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1 **Resetting the null hypothesis: early stone tools and cultural transmission**

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19
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22 Abstract

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

40

41 The archaeological record clearly shows that by at least 2.6 million years ago (Ma; and
42 likely much earlier, e.g., McPherron et al. 2009; Harmand et al. 2015), one or more fossil
43 hominin taxa were frequently making and using stone tools (Semaw et al. 1997). A
44 defining (and puzzling) feature of early stone tool assemblages is that patterns of

45 production appear to have little identifiable or directional changes over hundreds of
46 thousands of years. Over the last decade, archaeologists have come to rely more heavily
47 on findings from cognitive science to identify the mechanisms responsible for this pattern
48 in the early archaeological record (Morgan et al. 2015; Lycett and Gowlett 2008). For
49 example, some (Morgan et al. 2015; Putt et al. 2014) argue that various forms of teaching
50 (in some cases mediated by language) prevented substantial temporal changes in early
51 stone tool assemblages. Such studies tend to start from a seemingly unquestioned *a priori*
52 assumption that artifacts in the earliest archaeological record are products of culturally
53 transmitted information – or mental templates – concerning how to make a stone tool (but
54 see: Richerson and Boyd 2005; Corbey et al. 2016; Hovers 2012; Tennie et al. 2016). In
55 short, researchers interested in what the archaeological record can tell us about cognition
56 commonly ascribe modern human cognitive skills like shared intentionality, conformity,
57 overimitation, and teaching (skills that many have argued are key to the sophisticated
58 way that modern humans, but not other living primates, transmit information socially) to
59 Pliocene and Early Pleistocene hominins.

60

61 It is not surprising that archaeologists see signs of modern human cognition in Earlier
62 Stone Age tools given that the technology appears at once so impressive and so foreign.
63 If hive-making were culturally transmitted among bees today (it is not), then one could
64 excuse a hapless “modern bee-man” visitor of a future museum of “prehistoric bee-facts”
65 for making a similar inference about the cognitive abilities of her Early Pleistocene
66 ancestors from the impressively (but superficially) ordered and complex nature of her
67 lineage’s presumed “culture material” (Figure 1). Despite the complexity of beehives

68 there is no evidence that the structure of these forms reflects anything other than low
69 fidelity social transmission at most.

70

71 [Insert Figure 1 here]

72

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

84

85 Our concern is that current explanations that view the earliest stone tools as *necessarily*
86 cultural products likely over-interpret the underlying cognitive mechanisms. This view on
87 the archaeological record comes in part from research on tool-use by living great apes
88 (i.e. the phylogenetically most appropriate comparison group) where similar difficulties
89 are faced. For instance, when the available evidence is analyzed, an argument can be
90 made that high fidelity cultural transmission is not necessarily responsible for many great

91 ape tool “cultures” (Tennie et al. 2009). Instead population-wide behaviors currently
92 described as cultural are largely the result of individual learning, loosely connected by
93 low-fidelity social learning, such as stimulus enhancement. Tennie and colleagues (2009)
94 describe this as “latent solutions,” and they are distinct from modern human phenomena
95 expressed as fully cumulative culture and requiring high-fidelity transmission
96 mechanisms.

97

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

110

111 The “Island Test” (Tomasello 1999) is a useful metaphor for examining to what extent
112 early stone tools fit the expectations of latent solutions. Imagine a *Homo habilis* (or
113 *Australopithecus boisei*, for that matter) individual raised alone on an island. This

114 individual is never shown how to make an Oldowan flake tool (or any stone tool), nor do
115 they ever find a discarded tool lying about the island. Now imagine that in the presence
116 of stone that is easily conchoidally fractured and a fitness mediated goal (say, to cut
117 through a thick hide that teeth can not penetrate to gain access to a valuable resource, like
118 animal tissue) this individual, naïve to stone tool production, proves able to produce a
119 stone implement indistinguishable from a typical Oldowan flake. In this case, we can
120 reasonably conclude that cultural transmission is not required to make such an
121 implement. Put differently, in this scenario the kind of flake tool we associate with
122 Oldowan technology fails the Island Test for cumulative culture, meaning instead that it
123 is consistent with the expectations of a latent solution rather than a culturally transmitted
124 technology (Tennie et al. 2016).

125

126 Although an actual “Island Test” is obviously impossible to conduct in this case, we find
127 that the thought experiment raises important questions. What is the likelihood that an
128 Earlier Stone Age tool could be fashioned by a (now extinct) hominin individual without
129 high fidelity cultural transmission? This question in turn forces a consideration of a
130 possibility infrequently encountered in the Paleolithic archaeological literature. Given all
131 that has been learned about tool manufacture and use in the animal kingdom since Jane
132 Goodall’s groundbreaking observations at Gombe (Goodall 1968), we propose that a
133 more appropriate null hypothesis at this time for the first stone tools is that they were
134 latent solutions resulting from individual learning augmented by low fidelity social
135 learning. The question that must then be asked is, what is the data from Oldowan,
136 Acheulean or even the Middle Stone Age/Middle Paleolithic stone tool assemblages that

137 can falsify this hypothesis. In other words, when we set aside the presumption that the
138 very presence of similar stone tools must mean cumulative culture, we can ask the
139 question of fundamental interest to human origins - when did cumulative culture begin?
140
141 While difficult, demonstrating rather than presuming high-fidelity cultural transmission
142 does not strike us as a trivial or hollow task. For one, it will force us to take a closer look
143 at variation in tools that result from low fidelity social learning as we develop null-based
144 expectations for the archaeological record. Quantitative analyses of Chimpanzee tools,
145 such as termite probes and galago spears (Pruetz and Bertolani 2007; Sanz et al. 2009)—
146 possibly examples of latent solutions—could inform us about the level of variation one
147 would expect to see in Earlier Stone Age tools in the *absence* of high fidelity cultural
148 transmission (there are already promising attempts, e.g., Gowlett 2009). Just as
149 importantly, the task will also force us to dramatically improve our ability to identify
150 aspects of stone tool production that require the cognitive structure necessary for high
151 fidelity transmission (Stout et al. 2008; Stout et al. 2009). Currently, we have a
152 frustratingly limited understanding of what *quantifiable* components of the lithic
153 archaeological record are reflective of high fidelity transmission. Any successful
154 investigations of this question must contend with the time-averaged nature of the
155 Paleolithic record and further incorporate the necessarily reductive nature of flaked stone
156 tool technology (e.g., the finished artifact fallacy: Davidson and Noble 1993). Absent
157 these quantifiable and archaeologically relevant components, attempts to better
158 understand the cognitive mechanisms responsible for observed variation in stone tools are
159 unlikely to provide realistic insights into the origins of high fidelity transmission.

160

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

178

179 A shift in perspective will be productive regardless of where the chips may fall. Finding
180 evidence for high fidelity cultural transmission in Earlier Stone Age tools would be
181 evidence for a necessary relationship between the two. On the other hand, finding that
182 Oldowan, and even Acheulean (and beyond?), stone tool assemblages do not exhibit

183 characteristics that require high fidelity cultural transmission would open the door to
184 important questions concerning when, where, why, and how high fidelity cultural
185 transmission evolved on our lineage. Maintaining the *status quo* ensures a tautology: if
186 we continue to assume *a priori* that Stone Age stone tools required high fidelity cultural
187 transmission, then how can we ever arrive at a finding other than that which we assume
188 from the start? We count ourselves among those (Corbey et al. 2016; Tennie et al. 2016)
189 who think the best practice in this case is to assume that early stone tools were not
190 culturally transmitted until demonstrated otherwise.

191

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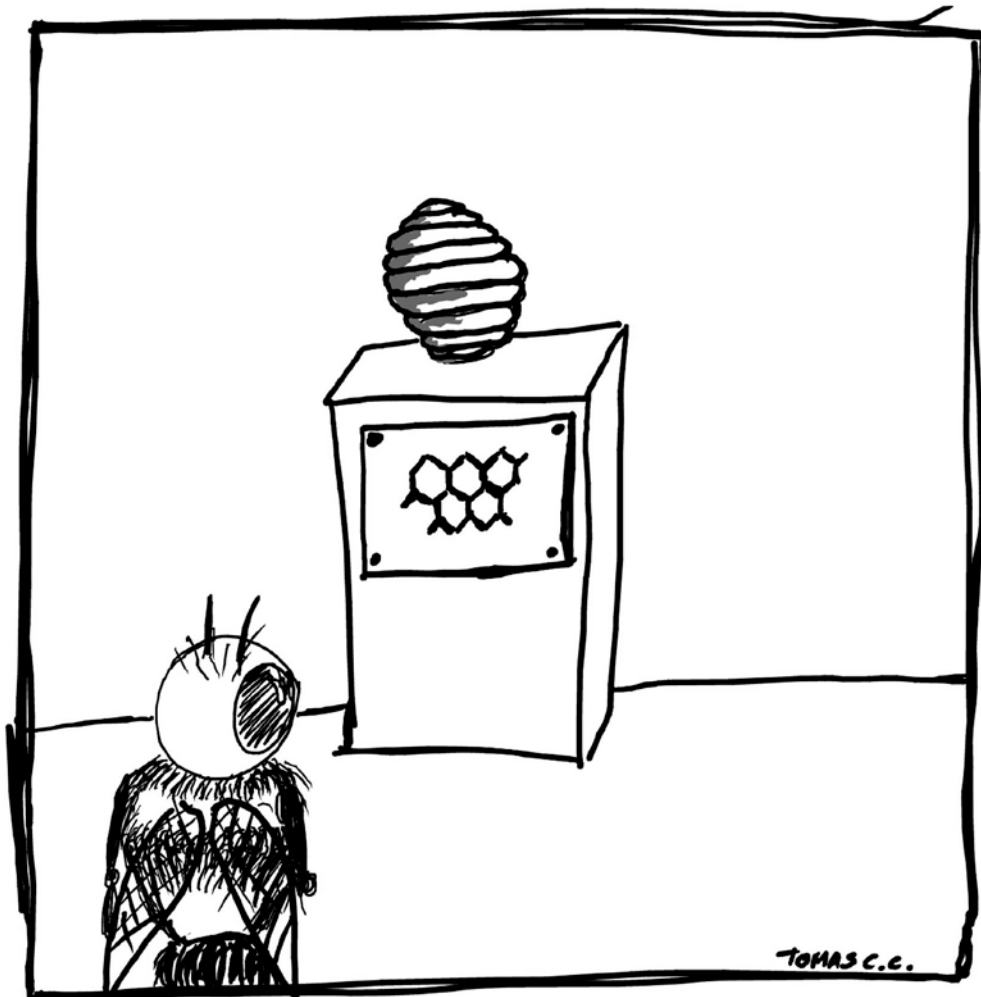
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290



291

292 Figure 1: Francis sighed. “Two million years ago,” she thought, “and yet I couldn’t pull
293 that off today!” (idea by CT - inspired by Gary Larson. With thanks to Tomás Cabanelas
294 Costas for the drawing)
295