CHAPTER 2

Tool-Use by Great Apes in the Wild

Abstract Evidence for tool use and tool-making by great apes in the wild is contrasted against the earliest stone artifacts and signs of their use before 2 million years ago by hominins who had attained a cognitive capacity both to envisage how by manipulating one object they could modify another in order to transform it into a tool, and to remember the manual behavior required to carry out the procedure.

Keywords Behavior · Chimpanzee · Cognition · Hammer · Hominin Memory · Stone · Tool

Among several claims for their ingenuity with tools are observations of chimpanzees using sticks, twigs, stalks, leaf midribs, or petioles, in order to feed on termites, either "fished" out from ant hills that first have been perforated with rigid sticks, or lifted up on plant materials dipped into ant trails (Goodall 1986; McGrew 1974, 1992; McGrew and Tutin 1978; McGrew et al. 1979; Sabater 1984a; Van Lawick-Goodall 1970). Other observations range from using leaves as sponges to draw water from holes in tree trunks (Goodall 1964a), using sticks to extract honey from hives of wild bees (Brewer and McGrew 1990; Boesch et al. 2009; Izawa and Itani 1966; Standford et al. 2000), to beat fruit-bearing trees (Sabater 1974a, b, 1984a, b, 1992, 1993), to fend off leopards (Boesch 2009; Jones and Sabater 1969, 1971; Kortlandt 1965),

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to throw (Goodall 1964b), or to hurl in attempts to bring down prosimians (Pruetz and Bertolani 2007), not to mention using stones for cracking open kernels or stones in fruit (Beatty 1951; Matsuzawa 1991; Rahm 1971; Struhsacker and Hunkeler 1971; Sugiyama and Koman 1979). Perforation of ant hills with rigid sticks, followed by the introduction of pliable stalks with chewed brush-like tips to maximize ant collection, may reflect a capacity to devise a complex tool kit (Sanz et al. 2004; Sanz and Morgan 2007). During different stages of extraction of honey from hives, manipulation has been observed of up to five sticks differing in rigidity (Brewer and McGrew 1990; Stanford et al. 2000). Such tool kits seem to show that chimpanzees both recognize appropriate properties of things to be chosen for a given task and can plan the order of their deployment.

Cracking kernels open may involve chimpanzee tool kits comprising an "anvil" (such as a rock or a tree root), on a relatively flat surface of which a kernel is set that is broken open using stone or wooden hammers (Humle and Matsuzawa 2001; Matsuzawa 1991; McGrew 1992); chimpanzees may seek out and then carry appropriate stones for use as both hammers and anvils to where they will be used, perhaps aware that both are needed to crack kernels (Carvalho et al. 2013). Analysis of the artifacts employed as anvil or hammer in an outdoor laboratory at Bossou revealed that chimpanzees tend to prefer wider and lighter objects to be used as hammers, while height or length do not significantly differ, which reinforces the notion that both anvil and hammer might be perceived as an integrated working unit (Carvalho et al. 2008). Sometimes a third stone is wedged below the anvil to keep its surface horizontal (Humle and Matsuzawa 2001; Matsuzawa 1991; McGrew 1992). It has been argued that such behavior may have arisen quite late during the Pleistocene (Haslam 2014). Wild panins more often use plant-derived tools. Gorillas in the wild have been reported to use sticks to reach fruit on a tree (Pitman 1931, cited in Sabater 1984b) and to gauge the depth of water when wading (Breuer et al. 2005). In addition to the hominoid taxa mentioned above, some of those activities, especially manipulation of stone, are reported in other anthropoid Primates, both in catarrhine (Malaivijtnond et al. 2007; Gumert et al. 2009; Haslam et al. 2013) and platyrrhine monkeys (Cummins-Sebree and Fragaszy 2006 and references therein; Visalberghi and Fragaszy 2013 and references therein; Proffitt et al. 2016); although the anatomy of their hands is clearly compatible with such behavior, their cognitive understanding of it is far from clear, nor do they regularly use as tools the stone products of their manipulations. Plausibly, some stone artifacts uncovered by archeologists could owe to nonhuman anthropoid behavior (Fiedel 2017; Haslam et al. 2009).

Raw stones from Olduvai Gorge in Tanzania were used to crack nuts by chimpanzees at the Japanese Kumamoto Sanctuary of the Kyoto University Wildlife Research Center, and, after use, detailed inspection of stones, including microscopy, enabled interesting comparisons and contrasts to be drawn, both with stones used in like fashion by humans and with Paleolithic finds excavated at Olduvai which show more modification of working surfaces than those used by the chimpanzees (Arroyo et al. 2016). The findings chime with those from a comparative analysis of stone cores, flakes, and fragments from the 2.6 Ma site of Gona in Ethiopia (commonly attributed to *Australopithecus garhi*) were compared and contrasted with those produced by humans and by captive bonobos that had learnt how to knap a stone core held in one hand by wielding a hammer-stone held in the other; the bonobos did not attain the degree of core-reduction or the frequency of parallel-sided flakes observed in the Gona assemblage, and produced more edge-battered cores and broken flakes and fragments, although the Gona assemblage itself showed a lower degree of core-reduction than that of human knappers (Toth et al. 2006); the research did not extend to use of the modified stones (despite referring to the study, only the ability of the captive bonobos to learn percussive technology from one another has captured the attention of Whiten 2015). Excavation at the 2.34 Ma Lokalelei site in Kenya has allowed reconstruction of the knapping sequences of cores, by refitting flakes and fragments, which testifies to the accuracy with which hominins knapped stone and implies their ability to strike cores repeatedly on angular surfaces recognized as propitious for removal of flakes (Delagnes and Roche 2005; Roche 2005). For efficient ("conchoidal") flaking of siliceous rock, an appropriate surface angle is one that does not exceed 90°. Trained bonobos seem to find it harder than human apprentices to remember to take advantage of this. A recent analysis concluded that "transition from anvil and hammer percussive techniques (such as nut-cracking) to freehand knapping techniques in early hominins necessitated improved perceptual abilities, learning capacities, and bimanual dexterity superior to that of non-human Primates" (Bril et al. 2015).

It should be borne in mind, however, that nonhuman wild Primates do not modify a stone in order to use it for modifying another object

Table 2.1 A convenient classification of both present-day Hominoids and some extinct Pliocene and Pleistocene genera

A convenient classification of both present-day Hominoids and some extinct Pliocene and Pleistocene genera
(alternative classifications exist)

superfamily	H o m i n o i d e a			
families	H o m i n i d a e		Pongidae	Hylobatidae
subfamilies	Hominini	Panini	Pongini	Hylobatidini
genera (or subgenera)	†*Ardipithecus* †*Australopithecus* (†*Paranthropus*) *Homo*	*Gorilla* *Pan* gorillas, chimapanzees, bonobos	†*Gigantopithecus* *Pongo* orangutan	*Hylobates* (*Symphalangus*) gibbons, siamangs

† = extinct

Note: Within the order Primates and its suborder Haplorrhini, the infraorder Simiformes (anthropoid Primates) is often divided into Platyrrhines (New World monkeys) and Catarrhines (Old World monkeys, which have tails, and Hominoids, which do not). Gorillas, chimpanzees, bonobos, and orangutans are called often "great apes" because of their size.

that *thus transformed is then used as a tool*. Just when that procedure began to characterize the activities of human forerunners early on is a matter of great interest both in the study of human evolution and for understanding the evolutionary trajectory of human cognition *in relation to memory*; our principal concern is with this particular aspect of the matter. It is for this reason that we give pride of place to the modification of one stone by wielding another in order to make a usable tool. This requires more than the simple awareness that an unmodified or slightly modified object can be handled as a useful tool for attaining foreseeable short-term goals (perhaps for immediate achievement of speedy gratification) with which its evident physical properties are perceived as being sufficiently commensurate. It requires *remembering* how two "unpromising" objects (stones) can be made to react with each other, by being moved differently by the right and left hands, in order that one or more products of such reactions may be suitable for application to tasks that may not be limited to immediately attaining an obviously foreseeable goal, but instead may involve forward planning of activities, based on the *remembered* experiences or different circumstances that could be *envisaged* (and perhaps implying that gratification may be deferred for some time after the tool has been made) (Table 2.1).

The nature of the geological record is such that stones, bones, and teeth are preserved far better than softer materials, including wood, and therefore are the principal raw materials on which commensurable analysis of modification can be carried out for rigorous comparison or contrast with experimental modification of objects either into artifacts or caused by their use as tools (wooden artifacts have not survived from before 0.5 Ma). Our inquiry into the evolution of human memory therefore is constrained by the nature of the archeological record itself. Assuredly our hominin ancestors made and used tools from a wide variety of perishable materials, but plausible conjectures drawn from primatology or ethnography about what likely they may have made or used from perishable materials are not particularly helpful in considering how human memory probably evolved.

Tool-use in the wild by chimpanzees, and their ability to modify natural substrates in order to improve tool functionality, underlie a conjecture that their behavior can be compared with that of Australopithecines. This may be a risky conjecture, grounded in a superficial reading of alleged tool-related achievements by nonhuman Primates, rather than rigorous analysis of the underlying cognitive complexity of their use and modification of tools. Herein lies the rub. In short, comparing the technology of chimpanzees and early humans is more than just a matter of detailed analysis of the physical features of the objects themselves; it requires taking into account the cognitive capacities implicit in their use or preparation.

Producing apparently comparable technological outcomes need not imply recruitment of *identical* cognitive processes, because *analogous* cognitive capacities can lie behind the production of apparently similar technological outcomes as circumstances require, albeit with different functions. Thus, whereas a washing machine and a refrigerator may present external features in common (a big white box, so as to fit in with kitchen décor), their internal structures and functions differ utterly; contrariwise, a circular washing machine shares more technology in common with a box-like one than with a refrigerator. Such paradoxes exist in very simple tools indeed; thus, a ladle for serving soup looks superficially like the ladle with which Spanish grocers serve customers with olives extracted by it from a tub, with the fundamental difference that this ladle has holes to strain off the liquid that has conserved them.

Late Pliocene Australopithecine stone artifacts will be considered from a standpoint of prerequisites for cognitive capacity and brain circuitry, leading up to consideration of behaviors involving tool use and the resolution of problems demonstrated by recruitment of similar cognitive processes by chimpanzees, be they in the wild or captivity. Ostensive similarity between the apparent structures of tasks will be side-stepped here, in order to pay attention first and foremost to cognitive requirements that are linked causally. Diverse tasks resolved by *Pan* and *Homo* will be analyzed such that the cognitive capacities underlying them may be considered in a range of problems, with disregard to the external form of each. Where a specific problem can be approached from only one angle, it yet may be possible to infer from the cognitive capacities of another genus that a solution may lie within its grasp (albeit beyond the possibility of experimental demonstration in the laboratory, perhaps owing to lack of sufficient motivation in artificial circumstances).

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