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Resetting the null hypothesis: early stone tools and cultural transmission

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Abstract

We have learned much about tool use in non-humans since the first discovery of Oldowan stone tools. Despite the ongoing debate over whether tool use in other animals requires cultural transmission, it seems clear that today humans show a quantitative, if not qualitative, difference in our ability to transmit information socially through cultural transmission. This ability makes cumulative culture possible. Comparative studies provide relevant insights, however to address the when, where, and ultimately why this shift to high-fidelity social learning occurred we must look to the Paleolithic archaeological record. Yet here the *de facto* assumption that even the earliest stone tools serve as evidence of high-fidelity cultural transmission hinders investigation more than it helps. Here, we pragmatically suggest "resetting" the null hypothesis for the processes underlying early stone tool production. The null hypothesis we prefer is that Earlier Stone Age tools might have been so-called latent solutions rather than cultural material that derived from – and depended upon – modern human-like high-fidelity cultural transmission. This simple shift in perspective prioritizes the systematic investigation of more parsimonious potential explanations and forces us to demonstrate rather than presume that stone tools could not have existed without high-fidelity cultural transmission.

The archaeological record clearly shows that by at least 2.6 million years ago (Ma; and likely much earlier, e.g., McPherron et al. 2009; Harmand et al. 2015), one or more fossil hominin taxa were frequently making and using stone tools (Semaw et al. 1997). A defining (and puzzling) feature of early stone tool assemblages is that patterns of production appear to have little identifiable or directional changes over hundreds of thousands of years. Over the last decade, archaeologists have come to rely more heavily on findings from cognitive science to identify the mechanisms responsible for this pattern in the early archaeological record (Morgan et al. 2015; Lycett and Gowlett 2008). For example, some (Morgan et al. 2015; Putt et al. 2014) argue that various forms of teaching (in some cases mediated by language) prevented substantial temporal changes in early stone tool assemblages. Such studies tend to start from a seemingly unquestioned *a priori* assumption that artifacts in the earliest archaeological record are products of culturally transmitted information – or mental templates – concerning how to make a stone tool (but see: Richerson and Boyd 2005; Corbey et al. 2016; Hovers 2012; Tennie et al. 2016). In short, researchers interested in what the archaeological record can tell us about cognition commonly ascribe modern human cognitive skills like shared intentionality, conformity, overimitation, and teaching (skills that many have argued are key to the sophisticated way that modern humans, but not other living primates, transmit information socially) to Pliocene and Early Pleistocene hominins.

It is not surprising that archaeologists see signs of modern human cognition in Earlier Stone Age tools given that the technology appears at once so impressive and so foreign. If hive-making were culturally transmitted among bees today (it is not), then one could excuse a hapless "modern bee-man" visitor of a future museum of "prehistoric bee-facts" for making a similar inference about the cognitive abilities of her Early Pleistocene ancestors from the impressively (but superficially) ordered and complex nature of her lineage's presumed "culture material" (Figure 1). Despite the complexity of beehives there is no evidence that the structure of these forms reflects anything other than low fidelity social transmission at most.

[Insert Figure 1 here]

Our attempt at humor aside, clearly hominins were making and using Earlier Stone Age tools. For us, however, a null hypothesis that this technology was passed from hominin brain to brain and from generation to generation via cultural transmission in a way reminiscent of, if not exactly like, that used by humans today is not clearly supported by the archaeological evidence. Here, we suggest "resetting" the null hypothesis for stone tool production (e.g. Corbey et al. 2016; Tennie et al. 2016), if for no other reason than to make room for simpler explanations to be systematically investigated, and perhaps rejected, before we reach a hypothesis that invokes modern high-fidelity social learning mechanisms (i.e. cultural transmission) in hominin species living more than a million years ago. The null hypothesis we prefer is that Earlier Stone Age tools might have been so-called latent solutions rather than cultural material (Tennie et al. 2016).

Our concern is that current explanations that view the earliest stone tools as *necessarily* cultural products likely over-interpret the underlying cognitive mechanisms. This view on the archaeological record comes in part from research on tool-use by living great apes (i.e. the phylogenetically most appropriate comparison group) where similar difficulties are faced. For instance, when the available evidence is analyzed, an argument can be made that high fidelity cultural transmission is not necessarily responsible for many great ape tool "cultures" (Tennie et al. 2009). Instead population-wide behaviors currently described as cultural are largely the result of individual learning, loosely connected by low-fidelity social learning, such as stimulus enhancement. Tennie and colleagues (2009) describe this as "latent solutions," and they are distinct from modern human phenomena expressed as fully cumulative culture and requiring high-fidelity transmission mechanisms.

Latent solutions are behaviors that an individual can generate largely through individual learning, leavened in some cases with low-fidelity social learning. The behavior is "latently" present in the individual and expressed when in the context of the right stimuli or when one recognizes the behavior (or: its effects on the environment) expressed by others. Unlike culturally transmitted behaviors, latent solutions themselves are not transmitted from individual to individual by cultural means. Whereas cultural transmission allows for the accumulation of modifications through time—the so-called ratcheting effect of cumulative culture—latent solutions are more tightly bounded, or canalized, by each individual's cognitive and/or motor abilities, which are ultimately underwritten by genes (and not in the specific sense that a gene "codes for" a particular behavior or tool). It follows that one would generally expect diachronic change in latent solutions to come about much more slowly than changes in culturally transmitted traits.

The "Island Test" (Tomasello 1999) is a useful metaphor for examining to what extent early stone tools fit the expectations of latent solutions. Imagine a *Homo habilis* (or *Austalopithecus boisei*, for that matter) individual raised alone on an island. This individual is never shown how to make an Oldowan flake tool (or any stone tool), nor do they ever find a discarded tool lying about the island. Now imagine that in the presence of stone that is easily conchoidally fractured and a fitness mediated goal (say, to cut through a thick hide that teeth can not penetrate to gain access to a valuable resource, like animal tissue) this individual, naïve to stone tool production, proves able to produce a stone implement indistinguishable from a typical Oldowan flake. In this case, we can reasonably conclude that cultural transmission is not required to make such an implement. Put differently, in this scenario the kind of flake tool we associate with Oldowan technology fails the Island Test for cumulative culture, meaning instead that it is consistent with the expectations of a latent solution rather than a culturally transmitted technology (Tennie et al. 2016).

Although an actual "Island Test" is obviously impossible to conduct in this case, we find that the thought experiment raises important questions. What is the likelihood that an Earlier Stone Age tool could be fashioned by a (now extinct) hominin individual without high fidelity cultural transmission? This question in turn forces a consideration of a possibility infrequently encountered in the Paleolithic archaeological literature. Given all that has been learned about tool manufacture and use in the animal kingdom since Jane Goodall's groundbreaking observations at Gombe (Goodall 1968), we propose that a more appropriate null hypothesis at this time for the first stone tools is that they were latent solutions resulting from individual learning augmented by low fidelity social learning. The question that must then be asked is, what is the data from Oldowan, Acheulean or even the Middle Stone Age/Middle Paleolithic stone tool assemblages that can falsify this hypothesis. In other words, when we set aside the presumption that the very presence of similar stone tools must mean cumulative culture, we can ask the question of fundamental interest to human origins - when did cumulative culture begin?

While difficult, demonstrating rather than presuming high-fidelity cultural transmission does not strike us as a trivial or hollow task. For one, it will force us to take a closer look at variation in tools that result from low fidelity social learning as we develop null-based expectations for the archaeological record. Quantitative analyses of Chimpanzee tools, such as termite probes and galago spears (Pruetz and Bertolani 2007; Sanz et al. 2009) — possibly examples of latent solutions—could inform us about the level of variation one would expect to see in Earlier Stone Age tools in the *absence* of high fidelity cultural transmission (there are already promising attempts, e.g., Gowlett 2009). Just as importantly, the task will also force us to dramatically improve our ability to identify aspects of stone tool production that require the cognitive structure necessary for high fidelity transmission (Stout et al. 2008; Stout et al. 2009). Currently, we have a frustratingly limited understanding of what *quantifiable* components of the lithic archaeological record are reflective of high fidelity transmission. Any successful investigations of this question must contend with the time-averaged nature of the Paleolithic record and further incorporate the necessarily reductive nature of flaked stone tool technology (e.g., the finished artifact fallacy: Davidson and Noble 1993). Absent these quantifiable and archaeologically relevant components, attempts to better understand the cognitive mechanisms responsible for observed variation in stone tools are unlikely to provide realistic insights into the origins of high fidelity transmission.

The time seems right to "reset" the null hypothesis for early lithic technology and cultural transmission. The picture emerging from both primate studies and Paleolithic archaeology is one in which simple stone tool technology might not require the cultural scaffolding or related cognitive hardware modern human flintknappers use. Despite the fact that great apes seem incapable of the "sophisticated" cognitive skills that underwrite cultural transmission among living humans, such as imitation, let alone overimitation (Tennie et al. 2009; but there are also opposing views: Whiten et al. 2009), they exhibit behaviors that some argue are as complex as those required to manufacture Earlier Stone Age tools (Haidle 2010; Wynn et al. 2011). But comparing hominin technology from the last 50,000 years to both Earlier Stone Age technology and to tools chimpanzees make and use today suggests that something changed in hominins between the Early Stone Age and the Upper Paleolithic (at the very latest). One might point to increased brain size as the obvious explanation for such a change in hominin technology, but the toolmaking abilities of the relatively small-brained *Homo floresiensis* (or the beehives of tiny-brained bees) show that the relationship between brain size and technological sophistication, including examples of cumulative culture in the case of hominins, is not as simple or direct as it was once widely thought to be (Morwood et al. 2004).

A shift in perspective will be productive regardless of where the chips may fall. Finding evidence for high fidelity cultural transmission in Earlier Stone Age tools would be evidence for a necessary relationship between the two. On the other hand, finding that Oldowan, and even Acheulean (and beyond?), stone tool assemblages do not exhibit characteristics that require high fidelity cultural transmission would open the door to important questions concerning when, where, why, and how high fidelity cultural transmission evolved on our lineage. Maintaining the *status quo* ensures a tautology: if we continue to assume *a priori* that Stone Age stone tools required high fidelity cultural transmission, then how can we ever arrive at a finding other than that which we assume from the start? We count ourselves among those (Corbey et al. 2016; Tennie et al. 2016) who think the best practice in this case is to assume that early stone tools were not culturally transmitted until demonstrated otherwise.

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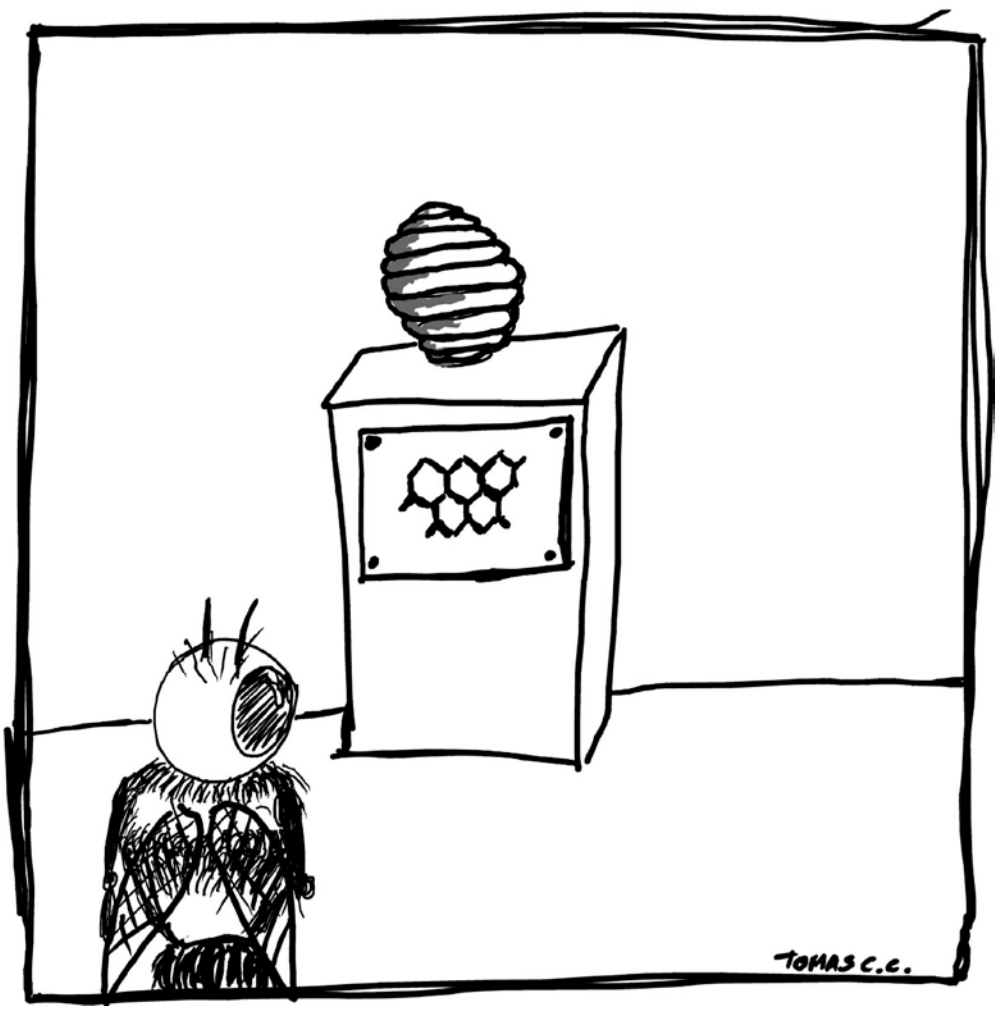

Figure 1: Francis sighed. “Two million years ago,” she thought, “and yet I couldn’t pull that off today!” (idea by CT - inspired by Gary Larson. With thanks to Tomás Cabanelas Costas for the drawing)