

## REPLY TO BARKAI:

## Implications of the Konso bone handaxe

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We welcome Ran Barkai's thoughts (1) on the symbolic significance of the Konso bone handaxe that we recently reported (2). First, we agree that African *Homo erectus* at 1.4 Mya may have been considerably sophisticated in their cognitive capacities, including potential symbolic perception and behavior. Indeed, the technological context of the find suggests a higher level of cognition than previously thought, a point we further discuss below. Next, we note that, although bone marrow was exploited, fragmented fresh bones at processing sites are covered with soft tissue. One experimental work (3) reports that presence of periosteum precludes efficient controlled percussion, and another reports that weathered bone (and stone) is easier to flake than newly broken and fresh bone (4). These are probably the underlying reasons why bone shaping was undoubtedly rare compared to lithic shaping. Therefore, we agree that whoever made the Konso bone handaxe probably did so purposefully. Given the abundance of lithic raw material at Konso, the maker of the bone handaxe must have specifically chosen bone, even though this was not necessary. However, the sheer rarity of bone handaxes in the Early Pleistocene at Konso, Olduvai, and elsewhere speaks against a recurrent symbolic function. Rather, the occurrence of bone handaxes exemplifies the behavioral breadth and cognitive capacities attained by that time. We emphasize that the Konso bone handaxe occurs in the context of an increasingly complex tool technology, and associated cognition, that progressed between 1.75 Mya and 1.2 Mya, as evinced by the large centripetal cores, Kombewa flakes, and other prepared-core reduction techniques

seen at Konso by ~1.45 Mya to 1.2 Mya (5). The bone handaxe can be considered an alternative output of this cognitive complexity. Allowing speculations, the reason for its making can range widely: from curiosity about applying percussion techniques on a different physical material, as a symbolic item related to large mammal resources (6), or, similar to "overly made" stone handaxes, proclivity for aesthetics (7), or to show off technological prowess for social status or to attract the opposite sex (8). Recent functional studies of the brain have increasingly shown the actual neural activation and connectivity patterns that accompany tool making and its learning, and that, especially regarding the Middle Pleistocene Acheulean handaxe replication skills, overlap in circuitry occurs with language (9). This has been interpreted to imply coevolution of tool technology and verbal communication (9), or a parallel development of the two (10). The emerging hierarchical complexity of the pre-1.0 Mya Acheulean technology suggests that coevolution of tool technology, social learning, and some form of verbal or vocal communication might have extended well back into the Early Pleistocene, and formed a key component of the brain–behavior–culture coevolutionary "helical cycle" that characterizes both Pleistocene *Homo* and extant humans (11). It is quite striking that a clear, early manifestation of this cycle is represented by the earliest Acheulean at ~1.75 Mya and the near-coeval transition to a hominin morphology that we recognize as *Homo erectus*. Lastly, we await further descriptions of the much younger suggested bone handaxe from China.

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