

Early human mental abilities

Every day, each of us performs many tasks beyond the abilities of any other animal. To a certain extent we depend on specialised adaptations, particularly bipedal locomotion and the precision grip between thumb and the first two fingers. But even without these, an ape such as a chimpanzee can carry out many straightforward tasks analogous to those performed by humans. The ape's ultimate limitations, which are apparent even after rigorous training, are not so much physical as behavioural and mental, and reflect the fact that human intelligence far exceeds that of our nearest relatives.

The human brain is highly adapted to promoting a cultural way of life, and can be regarded as the most specialised organ of the body. Only humans depend for their success on elaborate systems of culturally transmitted information. There is no doubt that the brain has taken several million years to assume this special complexity.

Fossils allow us to chart an evolutionary sequence of cranial form, from the australopithecines and early *Homo* through *Homo erectus* and 'archaic *Homo sapiens*' to modern people. This physical evidence for an evolutionary development of the brain is itself convincing, but impressions of hominid brains on the inside of skulls (endocasts) give only limited information about internal structure, and hardly any insight into rates of change in behaviour or the evolution of culture. For the past 2 million years, however, at least some hominids have left impressions of their behaviour in the form of stone artefacts and other traces recoverable by archaeology. Much as a footprint conveys information not apparent from a set of bones, modification of the environment gives clues about cognitive abilities, and hence indirectly about the brain.

Any reconstruction of past cognitive developments cannot be entirely balanced because of the differences between humans and our relatives. Human prehistory is marked by a trail of archaeological evidence that goes back to Pliocene times, 2.5 million years ago. There is nothing remotely similar for chimpanzees or gorillas. Although chimpanzees use simple tools, such as termite-fishing sticks and leaf sponges, there is no archaeological record of these; only humans are dependent on tools that can leave a long-term record.

The processes that have 'forced' high intelligence in hominids are not fully understood. One idea is of an autocatalytic feedback model, in which increased intelligence and increased use of technology stimulate each other repeatedly. Social competition may also be invoked. Technology provides the best evidence of intellectual development. Various approaches can be used, including analyses of sequences of past actions (operational chains) and

models based on the ideas of psychologists, including Jean Piaget and other researchers.

Tools give information about culture and its transmission. They were made through increasingly complex routines and came to assume very complicated forms. Even in the earliest stone industries raw materials could be transported several kilometres from their place of origin; they act for us as 'visiting cards', signalling the distances travelled by their makers.

From the time that an element of behaviour is manifest in stone-working, early hominids show abilities not found in living apes. Their goals were longer term and were reached by more lengthy 'operational chains'. Stone tools themselves represent only an intermediate means, produced by the steps of transport and manufacture, but aimed at a subsequent end, such as processing animal carcasses or making wooden tools aimed at an even more remote goal.

There are certain behavioural continuities between the abilities of chimpanzees and our own, particularly in the use of tools (see p. 342). The last common ancestor of the hominids and chimpanzees probably lived more than 5 million years ago. We do not know whether that ancestor's tool-using abilities approached those of chimpanzees. Plants are important in tool use by modern apes, so they probably featured in early hominid behaviour long before the first stone tools, even though they left no trace. Bipedalism, which gives the hands more scope for tool use, was fully evolved by about 3.6 million years ago.

Toolmaking

The most basic step in making a stone tool – striking a flake from a cobble – is relatively simple. To strike a sequence of flakes, in such a way that each one helps in the removal of others, demands much more ability, not so much in terms of manual dexterity as in control by the brain. Each step must be evaluated for its own merits, and its consequences for future steps. No ape in captivity has yet been induced to strike more than a single flake from a cobble. Stone-working cannot be operated by an inflexible and mechanical routine, because there are too many possibilities at every strike. Control of the process can be maintained only by constant re-evaluation 'in the mind's eye' – a phrase that suggests the importance of visual imagination.

The modified cobbles (core tools) found on early sites do not represent simple experiments, but pieces flaked using well-learned routines that involved the recurrence of similar forms. An important question about early human abilities is whether the tools are deliberately shaped in a set form, or are simply the end-results of flaking along a path of least

TOOLMAKING BY APES

Many animals use tools. Vultures smash ostrich eggs using stones and Galápagos finches probe into bark for insects with sticks. However, apes, especially chimpanzees, are the pre-eminent users and makers of tools. Many primates in the wild or in captivity can use tools to acquire or process food, for hygiene, and during displays to members of the same species or at predators. This demands dexterity, some cognition – such as understanding the relations between two objects, say food and a twig – and the ability to plan which tool to use. In toolmakers, such cognitive skills, rather than trial and error, come into play.

The making of tools requires choosing an appropriate material from the surrounding environment. A specific tool type may be used for each task. Wild chimpanzees select sticks for probing into a termite mound on the basis of width, strength and length. They modify the stick, stripping the leaves so that it suits its purpose. A leaf used as a sponge for soaking up water from a crevice will first be chewed and crumpled to make it absorbent. It may also be used to clean blood or excrement off the body. Thus the raw material is not seen as a single tool, but can suit a variety of purposes.

In West Africa – in, for example, the Tai Forest, Ivory Coast – chimpanzees use hammer sticks and stones with a wooden anvil to crack open palm nuts. The hammers and anvils are seldom modified, but as they occur mainly where the roots of fallen trees have raised the rocky subsoil, chimpanzees have to carry the food to the sites or the hammers or stones to the fruiting trees. This requires foresight and planning.

Stones and twigs may also be used by chimpanzees to smash bones and extract the marrow from animals such as monkeys, which have been captured during co-operative hunts. A chimpanzee 'toolkit' with successional use has even been described. Researchers have reported seeing a young female using four different types of tools, each with a different function, to get honey from a hive.

Chimpanzees in contact with humans may extend their tool-using and toolmaking

capacities to incorporate human materials. They will, for instance, invent new tools to solve the problems of a captive environment, making ladders from branches or poles to climb trees protected by electric fences at their base, or using makeshift rakes to get hold of distant objects. Chimpanzees trained to use symbols will even ask for tools from other chimpanzees. Tool use thus forms part of the social traditions of chimpanzee society, and can be learned during infancy or later in life.

Not all apes use or make tools as well as do chimpanzees. Orang-utans in the wild have yet to be seen to use tools to any great extent, but in captivity they can be competent tool users. One captive orang-utan was taught to break a flint with a hammerstone, producing a sharp cutting edge, to slice a string and so gain access to a food box.

Gorillas do not seem to use or make tools much in the wild or in captivity although they will hurl stones, branches or grass at intruders, and, like chimpanzees, build nests for sleeping in. One female gorilla, Koko, trained to use sign language could manipulate a variety of objects as tools.

Perhaps the natural environment of orang-utans and gorillas does not challenge their cognitive capacity enough to stimulate a need for tools. Toolmaking is related to the problem to be solved, to the incentive to solve it (such as access to an especially nutritious food or escape from captivity) and to the time and energy needed to make the tool. The substrate for the tool must be present, as well as sufficient time to risk making a tool that does not work.

All apes probably have the ability to make tools, but only chimpanzees consistently have the need in their natural environment. Among apes, there has been selection for a general ability to solve problems, and making and using tools represents one solution to such problems.

P.C. Lee

See also 'Testing the intelligence of apes' (p. 111)



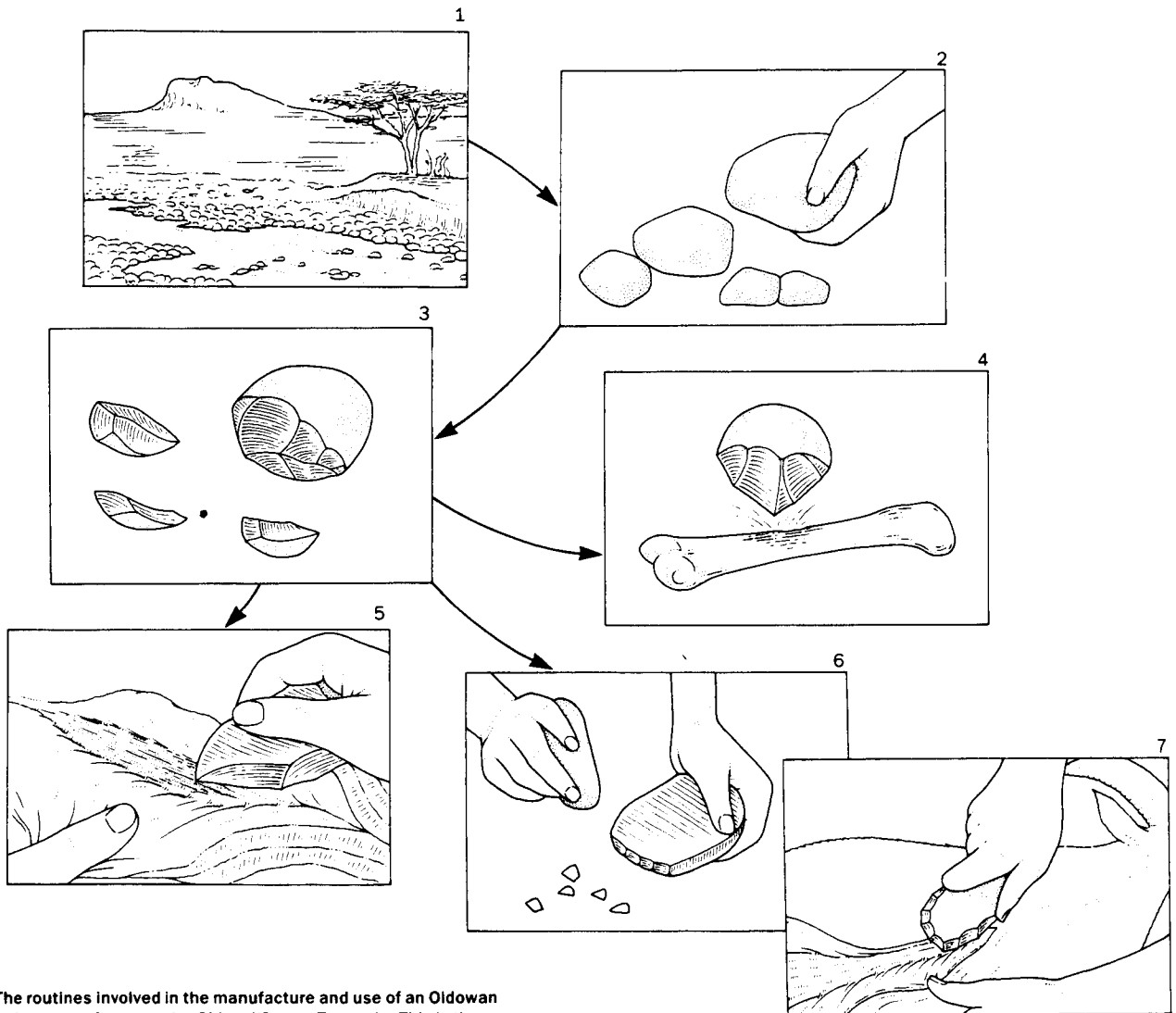
Learning how to make and use tools is an important part of a chimpanzee's upbringing. (Above) While an adult female in Tai Forest, Ivory Coast, uses an 8-kilogram hammerstone to crack open hard palm nuts, her 3-year-old daughter watches a male using a small stick to extract bits of kernel from a nut opened and partly eaten by the female. (Below) An infant looks on as her mother 'fishes' for ants in Gombe National Park, Tanzania.

resistance: flakes might be produced only by following certain sets of rules that can determine form, without the maker having the intention of creating a special shape. Yet even the second view is sufficient testimony to the abilities of the early stone-workers. They had to execute the routine in a controlled way, to have in mind the different options for working a core, and must hence have assimilated the results of past experience.

The working of a stone to a set form was plainly established by 1.5 million years ago when early humans made

large, bifacial cutting tools, or Acheulean handaxes. This tells us a great deal: that an 'arbitrary', preconceived form was held in the mind, and could be impressed on stone. This has been seen as a fundamental hallmark of culture. Such form is shown even in the earliest handaxes, where the ideas of an imposed long axis, bifacial working, and controlled curves are brought together. In even earlier Oldowan stone industries similar ideas may underlie the careful flaking of discoid cores or core tools.

Linguistic abilities may or may not be associated with

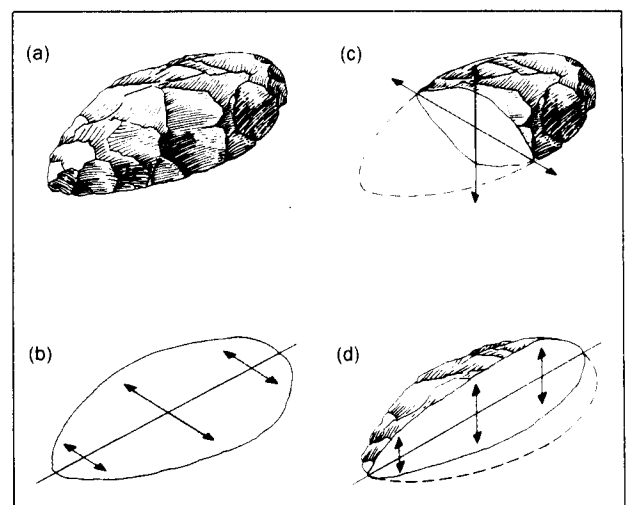


The routines involved in the manufacture and use of an Oldowan industry, at, for example, Olduvai Gorge, Tanzania. This is the minimum number of steps documented at early sites; the complete range of processes did not necessarily occur on a single site.

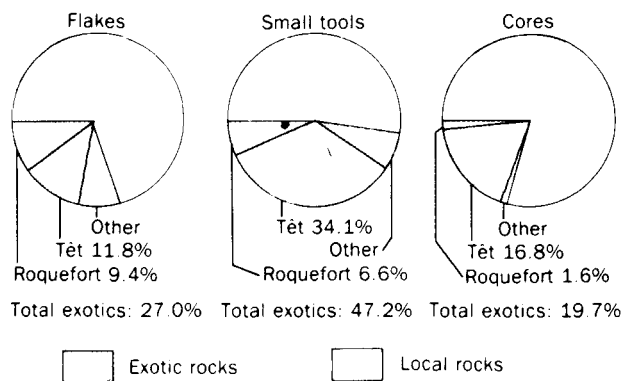
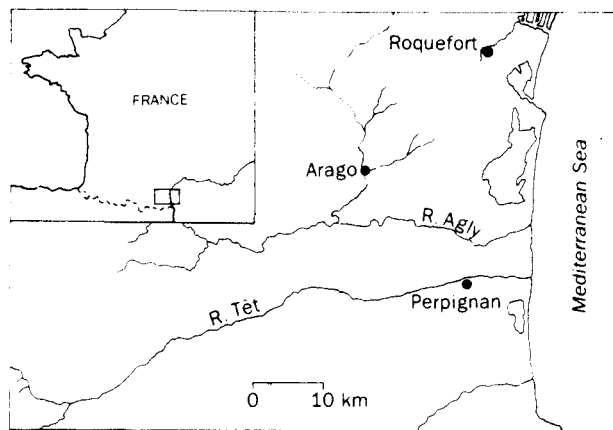
1. Visit to source of raw materials
2. Selection of suitable pieces
3. Basic flaking, yielding heavy core/core tool and lighter flakes
4. Use of heavy elements to batter (e.g. bones)
5. Use of flakes to cut (may leave cut marks on bone)
6. Retouching of flakes with a hammerstone
7. Use of tool with retouched edge (e.g. on skins); microwear analysis of tools is the only source of knowledge of materials other than bone

such an imposition of arbitrary form. Language seems to go hand-in-hand with lateralisation of the brain, but chimpanzees may also show signs of lateralisation in the form of handedness. The proportions of flakes struck in particular directions suggest that hominids may have been predominantly right-handed as long ago as 1.9 million years.

Evidence on the transport of raw materials is particularly helpful to the archaeologist: even on the earliest sites, stone tools may be made of materials that must have been carried for several kilometres. The stones were selected, as differing proportions of artefacts were made from particular stones. At Olorgesailie in Kenya, a middle Pleistocene site



Ideas embodied in a bifacial handaxe. Acheulean bifaces were made with varying degrees of symmetry. Most examples have one or more of the following characteristics, and the finest specimens include all. The basic design (a) can incorporate (b) bilateral symmetry of the major plane around a long axis; (c) quadrilateral symmetry in the transverse section; and (d) bilateral symmetry around the long axis in the thickness plane.



The hominids occupying the Lower Palaeolithic site of Arago in southwestern France between 400 000 and 300 000 years ago obtained some of the raw materials for their tools from distant sources – for example, good-quality chalcedony and chert from Roquefort-des-Corbieres about 30 kilometres to the north-east and quartzite from the River Têt, at least 20 kilometres to the south. The pie diagrams show the percentages of exotic rocks in flakes, small tools and cores found in Layer G at the site.

dating to around 800 000 years ago, finds of manuports (unmodified stones) are of a type of lava available about a kilometre away, but unsuitable for toolmaking. By contrast, lavas suitable for handaxe-making were brought from volcanic mountains several kilometres distant. This shows active discrimination on a rational basis, doubtless reinforced by the hard work involved in carrying stones. At Olduvai in Tanzania, too, some handaxe sites in Bed IV, aged about 700 000 years, are made up of specimens of selected lavas brought from as much as 20 kilometres away. Similar transport distances are known from the French site of Arago (about 300 000 years ago).

In some circumstances, it must have been worthwhile to carry hundreds of kilograms of tools for distances difficult to cover in less than a day's walk. *Homo erectus* was thus able to plan at least a day's activity at a time (or had exchange networks, or both) – and, if the return journey is taken into account, perhaps further ahead. Such carrying must have had a useful economic return, or it could not have persisted for hundreds of thousands of years.

The production of artefacts and the transport of raw materials both give insights into routines that were



All peoples of recent times knew how to kindle fire, often by means of a bow drill like these Igwi San of the Kalahari. Fire use may go back much further in time than fire-making.

repeated, with variations in detail, many millions of times through the Stone Ages. Other routines are preserved with far less certainty. The manufacture of wooden tools can be inferred from microwear traces on stone tools, and within the past 300 000 years from preserved wooden tools such as spears. The abilities demanded to work wood were essentially similar to those used in stone-working. Control of fire would have helped, although its early prehistory is controversial.

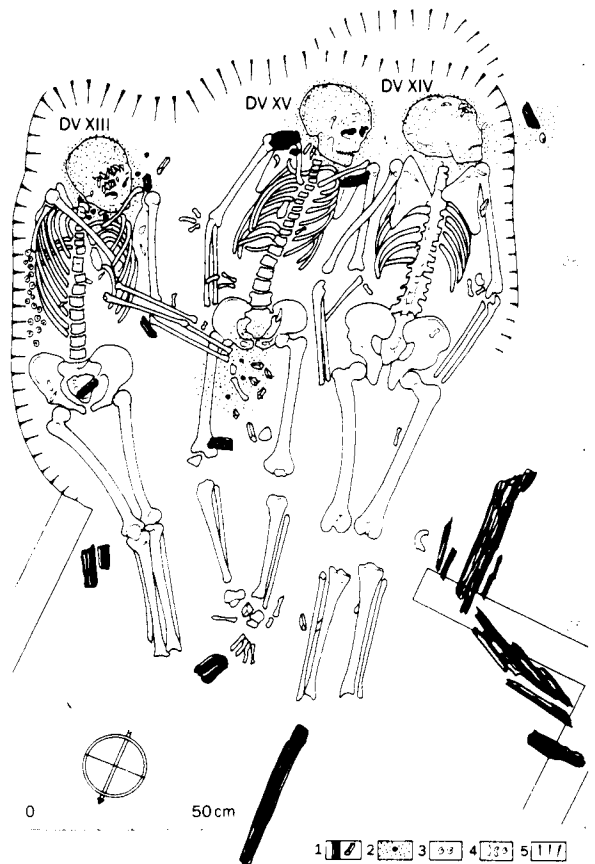
Coping with the cold

Early sites in Africa have some suggestion of the use of fire, but clear evidence of its controlled creation occurs only in the past 10 000 or 20 000 years. There is good evidence for its use in Europe and Asia within the past 500 000 years, and human colonisation of temperate lands may have been impossible without it. This is not certain, because this occupation took place mainly during periods when the world's climate was warmer than today. It seems likely, however, that the seasonal and diverse northerly climates placed more demands on planning and cultural specialisation than did the tropics and subtropics.

The management of hunting and gathering in such circumstances represents an economy rather than mere opportunistic existence, and selection for advanced cognitive abilities must have increased as the climate worsened. Populations that advanced northwards in the warmth of the interglacials probably had a hard time when colder glacial climates returned. Apparently, such populations were rolled back southwards, as late as the peak of the last glacial period 20 000 to 18 000 years ago, even with the technological improvements in clothing and structures represented in the Upper Palaeolithic sites of the Russian plains and elsewhere. Although these innovations arise from manual skills they depend equally on complex routines controlled by the brain.



Middle and Upper Palaeolithic burials are known from Europe and Asia. Those of Neanderthals, such as the example here from Kebara Cave in Israel (above), are simpler than later Upper Palaeolithic burials, such as the triple burial from Dolni Veštonice in Czechoslovakia (right), which often include personal decorations. Key to the symbols on the reconstruction by B. Klima of the Dolni Veštonice burial: 1, charred wood covering the bodies; 2, red pigment; 3, mollusc shells used as decorations and land snails; 4, human teeth, perforated animal teeth used for decoration and pendants of mammoth ivory; 5, grave walls.



Representational art and burial

We gain most insight into such routines where organic preservation is good. This rarely applies beyond the past 10 000 years. Nevertheless, a greatly increased variety of skills appears within the past 100 000 years, coinciding approximately with the first appearance of modern humans. In the past 40 000 years, we see the first shaped bone tools, decoration and representational art, and pointers towards secondary skills – for example, bone needles indicating the existence of thread and sewing. Many archaeologists therefore look on the coming of modern humans and then of the Upper Palaeolithic as the greatest watersheds in human evolution. They may well be right. However, much of the detail of earlier cultures is lost to us and we should not assume that all important changes were concentrated within a short period late in human evolution.

Deliberate burial is one major development that appears before art and the technological advances mentioned above. It is found first around 100 000 years ago, and has a geographical distribution over most of Eurasia. Burial suggests an awareness of the possibility of future life and demonstrates the existence of formal ritual. Even so, we should remember that most human remains found in caves

occur in bits and pieces, and that some of them have cut marks (see p. 330): Middle Palaeolithic burial practices do not fit neat preconceptions about ‘care’ for the dead. The continued, worldwide practice of burial in Upper Palaeolithic times implies a continuity not seen in economic practices or in stone tools.

Technological specialisation often affected the economy. The sophisticated bone and antler tools of the Magdalenian (about 17 000 to 12 000 years ago), which include spearthrowers and harpoon heads, must have given greater success in hunting, and the chance for more selection of prey species. The earlier Mousterian sites occupied by Neanderthals often contain a mixed bag of remains, but later Upper Palaeolithic sites frequently show a concentration on single species, such as reindeer or horse.

All this reinforces the view that through the past 30 000 to 40 000 years the brains of modern *Homo sapiens* were similar to our own. Physical and cultural evidence points to lower levels of mental ability and craft skill in earlier periods. Nevertheless, we may have to concede that the foundations of many basic human skills were laid 1 or even 2 million years ago, rather than at the origins of our own species.

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See also ‘The human brain’ (p. 115), ‘The hominid way of life’ (p. 325), ‘Evolution of human manipulation’ (p. 346), ‘Tools – the Palaeolithic record’ (p. 350) and ‘Ancient art’ (p. 361)