NEWS

Uncovering the Behavior and Cognition of the Earliest Stone Tool Makers

Participants at the 13th Human Evolution Workshop at the Turkana Basin Institute, Kenya. (Color figure can be viewed at wileyonlinelibrary.com)

In August 2016, the 13th Human Evolution Workshop at the Turkana Basin Institute (TBI) brought together a diverse group of scientists from archeology, paleontology, geology, primatology, cognition, and neuroscience. Organized by Sonia Harmand (Stony Brook and TBI), and Hélène Roche (Centre National de la Recherche Scientifique) along with TBI director Lawrence Martin (Stony Brook), the workshop focused on the earliest evidence of stone knapping. This focus was spurred by the recent discovery of stone tools at the Lomekwi 3 site in Kenya, which have been dated to 3.3 Mya.[1] It is suspected that these tools were produced by *Kenyathropus platyops*, the only hominin found in the region during that period. As delineated by Richard Leakey (Stony Brook and TBI), our task was to assess whether these tools represent a "cognitive Rubicon" —a fundamental transition in our lineage that demarcates the human species. To understand these artifacts and the individuals who made them, we sought to uncover the Lomekwi tools' relationship with what came before, as well as what came after.

Over four days of discussion (and some practical lessons in the production and use of stone flakes), we could agree that these tools do diverge in important ways from the tools that living primates make. While some populations of chimpanzees and capuchins use rocks to crack nuts, there is no evidence of any wild primates purposefully producing flakes. The Lomekwi tools also differ from the next-oldest known stone tools, Oldowan flakes found in Ethiopia and dated to 2.6 mya.[2] Erella Hovers (Hebrew University) discussed how Oldowan tools were made primarily with freehand techniques, with the core held in one hand, then hit with a hammer held in the other to produce several flakes in a sequence. In contrast, the Lomekwi flakes are notably larger and were produced by pounding actions, either stabilizing the core on an anvil and then striking it with a hammer or striking the core itself on the anvil (passive hammering). In this way, the Lomekwi tools appear to be intermediate between other primates' stone tool use and the more complex Oldowan production methods. Yet this consensus that the Lomekwi tools are a transition point generated a new question, which proved much more difficult to answer: What spurred the emergence of this novel form of tool making?

The making of stone tools poses a real puzzle to primatologists because, at first glance, several other species would seem to have many of the psychological skills needed to create at least a simple flake. Crickette Sanz (Washington University in St. Louis) detailed how some populations of chimpanzees have complex tool repertoires involving sequential use of multiple tools, such as puncturing a subterranean termite mound with a wooden stick, then fishing for insects with a more delicate herbaceous probe.[3] Tiago Falótico (São Paulo) described how Brazilian capuchins, which are expert stone tool users, will even accidentally break off flakes in the process of cracking nuts. William McGrew (Cambridge) pointed out that there is also important diversity in these tool-related behaviors. Only two populations of chimpanzees have been observed to use stone tools routinely to crack nuts, either because of lack of knowledge or lack of opportunity stemming from the absence of appropriate materials.[4] Along this vein, Catherine Markham (Stony Brook) highlighted the point that even very intelligent animals such as baboons may completely lack tool-using behaviors, let alone make tools.

What, then, prompted early hominins to start making stone tools? We

often returned to the possibility that an ecological shift into more open habitats precipitated this change by presenting novel problems that flakes could solve. To address this, Craig Feibel (Rutgers) described reconstruction of the physical environment at the Lomekwi 3 site and Jason Lewis (Stony Brook and TBI) detailed how isotope analyses and the fossil remains of other species indicate that this environment was a mixture of woods, bushes, and shrubs.[1] The critical question, then, is whether this would have actually necessitated a major shift in behavior. In fact, chimpanzees, although typically characterized as a rainforest species, can successfully eke out a living in mixed or even savanna habitats.[5] This suggests that a move into such habitats might not inherently have necessitated the adoption of stone-tool making. Nonetheless, these hominins may have begun exploiting a resource that other apes never or rarely use, such as large game (either hunted or scavenged) or tubers and other underground storage organs.

What were the Lomekwi tools actually used for? Nicholas Taylor (Stony Brook) discussed how microscopic traces and wear patterns could shed light on the use of a given tool, but also noted that such analyses were limited by the age of the tool in question. Previous work on Oldowan tools have also generated mixed results. Our discussion therefore ranged widely to other hypothetical uses of stone tools. For example, Carel van Schaik (Zürich), proposing a social function for this tool-making behavior, noted that the production of stone flakes may have coincided with the loss of slashing canines. There was then an animated discussion concerning the potential utility of flakes for aggressive interactions, such as the lethal intergroup attacks observed in wild chimpanzees.[6] This discussion concluded with some members of the group agreeing to disagree.

It is also possible that other species may be fundamentally limited in their ability to make stone tools in the first place. Thus, much of our discussion focused on potential mechanistic constraints on nonhuman tool making. Sandrine Prat (CNRS) pointed out that changes in hand morphology across hominin evolution likely increased manual dexterity in our lineage. Yet we agreed that producing at least crude flakes is well within other primates' abilities, even if their technique would be less sophisticated than that seen in the Lomekwi material. Indeed, even naïve members of the group could rapidly produce a functional tool using the passive hammering technique (with only a little blood lost in the process). This was a contrast with the Oldowan knapping techniques demonstrated by Michel Brenet (INRAP). We therefore quickly narrowed in on the cognitive traits needed for stone tool making.

While other primates can use and even make tools, creating a flake requires using a tool in order to make a tool. Perhaps this sort of hierarchical goal sequence — one tool creates a second tool, which then allows an individual to reach its goal — is beyond other primates' abilities. Along these lines, Jeroen Smaers (Stony Brook) argued that evolutionary variation in the brain systems involved in the automatization of complex motor behaviors, such as circuits linking the cerebellum to prefrontal cortical regions,[7] may underpin differences in human and nonhuman tool-making behaviors. Dietrich Stout (Emory) further pointed out that humans and chimpanzees show important differences in the neurobiological regions activated when they observe others engaged in a manual grasping action.[8] This speaks to the fact that other apes differ from humans in how they learn socially, which likely affects the cultural spread of complex technologies like the Lomekwian tools.

Inferring the cognition and behavior of an extinct species will always be a challenge, but our discussions highlighted several ways to winnow down the scope of possibilities. First, stone flakes are flexible multipurpose tools that could potentially be incorporated into a variety of hunting, foraging, and defense behaviors. Therefore, the important question probably is not what new purpose drove hominins to make tools, but rather what constraint prevented other species from already doing so. Second, at least some nonhuman primates have access to stone materials and are physically capable of making flakes, yet neither do so on purpose nor use flakes produced as byproducts of other activities. This indicates that the constraint is likely cognitive rather the morphological in nature. Finally, the level of sophistication needed to produce the Lomekwi tools suggests that earlier, simpler experiments in stone tool making are out there waiting to be found. This is an exciting development for the study of hominin material culture. We can hope that the sort of cross-disciplinary exchange exemplified by the 13th Human Evolution Workshop will help scientists recognize and interpret such finds in the future.

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