STONE TOOLS AND THE UNIQUENESS OF HUMAN CULTURE

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There is growing evidence that some species other than the human have behaviour that should be called cultural. Questions arise, then, of how human (and, perhaps, ape) cultures are different from those of other animals and how they have become so different. Human cultures are creative, generating new patterns of behaviour from those learned from others. Stone tool making provided a niche for the recruitment of tools and tool-making processes from one function to another. This is something not yet recorded for apes. This article explores the possible role of stone tools in the emergence of this creativity.

There is growing evidence that some species other than humans have behaviour that should be called cultural in recognition of common features between the way in which their behaviour is structured and the way in which behaviour is structured in human societies. For all animals, and for humans before written records, identification of their cultural nature is a matter of inference from an incomplete record. Among animals, the strongest case for cultural behaviour is for the chimpanzee (Boesch & Tomasello 1998; McGrew 1992; Whiten et al. 1999; 2001). Other cases have been mounted for the capuchin (Perry et al. 2003), the orangutan (van Schaik et al. 2003), and the bonobo (Hohmann & Fruth 2003), as well as for whales and dolphins (Rendell & Whitehead 2001), but no claim has yet been made for the gorilla. An important alternative view is that the only species for which culture can be claimed are ‘humans, plus a handful of species of birds, one or two whales, and two species of fish’ (Laland & Hoppitt 2003: 151). In all cases, one of the major issues is the question of socially learned behaviour, a perfectly respectable aspect of any definition of culture among humans. Laland and Hoppitt provide a preliminary definition of culture: ‘[C]ultures are those group-typical behavior patterns shared by members of a community that rely on socially learned and transmitted information’ (2003, 151; we note that the concept of information is difficult to operationalize in a consistent way). If, as most anthropologists would argue (e.g. Kuper 1999), the context of social learning and information transmission in cultures necessarily involves symbols and language, then the mainstream view is that culture is still confined to humans. This article explores aspects of how human cultures became evolutionarily differentiated from those of other animals.

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Using Laland and Hoppitt’s definition, there are questions not only of how learning occurs but also of how to characterize the nature of the imitation that takes place among animals (Byrne 2002; Byrne & Russon 1998; Miklósi 1999; Whiten, Horner & Marshall-Pescini 2003). These are complex issues, and, though there is abundant laboratory evidence for social learning in several species (Fragaszy & Perry 2003), few examples actually demonstrate social learning in the wild. There is a further question of whether such learning, with or without imitation, leads to the development of traditions (Janik & Slater 2003) among different populations of the same species such that these populations have what might be called different cultures, in rather the manner that humans do not just have culture, but cultures. This claim has been made for chimpanzees and orangutans (Fragaszy & Perry 2003). Identification of animal populations with distinct patterns of behaviour that cannot be accounted for by ecological differences enhances the likelihood that such differences are due to social learning, although it does not prove this.

How are human (and, perhaps, ape) cultures different from those of other animals, and how did they become so different? The simplest argument is that culture has been a feature of humans and great apes since the time of their Last Common Ancestor. The distinctiveness of human culture is thus a result of a specific history of the operation of the same processes as were operating among other animals. One way of approaching the apparent surprise of the identification of cultures in non-human primates is to try to identify how the factors in this specific history operated. Christophe Boesch, one of the cultural primatologists who emphasize the cultural nature of chimpanzees, has recently acknowledged that ‘language would have opened a wide new window, facilitating the development of cultural traits in the communicative and the shared reflective domain, and paving the way for all our cultural beliefs and rituals’ (2003: 90). Various people have tried to consider questions of the evolutionary emergence of language, particularly in relation to the generativity that results from reflectivity (e.g. Noble & Davidson 1996, and see papers in Christiansen & Kirby 2003), since symbol use and its later emergence as language (as we know it) is crucial to the later stages of hominin and human evolution. It probably is not, however, an important part of the question of how hominins and ancestral chimpanzees (and gorillas) set off in different directions long before any apparent emergence of language use through the operation of natural selection on existing variations of behaviour. In this article we explore the nature of stone tool use and how it may have had a priming effect.

What is culture if it can be found in chimpanzees, bonobos and orangutans?

The use of the word ‘culture’, which has its origins in descriptions of agriculture (see Goddard 2005), was adopted in anthropology to describe those features that made humans distinctive (Tylor 1881). Anthropologists were using the word metaphorically by pointing to the similarities between the original meanings and the ‘self-cultivation’ implied in what we understand by the anthropological culture concept. Thus, once the concept was defined, anyone
could take it and see (a) how culture is composed and (b) how the constituent elements differ (or not) from the equivalent elements in non-humans. McGrew and Tutin (1978) described the grooming hand clasp (Fig. 1), a form of social interaction during grooming among chimpanzees at Mahale that they had not seen previously at Gombe. They took anthropological recognition criteria for culture and applied them to learned behaviour among chimpanzees.

Figure 1. Chimpanzees at Mahale doing grooming hand clasp 1975. (Photo C.E.G. Tutin from W.C. McGrew collection, reproduced with permission.)
They emphasized that the chimpanzee behavioural repertoire that included the grooming hand clasp could be seen to exhibit those common features of culture defined, following Kroeber (1928), by innovation, dissemination, standardization, durability, diffusion, and tradition in both subsistence and non-subsistence activities. The impact of that article was that scholars more widely recognized the claim that apes (at least) might ‘have’ culture, a view promoted by McGrew’s (1992) demonstration of the diversity of chimpanzee material culture and its similarity in many respects to that of humans.

**Chimpanzee ‘culture’ and ‘cultures’**

The question of non-human culture was thrust into the limelight more recently by a paper called ‘Cultures in chimpanzees’ (Whiten et al. 1999). This argued that variation in the manifestation of cultural behaviour among ape populations separates them into cultural populations differing from one place to another. This enhances the claim that these behavioural features have strong similarity with the cultures of humans. The synthesis by Whiten and colleagues (1999) of research on seven groups of chimpanzees showed that there were sixty-five behavioural patterns that might qualify as culture. These were further analysed. Conservatively, only the thirty-nine patterns ‘found to be customary or habitual at some sites and absent at others when there was no ecological reason for the absence’ (Whiten et al. 2001: 1495) were considered relevant to the question of whether there are different chimpanzee cultures. These patterns could be categorized into those relating to food-getting, food-processing, personal comfort, and signalling, although specific patterns did not need to be confined to these functions.

There is a feature of these activities that is little commented on. Trimming leaves off a grass stem to make a termiting probe, or cracking nuts with a stone hammer, do not seem likely to generate new patterns except in relation to grass stems and to nuts. While this is irrelevant to the assessment of whether the behaviour is socially learned or not, it does relate to an apparently distinctive feature of human cultures that recruit behaviour from one function to another. In assessing tool use and its role in transforming non-human culture into something more like that of humans, it may be productive to concentrate on examples of behaviour in which there are opportunities for transformation of a behaviour through extension into new contexts. For example, it has been argued that actions of pounding are important precursors in the evolution of tool-making by percussion since they can lend themselves to the application of the same bodily motor actions to different raw materials and with novel purposes (de Beaune 2004; Marchant & McGrew 2005).

**Orangutan ‘culture’ and ‘cultures’**

Following Whiten and colleagues’ claim for different chimpanzee cultures, van Schaik and colleagues collected similar data from orangutan studies (van Schaik et al. 2003). The research synthesized 6 field sites and found 36 patterns, of
which 24 could be seen as equivalents to those of the Chimpanzee Culture Trait group. The largest group of behaviours \((n = 12)\) related to specialized feeding, while six were forms of social signal such as ‘kiss-squeaks’. Two of these were interpreted as coming ‘close to reflecting shared meaning based on arbitrary symbols’ (van Schaik et al. 2003: 102; for further comparison between chimpanzees and orangutans, see McGrew 2004: 74–85).

The following points of comparison were found between the two species:

• The range of ‘cultural’ traits among orangutans is much smaller than among chimpanzees.
• A few traits (such as two used for food-getting and three related to comfort) are similar across species.
• Nine of the chimpanzee traits appear to be related to signalling or display, but only four of the orangutan traits appear to be. Of these, only two of the orangutan signals do not involve materials external to the animal.
• There is an almost complete absence of food-processing traits among orangutans (except tool use to extract seeds) compared to an extensive array of tool use for food-processing among chimpanzees.

One difference between chimpanzee and orangutan culture is the constraints imposed by the extreme arboreality of orangutans (cf van Schaik et al. 2003). This occupation of the hands in positional behaviour, together with constraints in availability of raw material, limits the amount of material culture they can make and use with their hands. By contrast, chimpanzees spend half their working day on the ground and have more opportunities for object manipulation (Doran & Hunt 1994: 100; Goodall 1986; McGrew 2004; McGrew field observations). Bipedal, terrestrial hominins, presumably, had even more opportunities for manipulation.

**Chimpanzee stone tools**

Mercader, Panger, and Boesch (2003) recently looked at the question of stone material culture among the chimpanzees of the Tâi forest of the Ivory Coast. Boesch (1991; Boesch & Boesch 1984a; 1984b; 1993; Boesch, Marchesi, Marchesi, Fruth & Joulian 1994) had previously described various aspects of nut-cracking among these chimpanzees, showing not only that they rested nuts on stone or wooden anvils and used stone or wooden hammers to crack them, but also that they sometimes even appeared to teach infants the technique by a form of scaffolding of their actions. Importantly, the Boesches (1984a) showed through an elegant comparison of the positions of stone hammers at the end of one nutting season with their distribution early in the next season that the chimpanzees were moving hammers from one site to another, and appeared to be making decisions about the relative costs and benefits of choosing one hammer rather than another.

Kortlandt (1986) and McGrew (1992: 205) separately observed that occasionally stone anvils were accompanied by flakes that appeared to have been removed from the margins of the anvil, presumably when a hammer did not hit the nut appropriately and incidentally hit the margin of the anvil at the
correct angle. Mercader, Panger, and Boesch (2003) investigated how much stone-flaking debris might accumulate at long-lasting nut-cracking sites. They excavated around a dead nut tree that had extensive indications, in the form of characteristic pitting, that the tree buttresses had been used as anvils for cracking nuts. Further investigation showed that there were at least six wooden anvils in the vicinity and broken stones were excavated at all of them.

Given that the sites were identified because of the presence of wooden anvils, all artefacts seem to be fragments broken off hammer stones. However, a small number show the scars of previous removals from the same hammer. Some informal scepticism has been expressed about the similarity between these artefacts and those of early hominins (cited in Vogel 2003), but the results are unsurprising. Choice of shape and raw material suitable as hammers need not lead to an expectation of ‘well-formed’ flakes of the type that are stock-in-trade for archaeological analysis. McGrew has observed that fragments of stone may result from hammer stones that break while in use. But the broken hammer stones may not be suitable for use, because the edges of the fragments are not sharp in the manner of flakes removed from anvils.

On the other hand, fragments of stone can also result from hard-shelled fruits being struck against anvils without stone hammers. This happens, for example, when anvils are laterite. Sharp-edged flakes can also result from the use of hammers which miss the nut and hit the margin of the anvil (Fig. 2). This is an indication of the selective context in which early hominins could have observed the possibility of using sharp-edged flakes, and hence learned to make them. It is, arguably, less suitable for such observation than the situation described by Kortlandt and McGrew, where flakes were taken off the margins of stone anvils (Fig. 2).

**Stone tools among captive apes**

Wright (1972) experimented with getting apes to flake stone. In this experiment, an orangutan was shown how to make flakes by knapping, and then provided with a stone core fixed to the floor. The animal was encouraged to knap the core by the provision of food reward when it cut a string that was holding a feeding box closed. The animal successfully removed flakes and cut the string. One uncommented aspect of this work, and the later work with bonobos, is that cutting is not one of the activities recorded for wild orangutans, chimpanzees, or bonobos. One reason for this, as with its absence in other carnivores, is that many of the purposes for which cutting is necessary can be accomplished using the teeth.

Two captive bonobos, Kanzi and Panbanisha, were taught to make stone tools by observation and imitation (Schick et al. 1999; Toth, Schick, Savage-Rumbaugh, Sevcik & Rumbaugh 1993). Kanzi initially overcame the problem of preventing unwanted movement of the core by throwing the core against the concrete floor of their cage (in effect using the floor as a hammer stone). Later, he learned to make flakes by throwing one rock against another. Both apes were also able to make flakes by direct freehand percussion (Savage-Rumbaugh, Fields & Spiru 2004; Davidson personal observation).
De Beaune (2004: 141) has suggested that Kanzi did not seem to calculate striking angles during freehand percussion, and that was Davidson’s impression on a visit in 1993 (Savage-Rumbaugh & Lewin 1994: 243). On his second visit in 1998, however, he observed Panbanisha making stone tools, and she appeared to calculate angles before hitting the core (Fig. 3). One anecdote does not make the case, but we can hope for further detailed observations of these two ape knappers.

One way of interpreting Kanzi’s approach to knapping is that he found solutions (throwing cores against the floor or against other rocks) to the problem that he was being asked to solve. In a similar way chimpanzees in
the wild observed to use a small stone to balance a nut-cracking anvil may be showing that they are able to respond to more than just immediate contingencies (Matsuzawa 1994). Some might conclude that these captive and wild apes were showing insight otherwise thought restricted to humans, but it would be difficult to say why this should be given greater value than an interpretation that it was a result of trial and error in individual learning. The methodological problems involved in distinguishing between these options are formidable.
What happens when hominins or humans make stone tools?

The process of making stone tools by percussion depends on the control of the pattern of application of forces to a rock (Whittaker 1994) – features external to the rock – and the mechanics of the rock fracture when the force is applied (Cotterell & Kamminga 1987) – features that are properties of rocks. While there are exceptions, it is generally the case that failure to apply force in the right way will not produce useful modifications to the stone even when the raw material has the right mechanical properties (although it may create incipient fractures that cause problems later on). Equally, applying force in the right way to unsuitable raw materials may also produce no useful result. This occurs, for example, in the selection of appropriate hammer stones with no angled edges from which flakes will be removed. This may be one of the reasons why the broken (hammer) stones excavated by Mercader, Panger, and Boesch (2003) do not have the characteristics of ‘well-made’ flakes.

Cognitive requirements for stone tool knapping

Byrne (2004) has recently shown that the process of making stone tools can be analysed into a number of cognitively significant characteristics: precision handling; accurate aiming; bimanual role differentiation; regular and sequential plan; hierarchical organization with sub-routines; corrective guidance by anticipatory schema; high individual manual laterality; and population right-handedness. He identified substantial overlap of these manual skills among the apes. The purpose of Byrne’s analysis was to assess what cognitive similarities and differences there might be in the manual skills of apes and those of early hominins. He identified a substantial overlap between ape manual skills and those required for stone-knapping, concluding that the single characteristic unequivocally necessary for the manufacture of stone tools but missing from the ape repertoire is accurate aiming of powerful blows. Aimed throwing occurs among chimpanzees (as many visitors to zoos can testify), but whether it has the accuracy needed for precision knapping is a more open question. Calvin (1982) speculated that the habitual application of aimed force, including aimed throwing, depends in part on neural changes that favour particular muscle co-ordination. In Calvin’s argument, the redundant circuitry could be recruited for language production.

Uses of stone tools

Most studies that discuss the importance of stone tools in hominin and human evolution emphasize the importance of cutting or other uses of the tools that were produced (Ambrose 2001), and we have previously noted that this does not seem to be present among wild apes. These and other processes described are summarized in Table 1. In addition to the observation that human tools bear signs of use for obtaining meat or other animal products, the polish on early stone flakes also suggests that some tools were used for cutting and scraping wood or other plant products (Keeley 1980: 86-165; Keeley & Toth 1981). More recent studies show that plant phytoliths from woody species can be

IAIN DAVIDSON & WILLIAM C. McGREW 801
found on the margins of some of these early tools (Dominguez-Rodrigo, Serrallonga, Juan-Tresserras, Alcala & Luque 2001). Wooden objects, modified by cutting, appear in the archaeological record when the conditions are good enough for their preservation (Goren-Inbar, Werker & Feibel 2002; Thieme 1997; Thieme & Veil 1985).

Producing and not producing stone tools

All of our remarks about stone tools, as made by other animals and as made by hominins, presuppose that the creatures had access to a supply of raw material for flaking and for use as hammers (McGrew, Ham, White, Tutin & Fernandez 1997). Commonly, for the mechanical reasons discussed on page 801, hammers made of stone might be obtained from a different source than the raw material used to produce flakes. However, the whole business of archaeological inference of the behaviour of early hominins depends on another property of this early stone tool making. This is that the making of stone tools leaves behind stone flakes (some of which may have been used), stone cores from which flakes have been removed, and hammers. This property is an index of stone tool making.

There are two other classes of evidence about early hominin behaviour. The first is that at a small number of sites at which stone tools have not been found, there is evidence of animal bones that show cut marks made by stone tools (de Heinzelin et al. 1999). This implies that hominins had used and carried away stone tools (and meat). The second is that at many of the early sites with evidence for flakes, cores, and hammers, there are also stones labelled ‘manuports’ by archaeologists, who think that only transport by hominins can account for their presence in the sediments. McGrew (1992: 202-7, 212-14) pointed out that there are several published examples of other animals (wasps, dinosaurs, sea-lions, moas, rhesus and Japanese macaques, baboons, and bower birds, in addition to chimpanzees) using or moving stones.

<table>
<thead>
<tr>
<th>Procurement: Raw material and hammer stone</th>
<th>Hominins and humans</th>
<th>Chimpanzees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (and abandonment)</td>
<td>Yes</td>
<td>Yes for hammers, but maybe not both</td>
</tr>
<tr>
<td>Learning</td>
<td>Yes</td>
<td>Probably not – the hammers are used on nuts</td>
</tr>
<tr>
<td>Carrying</td>
<td>Yes</td>
<td>Yes for hammer, but not for subsequent tool</td>
</tr>
<tr>
<td>Use 1</td>
<td>Yes, hammers, anvils and flakes</td>
<td>Yes, but only hammers and anvils</td>
</tr>
<tr>
<td>Use 2</td>
<td>Pounding and cutting</td>
<td>Pounding but not cutting</td>
</tr>
<tr>
<td>Abandonment: Persisting physical product</td>
<td>Yes</td>
<td>Yes, but the product is only nutshells</td>
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Although the original claims for manuports at Olduvai Gorge, Tanzania (Leakey 1971: 8, Table 6), have been questioned (de la Torre & Mora 2005), at other sites these can form as much as 2 per cent of the assemblage of excavated stones (e.g. at Lokalalei 2C, Kenya [Roche et al. 1999], and Omo Fj11, Ethiopia [Merrick & Merrick 1976]). These objects are generally stones foreign to the geological context in which they are found, but show no indication that they were used either as tools themselves or in making tools. Both of these situations indicate that hominins were carrying tools and other stone materials around with them on a regular basis. Sourcing of stone raw materials at Olduvai Gorge showed that, overall, stone raw materials were carried between 2 and 13 kilometres from source to site (Hay 1976: 182–186; Leakey 1971: 263; Potts 1984; 1988: 238–43).

By contrast, another striking feature of stone-flaking sites from all periods, including the earliest, is that many of the flakes removed during knapping were left at the site. At Lokalalei, one of the earliest stone artefact sites in east Africa, Roche and her team (1999) showed that at least 10 per cent of the artefacts could be fitted onto other artefacts, and four refitting sets had more than ten artefacts. About two-thirds of these sets did not have a core in the set.

Primatologists have been able to conjoin distal fragments of termiting probes and the rejuvenated tools from which they had been clipped. Some types of tools left at termite-fishing sites are rendered unusable in the process, but others are not and are re-used (Sanz, Morgan & Gulick 2004).

**The environment of opportunity of stone tools**

From the point at which stone tools first appear in the archaeological record two other processes seem to have occurred: (1) hominins carried stone tools and non-artefactual stone around with them and (2) the process of making stone tools left remains at sites, including cores, flakes, and hammer stones, which can be taken as indexical signs of an activity that may be peculiarly hominin.

For the first process, carrying, hominins seem to differ from chimpanzees in needing to obtain both raw material and hammer for removing a third object, the flaked stone. As far as we know, chimpanzees carry hammers only. For the second process, the knapping remains often included series of flakes from apparently single knapping episodes. In a context where hominins were seeking raw materials and hammer stones for knapping, these remains of past activity radically altered the environment of opportunity for them because not every piece of stone was removed from the place where it was first knapped. Apes also leave behind used and unused tools and raw materials of vegetation, but these perish quickly. The abandoned hominin hammers, cores, and flakes became a potential, and ongoing, new resource for the same or different individuals, in effect constructing a new niche for them. This is the fundamental observation about hominin stone tool production that is independent from any more complex claim, such as those by Potts (1988: 278–81), who argues that such behaviour led to the formation of stone ‘caches’ to which animal tissues were taken for processing.
In this regard, hominin activity seems to be different from the behaviour signalled by the discovery of stones flaked by chimpanzees, since there is as yet no evidence that wild chimpanzees were aware that the stone had been flaked. Moreover, whatever the observations by hominins or chimpanzees about the abandoned products of their tool-making, the hominin knapping site was a potential source of new raw materials, both hammer stones and usable flakes. Tools made as a result of a revisit to the site could be used for the same purpose as on the first visit, but they could also be used for different purposes. The conjoinable termite-fishing probes or ant-dipping wands are sometimes re-used, but this has only been seen to be when they have been used for the same purpose.

Can we establish whether early hominins ‘had’ culture or cultures?

Some claim that the earliest stone tools from beyond two million years ago indicate the beginnings of human culture. But Wynn and McGrew (1989) argued that for those early east African stone industries known as Oldowan some of the evidence was little different from the evidence then emerging about chimpanzee behaviour. Byrne’s (2004) argument demonstrated the similarity of the cognitive abilities implied by the evidence of manual skills.

Early archaeology and the criteria for culture

One way of approaching the early stone industries is to assess them using the same criteria as those used by McGrew and Tutin (1978) when evaluating the grooming hand clasp. The criteria that those authors selected from their reading of the anthropology of culture were innovation, dissemination, standardization, durability, diffusion, tradition, non-subsistence behaviours, and natural adaptiveness. Some of their considerations are set out in Table 2. This summary suggests that the case for culture among early hominins is not so clear-cut when rigorously evaluated using the method of McGrew and Tutin.

Detailed analysis of early stone tool assemblages suggests that the technological transformations of the stone were not very complex. Roche and her collaborators at Lokalalei described ‘unidirectional or multidirectional removals … on a single debitage surface, from natural or prepared platforms’ (1999: 59). The illustrated examples of conjoined sets suggest that in all cases these are sets of flakes removed in sequence but without any great dependence of removals on prior removals at any stage. Removal of many flakes from cores implies skill at knapping (as anyone will agree who has begun to learn to knap), but this seems to be a fairly simple level of application of skills, exploiting available angles on core margins (what Roche et al. called ‘judicious exploitation of the natural morphology of the blocks’ [1999: 59]), and it is enigmatic why so many conjoinable sets were left behind at Lokalalei. It is not obvious which flakes might have been used from the sets that Roche et al. illustrated, and how many removals from the cores took place before a used flake was produced.
Table 2. Assessment of early stone industries against criteria used by McGrew and Tutin (1978) for the recognition of cultural behaviour in chimpanzees.

<table>
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<tr>
<th>Criterion</th>
<th>Discussion in relation to earliest stone industries</th>
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<tr>
<td>Innovation</td>
<td>The earliest stone industries are innovative (unless they were imitated from other apes), though once learning of the techniques of flake removal was established, flaking alone cannot indicate innovation. There was little innovation for the first million years of stone flaking (Toth 1985), but this may be a result of lack of emphasis on variation rather than pattern. There is some evidence that knapping produced outcomes that became characteristic of later industries such as the Levallois technique (de la Torre, Mora, Dominguez-Rodrigo, de Luque &amp; Alcala 2003) without becoming characteristic of early industries.</td>
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<td>Dissemination</td>
<td>Hardly any attention has been paid to the methods of transmission of stone tool making skills from one individual to another. One avenue for investigating this would be the study of knapping errors. But there are two problems with this. First, the data would be difficult to interpret in terms of the learning of knapping. Second, the data would need to be put into the context of knapping errors in other times and other places, but the data are not good for any time or place.</td>
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<tr>
<td>Standardization</td>
<td>The products of stone tool making in the earliest stone industries have always been recognized by the fact that they are patterned. But Toth (1985) argued that some of the variation between ultimate forms was a result of the operation of simple processes on different initial raw material forms. Many non-cultural behaviours produce similar outcomes because of stereotyped processes with limited options.</td>
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<tr>
<td>Durability</td>
<td>The stone tools themselves are durable, but we cannot be sure that the tradition of flaking was. It is possible that the earliest stone tool making involved individual discovery with minimal learning either vertically or horizontally (Janik &amp; Slater 2003).</td>
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<tr>
<td>Diffusion</td>
<td>Early stone industries are widely separated in space and time, and later sites are more frequent and densely distributed. This might imply several independent discoveries of stone-knapping, followed by a more consistent tradition as the practice spread from one group to another. No distinctiveness of earliest stone industries has been described which would show the spread of particular knapping skills from one place or one group to another.</td>
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<tr>
<td>Tradition</td>
<td>Although archaeological descriptions of stone tools have routinely used the word ‘tradition’ associated with stone industries such as the ‘Acheulean tradition’ and particularly ‘the Mousterian of Acheulean Tradition’ (MAT), transmission of a tradition from one generation to the next is not the only way to view the regularities in these stone industries. For the Acheulean, we know that the MAT occurred many tens of thousands of years after the end of the Acheulean as a tradition (if it ever was one) and hence the occurrence of the bifacial flaking that led to the particular naming may occur without the presence of the tradition (Davidson 2002).</td>
</tr>
<tr>
<td>Non-subsistence</td>
<td>We cannot be sure that any particular artefacts of the earliest hominins were related or unrelated to subsistence, except when demonstrated by use-wear analysis. Even when cut-marks are present on bones (Bunn 1981; Potts &amp; Shipman 1981; Shipman 1986), we cannot be sure which artefacts inflicted them. When behaviour was unrelated to archaeological evidence of artefacts, we have no information at all. But the fact that flaked stone was left at sites while other flakes were carried around suggests that not all learning about knapping necessarily needs to be considered as directly related to subsistence. As a result, it seems appropriate to include stone tool making in consideration of the cultural status of the behaviour.</td>
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The question arises, following Byrne’s approach to manual skills and Wynn and McGrew’s (1989) assessment of spatial behaviour, whether the evidence from early archaeological sites would meet the recognition criteria of Whiten and colleagues (1999) for chimpanzee cultures and van Schaik and colleagues (2003) for orangutan cultures. In the ape culture papers, an important argument was that variation in several habitual or customary patterns of behaviour between different communities of the species in question was maintained by mechanisms of social transmission. Processes of social transmission are extraordinarily difficult to document for animals that cannot speak to us. Can we at least find evidence in the early archaeology for behaviour ‘found to be customary or habitual at some sites and absent at others where there was no ecological reason for the absence’ (Whiten et al. 2001: 1495), as is available for modern chimpanzees? And could this be taken to imply social transmission?

When we turn to assess the evidence from early human stone tools in this way we still find that the situation is worse than for non-human primates.

Learning stone tool making

We know little about how hominins or humans learned to make stone tools. There are several reasons for this:

- Early hominins cannot speak to us about their learning processes any more than apes can. Archaeologists rely on inference, in this case from the products of their behaviour rather than, as for primatologists and psychologists, from observation of their behaviour. On the other hand, almost all of the published work on chimpanzees comes from seven of the more than fifty populations where the animals are sufficiently habituated for direct observations of behaviour. For the remaining populations behaviour can only be inferred from indirect evidence that is similar in form to inference in archaeology.
- We know nothing about the ontogenetic process of acquiring the skills of knapping. There are few studies of how modern people learned stone-knapping (but see Stout 2002), and there are probably few remaining opportunities for studying knapping among people whose principal tools are stone.
Experiments are unlikely to provide useful information about learning. One of the crucial factors missing from all experimental stone-knapping is the context of the role of stone tools in the society and hence of the social roles of tool-making, including learning to make them. The question of interest, here, is how learning took place in societies where many individuals made and used stone tools to provide the overwhelming majority of cutting and scraping tools.

Shennan and Steele (1999) reviewed modern ethnographic data about craft-learning, and notably there was hardly any literature about knapping stone. What evidence there was principally concerned the method of transmission. There is, however, substantial anecdotal evidence that children begin hitting rocks together when in the company of other knappers.

The lack of information is particularly unfortunate because it is difficult to think about what was learned. Imitation of patterns of motor actions is reported by some experimental knappers (Mark Moore, pers. comm., April 2003; Steve Sutton, pers. comm., August 1988). In order to remove any flake successfully, the novice knapper must discover the regularities that make knapping possible, learning about angles of platforms, angles and forces of blows, and the topography of the external surface of the core (see, e.g., Andrefsky 1998: 17-20; Whittaker 1994: 91-8). This is arguably much more difficult cognitively than even the most complex leaf-processing among gorillas (e.g. Byrne 2004) due to the difficulty of maintaining the appropriate angles for flake removal. Once that skill is mastered, however, removal of another flake seems often to have been a matter of simply repeating the process (at least for early assemblages) (cf. Pelegrin 1993). Toth (1985) showed that the form of the resultant cores, left behind after removing the all-important flakes for use, had their form determined as much by the nature of the initial raw material as by any preconception of the final product. Mithen has claimed that the earliest stone industries could conceivably have been made by ‘trial and error learning from scratch’ (1999: 393) – in other words, individual learning. In his argument, the sequence of actions involved in making hand-axes, some million years after the earliest stone tool making, must have involved observational – i.e. social – learning. One of us would place emphasis differently for the knapping that produced Acheulean bifaces (Davidson 2002; 2003), but the Acheulean is not the point of this article. We acknowledge that if the intention of knapping was to produce Acheulean bifaces (hand-axes and cleavers), more skill was involved in the process of learning to make them. The fact that there may be some dispute about the intentionality of the production of the final form is further indication of the difficulty of making reliable inferences about social learning from the forms of artefacts.

Karlin, Ploux, Bodu, and Pigeot (1993) interpreted the knapping skills represented by the different conjoined sets at 15,000-year-old sites in the Paris Basin as indicating different levels of skill that may be those of individuals at different stages of learning. The extent to which their interpretation depended on assumptions about the methods of learning emphasizes both how little we know about the process of learning about stone tools, and the absence of discussion of different skill levels in the earliest stone industries.
Whatever the process of learning to knap, the outcome provided knappers with skills to remove flakes. However, the ways in which they applied these skills were not themselves cognitively much different from the procedures for leaf-processing in gorillas. As Foley and Lahr (2003: 120-1) have pointed out, learning probably involves imitation, while the lack of difference in the knapped products probably suggests a poverty of innovation in both the earliest hominins and apes. Reader and Laland (2002) have provided evidence that there is a strong relationship among modern non-human primates between behavioural innovation, social learning capacities, and brain size. We note that the most significant change in hominin brain size (increase in range of variation only by the addition of individuals with larger brains) took place a little more than two million years ago (Davidson 1999: 253–5; de Miguel & Henneberg 2001), at around the time that hominin stone tool making became widespread.

Variation, pattern and context in early hominin material culture

Archaeologists depend on the establishment of pattern to determine that broken stones were knapped by human ancestors. Before the development of dating methods the same patterning also provided the basis of a relative chronology. Methods of analysis are thus likely to be biased against observing variation in the early stone-knapping record. This is a difficulty that Foley and Lahr (1997: 11) acknowledge for their approach to establishing a relationship between hominin phylogeny and the clustering of variation and pattern in stone artefact modes. Much is made of the uniformity of the form of bifacially flaked hand-axes of the Acheulean industries; indeed some authors argue (Mithen 1999: 393–394; Pelegrin 1993: 313; Whiten, Horner & Marshall-Pescini 2003) that they are the first examples of hominin concern with the form of the product. However, some of this uniformity appears to be strongly influenced by the selection of specimens by archaeologists (Davidson 2002). Following the demonstration of patterned variation between the observed behaviours of different chimpanzee and orangutan populations, the question of the patterning of variation in early hominin behaviour (as represented by the remains of stone tools) is a matter of importance.

Roche and her collaborators (1999) claimed that there was technical diversity in the first million years of stone tool making, but gave no details of what that was. Just as with variation in the cultural behaviour of apes, care must be taken in understanding the sources of technical diversity. The authors of the ape culture papers (Whiten et al. 1999; 2001) made their strongest case where there was little possibility of ecological differences between sites. Some variation in stone artefacts may be due, for example, to variation in raw material (Ignacio de la Torre, pers. comm., 2004). If, as Roche and her colleagues claimed, ‘the variation observed probably reflects technical solutions to different environments and needs’ (1999: 59), then, using the criteria of the papers about ape cultures, those variations would be eliminated from the analysis.

Almost all of the ape behavioural patterns concern perishable materials (or no materials at all). Even with living humans a substantial proportion of the technology is perishable and will not appear in the archaeological record.
There is fragmentary evidence that hominin activities involved perishable materials such as meat (Bunn 1981; Dominguez-Rodrigo 2002; Keeley & Toth 1981), marrow (Bunn et al. 1980: 132-3), or wood or plants (Dominguez-Rodrigo, Serrallonga, Juan-Tresserras, Alcala & Luque 2001; Keeley & Toth 1981) and ultimately included cutting wood (Oakley, Andrews, Keeley & Clark 1977; Thieme 1997). There were, presumably, also interactions with perishable materials without the use of persisting material culture. We cannot rely on this sort of record to produce a pattern of variation in early hominin behaviour comparable to that for chimpanzees and orangutans. There is some potential for comparison when apes obtain food from hunting, and the bones of prey may be examined directly (Plummer & Stanford 2000).

**Are there cultures in early hominins just as there are in all the other apes?**

It seems unlikely that anyone would ever be persuaded that the evidence from stone tools was not cultural; the learning needed for any individual to remove flakes successfully ensures that. However, this catalogue of problems and lacunae suggests that one-to-one comparison with the behavioural and cognitive repertoire of apes is not as easy as we might have hoped. At very least, archaeologists should now pay more attention to the variation in the synchronic archaeological record of stone tools. The challenge issued by the claims for cultures in apes is to see the importance of the patterning of variation of the material record of early hominins in terms of synchronic cultures distinguishing among hominin populations rather than as (singular) culture distinguishing hominins from apes.

**How important were stone tools in the cognitive evolution of early hominins?**

*Aimed force, carrying and cognition*

Knapping skills need to be learned. Byrne (2004) has pointed to the distinctiveness of the aimed force involved in removing flakes. Aimed throwing is one of the behaviours considered in the chimpanzee culture studies (Whiten 2003; Whiten et al. 1999) and its presence is variable from one study area to another. It is not enough, when knapping stone, to be able to aim the force; it must also be aimed at a part of the core with the right angles and topography. Chimpanzees seem to need similar skills when cracking nuts, as the disposition of the nut on the anvil and its relation to the blow by the hammer is critical to success. If early knapping was error-free, it would seem to involve mental assessments that go beyond our present knowledge of ape abilities. Rather, apes, early hominins, and later knappers make or made errors, but we tend to minimize reporting of these even where evidence would be available. Karlin, Pigeot, and Ploux (1992) have argued that the apparent variety of skill shown in knapping debris from 15,000-year-old French sites is a result of unskilled knappers practising while more skilled knappers were working. It would be surprising if there were not similar situations among earlier hominin knappers.
Chimpanzees have been observed routinely carrying unprocessed grass stems in their mouths over distances of tens of metres (Fig. 4; McGrew personal observations). Hominins seem as well to have carried raw material, hammers, and manuports as well as the flakes that resulted from their knapping. On present evidence this seems to be different from apes in the necessary conjunction of disparate stone raw materials, but this depends partly on inferences about decision-making. Observers have inferred chimpanzee decision-making from changes in the positions of hammers in the forest rather than from direct observation of them carrying hammers. The uncertainty about decision-making arises because we do not know the sequence of actions involved in finding hammers and locating trees with nuts. Even when carrying hammers around the Taï forests, the chimpanzees are only taking them to nut trees where there are anvils made either of pre-existing stones or of the buttresses of trees. The prospective carrying of stone for tools is now reported in experimental conditions for the captive bonobo Kanzi (Sue Savage-Rumbaugh & Charles Menzel, pers. comm., 1998). Unlike the case with chimpanzees carrying hammers, there is a good inferential case that hominins were carrying flaked stone with them and removing it from the site where it was made.

Too much knapping is never enough

There seems to have been much more knapping than was necessary to acquire sharp flakes. There does not seem to be any good reason for it, but this excess
is quite common throughout the history of stone-knapping (up to and including modern experimental or hobby knappers!).

The abundance of stone-knapping remains at early hominin sites led Potts (1984; 1988: 278–309) to argue that early hominins established caches of raw materials and created central locations to which acquired food could be brought for processing. This example reveals just how difficult it is to gain any certainty about cognitive evolution from the evidence of archaeology. A strategy of creating caches would imply planning of an order very different from that of other non-human primates, and arguably characteristic only of modern humans. There is nothing about the collections of stones themselves that indicates that the hypothesis is either plausible or implausible (but see de la Torre & Mora 2005). Even if the collections of stones were incidental products of carrying and knapping, it would still be possible for these locations to have become the focus for hominin activity involving acquired foodstuffs; hominins must surely have been aware of the concentration of knappable stone at such locations to the same extent as other non-human primates are aware of the location of important resources in their environments.

In this sense, then, early hominins created a new behavioural pattern for themselves through knapping stone tools – a small element of niche construction (Odling-Smee, Laland & Feldman 2003). In our argument the new niche was created by the acts of stone tool production and use. In all of the examples of cultural behaviour among wild non-human primates, there is no other example where new behavioural opportunities opened up as a consequence of prior ones. Discarded nut shells are just that, and not a resource for some other activity. Ant dipping wands are discarded where they are used; new bouts of dipping can use these or newly made ones but the old ones are not recruited for a distinct activity. In terms of cognitive abilities, this knapping activity created a new context in which individuals could learn the statistical regularities underlying their behaviour, thus giving rise to the possibility that from them they could learn to copy the behaviour without being tied to the previous intentions (Byrne 2002).

Speculations about cognitive evolution from abandoned remains of material culture

What we have just outlined brings us closer to the sorts of recursive behaviour that may have been an elementary step on the path to reflective awareness. Early hominins were a long way from that sort of awareness.

Chimpanzees acquire substantial information about their environments and appear to remember aspects of their past behaviours, particularly in relation to stone hammers for nut-cracking. They repeatedly harvest a resource using elementary technology. This occurs both within and across seasons, and persists over decades. When McGrew first arrived at Gombe in 1972, Goodall showed him a particular termite mound that Gombe chimps had fished since the early 1960s. They were still using it in 1992. McGrew has seen them arrive there with tools, leave tools there, and re-use tools found there. There is no way of knowing how much is remembered from visit to visit, or what prompts such memories, either in chimpanzees or in early hominids.
The circumstances of knapping involve complex feedback between limbs, objects, the visual sub-system, and the acoustic sub-system (because there are distinctive sounds associated with the successful removal of a flake). For an early hominin returning to the remnants of the knapping of a previous time there is a possibility that the repetition of motor actions at the same place with the same rocks and with the same acoustic and physical consequences might have an effect, particularly if the separation of tool-making from the specific tool function brought attention to the making rather than the use.

Discussion and conclusion

It is a paradox that animal ethologists should be seeking to define the cultural nature of the species they study (see Byrne et al. 2004) at a time when the culture concept has become controversial in anthropology, the discipline that originally defined it as a characteristic of people and societies. Kuper, for example, says, ‘My conclusion will be that the more one considers the best modern work on culture by anthropologists, the more advisable it must appear to avoid the hyper-referential word altogether, and to talk more precisely of knowledge, or belief, or art, or technology, or tradition, or even of ideology’ (1999: x). Many of these substitutes are not characteristics of animal cultures. Yet Kuper, at the same time, bemoans the fact that ‘cultural studies’ have displaced other core social sciences, particularly anthropology, as an appropriate subject for study. Part of the problem is that there are different meanings for the one word, yet the meanings are closely tied to each other (see Goddard 2005). In looking at the cultural nature of other species, ethologists have provided insights into the continuity of the processes that led from the simplest learning to the most abstruse and heavily defended bastions of cultural elites.

In this article, we have identified cultural implications of the earliest hominin stone tools that point to a need for further research among apes and in archaeology. Among the questions these identifications raise are the following:

1. Are there any examples of wild apes cutting anything?
2. Can we establish that acculturated apes, learning to knap stone, develop skill at identifying the best angles for flake removal?
3. Is there evidence for the later re-use of hammers and cores previously abandoned by early hominins?
4. How can we obtain meaningful evidence of the process of learning to knap and use stone tools in a society that depends on them?
5. What is the extent of patterning of variation in early stone tools?
6. What is the sequence of actions leading to the transport by chimpanzees of stone hammers for nutting?
7. Do chimpanzees carry rocks as anvils for nutting?
8. Are there examples of apes recruiting tools, or tool-making processes, from one function to another?
9. Do apes learn to make tools by observing the tools previously abandoned by other apes?
One of the points on which cultural primatologists concur is the importance of symbols. Boesch, who contends that chimpanzees have culture, defined three generally agreed characteristics of culture: (1) ‘culture is learned from group members’; (2) ‘culture is a distinctive collective practice’; and (3) ‘culture is based on shared meanings between members of the same group or society’ (2003: 83). He concludes the same article by pointing out that the similarities between chimpanzees and humans in some respects are striking and presumably go back to the time of the common ancestor: ‘Much later, language would have opened a wide new window, facilitating the development of cultural traits in the communicative and the shared reflective domain, and paving the way for all our cultural beliefs and rituals’ (2003: 90). In similar vein, van Schaik and his colleagues acknowledge that cultural elements may be (i) labels … which generally involve little innovation; (ii) signals, involving socially transmitted arbitrary innovations as variants on displays … (iii) skills, involving rare innovations … ; and (iv) symbols, probably derived from signal variants … Only humans have all four kinds of cultural elements, whereas, unique among non-human primates, chimpanzees and orangutans show the first three (2003: 103–4).

It may well be that symbol use is the defining characteristic that distinguishes human cultures from ape culture. There are, however, at least two reasons for caution, since (1) experimental work on the use of symbols for communication between humans and apes shows that apes can use symbols under certain circumstances and (2) no intensive study has been carried out to discern what might constitute symbol use in wild apes (but see Boesch & Boesch 1991). Ape communication in captivity depends in all cases on the provision of a human-devised symbol system for the apes to communicate with and the social context of communication and reward provided by humans. It is the absence of examination of symbol use among wild apes that threatens to undermine the assumption that symbol use is an exclusive feature of human cultures.

What we are proposing here is that one of the small steps in the emergence of the differences between humans and chimpanzees involved the manner of interaction between early human ancestors and the remains from their activities of making stone tools. The act of knapping created a new niche for hominins which, on present evidence, began to differentiate their behaviour from that likely among ancestral chimpanzees and gorillas. When hominins returned to the scene of earlier knapping events and repeated the actions of tool-making, possibly with different intentions, they set off on the path to reflective awareness and the addition of a symbolic component to their ape-like culture.

NOTES

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1 Levallois knapping episodes show the flakes removed from the site, presumably for use (e.g. Schlanger 1996; Van Peer 1992); the English Acheulean sites of Caddington (Bradley & Sampson 1978) and Boxgrove (Austin 1994; Bergman & Roberts 1988; Bergman, Roberts, Collcutt & Barlow 1990) show that flakes and cores were removed from the sites.

2 For example, ‘for the first time in the history of life on the earth a vital feedback loop was created between the biological evolution of a species and its adaptation through learned, cultural behaviour, with technology an essential aspect of this culture’ (Schick & Toth 1993: 223). We note that this tends to undervalue the importance of technology among apes.

3 Modern experimental knappers routinely comment, however, on the emotional satisfaction of repeated successful application of the physical routines.

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Outils de pierre et unicité de la culture humaine

Résumé

L’existence d’activités que l’on pourrait qualifier de culturelles chez certaines espèces animales autres que l’homme fait de moins en moins de doute. On peut dès lors se demander en quoi les cultures humaines (et peut-être celles des grands singes) se distinguent de celles des autres animaux, et comment elles en sont devenues aussi différentes. Les cultures humaines sont créatives, développant de nouveaux schémas de comportement à partir de ceux qu’elles apprennent chez les autres. La fabrication d’outils de pierre a favorisé l’ouverture d’une niche pour l’utilisation des outils dans diverses fonctions et l’échange des méthodes de fabrication. Pour l’heure, rien de tel n’a été observé chez les singes anthropoïdes. Les auteurs étudient le rôle possible des outils de pierre dans l’apparition de cette créativité.

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