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# Understanding hunter-gatherer cultural evolution needs network thinking

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**Abstract:** Hunter-gatherers past and present live in complex societies, and the structure of these can be assessed using social networks. We outline how the integration of new evidence from cultural evolution experiments, computer simulations, ethnography and archaeology open new research horizons to understand the role of social networks in cultural evolution.

44 **Keywords:** Hunter-gatherers, Social Networks, Cultural Evolution, Archaeology,  
45 Evolutionary Anthropology.

46

#### 47 **Cultural evolution: it's time for thinking about social networks**

48

49 Social networks, referred here as a structure in which individuals and groups of  
50 individuals are connected to each other through social ties, play a central but not yet well-  
51 understood role in human cultural evolution. Here, we advocate for the adoption of a  
52 **'network thinking'** (see Glossary) perspective in cultural evolutionary research, when  
53 dealing with past and present hunter-gatherers populations. This approach necessarily  
54 requires (i) recognizing that social learning processes involved the transmission of  
55 information throughout different levels of social interaction: among individuals from the  
56 same residential group and between members of different residential groups. Therefore,  
57 this information flow is embedded in large and complex social networks; (ii)  
58 understanding that population size scales up the complexity of these social networks,  
59 from interactions among few individuals to direct and indirect interactions among  
60 hundreds of individuals in much larger metapopulations; and (iii) investigating the  
61 relationship between past social network dynamics and cultural change using  
62 archaeological datasets.

63 We argue the adoption of 'network thinking' in cultural evolution can only be  
64 adequately explored through a multidisciplinary combination of data, methodologies  
65 and theoretical frameworks from archaeology, evolutionary anthropology, psychology,  
66 and network science. Specifically, this includes the evidence available from the  
67 archaeological record, ethnographic studies, computer simulations and cultural  
68 evolution experiments on one side and the theoretical perspectives developed in cultural  
69 evolutionary and complex systems theories on the other. Here, we show how recent  
70 research has shifted the conceptual background of social connectivity in hunter-  
71 gatherer's cultural evolution and discuss three major areas for prospective research: (i)  
72 the application of social network analysis to the archaeological record; (ii) the  
73 introduction of conceptual frameworks from network theory (Fig.1) and (iii) the  
74 interdependence between social networks and cultural evolution.

75

76

Figure 1

77

78 **New perspectives on the role of social connectivity in hunter-gatherers cultural**  
79 **transmission**

80

81 The core principle of cultural evolutionary theory is that individuals learn through a  
82 combination of individual and social learning. Under certain conditions, these learning  
83 strategies can create cumulative culture which is recognized by the presence of traits that  
84 could not be invented by a single individual, and that are gradually improved over time  
85 due to the inheritance of knowledge and know-how from previous generations. We view  
86 social networks as a central but still understudied component of cultural evolution  
87 because, by definition, cultural transmission is information flow and retention through  
88 structured populations at multiple scales.

89 Recent research has applied social network analysis to explore the influence of social  
90 connectivity on cultural evolution using lab experiments, computer simulations and  
91 ethnographic data [1-3]. Cultural evolution experiments in which participants can learn  
92 from each other to develop complex artifacts have demonstrated that populations  
93 subdivided into partially isolated subgroups produce more diverse cultural traits than  
94 fully connected populations and reach higher levels of cultural complexity when  
95 innovation depends on cultural diversity [1]. Computational modeling has investigated  
96 the effect of different human mobility strategies on information transmission through  
97 social networks and found that central-place foraging, in which hunter-gatherers forage  
98 and bring food back to the campsite, improve the dissemination of social information in  
99 large populations [2].

100 Complementing these approaches, studies simulating cultural evolution over real  
101 networks from extant hunter-gatherer communities have shown that social structures  
102 characterised by multiple levels of clustering of households within camps and camps  
103 within meta-populations can accelerate cultural evolution [3]. Furthermore, features  
104 such as co-residence, cooperation with unrelated individuals, multilocality, fluid  
105 sociality and high between-camp mobility might have had a major influence on the  
106 cognitive mechanisms (e.g., high-fidelity transmission, innovation, teaching, and  
107 combinatorial innovation) underlying **cumulative cultural evolution**. This research has  
108 significantly contributed to replacing the long-held view of hunter-gatherers living in  
109 small-scale societies by a new perspective which highlights how small co-residence  
110 groups are dynamically connected to much larger populations forming expansive

111 networks of social interaction at large spatial scales [3-4]. In spite of contributing to a  
112 paradigm shift, experimental and ethnographic studies do not have the time depth to  
113 reveal how these changes might have impacted cultural evolution across generations.  
114 Archaeological data can step in here.

115

## 116 **Applying social network analysis to the archaeological record**

117

118 The archaeological record left by past hunter-gatherers provides long-term perspectives  
119 on the relationship between patterns of social interaction and cultural evolution. From  
120 the Upper Palaeolithic onwards, archaeological evidence is often sufficiently  
121 representative to build spatio-temporal networks at regional scales. Studies applying  
122 formal social network analysis to the hunter-gatherer archaeological record have focused  
123 on a range of issues including processes of cultural diversification, reconstructing  
124 network topologies, and the growth of settlement interconnectedness and its decline in  
125 relation to environmental hazards [5,6 and references in there].

126 The application of social network analysis to archaeological datasets faces many  
127 challenges including the low chronological resolution of the Paleolithic record –with  
128 time scales of centuries and millennia– research and **taphonomic biases**. These  
129 limitations are highly germane to the selection of appropriate classes of material culture  
130 to reconstruct archaeological networks, as well as in the selection of different statistical  
131 and modeling methods to evaluate their representativeness and robustness. Additional  
132 constraints come from the process of network construction itself, particularly when  
133 aggregating data over broader periods or when dividing the archaeological record into  
134 shorter subperiods for determining the spatial and temporal dynamics of those networks.  
135 A set of recent developments in evolutionary archaeology – in particular, new forms of  
136 quantitative archaeological systematics as well as chronological and spatial modelling –  
137 open new prospects for finer-grained applications of social network analysis to cultural  
138 evolutionary processes. First, the re-evaluation of **cultural taxonomy** using cultural  
139 evolutionary theory-driven approaches seeks to capture population and network  
140 structure through artefact proxies [7]. Second, recent advances in **radiocarbon**  
141 **chronological modeling** have yielded new insights into the reconstruction of long-term  
142 changes in population size and spatio-temporal settlement dynamics at regional scales  
143 [8]. Third, coupled geographic information systems and **agent-based modeling** allows  
144 a more realistic appreciation of the role of geographic barriers and environmental

145 constraints play in the formation of social networks in the archaeological record [9].  
146 Importantly, the publication of archaeological datasets and methods accessible through  
147 on-line data infrastructures facilitates new data science approaches and reproducibility.

148 Figure 2

149 In sum, the application of **social network analysis** to the hunter-gatherer archaeological  
150 record opens vistas onto *long durée* cultural evolutionary processes from a population  
151 perspective, such as the spread of new behaviors or technologies by social diffusion  
152 mechanisms, the diversification or decimation of culture, and the relationship between  
153 cultural changes with socio-spatial structures, climatic and environmental changes, and  
154 population dynamics.

155

156

### 157 **Hunter-gatherer social networks and cultural evolution interdependence**

158

159 Studying the influence of social connectivity on cultural evolution is central, but it is  
160 only one side of the phenomenon we are interested in. We also need to better  
161 understand how cultural transmission might in turn condition the dynamics of social  
162 networks.

163 Indeed, recent research suggests the presence of feedback between network dynamics  
164 and cultural transmission and highlights the long-term role such feedbacks may play in  
165 long-term cultural evolution [1, 10]. For instance, technological innovations may affect  
166 connectivity patterns through population increase or enhanced mobility, while social  
167 transmission rates or cultural trait stability might be conditioned by social structure.  
168 This interplay between network dynamics and cultural transmission is complex and  
169 likely to operate across multiple scales and with interactions of multiple factors (e.g.,  
170 biogeography, environmental dynamics and demography) that have not yet been fully  
171 explored in evolutionary archaeology [11]. Experimental and ethnographic studies can  
172 contribute to fill this gap, as they provide insight on culture-mediated mechanisms  
173 underlying social network change. Future work may profitably focus on integrating  
174 these complementary approaches, as well as their articulation with archaeological data  
175 of different granularity.

176 For decades, network scientists have developed a growing body of methods and  
177 concepts to explore dynamics of networks and their interplay with information

178 transmission [12]. We can now use this knowledge to test evolutionary models of the  
179 interdependence of social structure and cultural change in hunter-gatherer societies.

180

### 181 **A call for ‘network thinking’**

182

183 Our call for ‘network thinking’ in hunter-gatherer cultural evolution is based on  
184 growing evidence for the relationship between social connectivity and cultural change  
185 provided by recent ethnographic, computational and experimental studies. While  
186 research is beginning to show how hunter-gatherer sociality shapes cumulative culture  
187 today, the investigation of social structures in the past is required to fully understand  
188 cultural evolution. By using archaeological data to infer and analyze past social  
189 networks, we can offer unprecedented insights into how longitudinal changes in social  
190 connectivity interacted with human cultural evolution, both in terms of undergirding the  
191 remarkable accumulation of species-wide culture as well as the occasional shocks  
192 leading to demographic and cultural decline and extirpation. Network science naturally  
193 links interactions among individuals with emergent collective macrophenomena and so  
194 can be used to effectively integrate all these complementary perspectives. We believe  
195 that this cross-disciplinary application of network thinking will improve our  
196 understanding of the long-term interplay between human social structure and cultural  
197 change.

198

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208

### 209 **References**

210

- 211 1. Derex, M. and Mesoudi, A. (2020) Cumulative Cultural Evolution within Evolving  
212 Population Structures. *Trends in Cognitive Sciences* 24(8), 654-667. DOI:  
213 [10.1016/j.tics.2020.04.005](https://doi.org/10.1016/j.tics.2020.04.005)

- 214 2. Garg, K. *et al.* (2021) Hunter-gatherer foraging networks promote information  
215 transmission. *Royal Society Open Science*. DOI: 10.1098/rsos.211324  
216 (<https://royalsocietypublishing.org>).
- 217 3. Migliano, A. B. and Vinicius, L. (2021). The origins of human cumulative culture:  
218 from the foraging niche to collective intelligence. *Philosophical Transactions of the*  
219 *Royal Society B* 377, 20200317. DOI: [0.1098/rstb.2020.0317](https://doi.org/10.1098/rstb.2020.0317)  
220 (<https://royalsocietypublishing.org>).
- 221 4. Hamilton, M.J. (2022). Collective computation and the emergence of hunter-  
222 gatherer small worlds. *Journal of Social Computing* 3(1), 18-37. DOI:  
223 10.23919/JSC.2021.0019. (<https://dc.tsinghuajournals.com>).
- 224 5. Buchanan, B. *et al.* (2019). The small world topology of Clovis lithic networks.  
225 *Anthropological and Archaeological Sciences* 11, 3537-3548. DOI:  
226 [10.1007/s12520-018-0767-7](https://doi.org/10.1007/s12520-018-0767-7) (<https://link.springer.com>).
- 227 6. Riede, F. and Sheets, P., eds (2020) *Going Forward by Looking Back:*  
228 *Archaeological Perspectives on Socio-Ecological Crisis, Response, and Collapse,*  
229 *Catastrophes in Context*. Berghahn Books, New York, NY.
- 230 7. Riede, F., *et al.* (2019). Reconciling material cultures in archaeology with genetic data  
231 requires robust cultural evolutionary taxonomies. *Palgrave Communications* 5:55, 1-  
232 9. <https://doi.org/10.1057/s41599-019-0260-7>.
- 233 8. Crema, E. R. and Bevan, A. (2020). Inference from large sets of radiocarbon dates:  
234 software and methods. *Radiocarbon* 63(1), 23-39. DOI: [10.1017/RDC.2020.95](https://doi.org/10.1017/RDC.2020.95)  
235 (<https://www.cambridge.org>)
- 236 9. Gravel-Miguel, C. and Wren, C (2018) Agent-based least-cost path analysis and the  
237 diffusion of Cantabrian Lower Magdalenian engraved scapulae. *Journal of*  
238 *Archaeological Science* 99, 1-9. DOI: [10.1016/j.jas.2018.08.014](https://doi.org/10.1016/j.jas.2018.08.014)  
239 (<https://www.sciencedirect.com>)
- 240 10. Smolla, M. and Akçay, E. (2019). Cultural selection shapes network structure.  
241 *Science Advances*, 5(8), 1-10. DOI: [10.1126/sciadv.aaw0609](https://doi.org/10.1126/sciadv.aaw0609)  
242 (<https://www.science.org>)
- 243 11. Prentiss, A. M. (2021). Theoretical plurality, the extended evolutionary synthesis, and  
244 archaeology. *Proceeding of the National Academy of Sciences of the United States of*  
245 *America*, 118 (2) e2006564118; DOI: [10.1073/pnas.2006564118](https://doi.org/10.1073/pnas.2006564118)  
246 (<https://www.pnas.org>)
- 247 12. Newman M. E. J. (2018). *Networks: An introduction*. Oxford University Press.



248 **Captions list**

249

250 Figure 1. A) Crossing disciplinary boundaries to apply ‘network thinking’ in hunter-  
251 gatherer cultural evolution. Computational simulations including Agent Based Modeling  
252 (ABM), cultural evolution experiments and ethnographic studies provide evidence for the  
253 effect of social connectivity on cultural evolution. While laboratory studies offer insights  
254 into small-scale mechanisms operating between individuals, ethnographic studies allow  
255 the observation of social networks ‘in the wild’- Yet, these approaches alone cannot reveal  
256 how networks change over long period of time and how this impacts cultural evolutionary  
257 trajectories across generations and in relation to extrinsic factors such as between-group  
258 contact or climate change. Archaeological data fill this gap. B) Scaling effects of  
259 population size in hunter-gatherer social networks: populations are structured in nested  
260 levels of social organization (families or households, bands, regional bands,  
261 subpopulations and metapopulations). The analysis of world-wide ethnographic datasets  
262 recurrently finds this nested self-similar structure characteristic of small-world,  
263 hierarchically modular networks. The information flow leads to the emergence of small-  
264 world networks where highly clustered local interactions are embedded within much  
265 larger, but sparsely connected multilevel metapopulations forming decentralized  
266 knowledge systems [4]. Depicted networks have been produced by a network model  
267 combining constraints on module size at each hierarchical level and random wiring of  
268 links among families/nodes.

269

270 Figure 2. Network dynamics and archaeological social networks. The left panel depicts  
271 different kind of material culture proxies of social interaction: Pierced shells, used as  
272 personal ornaments, reflect broad social interactions in which long-distance circulation  
273 of materials are embedded, whereas lithic projectile points and harpoons are considered  
274 utilitarian objects, whose formal and technological traits were transmitted in social  
275 learning contexts. The central panel represents the reconstruction of social networks using  
276 archaeological data sets. The right panel shows a theoretical social network changing  
277 through three time slices ( $t_1$ ,  $t_2$  and  $t_3$ ), and potential consequences of such dynamics in  
278 terms of cultural evolutionary processes. At  $t_1$  we find the complete social network,  
279 formed by interconnected regional bands within a subpopulation. At that moment, the  
280 density and strength of connections favor processes of social diffusion of technologies  
281 (a); at  $t_2$ , the social network presents fewer nodes than at  $t_1$ , and the strength among the  
282 connections is higher within each regional band than at subpopulation level. This socio-  
283 spatial structural configuration privileges intra-regional band information exchange, and  
284 inter-regional differentiation which can result in cultural diversification (b). Finally, at  $t_3$ ,  
285 the network is significantly smaller, fragmented and connections are weak both within  
286 and across regional bands. This state increases the chances of cultural drift (c), a process  
287 by which random copying errors in smaller and/or less connected populations can lead to  
288 the disappearance of existing cultural variants.

289

290