COMMENTARY

Tar adhesives, Neandertals, and the tyranny of the discontinuous mind

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Were the builders of Stonehenge and the painters of Altamira (Fig. 1) cognitively and behaviorally like present-day humans? Did those prehistoric people have language? In the absence of writing, these never-asked questions cannot be answered with direct evidence. However, we take it for granted that, yes, they were, and they did. We do so because we instinctively know that such works require the capacity for abstract thought, deep foresight, and sophisticated communication. In current scientific discourse, this "complex" cognition is set against the simpler modes that can be observed in other species and are assumed to also have characterized our nonhuman ancestors. Hence the question that lies at the core of much paleoanthropological research: When, how, and why did humans acquire language and so-called "modern" (i.e., like present-day) cognition and behavior? Or, put another way, when did humans become, well, "human"? In PNAS, Niekus et al. (1) speak to these issues based on their analysis of a 50,000-y-old flint flake dredged from the postglacially submerged Rhine-Meuse Valley in the North Sea off Holland. The flake is embedded in birch bark tar and is of Neandertal make. It adds to comparable finds showing that Neandertals used artificial adhesives to haft, or better handle, stone tools across their entire geographic range and since at least 200,000 y ago.

Neandertals were discovered in a time of widespread acceptance that "race" and "intelligence" were correlated and of descriptions of the "primitives" encountered by colonial powers as living representatives of the different stages of European prehistory (2). The belief in a tight correspondence between form and function even led to the rise of the soon-to-be-discredited discipline of phrenology, or the speculation that an individual's psychological attributes could be inferred from minute details of external cranial shape. Unsurprisingly, thus, the christening of *Homo neanderthalensis* included this key statement: "Psychical endowments of a lower grade than those characterizing the Andamaner cannot be conceived to exist: they stand next to brute benightedness. . . . Applying the above argument to the Neanderthal skull, and considering . . . that it more closely conforms to the brain-case of the Chimpanzee, . . . there seems no reason to believe otherwise than that similar darkness characterized the being to which the fossil belonged" (3).

This mindset has defined the stage ever since. Its pervasiveness helps to understand why late 20th-century paleoanthropology so easily embraced a corollary of recent African origin models of modern human emergence—that behavioral and cognitive modernity seamlessly followed from anatomical modernity. Within this framework, particulars of cranial shape implied the Neandertals' distinctiveness at the species level and, since species are supposed to also differ in behavior, the lack of anatomically modern humans' species-specific behavior (and underpinning cognition). Thus, the demise of the Neandertals and coeval, anatomically nonmodern humans was self-explanatory: In a competitive exclusion scenario, the cognitively superior species, *Homo sapiens*, inevitably prevailed (4). This view found support in the claim that Neandertals did not engage in art or other symbol-mediated behaviors; the jewelry found in late Neandertal contexts was dismissed as reflecting postdepositional intrusion from overlying, modern human-related strata, and whether they buried their dead or could master fire was also brought into question.

Recent discoveries are overriding such views of Neandertal cognition. Not only did Neandertals use body ornaments, we also know now that they went deep inside caves to build large ritual features and indulge in speleothem and wall painting, all this predating comparable behavior in Africa (5–7). In addition, reexcavation of La Chappelle-aux-Saints, the site where, in 1908, the first Neandertal burial was found, proved that the body of the deceased had

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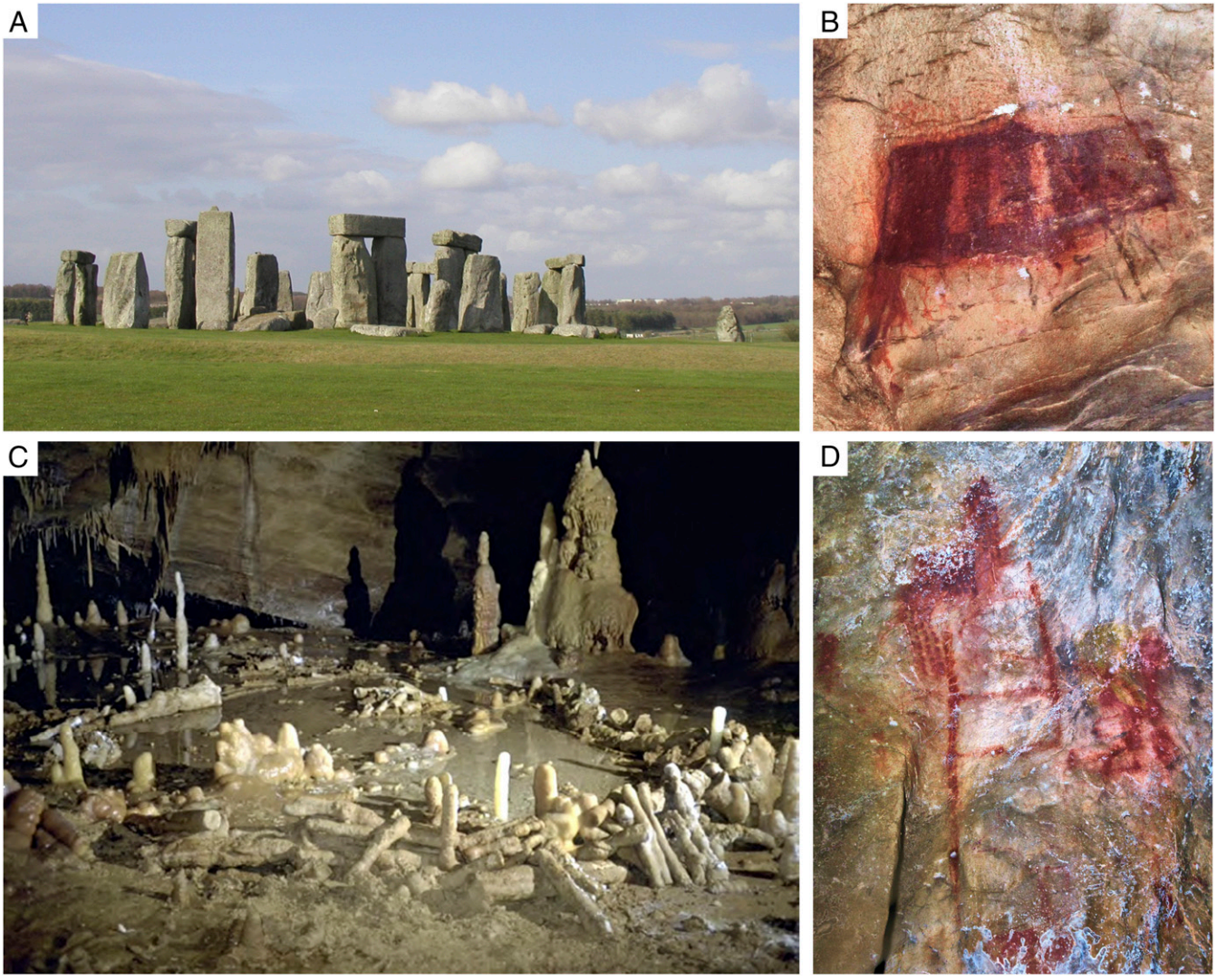

Fig. 1. Material culture as a basis for inferences about language and cognition. (*A*) Neolithic stone circle at Stonehenge, England. (*B*) Upper Paleolithic tectiform sign from El Castillo Cave, Spain. (*C*) Middle Paleolithic stalagmite circle at Bruniquel Cave, France. Reprinted with permission from M. Soulier/Société Spéléo-Archéologique de Caussade. (*D*) Middle Paleolithic scalariform sign from La Pasiega, Spain. If *A* and *B*, which were made by anatomically modern people, imply language and cognitive capacities like those of present-day humans, so too should *C* and *D*, which were made by Neandertal people.

been placed in a purposefully excavated pit (8), while strike-a-light fire making using pyrite on flint has been documented in the French Middle Paleolithic, some 50,000 y ago (9).

Niekus et al. (1) add to this rapidly growing corpus. Tar can be accidentally produced when burning birch bark over an open fire; small amounts will accumulate against the inclined surface of a stone above. An innovative Neandertal could have been led to deliberately recreate the conditions under which (s)he originally observed the phenomenon and, eventually, start making tar at will. Going from observation to production with this "condensation method" might well have represented the technology's starting point. However, that method would have been insufficient to regularly produce the necessary amounts, and it is also inconsistent with the chemical and textural properties of the archeological tars. As Niekus et al. (1) argue, these properties imply use of the more sophisticated "pit and vessel" and "raised structure" methods, which imply the command of a set of *chaînes opératoires* and, crucially, being capable of controlling for how long the fire burns so as to stop it before pyrolysis occurs and the tar combusts. Thus, the spatial and temporal span over which these tar adhesives was produced reflects the acquisition, mastering, and cultural, intergenerational transmission of a complex production technology.

It is important to note, however, that, if technologically simpler, the condensation method is nonetheless cognitively complex. Indeed, rather than in the technological aspects of production per se, the cognitive relevance of tar adhesives resides in the thinking that goes from observing the accidental production of the raw material to the inferences that 1) one might be able to reproduce nature's doings oneself, and 2) by doing so, one might be able to obtain a significant improvement in the efficiency of one's tools. The following analogy highlights this key point. Technologically, mobile phones are rather more complex than the telegraph, and the telegraph itself is rather more complex than light signs emitted through a chain of mountaintop fires. Cognitively, however, these technologies stand for the same thing—minds that make artifacts capable of transmitting and receiving symbolically encoded

information, even at a significant distance, way beyond interindividual contact. Likewise, cognitively, no categorical distinction exists between the Paleolithic mind that makes a technologically "simple" tar-hafted or tar-handled tool and the Industrial Age mind that makes the archeologist's technologically "complex" wood-hafted steel trowel.

Thus, as Niekus et al. (1) point out, it is now clear that, when submitted to evolutionary psychologists' tests of complex, fully modern cognition and behavior as can be inferred from material culture and other properties of the archeological record, Neandertals "tick the box" in all items. For instance, the large stalagmite-made constructions that they built ∼175,000 y ago 300 m from the entrance of Bruniquel Cave, in France (5), imply considerable social coordination—like Stonehenge, if on a different scale, and, cognitively speaking, conveying the exact same message. Ditto for the geometric signs and the stencils of their own hands that Neandertals painted inside the caves of western Europe >65,000 y ago. Cognitively speaking, those paintings are indistinguishable from the comparable imagery left at some of the same sites, 300 centuries later, by anatomically modern humans of the Upper Paleolithic—so much so that, until their true age was revealed, archeologists assumed that such geometric signs and hand stencils were of the latter's make. We are therefore called upon to apply to Neandertals the same chain of inference under which we do not even bother to ask whether the people who built Stonehenge and painted Lascaux were behaviorally and cognitively like "us," or whether they had language: Of course, they were; of course, they had. Under the rules of logic, the burden of proof lies on the side of anyone who would rather believe otherwise.

The picture of human evolution that this archeological evidence redefines is one where the emergence of humans, "the symbolic species," is a closely integrated process of interaction between the acquisition and transmission of culture and the biological transformation of the organism (10). While the former is cumulative and bears the potential to grow rapidly and, once certain thresholds are crossed, exponentially, the latter is a very slow and gradual Darwinian process. Thus, the magnitude of the transformations required to transform the brain of a chimp-like ancestor into our language-enabled brain requires amounts of time way greater than the couple hundred thousand years over which the Neandertal and modern phenotypes were constituted. Instead of a rather recent innovation, language, the fundamental machinery of human cognition, must be the result of a process of coevolution that also drove the growth and reorganization of the ancestral brain. Indeed, if not for the requirements placed by language and its correlates, our brains would be, by great ape standards, unnecessarily large and, metabolically, too expensive—and would already have been so 1.5 million years ago, in *Homo erectus* times.

Ultimately, the main lesson of the recent developments in the archeology of the Neandertals is, perhaps, that we ought to seriously reconsider the utility of framing the study of human evolution in terms of species distinctions and other such dichotomic, typological oppositions as simple versus complex or "archaic" versus "modern." One of the leading evolutionary biologists of our time has very aptly represented the controversies arising from such oppositions as a typical by-product of the "tyranny of the discontinuous mind" (11): "zoologists always insist on classifying a specimen as in one species or another. If a specimen is intermediate in actual form (as many are, in accordance with Darwinian expectations), zoologists' legalistic conventions still force them to jump one way or the other. . . . [The] claim that there are no intermediates has to be true by definition at the species level, but it has no implications about the real world—only implications about zoologists' naming conventions. . . . To look no further than our own ancestry, the transition from *Australopithecus* to *Homo habilis* to *Homo erectus* to 'archaic *Homo sapiens*' to 'modern *Homo sapiens*' is so smoothly gradual that fossil experts are continually squabbling about where to classify—how to name—particular fossils."

There is no question that Paleolithic humans were few and much more scattered and morphologically diverse than we are today. However, the archeological data, coupled with the ancient DNA evidence for Middle Pleistocene intercontinental gene flow and extensive Neandertal–modern admixture at the time of contact (12–14), increasingly make it clear that the Linnaean categories of human paleontology are ill-suited to frame our story. Irrespective of the boundaries that the tyranny of the discontinuous mind creates around such categories, what the Paleolithic of both Africa and Eurasia reveals is the unfolding of humankind's gradual, culture- and language-mediated accumulation of knowledge about the world and how to thrive in it. Eventually, this process led to the development of a more complex technology, of a body form adapted to a technology-dependent life, and of sophisticated forms of sociality and communication requiring material expressions amenable to archeological preservation. As one might expect of any exponential process, the early stages of symbolic material culture and complex technology are, like the light reflected by a distant planet, dimmed by distance, in this case temporal distance. In the Upper Paleolithic, the evidence, more abundant and closer, has been apparent for quite some time; thanks to the much better instruments currently available to paleoanthropology, we can now also reach out to its earlier, Middle Paleolithic beginnings.

1 M. J. L. Th. Niekus *et al.*, Middle Paleolithic complex technology and a Neandertal tar-backed tool from the Dutch North Sea. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 22081–22087 (2019).
2 W. J. Sollas, *Ancient Hunters and Their Modern Representatives* (Macmillan and Co., London, 1911).
3 W. King, The reputed fossil man of the Neanderthal. *Quarterly J. Sci.* **1**, 88–97 (1864).
4 R. G. Klein, Paleoanthropology. Whither the Neanderthals? *Science* **299**, 1525–1527 (2003).
5 J. Jaubert *et al.*, Early Neanderthal constructions deep in Bruniquel Cave in southwestern France. *Nature* **534**, 111–114 (2016).
6 D. L. Hoffmann *et al.*, Symbolic use of marine shells and mineral pigments by Iberian Neandertals 115,000 years ago. *Sci. Adv.* **4**, (2018).
7 D. L. Hoffmann *et al.*, U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art. *Science* **359**, 912–915 (2018).
8 W. Rendu *et al.*, Evidence supporting an intentional Neandertal burial at La Chapelle-aux-Saints. *Proc. Natl. Acad. Sci. U.S.A.* **111**, 81–86 (2014).
9 A. C. Sorensen, E. Claud, M. Soressi, Neandertal fire-making technology inferred from microwear analysis. *Sci. Rep.* **8**, 10065 (2018).
10 T. W. Deacon, *The Symbolic Species: The Co-evolution of Language and the Brain* (W. W. Norton, New York, 1997).
11 R. Dawkins, *Science in the Soul. Selected Writings of a Passionate Rationalist* (Random House, London, 2017).
12 E. Trinkaus, European early modern humans and the fate of the Neandertals. *Proc. Natl. Acad. Sci. U.S.A.* **104**, 7367–7372 (2007).
13 C. Posth *et al.*, Deeply divergent archaic mitochondrial genome provides lower time boundary for African gene flow into Neanderthals. *Nat. Commun.* **8**, 16046 (2017).
14 V. Slon *et al.*, The genome of the offspring of a Neanderthal mother and a Denisovan father. *Nature* **561**, 113–116 (2018).