New insight into the possible origin of chipped stone tool technology

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Many animals use natural objects, sometimes with some modification, as tools to obtain food. Examples include New Caledonian crows who cut twigs and leaves to produce a variety of tool forms and chimpanzees who strip the leaves from sticks to extract termites from their nests. However, humans are unique in their total dependence on manufacture and use of tools for their very existence. Studying the transition by human ancestors from the use of tools in ancillary behaviors into a fully technological species is key to understanding human evolution.

The earliest known evidence of human technology exists in stone tools, as many other artifacts were likely made of organic materials which have long since decomposed. Specifically, the earliest hominins (the human ancestral lineage) at some point began manufacturing and using stone flakes and other chipped stones as tools for such activities as butchering, plant processing, and digging. This step involved a leap in cognition—visualizing the form of tool not evident in the raw material that was necessary to accomplish a given task and then executing a sequence of manufacture in order to create the desired tool. The steps in the manufacturing process involved structured sets of behaviors equivalent to linguistic grammar. Indeed, the development of language and of stone tool manufacture are likely to have been intimately linked. A key question regards how this transition occurred.

Evolution is a dialectical process. When conditions change, natural selection operates on existing attributes, be they physical or behavioral, as the raw material to develop new adaptations. The opposites of environment and genetics interact with each other to create a new synthesis. Something new doesn't come from nothing.

New observations made on a previously observed behavior among chimpanzees and certain monkeys provide clues to the origin of human stone tool technology. It has long been known that these primates use a hammer-and-anvil technique to break open nutshells in order to access their edible contents. The process involves the wielding of a pebble or small cobble held in the hand as a hammer and a larger rock lying on the ground as a stationary anvil. The nut is placed on the anvil and struck with the hammer. These tools are intentionally selected for suitable characteristics, such as size, weight, shape, and hardness. But they are not modified preparatory to use, nor are they known to be used for other purposes when the task of extracting the nutmeat is done.

Heretofore, no specific attention had been paid to the incidental flakes that sometimes are struck off of either the hammer or the anvil as an accidental byproduct of the nut processing. In an article recently published in the journal *Science Advances*, researchers Lydia Luncz and Tomos Proffitt, both at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, report that they conducted field observations of long-tailed macaques at an abandoned oil palm plantation in Thailand to examine this phenomenon. They found that indeed in the process of using a hammer-and-anvil technique to crack open palm nuts these monkeys sometimes missed the nut and broke off fragments from the hammer or anvil that strongly resemble human-produced flakes, known as debitage.

The two researchers made similar findings during observations of capuchin monkeys in Serra da Capivara National Park, Brazil.

In retrospect, this is not surprising. Chipped stone tool production by humans, known as knapping, involves the physical property of "conchoidal fracture." This results when a hammer (a large pebble or small cobble) strikes a glancing blow on a piece of crystalline lithic raw material, removing a flake. This same phenomenon is commonly observed when a small projectile, such as a pebble, punches through a car's windshield, although in that case the blow is often direct rather than glancing. The flake that is driven off has physical characteristics (e.g., striking platform, bulb of percussion) which are the distinctive result of such an operation. This is true whether the procedure was purposely undertaken as part of chipped stone tool manufacture or, as has now been confirmed, the accidental byproduct of nut-cracking.

The useful insight provided by the reported observations is that the accidental production of flakes with sharp edges during nut-cracking, of no use in that procedure, has the potential, in a different context, to provide the basis for an entirely new technology. The earliest known archaeological examples of human-manufactured stone tool assemblages, known as Oldowan, are known from sites in East Africa, and date to between 3.3 and 1.5 million years ago. The Oldowan tool assemblages include both flakes and core tools. The latter are pebbles with flakes removed to create a sharp but robust working edge.

Most living apes are adapted to life in a wooded environment, as were their ancestors. However, ancestral hominins (modern humans and their ancestors), branched off from other apes and adopted a new mode of life by venturing into the expanding grasslands during the Miocene geological epoch (roughly 23 to 5 million years ago). In order to survive in this new and harsh environment, hominins had to evolve new adaptations. These included fully upright posture, intensification of social living and division of labor, and the development of technologies to compensate for limited physical attributes in order to effectively exploit dietary resources different from those to which their ancestors had been accustomed. Among these technologies was the manufacture and use of an increasing range of chipped stone tools to accomplish such actions as chopping, cutting, slicing, scraping, and digging.

The scenario postulated by the study's authors is that flakes and the cores from which they were struck, the incidental and previously useless byproducts of nut-cracking, now had definite utility for early hominins. Not only that, but the ability to wield a stone hammer with some precision would form the basis for the increasingly demanding hand-eye coordination necessary to intentionally manufacture specific forms of stone tools suited for particular purposes. This is a skill which requires much training, as modern knappers seeking to replicate ancient technology will attest.

Some popular press accounts suggest that this new proposed origin of stone tool technology casts doubt on much early archaeology, since the flakes accidentally produced by chimps and monkeys during nut-cracking are indistinguishable from those resulting from intentional chipped stone tool manufacture. The authors of the study themselves caution that repeated use of a hammer and anvil may result in multiple scars on the detached flakes that could resemble intentional manufacture.

A further complication in differentiating sites of nut-cracking from those of stone tool manufacture is that, given that the anvil in the former operation is stationary, repeated use could result in an accumulation of flakes in a limited area that could appear as the product of intentional incipient chipped stone tool manufacture.

While the waste flakes resulting from the two operations are largely similar, those used or subsequently modified by humans as tools are distinct from those that are simply discarded. Flakes used as tools, even without subsequent intentional modification, termed retouch, accumulate distinctive damage during use, such as microflaking and polish on their working edges resulting from contact with the material being worked. These damage patterns can be used to interpret specific past uses of the tools by comparing them with damage produced in modern replicative experiments. Such damage does not occur on waste flakes of whatever origin that have not been subjected to subsequent use.

Evidence that use of the hammer-and-anvil technique for nut-cracking occurs in at least two species of monkeys, who shared common ancestors with humans tens of millions of years ago, and by chimpanzees, our closest evolutionary relatives, suggests that the capacity for such behavior is likely to have been deeply rooted in the primate lineage. However, the potential of this behavior to form the basis for the development of chipped stone tool technology was only realized in one primate lineage—hominins—when they were confronted with the necessity of adapting to a radically new environment.

In separate research, archaeological investigations at a site in Tanzania dating to between 3 and 2.6 million years ago uncovered Oldowan stone tools in apparent association with remains of the extinct hominin genus *Paranthropus*, a variety of hominin closely related to australopithecines, but not thought to be in the direct line leading to modern humans, including the genera *Australopithecus* and *Homo*. Given the observation that modern chimpanzees engage in nut-cracking, this implies that such behavior was already in existence among the earliest hominins.

Evidence of the very earliest use of chipped stone tools manufactured for use by early hominins as opposed to the products of simple nut-cracking may be difficult to discern archaeologically. However, the hypothesis that hammer-and-anvil nut cracking provided the potential behavioral basis for this subsequent step in human evolution is certainly a valuable insight and points in a useful direction for further research.