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# ONE

## Introduction and Overview

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Stone tools are among the most distinctive features of the lives and evolution of hominins and, through them, material culture came to play an increasingly important role in the behavior of our ancestors. As a result, material culture and stone tools in particular have given archaeologists a window onto behaviors and lifeways that have long since disappeared. Although stone tools were initially studied primarily as indicators of cultural achievements and then of technology and subsistence strategies, our understanding of the kinds of information that can be inferred from stone tools has expanded significantly in recent years. This broadening of analysis is linked to the development of cognitive archaeology. In this volume, we focus on the multiple ways in which stone tools can inform archaeologists about the evolution of hominin cognitive abilities.

### THE EARLIEST STONE TOOLS

In the 1960s Mary and Louis Leakey uncovered 1.8 million-year-old stone tools at the site of Olduvai Gorge in Tanzania. These tools, which archaeologists called the Oldowan industry, were later associated with *Homo habilis*, the first member of the genus *Homo*. This was a significant discovery because relative to older hominin species that were not thought to be tool users, *H. habilis* had a larger brain size and possessed anatomical features reminiscent of later species (e.g., reduced molar size, flatter face). Increasing cranial capacity, tool use, and more modern-looking features fit together in the story of what made humans unique. In fact, for the first time the use of material culture was included in the official definition of a species (Leakey, Tobias, and Napier 1964)—and thus the phrase "Man the Tool Maker" was coined (Oakley 1952).

Since that time, our knowledge of the relationship between stone tools and the evolving human brain has grown and the resulting picture is predictably more complex. The earliest known stone tools now date to approximately 2.7 to 2.5 million years ago (mya) (Semaw 2000) whereas hominin evolution can be traced back using the fossil record to between 7.0 and 6.0 mya (see Wood 2002). Researchers question whether the "sudden" appearance of the Oldowan is the result of a dramatic change in cognitive abilities or the transition to a more archaeologically visible medium. One way to think about this is to consider the niche that was opened by the use of stone tools. Davidson and McGrew (2005; see also Davidson, Chapter 9) have suggested that the permanence of stone tools and the products of knapping on the landscape made a distinctive difference to the pattern of cognitive evolution. It also seems likely that *H. habilis* was not the only stone tool maker and user. Depending on how many species one recognizes between 2.5 and 1.5 mya, up to as many as eight hominin species have been found in direct or indirect association with stone tools (Toth and Schick, 2005). In addition, there is now good evidence that early hominins were using bone tools (Backwell and d'Errico 2001, 2008).

Thus, it is clear that tool use was a important behavioral adaptation of our hominin ancestors—but not only of our hominin ancestors, as there is considerable evidence that nonhuman primates also use a wide variety of tools for subsistence and display purposes (see, e.g., Boesch and Boesch 1984; Boesch et al. 1994; Goodall 1964; Whiten et al. 1999) (there is an extensive discussion of ape tools by de la Torre in Chapter 3), and that they reuse stone hammers from one year to the next, apparently remembering where they left hammers the previous season (Boesch and Boesch 1984). The key question is what are the similarities and differences in cognition that underlie human and nonhuman primate tool behavior? The search for answers to this question has led to new research directions, including teaching nonhuman primates how to knap stone (Schick et al. 1999; Toth et al. 1993); studies of the cognitive aspects of nonhuman primate tool use in the wild (Byrne 2005); archaeological excavations of nonhuman primate "sites" to see what behaviors leave archaeologically visible residue

(Carvalho et al. 2008; Mercader et al. 2007; Mercader, Panger, and Boesch 2003); PET scans of humans knapping (Stout, Chapter 8; Stout et al. 2000, 2008; Stout and Chaminade 2007); and research into the kinds of learning, memory, and skill required to make Oldowan tools versus nonhuman primate tools (see, e.g., Davidson and McGrew 2005; Haidle 2009; Wynn and McGrew 1989). This last set of studies includes questions concerning the origins of language—can you learn how to make stone tools in the absence of language (see discussion in Nowell 2000; Wynn and Coolidge, Chapter 5) or other verbal instruction (Davidson 2009)? Can you tell from flakes whether knappers were preferentially right-handed and does this imply brain lateralization and preconditions for language specialization in the left hemisphere (Corballis 2003; Noble and Davidson 1996; Pobiner 1999; Steele and Uomini 2005; Toth 1985a; Wilkins and Wakefield 1995)? Moore (Chapter 2), de la Torre (Chapter 3), and Davidson (Chapter 9) all explicitly address the question of the transition to hominin knapping from a common ancestor similar to chimpanzees and bonobos in its abilities. Davidson (Chapter 9; Davidson and McGrew 2005), in particular, draws attention to the obvious fact that apes have never been claimed to cut anything in the wild, although they can learn to cut a string in the lab. He argues that "cutting" is one of the key innovations to making stone tools part of the hominin adaptation.

## STONE TOOLS IN DAILY LIFE

Based on microwear studies, experimental work, and cutmarks on animal bones, we know that our ancestors used stone tools for a variety of tasks, including skinning, disarticulating and defleshing animals, breaking open long bones to access marrow, working wood, and processing vegetable matter (see, e.g., Bunn 1981; Dominguez-Rodrigo et al. 2005; Keeley and Toth 1981; Pobiner et al. 2008; see also Shea 2007). They even used bone tools to break into termite mounds to exploit a readily available resource rich in protein (Backwell and d'Errico 2001, 2008). We know that they carried stones around the landscape because we find artifacts far from their sources (Ambrose 1998; Braun et al. 2008 and references therein; Whallon 1989), knapped stones from different sites that can be fitted back together but with some of the flakes missing (Delagnes and Roche 2005; Van Peer 1992), and cut bones with no stone tools associated with them. These observations have led researchers to study a number of cognition-based questions, including what types of mental maps are required to coordinate resources across a diverse landscape and whether this exceeds what nonhuman primates are capable of (e.g., Boesch and Boesch 1984) and the degree to which Oldowan and especially later stone industries are evidence of forethought, planning, and enhanced working memory (Haidle 2009; Wynn and Coolidge, Chapter 5). One of the ways in which scholars have attempted to show the depth of intentionality in stone tool making has been through the identification of standardized tools (see discussion in Nowell 2000; Nowell et al. 2003). Kuhn (Chapter 6) shows that even this is not straightforward and that some of the attempts need to take into account the way in which archaeological analysis forces the appearance of standardization.

Stone tools were obviously important in the everyday activities of our ancestors, but we may never know how they learned to make them in communities of their fellow creatures. It is one of the missing parts of the story. Even recent ethnographic accounts (e.g., Stout 2002, 2005) cannot claim to be complete, such is the penetration of modern technology into all societies. Yet Nowell and White in Chapter 4 show that such considerations of life histories of our hominin ancestors might be the key to understanding some of the repetitive patterning in early stone tools. They argue that some of the stasis visible in the archaeological record may be the result of demographic and not necessarily cognitive factors (see also Powell, Shennan, and Thomas 2009; Shennan 2001). They also explore how the insertion of a uniquely human childhood stage of growth and development into the typical primate pattern affects learning and sociality.

## STONE TOOLS, DECISION MAKING, AND THE CONCEPTUAL PROCESS

From the moment of discovery of a handaxe in 1797 (Frere 1800), much of our understanding of our Pleistocene ancestors has been based on knowing the history of stone tool making from the earliest times until the emergence of settled agricultural societies. By the beginning of the twentieth century, the basic sequence of stone industries was well-established, at least in Western Europe (e.g., Grayson 1983). The details of the industries are now much better known (Delagnes and Roche 2005; Leakey 1971; Toth 1985b) but the basic framework has remained remarkably little changed in the intervening century (see also the discussion in Davidson and Noble 1993). As this framework emerged, it was based on the form of the distinctive artifacts, in other words, their typology: Oldowan choppers and chopping tools; Acheulian handaxes and cleavers; Levallois prepared cores and flakes; Mousterian scrapers; Upper Paleolithic blade-based end scrapers, burins, and projectile points—what Davidson (2009) has called the "OALMUP" sequence. Some of the assumptions about the wider significance of the characteristics of the European Upper Paleolithic industries have been questioned (Bar-Yosef and Kuhn 1999; Davidson 2003a; McBrearty and Brooks 2000). Wurz (Chapter 7) directly addresses some of these questions in relation to the Middle Stone Age industries of southern Africa. The contributions by both Kuhn and Wurz bring into relief just how difficult it is for analysts to separate out those components of stone tools that may indicate style or convention, from which symbolic representation of the target tool types could be inferred. This may be one of the key issues in the use of artifact form to understand cognition (see Davidson 2003b).

Cognitive approaches have affected how we approach typological studies. Typology of artifact form remained the basis for analysis for many archaeologists throughout the past century (cf. Ambrose 2001), particularly as a result of the assumption that stone artifacts should be considered as cultural products; although the emphasis switched from typologically idiosyncratic markers to a statistical analysis of relative frequencies of a range of types (see discussion in Davidson 1991). But more recently, there has been a shift away from emphasizing the artifact as an end product (Davidson and Noble 1993; Dibble 1989; Dibble and McPherron 2006; Frison 1968), appropriately in light of the paradox recognized by Hiscock and Attenbrow (2005). They ask, "[H]ow can implements be designed for, and be efficient in, a specific use if their morphology is continuously changing?" Some progress can be made toward understanding the process that created artifact form through the analysis of reduction sequences or *chaînes opératoires* (Bar-Yosef and Van Peer 2009; Pelegrin 1993)—a method for reconstructing sequences of decisions made by ancient flint knappers. In the best of cases, refitting of flakes and cores left by the knappers allows for relatively complete analysis of the knapping procedures (Delagnes and Roche 2005). In others, experimental knapping allows identification of the products that are distinctive of particular processes (see discussion in Moore 2005)—a new version of typology, but one based firmly on an understanding of processes rather than a belief that the form of the discovered artifact type was an intended product of the manufacture. Moore (Chapter 2) develops a theoretical approach to analyzing the process of flake removal in a way that shows not only how the standard sequence works but also how the operations must have been related to each other in cognition. In doing this, he derives some of his argument from Greenfield's (1991) "grammars of action," elaborated as a way of identifying cognitive development in young children through their combinations of objects in play. But because stone knapping is subtractive, Moore's argument not only is original for the understanding of stone tool knapping but also might be adapted for further understanding of the ontogeny of cognition of modern children.

## STONE TOOLS AND COGNITIVE ARCHAEOLOGY

In 1954, Christopher Hawkes published an influential paper in which he described what became known as a "ladder" of archaeological inference. Following this metaphor, as one proceeded from lower to higher rungs, there was "an ascending scale of difficulty in reconstructing a culture's technology, economics, sociopolitical organization, and religious beliefs" from the actual physical remains that archaeologists regularly uncovered. For Hawkes, it was ironic that what was unique about humans, what made us the most interesting, was the least knowable from the archaeological record. For many archaeologists working in the 1960s and early 1970s, the mind was largely epiphenomenal (although the early assumption that the "final" Levallois flake was somehow predetermined by the whole flaking effort anticipatory of it implied a cognitive ability among Middle Pleistocene knappers that needs to be considered here). As Lewis Binford (1965, 1972) famously wrote, archaeologists were not in the business of "paleopsychology." This attitude began to change, partly through emphasis on later prehistory where the evidence was more complete (Renfrew 1982; Renfrew and Zubrow 1994), but also for earlier prehistory as the result, almost single-handedly, of the efforts of Thomas Wynn (e.g., 1979, 1981, 1989, 2002; Wynn and Coolidge 2003, 2004, and Chapter 5). Wynn has been and continues to be a pioneer in developing cognitive archaeology in a way that Binford could never have envisioned when he coined the term "paleopyschology." Wynn's research has opened our minds to the possibilities of inference from stone tools and pushed the boundaries of what we thought was possible to learn from them. Many of the studies discussed above and the chapters in this volume are a direct result of his innovative research.

The final chapter in this volume (Chapter 10), by Barnard, considers the current state of the field by discussing recent developments in inferring cognitive capabilities from stone tools. Barnard summarizes the contributions to this volume from the perspective of a behavioral scientist attempting to make inferences about the mind from the sorts of observations and theoretical perspectives available to archaeologists. Underlying Barnard's contribution is an understanding of a more complex model of cognition and its evolution (Barnard et al. 2007) that allows the early emergence, among apes and the last common ancestor of apes and humans, of complex spatial-praxic actions in a way some earlier theorists had not acknowledged. This model also predicts that complex vocal utterances and combinations of them emerged earlier among hominins than the reflexive thought generated only from the inputs of mental activity of the agent concerned. In this way, learning to make stone tools by knapping may have been guided by vocal utterances without those utterances having all of the symbolic and reflective qualities of language (Davidson 2009).

More recent fieldwork has complicated the picture the Leakeys and Oakley developed, but their intuitions were fundamental to the modern interest in the cognitive significance of stone tools. Moreover, although the accumulation of evidence from both archaeology and primatology has blurred the distinctions between human and nonhuman primates, decades of research into the relationship between stone tools and the emerging human mind have served ultimately to highlight hominin uniqueness rather than to erode it. The studies in this volume show us just how data collection and theorizing can move us forward in understanding the evolution of hominin and human cognition through the study of stone tools now and in the future.

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