and persuasive is to document the advantages that come from having them. For example, recent work with Crompton on allometry shows the importance of weight saving in large Acheulean artefacts (shaped so as to save up to 30% of volume compared with the shape of smaller specimens). It reinforces the view that artefacts need to be effective in energetic terms - or selection will literally weigh against them (Crompton & Gowlett 1993).

Efficiency can only be ensured through mental simulation - that is a planning of activities in which alternatives can be evaluated, and discarded if found wanting. Of course it can be argued that in the Acheulean this is not planning, because the same principles are maintained for a million years. Categories of planning have been outlined by Parker & Milbrath (1993) and Gibson (1993). Following a plan that is in the collective memory of a cultural tradition (e.g. selecting material for and manufacturing an Acheulean hand-axe) does not exert the same demands as making a new plan, but it surely still meets the criteria of any definition of planning.

My initial example in this paper was about classification; but much of the rest of it has been about routines. We can attempt to bring the two together through the idea that in the demands of life different routines have to be dovetailed. Animals such as chimpanzees and baboons use large numbers of plant species for food, and it is essential for them to know the differences between them. Technology would reinforce any such internal classification system in early hominids simply because of the physical interaction with its components, and the incorporation of them in planning: flakes for this, cores for that; lava for one task, quartz for another. Even in a very simple industry the number of variables imposing themselves on the makers is very considerable. One can argue that the use of established categories will help to minimise the cognitive load.

Finally I return to our modern application of such categories. We can never forget that our abilities evolved for dealing with the stone age, the world of hunting and gathering, and that however useful they are, our classifying abilities can mislead us. One position emerges which appears to resist argument: that the rule systems in the archaeology of *Homo erectus* are essentially the same as those of early *Homo sapiens* (cf. Gowlett & Crompton in press). This implies not just that there is a mosaic of change between the two, but that the junction or transition between the two is entirely arbitrary. It would benefit the practice of palaeoanthropology if we tried more formally to look for real transitions, rather than accepting those created by arbitrary classifications. When necessary we should suspend judgment on classification. In practice the Linnaean system finds this hard to do, whereas archaeological classification, whatever its imperfections, is less likely to impose premature interpretations.

References

ADRIAN, E.D.,1950: What happens when we think. In: P. Laslett (ed.), *The physical basis of mind,* 5-11. Oxford (Basil Blackwell).

ASFAW, B., BEYENE, Y., SUWA, G., WALTER, R.C., WHITE, T.D., WOLDEGABRIEL, G. & YEMANE, T., 1992: The earliest Acheulean at Konso-Gardula. *Nature* 360, 732-735.

AYALA, F.J.,1983: Microevolution and macroevolution. In: D.S. Bendall (ed.), *Evolution from molecules to men* , 387-402. Cambridge (Cambridge University Press).

BENDALL, D.S. (ed.), 1983: *Evolution from molecules to men.* Cambridge (Cambridge University Press).

BILSBOROUGH, A., 1992: *Human evolution.* London (Blackie).

BINFORD, L.R., 1981: *Bones: ancient men and modern myths.* New York (Academic Press).

BINFORD. L.R., 1989: Isolating the transition to cultural adaptations: an organizational approach. In: E. Trinkaus (ed.), *The emergence of modern humans,* 18-41. Cambridge (Cambridge University Press).

BISHOP, W.W. & CLARK, J.D. (eds), 1967: *Background to evolution in Africa.* Chicago (University of Chicago Press).

BOEDA, E., GENESTE, J.-M., & MEIGNEN, L., 1990: Identification de chaines operatoires lithiques du paléolithique ancien et moyen. *Paléo* 2, 43-80.

CHASE, P., 1991: Symbols and palaeolithic artefacts: style standardization, and the imposition of arbitrary form. *J. Anthrop. Archaeol.* 10, 193-214.

CLARK, J.D., 1980: The Plio-Pleistocene environmental and cultural sequence at Gadeb, northern Bale, Ethiopia. In: R.E. Leakey & B.A. Ogot (eds.), *Proceedings of the 7th Panafrican Congress of Prehistory and Quaternary Studies. Nairobi,* 189-193. Nairobi (TILLMIAP).

CLARKE, D.L., 1968: *Analytical archaeology.* London (Methuen).

CRAIK, K.J.W., 1943: *The nature of explanation.* Cambridge (Cambridge University Press).

CROMPTON, R.H. & GOWLETT, J.A.J., 1993: Allometry and multidimensional form in Acheulean bifaces from Kilombe, Kenya. *J. Human Evol.* 25, 175-199.

DAVIDSON, I. & NOBLE, W., 1993: Tools and language in human evolution. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 363-388. Cambridge (Cambridge University Press).

DEACON, T., 1992: Biological aspects of language. In: S. Jones, R. Martins & D. Pilbeam (eds.), *The Cambridge encyclopedia of human evolution,* 128-133. Cambridge (Cambridge University Press).

DUFF, A.I., CLARK, G.A. & CHADDERDON, T.J., 1992: Symbolism in the early Palaeolithic: a conceptual odyssey. *Cambridge Archaeol. J.* 2,2, 211-229.

EDDINGTON, A., 1939: *The philosophy of physical science.* Cambridge (Cambridge University Press).

FALK, D., 1993: Sex differences in visuospatial skills: implications for hominid evolution. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 216-229. Cambridge (Cambridge University Press).

FOLEY, R.A., 1977: Space and energy: a method for analysing habitat values and utilization in relation to archaeological sites. In: D.L. Clarke (ed.), *Spatial archaeology,* 163-187. London (Academic Press).

GAMBLE, C., 1986: *The Palaeolithic settlement of Europe.* Cambridge (Cambridge University Press).

GIBSON, K.R., 1993: Introduction: beyond neoteny and recapitulation: new approaches to the evolution of cognitive development. In : K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 273-278. Cambridge (Cambridge University Press).

GIBSON, K.R. & INGOLD, T. (Eds), 1993: *Tools, language and cognition in human evolution.* Cambridge (Cambridge University Press).

GOREN-INBAR, N., 1988: Notes on 'decision making' by Lower and Middle Palaeolithic hominids. *Paleorient* 14,2, 99-108.

GOWLETT, J.A.J., 1982: Procedure and form in a Lower Palaeolithic industry: stoneworking at Kilombe, Kenya. *Studia Praehistorica Belgica* 2, 101-109.

GOWLETT, J.A.J., 1984: Mental abilities of early man - a look at some hard evidence. In: R. Foley (ed.), *Hominid evolution and community ecology,* 167-192. London (Academic Press).

GOWLETT, J.A.J., 1986: Culture and conceptualisation: the Oldowan-Acheulian gradient. In: G.N. Bailey, & P. Callow (eds.), *Stone Age Prehistory: studies in memory of Charles McBurney,* 243-260. Cambridge (Cambridge University Press).

GOWLETT, J.A.J., 1988: A case of Developed Oldowan in the Acheulian? *World Archaeol.* 20,13-26.

GOWLETT, J.A.J., 1990: Technology, skill and the psychosocial sector in the long term of human evolution. *Archaeol. Review Cambridge* 9, 1, 82-103.

GOWLETT, J.A.J. & CROMPTON, R.H., 1994 (in press): Kariandusi: Acheulean morphology and the question of allometry. *African Archaeol. Review* 12.

GRAVES, P., 1994 (in press): Flakes and ladders: what the archaeological record cannot tell us about the origins of language. *World Archaeol.*26,2.

GREGORY, R.L. & Zangwill, O.L., 1987: *The Oxford Companion to the mind.* Oxford (Oxford University Press).

HARRIS, J.W.K. & HERBICH, I., 1978: Aspects of early Pleistocene hominid behaviour east of Lake Turkana, Kenya. In: W.W. Bishop (ed.), *Geological background to fossil man,* 529-548. Edinburgh (Geol. Soc. London/Scottish Academic Press).

HAY, R.L., 1976: *Geology of the Olduvai Gorge.* California (University of California Press).

HIGGS, E.S. (ed.), 1972: *Papers in economic prehistory.* Cambridge (Cambridge University Press).

HOC, J.-M., 1988: *Cognitive psychology of planning.* London (Academic Press).

HOLLOWAY, R.L., 1969: Culture: a human domain. *Current Anthrop.* 10,4, 395-412.

HUXLEY, J., 1963: *Evolution: the modern synthesis.* London (Allen & Unwin). Second Edition.

INGOLD, T., 1993: Technology, language, intelligence: a reconsideration of basic concepts. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution*, 449-472. Cambridge (Cambridge University Press).

ISAAC, G.L., 1977: *Olorgesailie: Archaeological studies of a Middle Pleistocene lake basin.* Chicago (University of Chicago Press).

ISAAC, G.L., 1978: The first geologists. In. W.W. Bishop (ed.), *Geological background to fossil man,* 139.147. Edinburgh (Geol. Soc. London/Scottish Academic Press).

ISAAC, G.L., 1981: Stone Age visiting cards: approaches to the study of early land-use patterns. In: I. Hodder, G. Isaac & N. Hammond (eds), *Patterns in the past,* 131-155. Cambridge.

ISAAC, G.L., 1984: The archaeology of human origins: studies of the lower Pleistocene in East Africa, 1971-1981. In: *Advances in World Archaeology* 3: 1-87. New York.

ISAAC, G.L., 1986: Foundation Stones: early artifacts as indicators of activities and abilities. In: G.N. Bailey & P. Callow (eds.), *Stone Age prehistory: studies in memory of Charles McBurney*, 221-241. Cambridge (Cambridge University Press).

KLEINDIENST, M.R., 1962: Components of the East African Acheulian assemblage: an analytic approach. In: C. Mortelmans & J. Nenquin (eds.), *Actes du 4éme Congrés Panafricain de Préhistoire et de l'étude du Quaternaire,* 81-105. Tervuren.

KOHLER, W., 1925: *The mentality of apes.* Harmondsworth (Pelican Books 1957).

LEACH, E., 1970: *Levi Strauss.* London (Fontana/Collins).

LEAKEY, M.D., 1971: *Olduvai Gorge, Vol. III: Excavations in Beds I and II, 1960-1963.* Cambridge (Cambridge University Press).

LEROI-GOURHAN, A. & BREZILLON, M., 1972: *Fouilles de Pincevent: essai d'analyse éthnographique d'un habitation magdalénien.* Paris (CNRS, 7th Supplement to Gallia Prehistoire.).

LIEBERMAN, P., 1993: On the Kebara KMH2 hyoid and Neanderthal speech. *Current Anthrop.* 34,2: 172-175.

McGREW, W.R., 1993: *Chimpanzee material culture: implications for human evolution.* Cambridge (Cambridge University Press).

MELLARS, P. & STRINGER, C. (Eds.), 1989: *The human revolution: behavioural and biological perspectives on the origins of modern humans.* Edinburgh (Edinburgh University Press). (Introduction: 1-12).

MILLER, G.A., GALANTER, E. & PRIBRAM, K.H., 1960: *Plans and the structure of behaviour.* New York (Holt, Rinehart and Winston).

OAKLEY, K.P., 1981: Emergence of higher thought 3.0-0.2 Ma BP. *Philosophical Transactions of the Royal Society of London,* Series B 292, 205-211.

PARKER, S.T. & MILBRATH, C., 1993: Higher intelligence, propositional language and culture as adaptations for planning. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 314-333. Cambridge (Cambridge University Press).

RENSCH, B., 1959: *Evolution above the species level.* London (Methuen).

ROCHE, H., 1980: *Premiers outils tailles de l'Afrique.* Paris (Société d'Ethnographie).

ROE, D.A., 1964: The British Lower and Middle Palaeolithic: some problems, methods of study, and preliminary results. *Proceed. Prehist. Soc.* 30, 245-267.

ROE, D.A., 1968: British Lower and Middle Palaeolithic handaxes groups. *Proceed. Prehist. Soc.* 34, 1-82.

SACERDOTI, E.D., 1977: *A structure for plans and behaviour.* New York, Elsevier.

SAVAGE-RUMBAUGH, E.S., 1986: *Ape language: from conditioned response to symbol.* Oxford (Oxford University Press).

SCHICK, K.D. & TOTH, N., 1993: *Making silent stones speak: human evolution and the dawn of technology.* New York (Simon & Schuster).

SCHMIDT, R.R., 1936: *The dawn of the human mind.* London (Sidgwick & Jackson).

SHERRINGTON, C., 1940: *Man on his nature.* Cambridge (Cambridge University Press).

STEELE, J., 1994 (in press): Dispersal as a mechanism of cultural diffusion: a revised equilibrium basin model of the persistence of the Acheulian. *World Archaeol.* 26,2.

TOBIAS, P.V., 1981: The emergence of man in Africa and beyond. *Philosophical Transactions of the Royal Society of London,* Series B 292, 43-56.

TOTH, N., 1985: The Oldowan reassessed: a close look at early stone artefacts. *J. Archaeol. Sci.* 12, 101-121.

TOTH, N. AND SCHICK, K.D., 1993: Early stone industries and inferences regarding language and cognition. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 346-362. Cambridge (Cambridge University Press).

TRINKAUS, E. 1990: Cladistics and the hominid fossil record. *Amer. J.Phys. Anthrop.* 83, 1-11.

WHITE, L.A., 1962: Symboling: a kind of behavior. *J. Psychol.* 53, 311-317. (Reprinted in: B. Dillingham & R.L. Carneiro [eds.], *Leslie A. White's ethnological essays,* 273-278. Albuquerque [University of New Mexico Press]).

WILSON, L., 1988: Petrography of the Lower Palaeolithic tool assemblage of the Caune de l'Arago (France). *World Archaeol.* 19,3, 376-387.

WOBST, H.M., 1974: Boundary conditions for Palaeolithic social systems: a simulation approach. *Amer. Antiquity* 39, 147-178.

WRANGHAM, R.W., 1974: Sex differences in chimpanzee dispersion. In: D.A. Hamburg & E.R. McCown (eds.), *The great apes,* 481-489. Menlo Park, California (Benjamin/Cummings).

WYNN, T., 1979: The intelligence of later Acheulian hominids. *Man* 14, 371-391.

WYNN, T., 1981: The intelligence of Oldowan hominids. *J. Human Evol.* 10, 529-541.

WYNN, T., 1985: Piaget, stone tools and the evolution of human intelligence. *World Archaeol.* 17, 32-43.

WYNN, T., 1993: Layers of thinking in tool behaviour. In: K.R. Gibson & T. Ingold (eds.), *Tools, language and cognition in human evolution,* 389-406. Cambridge (Cambridge University Press).

WYNN, T. & McGREW, W.C., 1989: An ape's-eye view of the Oldowan. *Man* 24, 383-398.

WYNN, T. & TIERSON, R., 1990: Regional comparison of the shapes of later Acheulean handaxes. *Amer. Anthrop.* 92, 73-84.

YELLEN, J., 1977: *Archaeological approaches to the present: models for reconstructing the past.* New York (Academic Press).