These and other factors demonstrate that by approximately one million years ago, before the end of the Early Pleistocene, underlying behavioral strategies had essentially reached modernity. As a rational and realistic working hypothesis it has been postulated that *Homo erectus* can reasonably be credited with the cognitive development of a modern juvenile of about 8 to 12 years of age (Bednarik 2012b, 2015b). Ontogenic homology and the proposed trajectory of cognitive development in hominins could thus reasonably account for the demonstrated ability of *H. erectus* of crossing the sea, confirming that substantially modern cognition and behavior were in place by about a million years ago. Contrary to latent archaeological dogma, 'modern behavior' does not refer to the behavior of any extant human group. It is defined by the state of the neural structures that are involved in moderating behavioral patterns, which ultimately are determined by inhibitory and excitatory stimuli in the brain (Bednarik 2013b). The correct null-hypothesis in hominin evolution is not that all humans before *Homo sapiens sapiens* were cognitively or intellectually primitive, but that the evolutionarily very expensive continuous encephalization of hominins until the final Pleistocene (Leigh 1992; Ruff et al. 1997; de Miguel and Henneberg 2001; Hawks and Wolpoff 2001; Lee and Wolpoff 2003; Rightmire 2004) must have had significant benefits in natural selection. It imposed a massive evolutionary burden on hominins, in obstetric demands (O'Connell et al. 1999), reproductive fitness (Joffe 1997), and metabolic, social, economic, and neurological costs (Bednarik 2011a). Its toleration can only be justified by significant advantages of the larger brain, particularly in cognitive and intellectual returns. A careful perusal of the archaeological record shows that language must have become available in the Early Pleistocene or even earlier, as indicated by maritime colonization. Self-awareness had become formalized in body ornamentation at least during the Middle Pleistocene. The self-awareness clearly present in apes had become expressed in thoroughly modern forms by the time beads and pendants were used.

The high level of perfection, finding expression in meticulously made handaxes, in ostrich eggshell beads and in such extraordinarily sophisticated behavior as the production of cupules of the Lower Paleolithic (which are all complex exograms; see below), is a particularly important factor in appraising hominin behavior. The development of biface implements during the Acheulian technocomplex to a functionally irrelevant level of esthetic refinement has been commented upon by many authors. Other examples are known from the Middle Pleistocene, such as the "aerodynamically designed" wooden spears from Schöningen, Germany. The Acheulian disk beads from the Pleistocene Lake Fezzan in Libya, excavated at El Greifa Site E (Bednarik 1997b, 2005), express this sense of perfection even better. Made from ostrich eggshell, they are worked to the smallest possible diameter as determined by replication. Indeed, replicative work has verified that there are strong behavioral indices expressed in these tiny artifacts. But even more than that, the behavior of creating cupules on the hardest rock they can be made on can only be considered obsessive. These are entirely non-utilitarian, spherical cup-shaped petroglyphs that require about 40–60,000 blows with a hammer-stone to be created on hard quartzite, i.e., they involve a significant commitment of effort. What is most important about them is that their makers took great pains in keeping the cupules' diameter as small as humanly possible, while trying to penetrate as deeply into the rock as is achievable with the available means (Figure 6). Cupules can occur in their hundreds on single panels, and the oldest so far found date from the Lower Paleolithic period at least at two sites in India, Auditorium Cave (Bednarik 1993) and Daraki-Chattan (Bednarik et al. 2005). At two sites in the South African Kalahari, at Nchwaneng and

Potholes Hoek, cupules have been estimated to be between 400–410,000 years old (Beaumont and Bednarik 2015).

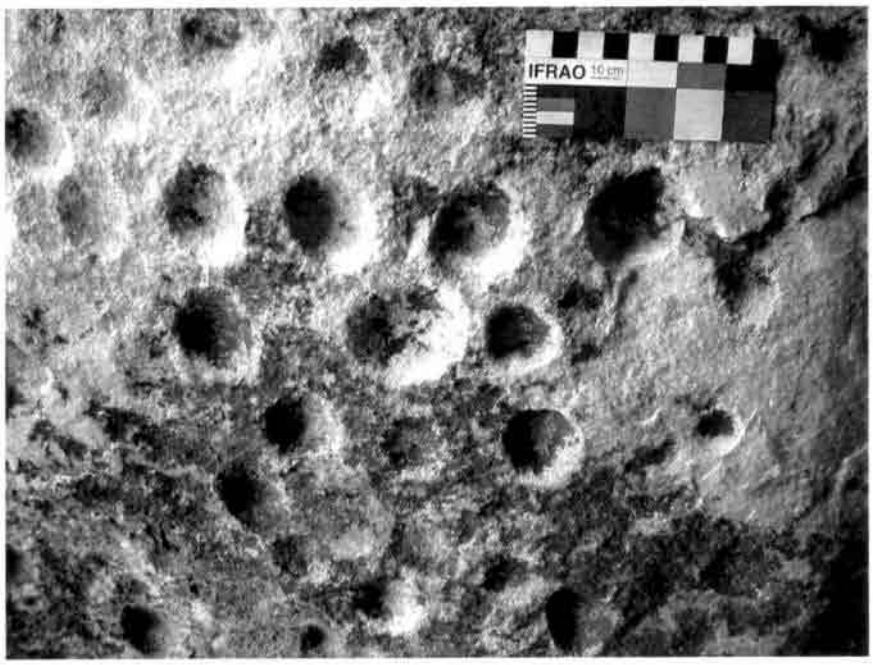

Figure 6. Cupules in Daraki-Chattan Cave, central India, some of the oldest known rock art in the world.

What connects all the petroglyphs, beads, portable engravings, proto-sculptures, pigment use, and manuports of early human history is that they are the oldest surviving exograms, which are externalized memory traces. The word 'exogram' derives from the concept of the engram, first proposed by Semon (1904, 1921: 24). Engrams are hypothesized memory traces, persistent protoplasmic alterations of neural tissue thought to occur upon stimulation of the brain, and accounting for memory in all animal brains. For much of the 20th century it was assumed that external sensory stimuli resulted in discrete biophysical or biochemical changes in neural tissue. Lashley (1923, 1930, 1932, 1950) spent several decades trying to locate engrams in rat brains, succeeding instead in demonstrating that there is no single biological locus of memory, but rather there are many. Similar findings were reported by Penfield (1952, 1954) and Thompson (1967, 1986, 1990; Thompson et al. 1976; Steinmetz et al. 1987, 1992; Christian and Thompson 2005). However, the concept of the engram spawned the idea of storage of memory traces *external* to the brain, at least in humans, first proposed by Gregory (1970: 148). The notion of such a 'surrogate cortex' was then developed by Goody (1977), Bednarik (1987), and Carruthers (1990, 1998). Bednarik's proposal identifying certain phenomena as engram-like, externalized, 'permanent' forms to which the human intellect of the creator as well as conspecifics could refer led to Donald's (1991; 2001) coining of the neologism 'exogram' to define the concept. Donald's ideas were marred by his reliance on the replacement hypothesis and his lack of familiarity with pre-modern exograms (Bednarik 2014a) and they were severely criticized by many (e.g., Brace 1993, 1996, 1999; Cynx and Clark 1993; Adams and Aizawa 2001).

Whereas engrams, as imagined, would have been impermanent, of constrained format, fixed physical medium, limited capacity and size, and not easily refinable, exograms exceed their potential in most respects. Exograms are semi-permanent, unconstrained and reformatable, can be of any medium, have virtually unlimited information capacity and size, and can be subjected to unlimited iterative refinement. In appreciating their roles in hominin evolution it may be useful to begin with the observation that even the most basic anthropogenic rock markings can carry numerous inherent messages, for both the maker and any conspecific (Bednarik 1987). All paleoart consists of exograms, yet the roles of exograms in human history have been ignored by mainstream archaeology. ('Paleoart' is a term applied to archaeological evidence that resembles art-like products, without implying that they are 'art' in the modern sense of that word.) But in the late part of the Pleistocene, competence in employing and exploiting exograms became the primary selecting factor in maximizing cognitive fitness, gradually replacing traditional, 'natural' selection criteria. This process is by its very nature autocatalytic, and its effects can be observed throughout present-day societies, being evident virtually everywhere. *Exograms generate not only frames of reference; they also create self-referential realities* (see above). The mechanism of establishing these realities remains unknown, but it probably resembles the much better understood system of body awareness, or of how the individual makes a judgment about a conspecific's body movements (Bednarik 2012b). The former is established in the right hemisphere's superior parietal lobule (Bednarik 2013c: 27); the latter has been suggested to be obtained by running a virtual reality simulation of the corresponding movements in one's own brain (Ramachandran 2009). Mirror neurons (Stern 1985; Di Pellegrino et al. 1992; Rizzolatti et al. 1996; Bråten 2004, 2007; Ramachandran 2009; Bednarik 2012b, 2013c) are probably involved in this process, as deduced from certain neuropathologies (Bednarik 2012a). Therefore the most likely explanation of how human constructs of reality are established is that the brain creates a virtual reality-like model of the external world, quite probably in the parietal lobe, in much the same way as the mental image of the body is formed (Bednarik 2012b). In this, the exograms are indispensable, forming the strongest link between brain activity and the external world. This is the mechanism by which humans experience 'reality' 'consciously,' and it is also the neural basis of what is termed 'volition.' This human ability of deriving abstract goals from the prefrontal cortex is unique in the animal world, but it would have been rendered possible by the described system.

Ultimately it is the consistent and skilled use of exograms that most separates humans from other animals and that serves as the clearest indicator of essentially modern behavior (Bednarik 2011a, 2012a, 2012b, 2013c). If Pleistocene archaeology ignores the early presence of exograms in the archaeological record, or is preoccupied with explaining it away, it fails completely in its professed task, the clarification of hominin history. In the same way as the use of an external drive unburdens the memory capacity of a computer, the storage of memory traces outside the human brain rendered its encephalization unnecessary. That is the very simple explanation for the rapid atrophy of the human brain since the final Pleistocene, its size collapsing at a rate 37 times that of the previous long-term rate of encephalization (Bednarik 2015a). This does not explain whether it was brain atrophy that drove the rise of exograms, or whether exograms came to the rescue of an over-burdened brain. Either way, human modernity began with the skilled use of exograms, and it was their burgeoning use around the advent of Upper Paleolithic technology and the consequent behavioral changes that directly led to the rapid neotenization of humans and the disappearance of robust traits. It

had nothing to do with any genocide or replacement or large-scale mass-movement of human populations. Until Pleistocene archaeology and paleoanthropology appreciate this, the relevant models of both disciplines need to be seen as superseded.

Conclusion

The kinds of observations concerning the sense of perfection, elucidated by detailed replication experiments (e.g., Bednarik 1997b, 1998; Kumar and Krishna 2014), provide valuable empirical insights into the behavior of hominins reaching far beyond lithocentric archaeological deductions. They suggest that the obsessive aspects of human behavior should be of particular interest in exploring its origins. Expressed today in obsessive compulsive disorder (OCD) and a suite of other conditions involving obsessiveness (Helvenston and Bednarik 2011; Bednarik and Helvenston 2012), this very human trait deserves much greater attention in the context of an etiology of human behavior. No extant pongid species displays obsessiveness or a penchant for perfection in everyday behavior: the sleeping nests apes build or the tools they use have probably not been improved upon for millions of years. They also display no signs resembling those of mental illness, unless animals are kept in captive environments without environmental stimulation and conspecifics present (Walker and Cork 1999; Olson and Varki 2003). The thousands of genetic disorders, neuropathologies, and neurodegenerative conditions afflicting modern humans appear to be largely results of the unintended self-domestication of humans in the course of the last fifty millennia or so (Bednarik 2008a, 2008b, 2011a, *et passim*). Domestcation is the only suggested process that can logically account for the Keller and Miller (2006) paradox: why natural selection has not suppressed the thousands of deleterious conditions afflicting modern humans (Bednarik 2012b); and it also explains numerous other outcomes, ranging from exclusive homosexuality to the abolishment of estrus, to the profound neotenization process in the most recent hominin history. None of these factors have ever been considered in any depth by either Pleistocene archaeology or paleoanthropology, even though they offer the only rational explanation for human modernity (Bednarik 2012a). This suggests that these disciplines have failed to consider the origins of what they define as 'anatomically modern humans' equitably, and have instead concocted an unsupported model involving a genocidal African 'new species' that conquered the world and replaced all other humans. This indicates how serious the issue is: the 'replacement theory,' based as it is on the hoax and fake datings of human fossils by a German archaeology professor, has taken over both named disciplines, which both suppressed the alternative model through dominating the refereeing system of the mainstream journals and thereby stifling hominin studies instead of furthering them. It is this factor that has prevented an equitable investigation of the behavior of hominins, and of the origins and etiology of that behavior.

The profundity of this realization is that it is actually behavior—culturally determined behavior—that was the cause of human self-domestication. No non-human animal shows any preferences in mate selection of youth, specific body ratios (e.g., hips vs waist), facial features and symmetry, neotenous features, skin tone or hair color. Since these culturally determined factors are undeniably crucial in the preference of mating partners in modern humans, they must have been introduced at some time in the hominin past. The evidence as it

stands suggests that this occurred in the order of 40,000 years ago. Apart perhaps from facial symmetry, which may imply high immunocompetence (Grammer and Thornhill 1994; Shackelford and Larsen 1997; Saxton et al. 2011; but cf. Boothroyd et al. 2005, 2009), there are no biological advantages in any of these strongly developed cultural biases. Facial 'attractiveness,' for instance, is a cultural construct found in all extant societies (Cunningham et al. 1995), and in female humans, neotenous facial features are strongly preferred by males (Jones 1995, 1996). These include, irrespective of cultural context, neonate large eyes, shiny hair, small noses, reduced lower facial regions, thin jaws, and high foreheads (Perrett et al. 1994; Sforza et al. 2009), which are all distinctive neotenous features (Bednarik 2011a), as are specific psychological features (De Beer 1930; Zebrowitz et al. 1998; Buchen 2011). The consistent selection in their favor inevitably leads to the collective genetic alteration of the physiology, behavior, or life cycle of a species through selective breeding, i.e., to domestication (e.g., Belyaev 1979; Belyaev et al. 1981): the laws of Darwinian evolution are replaced by the Mendelian laws of inheritance. Humans, through their behavior, became the only species on this planet that domesticated itself.

Hominin behavior is not just an abstract concept one might like to extract from the taxonomy of stone tools of humans one has invented, or from surveyed occupation floors or forensic traces one has excavated. It has been the most decisive factor in arriving at 'anatomically modern humans' (a term criticized by some; e.g., Latour 1993; Tobias 1995; Bednarik 2008a). It is perhaps the principal cause of 'the human condition': our capacity for both good and evil, the 'troubled state and nature' of the human being, our futile yearning for everlasting life, or our never-ending endeavors to construct meanings where there are none (Bednarik 2011a). Does this matter to us today? Yes it does! The modern human sub-species, this 'pinnacle of evolution' that is in fact an anomaly of evolution, is currently engaged in generating this planet's greatest extinction catastrophe since 65 million years ago; in changing its climate; and in altering its biochemistry irreversibly. In that sense it should be of concern, even though there is nothing that can be done about the genetic decline of humans: the explosion in neuropathologies and numerous other deleterious genetic traits due to neural proliferation under conditions of decreasing natural selection pressures began in the order of fifty millennia ago. As an ongoing process it is entirely inevitable, and has already progressed far towards the genetic 'implosion' of the human species.

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