Hafted spears and the archaeology of mind

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by as early as 200,000 years ago hunters in Africa, the Middle East, and Europe had begun hafting stone points onto the ends of their spears (1–3). This marked a significant step in the history of technology, for it was the first time that hominins had united separate elements into a single tool. Indeed, these compound tools actually consisted of three distinct elements: the point, the shaft, and the haft itself. It was the haft that was the challenge because it had to withstand significant impact forces when the spear was used. Many archaeologists consider the development of hafting to mark a major watershed not just for technology, but for the human mind itself (4). But just what is required, in a cognitive sense, to be able to haft a point to a shaft? In this issue of PNAS, Wadley et al. (5) set out to answer this question by duplicating one such hafting technology, identifying the procedures and knowledge required, and arguing that abstract reasoning was an essential prerequisite. In doing so they provide a good example of a relatively new perspective in paleoanthropology—that of cognitive archaeology.

How can archaeologists structure a persuasive argument about cognition in the evolutionary past? After all, archaeological data consist of the refuse of hominin activities—broken and abandoned tools, the detritus from tool making, discarded remains of meals, ash from fires, and so on—all disturbed by subsequent activities and natural processes. The answer is that an argument in cognitive archaeology must invariably be based on a sequence of inferences, each of which must be explicit and persuasive if the argument as a whole is to be credible. Fig. 1 is a diagram that summarizes the argument of Wadley et al. that the hafting of spear points with multicomponent glue required abstract reasoning. The organization of the diagram is borrowed loosely from Botha’s (6) detailed critique of an archaeological argument for the use of syntactical language by people at Blombos Cave 77,000 years ago (7). The upper row summarizes an idealized sequence of inferences, from prehistoric artifact to cognitive prerequisite, and the lower row, the specific argument of Wadley et al.

Technical System (ABC). The initial inference consists of artifacts or properties of artifacts (A), a bridging argument (B), and features of a technical system (C). For Wadley et al. (5), A consists of stone artifacts excavated from the Middle Stone Age site of Sibudu in southern Africa, which are about 70,000 years old. The heart of the inference is the argument B that takes us from features of A to the probable or necessary presence of C, in this case spears with hafted points. What powers this inference? To be persuasive, according to Botha (6), this bridging argument B must be grounded and warranted. Grounding is the requirement that the inference have some evidential basis, and warranting is the requirement that the evidence be relevant to connecting A and C. Here B is based on two established techniques in archaeology: analysis of residues found on tools and analysis of breakage patterns, which for the Sibudu artifacts are consistent with their having been hafted on shafts with a multicomponent glue that included haematite. B is both grounded and warranted. Such a bridging argument must also consider the problem of equifinality. Often, a variety of different activities could produce A, in which case the archaeologist must favor the simplest technical system that would account for the data. If anyone could demonstrate that the residue and wear patterns could have been produced by another, simpler system (e.g., without hafting), then Wadley et al. would need to reassess their conclusion that the tools were hafted.

This initial inference is, in fact, uncontroversial, and falls in line with other arguments for the presence of hafted spear points of similar antiquity from several sites in Africa, Europe, and the Middle East (many attributable to Neandertals) (8, 9).

Procedures and Knowledge (CDE). The second inferential step (CDE) takes us from the hafted spear points to the procedures and knowledge necessary to make them. The majority of Wadley et al.’s article (5) is devoted to establishing an appropriate bridging argument (D), and here again it is based on replicative research. Wadley et al. identified naturally available materials (acacia gums and beeswax) that could be combined with ochre (found as residue on the tools), after which they experimented with various combinations to find the most effective mixture. They also tried different techniques for producing the actual haft, including the use of fire for rapid drying of the adhesives. With the most effective procedure in hand they could then ask themselves what an artisan needed to understand in order to conceive of and execute this task. “We propose that these artisans were exceedingly skilled; they understood the properties of their adhesive ingredients and they were able to manipulate them knowingly” (5). In particular the artisans needed to understand the properties of their ingredients (e.g., cohesive-

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ness), to be able to judge the effects of temperature, to be able to switch attention back and forth between separate rapidly changing variables, and to be flexible enough to adjust to the variability inherent in naturally occurring ingredients.

**Cognitive Prerequisites (EFG).** Were the Sibudu artisans “highly skilled”? Did they reason abstractly? This is the final step in the sequences of inferences, and the one that presents the most difficulty for archaeologists and for those wanting to assess archaeological arguments. Some might reasonably suggest that a description of what the artisans knew (E) is about as good as archaeologists can hope, and that any further inference extends the reasoning in unacceptable ways. However, if archaeologists content themselves with only describing E they will never contribute significantly to the study of human cognitive evolution, and this would be a missed opportunity. Archaeological remains are the only direct evidence of past human activities that science possesses, and as such they have the potential to supply clues to cognitive evolution that other disciplines (e.g., evolutionary psychology) just do not have. The challenge lies in structuring the EFG inference.

While a modest amount of persuasive power lies at a common sense level, as when Wadley et al. (5) recognize skill in the products of Sibudu artisans, this makes for a weak bridging argument (F). A better approach is for archaeologists to articulate with established models of cognition, of which there are many. An explicit model supplies well-grounded descriptions of cognitive abilities, and with such a model one can take elements of E and build a bridging argument (F) to actual features of cognition (G). The primary task of the cognitive archaeologist is to be explicit about how his or her data (E) articulate with the model; in this way a compelling bridging argument can be constructed. This requires identifying how the archaeological data are equivalent to the data on which the model is based. Wadley et al. chose at the outset of their article to rely on a model of cognition developed by Philip Barnard (10). The final level of Barnard’s sequence is a system capable of processing, to quote Wadley et al., “...two levels of meaning simultaneously or generating fully abstract concepts about behavior.” It was Wadley et al.’s task to specify components of their evidence that are equivalent to components of Barnard’s model and that can act as evidence relevant to linking E to G. Because Wadley et al. have identified “switching attention,” for example, as an element of E, they feel they can use the abstraction reasoning (G) for the Sibudu artisans.

Of course, other models of cognition could be brought to bear on E. Indeed, it is at this level that cognitive archaeology demonstrates a promiscuity typical of many nascent scholarly endeavors. Some archaeologists (e.g., see refs. 11 and 12) go directly to the neuroscience literature, using brain imaging and actualistic studies as a basis for F and G, whereas others draw on cognitive neuroscience (e.g., see refs. 13 and 14), and still others apply theories of embodied cognition (15). Indeed, Wadley et al. (5) themselves tap into a cognitive model of working memory in their argument for mental rotation (16). In the face of competing cognitive models, how does one judge? The power and status of a particular theory or model is, of course, relevant; well-established theories have more explanatory power than tentative models. Moreover, some models incorporate development or individual differences, making them more amenable to evolutionary applications. On a specifically archaeological level, one must judge inferences by the quality of the bridging arguments (F), which one must evaluate on the basis of how well grounded they are and how relevant the evidence is to the conclusion. It is not necessary that all cognitive arguments in archaeology be organized like the current example. However, it is necessary that the sequence of inferences be presented in a way that invites careful critique.

**The Modern Mind.** A cognitive interpretation such as the one presented by Wadley et al. (5) enriches our understanding of the life world of the people who lived at Sibudu 70,000 years ago. But such an interpretation also carries implications for the evolution of the modern mind. One that has held central stage in paleoanthropology for two decades is the problem of modern mind evolve? Most of the focus in this debate has been on the role language and symbolism (e.g., see refs. 17–19) but, as Wadley et al. make clear, there is more to modern cognition than language and the use of symbols. Indeed, language has proven to be a particularly intractable topic for archaeologists, a point made cogently by Botha (6). By focusing on activities that tax reasoning ability and are also visible archaeologically, such as hafting, archaeologists are in a better position to contribute to an understanding of the evolution of the modern mind. In the current example, Wadley et al. have been able to demonstrate that some elements of modern cognition were in place by 70,000 years ago.