Chapter 15
Style, Function and Cultural Transmission

Stephen Shennan

Abstract Recent evolutionary approaches to the understanding of lithic variability take us back to long-standing issues in lithic studies to do with the claimed contrast between style and function and the Binford-Bordes debate of the 1960s concerning the factors that affect inter-assemblage variation. In fact, the style and function contrast is an unhelpful one, not least when considering the question of convergence. Taking the definition of style as 'a way of doing', all functions are carried out in locally specific ways that have a transmission history, although the extent to which the history of the attributes relevant to the function have been subject to random drift and innovation patterns, as opposed to selection, will vary. Moreover, in a subtractive technology like lithics the extent to which a transmission signal will be visible in an attribute like the angle of a cutting edge is unclear. The contrasting view is that, in the case of lithics, functional requirements will always call into existence the technical innovations to satisfy them, which in any case are not that difficult to find. The paper addresses these and related issues with reference to previous work by Shennan and colleagues on the use of material culture to identify within and between group variation, the extent to which isolation-by-distance in space and time can account for the similarities and differences between assemblages, and the role of phylogenetic methods.

Keywords Lithics • Heritability • Isolation-by-distance • Cultural evolution • Selection • Drift • Phylogenetics • The comparative method

S. Shennan (✉)
Institute of Archaeology, University College London, 31–34 Gordon Square, London, WC1H 0PY, UK

Introduction

The famous Binford-Bordes debate of the 1960s and early 70s (e.g. Binford and Binford 1966; Binford 1973; Bordes 1973) concerning how to explain the pattern of changing Mousterian assemblages in SW France in many ways encapsulated the contrast between the long-standing (European) tradition of culture history and the newly emerging (American) approach of 'new archaeology' (for a recent assessment see Wargo 2009). For the Binfords the patterning was explicable in terms of technical variation between the assemblages, responding to different functional requirements of groups exploiting different resources in different environments at sites that had different roles in mobile settlement systems; in other words, the reasons for the presence of different numbers of different tool types were situational, and by implication convergent. For Bordes they were simply assumed to be a reflection of the social traditions of different human groups, following the long-established interpretive conventions of culture history.

The contrast between the culture history and systemic 'new archaeology' perspectives was also played out, of course, in the study of later periods. Here Binford (1965) was concerned to make a number of important distinctions between different dimensions of variation: the tradition, 'is seen in continuity in those formal attributes which vary with the social context of manufacture exclusive of the variability related to the use of the item. This is termed stylistic variability…; the adaptive area exhibits the common occurrence of artifacts used primarily in coping directly with the physical environment' (pp. 208–9); these are 'technomic' artefacts, or the technomic dimension of artefacts, following Binford (1962). In principle, the commonalities of artefacts characterizing the adaptive area could be the result of independent convergence from different starting points.

Whereas for agricultural societies there may be multiple lines of evidence that can convincingly be argued to relate

H. S. Groucutt (ed.), *Culture History and Convergent Evolution: Can We Detect Populations in Prehistory?*,
Vertebrate Paleobiology and Paleoanthropology, https://doi.org/10.1007/978-3-030-46126-3_15

differentially to these different dimensions, as Binford showed, this is much more problematical for the Paleolithic, where variation in lithic assemblages has had to play multiple roles. In particular, recognizing the multi-dimensionality of the archaeological record meant distinguishing stylistic attributes of artefacts relating to the 'tradition', the ongoing social context of manufacture, from those related to function and adaptation, for which 'tradition' was, by definition, irrelevant. In keeping with Binford, Dunnell (1978) defined stylistic variation as variation not under selection and asserted that stylistic attributes could be defined *a priori*, on the basis of whether or not they involved differential energy expenditure.

However, this is not sustainable. Even decorative attributes on ceramic vessels, the stylistic attribute par excellence, can potentially be under selection for social reasons; for example, pressure to conform to group norms that might have a bearing on people's chances of marriage and reproductive success. In contrast, if we take the definition of style as 'a way of doing', all functions are carried out in locally specific ways that have a transmission history, including adaptive ones, although the extent to which the history of the attributes relevant to the function has been subject to random drift and innovation patterns (see below), as opposed to selection, will vary. Thus, explaining variation in lithic assemblages through time should take all these aspects into account and arrive at conclusions about the factors affecting variation in a set of attributes at the end of a process of analysis, not by *a priori* assumption.

In fact, of course, this was not a line that Binford pursued. His ethnoarchaeological work among the Nunamiut (1978) demonstrated strikingly different situational patterns, for example in the material left behind at different types of site associated with different activities, and the importance of practices such as tool curation in relation to factors such as time stress; in other words, technological organization. More generally, throughout his later career his interest focused on ecological aspects of adaptation, culminating in his 2001 book, *Constructing Frames of Reference*, along lines parallel to those of human behavioral ecology and specifically optimal foraging theory, though these were not approaches he ever accepted. Both exclude culture from consideration, whether tactically or on the basis of an in-principle rejection of the importance of culture in understanding human behavior. From this perspective we can understand the reasons for changing the atlatl for the bow-and-arrow, for example, simply by looking at their effect on the return rates of different prey in terms of the costs and benefits represented in the diet breadth model (e.g. Hames and Vickers 1982) in relation to the environmental conditions, such as the encroachment of forests in northern latitudes at the end of the last Ice Age. The dynamic comes from the environment, not from the cultural system and effectively assumes that as environments change they will call into existence the technical innovations to exploit them successfully. This implicitly presupposes that the innovations concerned lie within what Tennie et al. (2009) call the 'zone of latent solutions', things that are easily inventable by individuals working from first principles, and thus likely to be convergent. This may be true in some cases. It seems that wherever seed exploitation became important it led to the convergent innovation and use of grindstones, but this contrasts with the case of the more complex technology of the bow-and-arrow, for example, whose spread by diffusion can be traced across North America (e.g. Blitz 1988; Angelbeck and Cameron 2014).

If we return to the Bordes side of the argument, it has already been pointed out that the interpretation of the changing Mousterian assemblages as a reflection of changing human communities was no more than an interpretive convention characteristic of the time, based on the assumption that there was some mental template generating the patterns. There is no evidence for it other than the inter-assemblage variation that it seeks to explain and, as Binford pointed out, it seems highly unlikely that there would be a mental template for producing assemblages containing different proportions of different types. In fact, more recent assessments include elements of both interpretations, in keeping with the theoretical principles discussed below. Delagnes and Rendu (2011) argue that the different Mousterian types correspond to different technical principles in *lithic production* (my italics), which have implications for mobility.

Extensive discussions in the 1980s between Sackett (e.g. 1982, 1985), Wiessner (1983, 1985), and others, and later by Carr (1995), addressed the nature of different kinds of artefact variability and the factors affecting technological choices. They provided the theoretical basis for a more sophisticated approach that escaped the conflation of the adoption of different choices with 'ethnic identity' and included the possibility of choices made on the basis of differential efficacy in achieving a goal (summarized in Tostevin 2012, Chap. 3). However, this literature was focused on the choices involved in artefact production, not on the processes that generate assemblages, which are linked to technological organization and its situational use (see e.g. Holdaway and Douglass 2012 for a recent discussion), but are also strongly affected by taphonomy and time-averaging (e.g. Shott 2008), a point to which we will return.

Cultural Evolution and Lithics

With regard to the style and function issues, it has been the development of cultural evolutionary theory, in the sense of a set of ideas and methods for understanding cultural change as a process of descent with modification, since the 1980s (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985), that has provided a coherent theoretical framework that can be used to make further advances. This is because it has provided a set of relevant mechanisms for understanding continuity and change through integrating transmission and adaptation. The starting point is the process of cultural transmission, involving a variety of social learning mechanisms and the transmitted environments in which they take place—it may be difficult to distinguish the effects of the one from the other. Innovations, intended or unintended ('copying errors') generate new variation, and various sorting processes, including selection influenced by the environment but also drift, can act on the variation that is transmitted to change the frequencies of different variants. The effects of environmental adaptation on variation in artefacts (the 'technomic' dimension) cannot be considered independently of 'tradition' and the non-selective factors that also affect it. Importantly, the cultural evolution framework has also provided a set of tools for addressing the issues raised by the need to make these distinctions.

While the starting point for psychological or ethnographic studies of cultural transmission processes is the experimental or observational study of the processes themselves, in the case of archaeology it is variation in the artefacts, ecofacts and their spatial-temporal arrangements that is the basis of analysis (Shennan 2011) We need to distinguish the variation related to transmission and the sorting processes affecting what is transmitted from other factors. From the evolutionary point of view, testing hypotheses about convergence in lithic assemblages involves tracing different independent artefactual lineages through time and showing that they arrive at similar solutions from different starting points. Cultural phylogenetics provides a well-established set of methods for making these distinctions, which have been extensively applied to the study of lithics to distinguish convergent characteristics (homoplasies) from features arising from common descent, and specifically shared-derived characteristics (synapomorphies), provided that they are applied to appropriate variables (see e.g. papers in Lipo et al. 2006 or O'Brien et al. 2018). It is the application of these methods that enables us to evaluate the probability in any given case that an innovation is a homoplasy in the 'zone of latent solutions' or builds on a specific set of prior innovations in a specific lineage. . Importantly, it is necessary to recognize that lithic assemblages as such are not the results of transmission processes associated with specific ways of doing, though they are made up of the products of such processes. They are time-averaged outcomes of large number of events affected by many contingent factors as well as evolutionary forces, but also by factors such as artefact use-lives (e.g. Shott 2008). The relevant analogy is paleontological species assemblages. These came originally from ecological communities, made up of many evolving species but varying in response to local variations in temperature, precipitation and edaphic conditions that would have had a selective effect on the components and their relative representation. However, their composition in the paleontological record is likely to be overwhelmingly dominated by taphonomic factors and the scale of time-averaging of different conditions over which they accumulated. However, neither in their original, and even less in their time-transformed, state do they tell us about processes of descent with modification.

Artefact Production

Several recent developments based on adopting a cultural evolution approach to lithic variation contribute to making progress in distinguishing the role of transmission and performance characteristics in *producing* lithic artefacts, for example handaxes (e.g. Key and Lycett 2017), the sphere in which descent with modification becomes relevant. What is emerging from this is that, within broad functional limits where stabilizing selection influenced by the ergonomics of hand-held cutting tools becomes relevant, there is considerable variation that stems from the operation of other cultural transmission processes (Lycett et al. 2016). One of these is drift, chance variation in what is copied within particular transmission chains, depending on who is in contact with whom and therefore on both geographic and temporal distance. But selection also depends on transmission; thus, directional selection will result from the preferential imitation of some specific portion of the available range of variation. For example, if smaller tools are more effective for butchering smaller prey and climate change or an increase in diet breadth resulting from over-exploitation of resources results in increasing exploitation of small prey then the mean size of the tools produced may decrease. This will be spatially and temporally specific, like the fluctuating short-term environmentally-based selection pressures operating on the beaks of Galapagos finches (Grant and Grant 2002) although these time scales may be beyond our levels of resolution. Such pressures may also result in convergence. If the increasing exploitation of small prey is the result of large-scale climate change then the same directional change may occur in a number of local traditions as a result of the operation of the same selection process. This is potentially identifiable by assessing the extent to which tool variation and variation in relevant aspects of faunal assemblages correlate with one another, for example. On the other hand, it is important to emphasize that drift too, resulting simply from copying-error, can also be directional (Bentley et al. 2004; Eerkens and Lipo 2005) and is likely to be greater in a reductive technology such as lithics (Schillinger et al. 2014).

The fact that in finite populations, i.e. in all real world situations, chance processes occurring in the process of cultural transmission can have directional consequences was something never appreciated by the processualists.

This point leads on to another recent development, using what Lycett and von Cramon-Taubadel (2015) call a 'quantitative genetics' approach to distinguishing the role of transmission in generating lithic variation from other factors. The situation is similar to that faced by geneticists trying to understand the factors affecting quantitative dimensions such as variation in height between members of the same species which are the result of complex causality, including the action of multiple genes as well as environmental factors such as diet. We can in principle follow the geneticists in distinguishing between the heritable component of quantitative variation in the cultural phenotype and that produced by other factors as well as random variation. In the case of lithic artefacts, as noted above, in addition to raw material variation there may be variation resulting from re-sharpening. These latter effects are potentially quantifiable and can allow us to obtain the residual heritable variation by subtraction. In any case, as the authors emphasize, so long as there is *any* heritable variation, over the longer or shorter term evolutionary forces will have an effect on the variation concerned as a result of the operation of selection and drift, as discussed. Discontinuities in the heritable component are likely to indicate discontinuities in transmission.

Tostevin (2012) takes a different approach to the same question, proposing a positive approach to characterizing the variation that is culturally transmitted. It is generally agreed that the traditional characterizations of lithic 'industries' cannot be used for this purpose (e.g. Shea 2017), because transmission forces have a limited impact at best on assemblage formation, as noted above. In their place Tostevin proposes a series of variables associated with blank production as well as tool kit selection. These derive from the specific context of the acquisition of the skills of local lithic production in the close observation of flint-knapping episodes, and therefore what is visible in the relevant taskscape. In the light of the close contact implied by lithic learning and the strong evidence for the vertical transmission of craft skills, if not actually from parents then from other close group members of the older generation (Shennan and Steele 1999), continuities and discontinuities through time in the relevant variables reflect continuities and discontinuities in transmission, which are likely to correspond to continuities and discontinuities in gene flow. On this basis, after an analysis of relevant lithic assemblages Tostevin concludes that the appearance of the initial Upper Paleolithic 'Bohunician Behavioral Package' in Central and Eastern Europe and the Levant marked a discontinuity with what went before where it occurred and that it spread through a process of demic diffusion.

Building and Testing Models

Appropriate kinds of empirically and theoretically justified analytical description then potentially enable us to track transmitted variation and the forces that influence it, at the same time minimizing the possibility of mistakenly rejecting the conclusion that the patterns are a result of convergence. Given that this is the case we can define an initial null model to account for spatial and temporal variation in 'ways of doing' that are the outcome of social learning processes. In the spatial domain the model is what geneticists call 'isolation by distance' (cf. Scerri et al. 2018). Cultural transmission depends on interaction, and, for the transmission of skills, often close interaction, as Tostevin (2012) emphasizes. Interaction decreases with distance so, in the absence of other forces, similarity in transmitted variation will also decline in the same way. Similarly in the temporal domain. Other things being equal, change will result from 'drift', the chance loss of variants through time in the course of transmission, and innovation, the generation of novel variation, both dependent on the cultural effective population size, the number of individuals interacting with respect to the specific transmission process in question. When there are departures from such null models the reasons for them can be explored. Spatial and temporal discontinuities may be accounted for by discontinuities in transmission or by shifting selection pressures; continuities by preferential interaction or stabilizing selection. Whether there are indeed departures can be tested by the use of techniques similar to those used for the same purpose in genetics.

Thus Shennan et al. (2015) carried out an analysis to see if spatial and temporal distance were the only factors affecting variation in the sets of attributes describing pottery assemblages and types of ornament at Neolithic sites in Europe. In this case it was postulated that a site's traditional cultural affiliation, based on the characteristics of its domestic pottery, might also have an effect as an indicator of preferential interaction, implying a culturally structured population (cf. Scerri et al. 2018). The results showed that cultural affiliation accounted for significant variation in the similarity between sites in their pottery assemblages even when the temporal and spatial distances between them were controlled. They also showed that variation in the between-group similarity between cultures was strongly associated with time, pointing to the conclusion that there was not a continuum of temporal variation that was arbitrarily divided into different cultures but rather that the through-time patterns were marked by sudden changes. Variation in similarity between sites and cultures in terms of their ornaments did not show the same pattern of variation, with cultural affiliation much less important, pointing to the existence of distinct cultural 'packages' (Boyd et al. 1997) with their own transmission patterns, subject to different biases, as per Binford's argument about the different dimensions of cultural variation.

However, this is not the only possible line of approach. Cultural phylogenetic methods have a major role here in that trees corresponding to specific hypotheses can be constructed and tested, as they have been for later periods using other kinds of data (e.g. Gray and Jordan 2000). In fact, Tostevin could have used such an approach to test his hypotheses although he did not actually do so. However, it is surely no accident that the methods have mostly been successfully applied to rather elaborate types such as projectile points, which have relatively large numbers of distinctive features, some of which have then been shown to be convergent. In contrast, in the case of so-called production flakes, experimental work by Eren et al. (2018) showed that there was an enormous overlap in flake shape even when they resulted from the production of different tools, with different techniques from flint nodules of very different shapes and sizes. However elaborate the description of the objects concerned, they may simply lack information about their transmission history.

Nevertheless, we do not always need such methods to make such inferences. Space and time can themselves be used as independent variables to overcome the problem of lithic assemblages having to play multiple roles in description and explanation. Thus, Moore (2013) uses the differential timing of the appearance of hierarchical reduction sequences in addition to simple chaining sequences in Australia and the Old World to argue that they are convergent trends associated with demographic growth since they are unquestionably independent developments. In a similar vein Clarkson et al. (2018) use the differential timing of the appearance and disappearance of microlithic industries within and between several different world regions, including southern Africa, South Asia and Australia, to argue that they are convergent developments associated with changing mobility. In effect, their invention and use was always within Tennie's 'zone of latent solutions'.

However, a further source of independent evidence to test many Paleolithic hypotheses is now beginning to be provided by aDNA studies. These provide strong evidence, in addition to the rationale advanced by Lycett and colleagues, to believe that some proportion of the variation in space and time observed in lithic assemblages during the Paleolithic would have been the result of variations in interaction that influenced transmission processes. One example is Hajdinjak et al.'s (2018) study of genomic data from late Neanderthal populations in Europe, which showed that their relatedness decreased with geographical distance as a result of decreased interaction over greater distances. Whether this is simply isolation by distance or something more structured is currently impossible to say, but in any event, given the intimate interaction required for the learning of lithic skills, the prediction would be that there is a corresponding decline in similarity in lithic attributes linked to the learning context. Conversely, the genomic evidence from an earlier and a later Neanderthal individual from Mezmaiskaya cave in the Caucasus pointed to population turnover, possibly the result of local extinction and replacement, so the prediction would be that this was also associated with a discontinuity in learned attributes. In any case, the point is that the genomic evidence now provides a new basis for relieving the 'interpretative burden' (Kristiansen et al. 2017) on the archaeological evidence of the lithics themselves, by providing an independent set of data with which the lithic patterns can be compared, just as radiocarbon dating did for later prehistory in the 1970s. In doing so it shows that the kinds of interaction and transmission processes assumed (in a naïve form) by the culture historians can be identified even in the Middle Paleolithic and even though their dating is relatively imprecise.

Similar inferences can also be made for the Upper Paleolithic on the basis of the genomic data. Thus Fu et al. (2016) show that an individual from Goyet Cave in Belgium dating to c. 35 kya and thus corresponding in date to the early Upper Paleolithic Aurignacian complex belonged to a different population group from their Věstonice genomic cluster, which is associated with the Gravettian, and on this basis infer that the spread of the Gravettian was at least partly the result of population movements (see also Sikora et al. 2017). Conversely again, the Věstonice cluster represents a different population from that of the Mal'ta 1 individual from Siberia but examples of the well-known Venus figurines occur with both, suggesting that the relevant cultural process explaining the link is horizontal transmission across populations.

In evolutionary biology the standard way to assess whether traits are the result of common descent or convergent, and therefore by implication adaptive, is the use of the phylogenetic comparative method, in which the occurrence of the traits of interest is mapped onto an independently derived tree characterizing relationships of biological descent; statistical methods are then used to test hypotheses of independence in relation to the tree structure (Harvey and Pagel 1991). In the last 30 years these methods have been extensively used in cultural evolutionary studies of various attributes of present-day societies, for example whether they are matrilineal or patrilineal in descent rules and whether or not these rules are a convergent adaptation. In this case it is a language tree that is taken as the proxy for descent relationships between populations (e.g. Mace and Pagel 1994; Holden and Mace 2003). As Paleolithic ancient DNA data becomes increasingly available it should become possible to go beyond the *ad hoc* inferences made above to map archaeological traits onto the admixture trees being created by geneticists.

However, the ancient DNA evidence also points to other cultural evolutionary factors relevant to understanding cultural variation. Specifically it will enable us to address the much discussed role of population size in influencing cultural change in the Paleolithic (Shennan 2001; Powell et al. 2009), a period for which no other reliable source of information on this is available. In the case of the Neanderthals the genomic evidence of runs of homozygosity from both the Vindija cave individual and, even more so, the Neanderthal individual from Denisova cave in Siberia (Prüfer et al. 2017, 2014 respectively) indicates that the populations were small and isolated. Since drift is a much stronger force in small populations than in larger ones, and can potentially overwhelm selection, one likely inference is that it would also play a significant role in explaining variation within and between Middle Paleolithic lithic assemblages. But it is not just a matter of drift. Hamilton and Walker's (2018) modelling of stochasticity in hunter-gather population dynamics indicates that on average hunter-gatherer populations only continue to exist for a few hundred years, and often less. It is the repeated stochastic patterns of population extinction that produce the long-term outcome of effectively zero population growth in the Pleistocene. This would imply regular loss of cultural features and the need for re-invention, with the likely result again that only relatively obvious features within the zone of latent solutions will be re-invented (cf. Henrich 2004), resulting in a ceiling in the level of cultural diversity (cf. Premo and Kuhn 2010), and also a major role for convergence.

Conversely, as carrying capacity increases the average time to extinction also goes up, although the size of this effect decreases with increasing environmental stochasticity. Thus, evidence from Upper Paleolithic individuals from the well-known site of Sunghir (Sikora et al. 2017) suggests the existence of larger interacting populations with a structure similar to that of known modern hunter-gatherer groups, including low levels of relatedness between the members of co-resident groups. In these circumstances the effects of selection on genetic variation will not be overwhelmed by drift and the same principle should apply to culturally-transmitted variation as well. In other words, there is a greater potential for attributes that improve the efficiency of tools, for example, to increase in frequency. Combined with the fact that populations will on average last longer before they go extinct, there is more scope for the maintenance of cultural traditions, including the development of cumulative traditions that include the recombination of prior innovations (cf. Derex and Boyd 2015; Enquist et al. 2011). This may well be relevant to the increased rate of cultural change during the Upper Paleolithic. It should also lead to lower levels of homoplasy and more robust trees.

Conclusion

The production of lithic artefacts depends on learned behaviors and therefore on cultural transmission, thus the 'ways of doing' concerned have significant heritability, which can in principle be distinguished from the effects of raw material and re-sharpening. Progress has been made in identifying these and describing material in terms of attributes that relate to the transmission process. However, even though they are made up of products of social learning, the composition of lithic assemblages is not determined by transmission in the same way but by situational factors associated with technological organization in local environments (and then, of course, subject to processes specific to the formation of the archaeological record, like time-averaging). Insofar as these situations repeat themselves, there may be strong similarities between assemblages, but they do not tell us anything one way or the other about transmission and its role. Only attributes relating to the production process can tells us this.

With regard to transmitted variation, declining transmission with distance results in decreasing similarity because innovations occurring in one place are less likely to be transmitted to the other and the increasing availability of relevant genomic data provides a new basis for generating testable predictions about the role of population processes like isolation-by distance or expansions and extinctions. Phylogenetic methods have a major role to play in distinguishing isolation-by-distance, the existence of structured populations and the extent of homoplasy. Increasingly too, ancient DNA admixture trees will provide a basis for using the comparative method. For the reasons discussed above smaller effective cultural population sizes are likely to be associated with higher degrees of convergence than larger ones and this is likely to be one of the main factors distinguishing the Middle from the Upper Paleolithic. Here too ancient DNA will play a major role in model testing.

References

Angelbeck, B., & Cameron, I. (2014). The Faustian bargain of technological change: Evaluating the socioeconomic effects of the bow and arrow transition in the Coast Salish past. *Journal of Anthropological Archaeology, 36,* 93–109.

Bentley, R. A., Hahn, M. W., & Shennan, S. J. (2004). Random drift and culture change. *Proceedings of the Royal Society Biological Sciences, 271,* 1443–1450.

Binford, L. R. (1962). Archaeology as anthropology. *American Antiquity, 28,* 217–225.
Binford, L. R. (1965). Archaeological systematics and the study of culture process. *American Antiquity, 31,* 203–210.
Binford, L. R. (1973). Interassemblage variability-the Mousterian and the 'functional' argument. In C. Renfrew (Ed.), *The explanation of culture change* (pp. 227–254). London: Duckworth.
Binford, L. R. (1978). *Nunamiut ethnoarchaeology*. New York: Academic Press.
Binford, L. R. (2001). *Constructing frames of reference*. Berkeley: University of California Press.
Binford, L. R., & Binford, S. R. (1966). A preliminary analysis of functional variability in the Mousterian of the Levallois Facies. *American Anthropologist, 68,* 238–295.
Blitz, J. H. (1988). Adoption of the bow in prehistoric North America. *North American Archaeology, 9,* 123–145.
Bordes, F. (1973). On the chronology and contemporaneity of different Palaeolithic cultures in France. In C. Renfrew (Ed.), *The explanation of culture change* (pp. 217–226). London: Duckworth.
Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.
Boyd, R., Borgerhoff-Mulder, M., Durham, W. H., & Richerson, P. J. (1997). Are cultural phylogenies possible? In P. Weingart, S. D. Mitchell, P. J. Richerson, & S. Maasen (Eds.), *Human by nature* (pp. 355–386). Mahwah, NJ: Lawrence Erlbaum.
Carr, C. (1995). A unified middle-range theory of artefact design. In C. Carr & J. Neitzel (Eds.), *Style, society and person: Archaeological and ethnological perspectives* (pp. 171–258). New York: Plenum.
Cavalli-Sforza, L. L., & Feldman, M. W. (1981). *Cultural transmission and evolution: A quantitative approach*. Princeton: Princeton University Press.
Clarkson, C., Hiscock, P., Mackay, A., & Shipton, C. (2018). Small, sharp and standardized: Global convergence in backed-microlith technology. In M. O'Brien, B. Buchanan, & M. I. Eren (Eds.), *Convergent evolution in stone tool technology* (pp. 175–200). Cambridge, Mass: MIT Press.
Delagnes, A., & Rendu, W. (2011). Shifts in Neandertal mobility, technology and subsistence strategies in western France. *Journal of Archaeological Science, 38,* 1771–1783.
Derex, M., & Boyd, R. (2015). The foundations of the human cultural niche. *Nature Communications, 6,* 8398.
Dunnell, R. C. (1978). Style and function: A fundamental dichotomy. *American Antiquity, 43,* 192–202.
Eerkens, J. W., & Lipo, C. P. (2005). Cultural transmission, copying errors, and the generation of variation in material culture in the archaeological record. *Journal of Anthropological Archaeology, 24,* 316–334.
Enquist, M., Ghirlanda, S., & Eriksson, K. (2011). Modelling the evolution and diversity of cumulative culture. *Philosophical Transactions of the Royal Society of London. Biological Sciences, 366,* 412–423.
Eren, M., Buchanan, B., & O'Brien, M. (2018). Why convergence should be a potential hypothesis for the emergence and occurrence of stone-tool form and production processes: An illustration using replication. In M. O'Brien, B. Buchanan, & M. I. Eren (Eds.), *Convergent evolution in stone tool technology* (pp. 61–72). Cambridge, Mass: MIT Press.
Fu, Q., Posth, C., Hajdinjak, M., Petr, M., Mallick, S., Fernandes, D., et al. (2016). The genetic history of Ice Age Europe. *Nature, 534,* 200–205.
Grant, P. R., & Grant, B. R. (2002). Unpredictable evolution in a 30-year study of Darwin's finches. *Science, 296,* 707–711.
Gray, R. D., & Jordan, F. M. (2000). Language trees support the express-train sequence of Austronesian expansion. *Nature, 405,* 1052–1055.
Hames, R. B., & Vickers, W. T. (1982). Optimal diet breadth theory as a model to explain variability in Amazonian hunting. *American Ethnologist, 9,* 358–378.
Hajdinjak, M., Fu, Q., Hubner, A., Petr, M., Mafessoni, F., Grote, S., et al. (2018). Reconstructing the genetic history of late Neanderthals. *Nature, 555,* 652–656.
Hamilton, M., & Walker, R. (2018). A stochastic density-dependent model of long-term population dynamics in hunter-gatherer populations. *Evolutionary Ecology Research, 19,* 85–102.
Harvey, P., & Pagel, M. (1991). *The comparative method in evolutionary biology*. Oxford: Oxford University Press.
Henrich, J. (2004). Demography and cultural evolution: How adaptive cultural processes can produce maladaptive losses: The Tasmanian case. *American Antiquity, 69,* 197–214.
Holdaway, S., & Douglass, M. (2012). A twenty-first century archaeology of stone artifacts. *Journal of Archaeological Method and Theory, 19,* 101–131.
Holden, C., & Mace, R. (2003). Spread of cattle led to the loss of matrilineal descent in Africa: A coevolutionary analysis. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 270,* 2425–2433.
Key, A. J., & Lycett, S. J. (2017). Influence of handaxe size and shape on cutting efficiency: A large-scale experiment and morphometric analysis. *Journal of Archaeological Method and Theory, 24,* 514–541.
Kristiansen, K., Allentoft, M., Frei, K. M., Iversen, R., Johannsen, N., Kroonen, G., et al. (2017). Re-theorising mobility and the formation of culture and language among the Corded Ware Culture in Europe. *Antiquity, 91,* 334–347.
Lipo, C., O'Brien, M., Collard, M., & Shennan, S. (Eds.). (2006). *Mapping our ancestors*. New Brunswick: Aldine Transaction.
Lycett, S. J., & von Cramon-Taubadel, N. (2015). Toward a "quantitative genetic" approach to lithic variation. *Journal of Archaeological Method and Theory, 22,* 646–675.
Lycett, S. J., Schillinger, K., Eren, M. I., von Cramon-Taubadel, N., & Mesoudi, A. (2016). Factors affecting Acheulean handaxe variation: Experimental insights, microevolutionary processes, and macroevolutionary outcomes. *Quaternary International, 411,* 386–401.
Mace, R., & Pagel, M. (1994). The comparative method in anthropology. *Current Anthropology, 35,* 549–564.
Moore, M. W. (2013). Simple stone flaking in Australasia: Patterns and implications. *Quaternary International, 285,* 140–149.
O'Brien, M., Buchanan, B., & Eren, M. I. (Eds.). (2018). *Convergent evolution in stone tool technology*. Cambridge, Mass: MIT Press.
Powell, A., Shennan, S. J., & Thomas, M. G. (2009). Late Pleistocene demography and the appearance of modern human behavior. *Science, 324,* 1298–1301.
Premo, L. S., & Kuhn, S. L. (2010). Modeling effects of local extinctions on culture change and diversity in the Paleolithic. *PLoS ONE, 5,* e15582. https://doi.org/10.1371/journal.pone.0015582.
Prüfer, K., Racimo, F., Patterson, N., Jay, F., Sankararaman, S., Sawyer, S., et al. (2014). The complete genome sequence of a Neanderthal from the Altai Mountains. *Nature, 505,* 43–49.
Prüfer, K., de Filippo, C., Grote, S., Mafessoni, F., Korlević, P., Hajdinjak, M., et al. (2017). A high-coverage Neandertal genome from Vindija Cave in Croatia. *Science, 358,* 655–658.
Renfrew, C. (1973). *Before civilization: The radiocarbon revolution and prehistoric Europe*. London: Jonathan Cape.
Sackett, J. R. (1982). Approaches to style in lithic analysis. *Journal of Anthropological Archaeology, 1,* 59–112.
Sackett, J. R. (1985). Style and ethnicity in the Kalahari: A reply to Wiessner. *American Antiquity, 50,* 154–159.
Scerri, E. M. L., Thomas, M. G., Manica, A., Gunz, P., Stock, J. T., Stringer, C., et al. (2018). Did our species evolve in subdivided populations across Africa, and why does it matter? *Trends in Ecology and Evolution, 33,* 582–594.

Schillinger, K., Mesoudi, A., & Lycett, S. J. (2014). Copying error and the cultural evolution of "additive" versus "reductive" material traditions: An experimental assessment. *American Antiquity, 79,* 128–143.

Shea, J. J. (2017). *Stone tools in human evolution: Behavioral differences among technological primates*. Cambridge: Cambridge University Press.

Shennan, S. J. (2001). Demography and cultural innovation: A model and some implications for the emergence of modern human culture. *Cambridge Archaeological Journal, 11,* 5–16.

Shennan, S. J. (2011). Descent with modification and the archaeological record. *Philosophical Transactions of the Royal Society B, 366,* 1070–1079.

Shennan, S. J., Crema, E., & Kerig, T. (2015). Isolation-by-distance, homophily, and "core" vs. "package" cultural evolution models in prehistoric Europe. *Evolution and Human Behavior, 36,* 103–109.

Shennan, S., & Steele, J. (1999). Cultural learning in hominids: A behavioural ecological approach. In H. Box & K. Gibson (Eds.), *Mammalian social learning*. Symposia of the Zoological Society of London (Vol. 70, pp. 367–388). Cambridge: Cambridge University Press.

Shott, M. (2008). Lower Palaeolithic industries, time, and the meaning of assemblage variation. In S. Holdaway & L. Wandsnider (Eds.), *Time in archaeology: Time perspectivism revisited* (pp. 46–60). Salt Lake City: University of Utah Press.

Sikora, M., Seguin-Orlando, A., Sousa, V. C., Albrechtsen, A., Korneliussen, T., Ko, A., et al. (2017). Ancient genomes show social and reproductive behavior of early Upper Palaeolithic foragers. *Science, 358,* 659–662.

Tennie, C., Call, J., & Tomasello, M. (2009). Ratcheting up the ratchet: On the evolution of cumulative culture. *Philosophical Transactions of the Royal Society B, 364,* 2405–2415.

Tostevin, G. B. (2012). *Seeing lithics: A middle-range theory for testing for cultural transmission in the Pleistocene*. Oxford: Oxbow.

Wargo, M. C. (2009). The Bordes-Binford debate: Transatlantic interpretative traditions in Palaeolithic archaeology. Unpublished Ph.D. thesis, University of Texas at Arlington.

Wiessner, P. (1983). Style and social information in Kalahari San projectile points. *American Antiquity, 48,* 253–276.

Wiessner, P. (1985). Style or isochrestic variation? A reply to Sackett. *American Antiquity, 50,* 160–166.