Toward an archaeology of pedagogy: learning, teaching and the generation of material culture traditions

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Abstract

In this article we seek to build on efforts to apply the insights of social learning theory to interpret patterns of continuity and change in the archaeological record. This literature suggests that stable and often highly arbitrary material culture traditions are likely to be founded on our biologically-evolved capacity for imitation. However, it has recently been argued that the latter may be insufficient to explain the long-term maintenance of complex and difficult-to-master skills, such as those required to produce stone tools, pots, textiles and other cognitively opaque cultural forms. To ensure that these skills are accurately transferred to the next generation, adults must actively guide and control the learning activities of their children, a mode of transmission that can be labelled 'pedagogy'. The importance of pedagogy has often been overlooked in the theoretical and empirical literature on craft learning, a fact that can probably be attributed to an unnecessarily narrow conception of teaching that equates it with explicit linguistic instruction. Using ethnographic data gathered from detailed case studies, we characterise pedagogy in the context of craft apprenticeships as involving the gradual scaffolding of skill in a novice through demonstration, intervention and collaboration. Although these processes cannot be directly observed in the archaeological record, they can sometimes be inferred through the detailed reconstruction of operational chains in past technologies. The evidence we present suggests that pedagogy has played an essential role in securing the faithful transmission of skills across generations, and should be regarded as the

central mechanism through which long-term and stable material culture traditions are propagated and maintained.

Keywords

Cultural transmission, tradition, pedagogy, teaching, apprenticeships, chaîne opèratoire

Introduction

In all societies, people share and transmit a multitude of ideas, habits and behaviours. Many fail to catch on and are soon forgotten, while others flourish for a short time before they expire or get swept away by new fads and fashions. Here, we focus on those bodies of knowledge and skill that are accumulated and consistently handed down from generation to generation, which can be usefully defined as "traditions". Traditions can be identified within a wide range of cultural spheres, from the core vocabulary of languages to subsistence know-how, ritual performance and written and oral literatures. In material culture, recognizably coherent lineages of tool-making and craft production can be traced through continuities among artefacts produced hundreds, even thousands of years apart (e.g. Collard and Shennan 2000; Kirch and Green 2001; O'Brien and Lyman 2003; Tehrani and Collard 2002, in press; Lipo et al. 2006; Riede 2008). Yet, while these homologies are often highly visible in the archaeological record, the processes that are responsible for generating them remain obscure. Why are some cultural forms so resilient and slow to change when others degenerate or transform so quickly?

FIGURE 1 ABOUT HERE

In many cases, the relative stability of a particular kind of technology is likely to be strongly conditioned by raw materials and other functional constraints, which may either

inhibit innovations, or winnow them out before they can be inherited by the next generation (e.g. O'Brien and Holland 1990). In other cases, certain kinds of aretfacts might spread and take hold in a population because they are intrinsically more memorable and easy to learn, whereas others are more difficult to copy and reproduce (e.g. Sperber and Hirschfeld 2004). However, it is important to recognize that many of the ceramic, textile and lithic traditions documented in the material culture record are basically *arbitrary*, and cannot be accounted for in terms of inherent material or psychological constraints. Thus, there are often strong distinctions in the craft styles and techniques associated with different social groups despite broader similarities in their environments and technological capacities, many of which persist even when there is a significant flow of people, goods and ideas among them (e.g. Pétrequin and Pétrequin 1999). Moreover, technologies that appear to be highly stable and uniform in some populations are much more heterogeneous and changeable in others (e.g. Bettinger and Eerkens 1999). In recognition of these patterns, a growing number of archaeologists have focused their attentions onto how the development of artefact forms over time might be influenced by the specific mechanisms through which information gets transmitted within and between generations (e.g. Shennan 2002; Eerkens and Lipo 2005, 2007; and papers in O'Brien 2008).

Much of the inspiration for this work comes from social learning theory, an inter-disciplinary field of study that incorporates research from anthropology, archaeology, comparative biology and cognitive pyschology (e.g. Tomasello et al. 1993; Want and Harris 2002; Csibra and Gergeley 2006; Richerson and Boyd 2005). Social learning theorists suggest that humans have evolved a variety of different strategies to copy one

another, the accuracy and fidelity of which vary significantly. For example, they highlight an important distinction between *imitation*, in which an observer copies the specific set of actions enacted by a role model to accomplish some task, and *emulation*, in which an observer focuses only on the outcomes of those actions (i.e. the goals that motivated them or the qualities that made them efficacious). Both strategies are likely to have played important roles in giving shape to the material culture record: Thus, emulation enables us to borrow and creatively manipulate behaviours observed in others, making it an important source of volatility and innovation in the evolution of styles and technologies. Imitation, on the other hand, allows us to accurately reproduce complex and intricate patterns of action, even when we do not necessarily understand exactly how they work (e.g. Whiten et al. 2006). As such it is thought to be particularly important to the emergence and long-term stability of cognitively opaque and arbitrary craft and tool-making traditions (e.g. Want and Harriss 2002). Significantly, while these kinds of traditions can be found in all human societies, they are conspicuously absent in other primate species who lack similarly advanced imitative abilities, and generally only copy and pass on behaviours that have immediate and transparent pay-offs (e.g. Whiten 2005).

However, while imitation has undoubtedly played a vital role in human cultural evolution, we think that it is unlikely to be able to sustain material culture traditions over the sorts of time-scales that are seen in the archaeological record. Consider, for example, the obvious difficulties of reproducing the rapid motor patterns that are involved in the production of stone tools, textiles and pottery. Even armed with a highly sophisticated set of imitative abilities, it is difficult to imagine how a novice could accurately copy the blur of finger movements of an expert weaver, or achieve the delicately calibrated balance

between precision and power exercised by a master stone knapper, just by repeated observation. Indeed, if observation and imitation were the major modes of transmission for these skills, we might expect that, over the course of many generations, complex craft and tool-making traditions would be extremely vulnerable to the failings of memory, copying error, and inter-individual differences in natural ability. In order to explain how they are able to repeatedly withstand these hazards, we draw on recent developments in social learning theory that emphasize the role played by active teaching in the transmission of these types of skills.

2. The theory of pedagogy

As the name suggests, social learning theory has focussed mainly on how individuals acquire cultural traits, rather than on how they subsequently pass them on. Consequently, teaching has been heavily under-theorized, and has often been viewed as a by-product of more general cognitive abilities like language or the ability to infer and manipulate others' mental states (e.g. Tomasello *et al.* 1993). Whereas these conceptions identified teaching with explicit linguistic instruction, recent theories (e.g. Caro and Hauser 1992; Gergeley and Csibra 2006) suggest that teaching can be said to take place in a variety of other contexts in which an experienced individual modifies their behaviour with the specific aim of facilitating learning in a novice. These kinds of interactions are often much simpler and more implicit than formal schooling, and can even be observed in other animal species, where they play an important role in the development of motor-skills, foraging instincts and other behaviours (Thornton and Raihani – in press;).

In the human case, it has been suggested by Castro and Toro (2004) that one of the earliest and most rudimentary types of teaching may have consisted of the ability to

approve or disapprove of an offspring's behaviour. Noting that such judgements appear to be absent in other primate species, they speculate that the emergence of this ability was crucial to the emergence of complex culture: By expressing approval/disapproval, parents were better able to guide and optimise cultural learning in their children, thereby increasing their chances of adopting the most locally adaptive behaviours. Castro and Toro further argue that approval/disapproval of learner's behaviour would have also helped to foster the creation of traditions that are based on purely arbitrary conventions, thereby "transforming culture into an inheritance system in a strict sense" (Castro and Toro 2004:10235).

In similar vein, the cognitive psychologists Gergely and Csibra (2006) argue that human cultural capacities co-evolved with the ability to learn and transfer knowledge through teaching, which they believe to be "a primary, independent, and possibly even earlier adaptation than either language or the ability to attribute mental states" (Csibra and Gergely 2006:2). This pedagogical instinct finds expression in specific forms of parent-offspring communication like "motherese", the distinctive tone and vocal modulations adopted by a parent when addressing a small child, which appears to universal to all cultures. Gergely and Csibra also cite experimental evidence suggesting that children copy the behaviour of a role model with a much higher degree of fidelity when provided with explicit pedagogical cues. By manipulating these cues, parents and tutors are able to increase the efficiency of a child's social learning by focussing their attention onto the functionally important aspects of a particular skill or task complex. They propose that this kind of relevance-guided transmission is essential to the maintenance of difficult-to-master skills and behaviours, pointing out that "blind imitation – without any correction

mechanism – would be a wasteful and error-prone social transmission process that would represent a serious danger for the cultural and cross-generational survival of cognitively opaque cultural forms" (Gergely and Csibra 2006:239). With these points in mind, we turn now to the empirical literature on skill transmission to examine the evidence for pedagogy in the reproduction of craft and tool-making traditions.

3. The ethnography of pedagogy

At first glance, ethnographic accounts of craft learning appear to provide little support for the pedagogy hypothesis. Indeed, in a recent review, MacDonald concluded that "descriptions of how children learn to use and manufacture hunting weapons indicate that teaching is unimportant relative to observation and practice" (MacDonald, K. 2008:398). This assessment is consistent with the wider literature on apprenticeships, which tends to play down the role of active teaching by a master or tutor and emphasises instead the importance of 'learning by doing', i.e. the ratcheting up of skill gained through experience and direct participation in the production process (e.g. Coy 1989; Lave and Wenger 1991; Bamforth and Finlay 2008). However, we believe that this bias obscures two important points.

First, as Shennan and Steele (1999) have pointed out, it is crucial to acknowledge the significant costs that are incurred by adults in order to facilitate learning in young novices. In the case of difficult-to-master skills such as pot-making and weaving or making and hunting with stone tools, apprenticeships may require the adult to invest several years worth of time and energy that could be directed toward the pursuit of other goals. Shennan and Steele (1999) suggest that this explains why these skills are usually transmitted within the naturally altruistic context of the parent-child relationship, noting

that, in cases where the teacher is not a direct relative of the learner, the issue of teaching costs is explicitly addressed in the form of financial payment or rights over the future labour of the apprentice. Even in the material presented by MacDonald, it is clear that adult males are forced to compromise their foraging returns in order to train young hunters, "[altering] their activities to accommodate children's learning of a range of hunting skills by changing the time of day and choice of target" (MacDonald, K. 2008:398). If the agency of adults really were unimportant to the transmission of these forms of knowledge, one many wonder why such sacrifices are deemed necessary.

Secondly, as we pointed out earlier, teaching can take a variety of different forms and should not necessarily be equated with explicit linguistic instruction, like the kind used in a school classroom. The latter represents a specific mode of pedagogy that is primarily aimed at communicating 'declarative' information, which is fact-based, often independent of context (i.e. abstract) and can be verbalised and explained (e.g. Gibson 1999; Thornton and Raihani – in press). In contrast, craft and tool-making skills are based on a different kind of information, which can be described as 'procedural' knowledge (ibid.), or 'know-how' (Pelegrin 1990). The latter consists of routinized motor-patterns that are acquired and re-enacted automatically without conscious thought (e.g. Pelegrin 1990; Roux and Blandine 2005, Apel 2008). These skills cannot be taught in a classroom, but are passed on to the next generation via a different and more suitable strategy, which can be labelled as "progressive teaching" (Thornton and Raihani – in press:6-7), or "scaffolding" (e.g. Greenfield et al. 2000; Stout 2002, 2005).

Scaffolding involves building up a learner's capabilities gradually, by facilitating the acquisition of more complex skills via the cumulative mastery of increasingly demanding

tasks. Since this requires a high degree of co-ordination between teacher and learner, scaffolding is an inherently conservative mode of cultural transmission. This is exemplified by the transmission of textile knowledge from mothers to daughters in Iranian and Central Asian pastoralist tribes (e.g. Tehrani and Collard 2002; Tehrani and Collard, in prep). Weaving apprenticeships in these communities usually begin before the age of nine and can last for several years. Following the pattern of other apprenticeships (e.g. Ruddle and Chesterfield 1977; Ohmagari and Berkes 1997; Greenfield et al. 2000; Stout 2002, 2005), teaching involves little linguistic instruction, but occurs through a mixture of demonstration, collaboration and, when necessary, the correction of mistakes. For instance, the instructor teaches a rug design by weaving part of it (e.g. a geometric section or outline) leaving the learner to 'fill in' the remainder. This exercise is then repeated with larger and more complex sections of the design until the learner has memorized every detail of its production. Any mistakes are immediately rectified by the instructor, who demonstrates the correct method to the learner. In accordance with the pedagogical mode of transmission described by Csibra and Gergeley (2006; Gergeley and Csibra 2006), this enables the instructor to guide and constrain the imitation of specific patterns and weaving techniques by the learner and ensures that the tradition is passed on from one generation to the next with a high degree of fidelity. This is evidenced by the remarkable continuities that can be observed in the styles and techniques used by related tribes: Phylogenetic analyses of the textiles produced by groups in different regions found that many features of these assemblages could be traced back to common ancestral populations that existed in the medieval period, when Oguz Turkic tribes swept westwards from Central Asia (Tehrani and Collard 2002, in press).

Similarly structured, informal modes of teaching appear to be involved in the reproduction of many other ethnographically documented traditions, from stone-knapping in New Guinea (Stout 2002, 2005), and weaving in Chiapas (Greenfield *et al.* 2000), to the transmission of foraging technologies in indigeneous communities of Orinoco (Ruddle and Chesterfield 1977) and James Bay, Canada (Ohmagari and Berkes 1997). Although these studies do not specifically investigate the long-term stability of these traditions, they implicitly assume that the skills which they describe have been faithfully transmitted over many previous generations. This assumption is borne out by studies describing the decline of traditional skills. For example, Ohmagari and Berkes (1997) explain that until recently, Cree families in James Bay Canada used to go on hunting, fishing and foraging expeditions that lasted months. During this time, children would acquire a diverse range of tools and techniques with which to track and kill prey, graduating from simple to increasingly more complex tasks under the close supervision and guidance of their parents. Today, however, new hunting technologies, together with the demands of adult wage-labour and a school-based education system mean that families can spend much less time in the bush together, which has resulted in a severe and rapid loss of bush skills among the young (Ohmagari and Berkes 1997). Similarly, Greenfield and colleagues describe how, in the 1960s, Zinacantec weavers underwent a long and intensive period of craft training by their mothers, producing a highly stable tradition: "Pattern innovation and the creation of new patterns were simply not a part of the culture or the transmission process…. Teachers stayed close to their pupils and prevented errors before they happened". In recent times, however, there have been profound shifts in modes of craft learning in these communities, with young girls

depending much more heavily on individual trial-and-error. As a result, traditional decorative styles have been overwhelmed by a proliferation of new, more idiosyncratic patterns (Greenfield et al. 2000). Although they focus on very different kinds of traditions, the lessons of the Cree (Ohmagari and Berkes 1997) and Zinacantec studies (Greenfield et al. 2000) are the same. Both indicate that when pedagogical modes of transmission are undermined or replaced by other types of learning, there is a sharp and almost instant decline in the inter-generational transfer of knowledge and skills.

4. Toward an archaeology of pedagogy

Based on the theoretical and ethnographic material presented above, it seems highly probable that teaching has been an important mechanim of material culture transmission since at least the Lower Palaeolithic, when the first complex lithic forms emerged (see Lycett and Gowlett, this volume), and was almost certainly present in later prehistoric and historic periods, which are replete with artefacts so intricate and beautiful that they must have been produced by a highly skilled and trained specialist (e.g. Apel 2001; Milliken and Vidale 1998). However, any attempt to build an empirical case in support of this assertion is bound to face significant challenges, not least because of the difficulties of trying to discriminate among specific modes of information transmission that cannot be directly observed. Nevertheless, recent attempts to identify the archaeological signature of children (e.g. Finlay 1997) draw attention to the possible role played by teaching in the past, as do efforts to reconstruct the broader social context of craft transmission. For example, MacDonald (1998) presents evidence indicating that teaching probably played an important role in the maintenance of Folsom Paleoindian culture of the North American Great Plains between 10,900 and 10,200 BP, arguing the

transmission of craft skills was combined with the passing on of "esoteric knowledge of elders". McDonald's assertion that craft education "was likely…much more valued by the young and uninitiated" in the context of "a more than utilitarian projectile technology" (MacDonald 1998:232 and 231) finds resonance with the European case studies, where the transmission of lithic and other technology is also thought to have been associated with initiation rituals and the passing on of restricted bodies of knowledge (e.g., Barton et al. 1994; Mithen 1991). In other cases, episodes of pedagogy can be inferred through detailed spatial and technological analyses of artefact forms and distribution patterns that suggest a close connection between individual enskillment and contact with master craftsmen. Thus, in her study of pre-Hispanic ceramic production in Southwest North America, Crown (2001) was able to detect marked differences in levels of expertise, along with evidence that accomplished potters assisted less skilled individuals regularly in the manufacture of acceptable vessels as well as designs, contributing both "time and energy to the learning process" (2001:462).

While the archaeology of pedagogy can be usefully explored using a number of different approaches, we suggest that the most promising of these is to be found in the *chaîne opèratoire* approach that was originally pioneered by Leroi-Gourhan (1964). *Chaîne opèratoire* technological studies aim to elucidate the operational sequences from raw material acquisition to discarded tool (and beyond) – the full 'life cycle' of a given implement (Figure 2). In the context of such highly detailed studies, the multiple technological options available to past craftsmen and -women can be reconstructed. This enables researchers to separate those features of craft production that are conditioned closely by the properties of the raw material, from such features contingent more on the

social and pedagogical context within which a given craftsman or -woman is situated, and those that are idiosyncratic. Most *chaîne opèratoire* research foregrounds issues of cognitive development (see Roux and Blandine 2005) or social context (e.g., Dobres 2000; Apel and Knutsson 2006) over issues of social information transmission. Yet, clearly a *chaîne opèratoire*-inspired approach to technology allows the identification of those technological choices repeatedly and consistently realised across generations (Riede 2006, 2008; Apel 2008:95). If we can confidently exclude raw material, cognitive or physical constraints – which is by no means straightforward – we are left to invoke the transmission of particular 'ways of doing things' (*sensu* Hodder 1990:45).

FIGURE 2 ABOUT HERE

The potential of the *chaîne opèratoire* approach in relating the long-term maintenance of cultural traditions to a specifically pedagogical style of cultural transmission has already been demonstrated in a number of studies. Amongst the most notable of these is Pigeot's (1990) study of skill transmission of in the Late Glacial sites of Etiolles and Pincevent, in the Paris Basin, where stone tool industries appear to have been extremely conservative (Bodu 1996; Julien 2003). By comparing instances of flawed lithic reduction sequences with those produced by master knappers – and by linking spatially discrete knapping clusters together via refitting – Pigeot was able to confidently reconstruct a prehistoric apprenticeship system based on clearly differentiated levels of "knowledge and know how" (Pigeot 1990:132), as well as, ostensibly, "educational intervention by adults" (Pigeot 1990:137). In keeping with our earlier characterization of the transmission of procedural knowledge, the teaching of tool-making techniques appears to have involved a gradual scaffolding of skill: Cores made redundant by unskilled knapping, for example,

were corrected by masters using specific techniques and then returned to the apprentices. Practice flint-working is also expressed in the different ways in which the products (blanks) were treated at Etiolles. High-quality products furnished by master knappers circulated widely within the settlement and beyond it, but those of less skilled knappers were simply discarded where they were made, leaving virtually complete scatters and reflecting "an educational, rather than economic, purpose" (Pigeot 1990:132). Instances of teaching have been identified in later Paleolithic sites such as Trollesgave, in eastern Denmark belonging to the Late Glacial Bromme culture (Fischer 1989, 1999). Here, through detailed refitting and spatial analysis, Fischer (1989:33) claims to have identified a "school of flint-knapping", where a master knapper, seated on a boulder, demonstrated his skills to younger members of the group.

Whilst Trollesgave and the Paris Basin sites do remain outstanding with regards to their preservation, they are not the only sites dating to the Late Palaeolithic at which the presence of learners or apprentices and their teachers is attested (Solvieux, France: Grimm 2000; Oudehaske and Gramsbergen, Netherlands: Johansen and Stapert 1997/1998), and there are also sites dating to earlier (Stapert 2007) as well as later prehistoric periods (the Neolithic: Högberg 1999, 2008; Paleo-Eskimo period: Milne 2005). Although distorted by the vagaries of preservation and patchy in its geographic and chronological coverage, the reconstruction of operational chains in past technologies has yielded significant insights into prehistoric systems of apprenticeship that are broadly consistent with the ethnographic materials discussed previously. Like the latter, they indicate that stable and long-term maintenance of tool-making traditions did not occur simply through observational learning and imitation, or through the repeated efforts and

practice of individuals. Instead, it depended on the existence of institutions and practices that were specifically designed to train successive generations of craftsmen and -women.

5. Future directions

Archaeologists have often implicitly incorporated notions of learning and teaching in their formulations of culture (O'Brien et al. 2008), most notably in studies concerned with identifying community structures and social interactions (e.g. Hayden & Cannon 1984; Crown 2001; Lipo 2001; Bamforth and Finlay 2008). However, they have rarely sought to explicitly discriminate between specific modes of cultural transmission, or analyze the impact these might have in generating large-scale patterns of synchronic and diachronic variation in material culture. Recent efforts to apply social learning theory to the archaeological record have made considerable headway in redressing this shortcoming (e.g. Bettinger and Eerkens 1999; Eerkens and Lipo 2005, 2007; and papers in O'Brien 2008), and suggest that the diversity and stability of artefact assemblages are often heavily influenced by the specific ways in which they are learned and transmitted by individuals, rather than by inherent design constraints. In seeking to build on this work, we have highlighted recent developments in an area of social learning theory that are of particular significance to understanding the long-term reproduction of material culture traditions, which focus on the role played by teaching in the inter-generational transmission of complex knowledge and skills (e.g. Castro and Toro 2004; Gergeley and Csibra 2006; Csibra and Gergeley 2006).

Teaching has often been neglected in both the social learning and apprenticeship literatures, both of which have tended to emphasise the importance of observation

learning and/or individual practice in the acquisition of craft knowledge. We have suggested that one of the principal reasons for this oversight is that researchers have tended to conceptualise teaching too narrowly, equating it with explicit linguistic instruction (e.g. Tomasello et al. 1993). Yet, as we have shown, the transmission of difficult-to-master procedural skills such as those required to make pots, textiles and stone tools typically involves a more implicit, but nevertheless essential, form of pedagogy. Thus, the material that we have reviewed indicates that, in both contemporary and prehistoric contexts, craft learning does not occur simply through observation and practice, but is typically directed by an experienced and accomplished tutor. Through carefully targeted demonstration and, occasionally, direct intervention, the latter is able to guide a learner toward a level of expertise that would be extremely difficult for them to acquire on their own (e.g. Castro and Toro 2004; Gergeley and Csibra 2006; Csibra and Gergeley 2006).

By enhancing the accuracy with which skills are transmitted between separate generations of social learners, pedagogical transmission can support much more stable patterns of cultural inheritance than would be possible under other modes of social learning. These differences are likely to be especially detectable over longer time periods, as Figure 3 illustrates. It shows hypothetical trajectories of change for an artefact form (in this case, a woven textile design) under three of the transmission regimes discussed in this paper. Under emulation, each new generation of learners tries to reproduce the artefacts made by the predecessor generation by experimenting with different techniques and/or methods of pattern construction. As a result, artefact forms evolve very quickly and are soon unrecognizable from those that existed in the past. Under imitation, the

transmission of cultural forms over time would be expected to be more conservative due to learners copying specific methods and styles of artefact production, rather than just the goals or functions that they serve. However, without the assistance of a role model clearly demonstrating his/her skills, or intervening to correct errors, we would still expect transmission fidelity to be quite low, at least until the artefact devolves into forms that are simpler and easier to copy and remember. Under teaching, on the other hand, we predict highly complex forms to survive for very long periods of time, as both donors and recipients actively collaborate in the transfer of knowledge from one to the other. Similarly diverse trajectories ought to be manifested in a spatial dimension. Thus, under emulation we would predict that the variance in artefact forms would be high within assemblages due to individual experimentation and error, but for the variance between assemblages to be low as individuals belonging in different groups converge on similar solutions for a given task. In contrast, imitation would be expected to produce low variance within assemblages due to members of the same group copying one another, but a high variance between assemblages as minor errors and innovations accumulate within separate populations (e.g. Eerkens and Lipo 2005). For teaching, variance is likely to be high between assemblages for the same reason. However, we would also expect within-assemblage variance to be relatively high due to the probable co-existence of several or more lineages of cultural learning within the same population (e.g. specific "schools" of craft production, workshops, family traditions, etc.).

FIGURE 3 ABOUT HERE

Recent methodological breakthroughs in evolutionary archaeology have equipped researchers with a battery of analytical techniques with which to verify these patterns.

These include updated versions of seriation analysis (e.g. Lipo 2001) computer simulation (e.g. Eerkens and Lipo 2005) and the application of phylogenetic methods imported from biology (e.g. Collard and Shennan 2000; Tehrani and Collard 2002; O'Brien and Lyman 2003; papers in Lipo et al. 2005), which were developed with the specific aim of tracking the descent with modification of forms over time. By linking such analyses to ethnographically and archaeologically documented instances of teaching like those described in this article, the archaeology of pedagogy promises to generate important insights into the mechanisms responsible for generating stable craft and tool-making traditions, as well as providing a rich point of contact with social anthropology, cognitive psychology and evolutionary biology.

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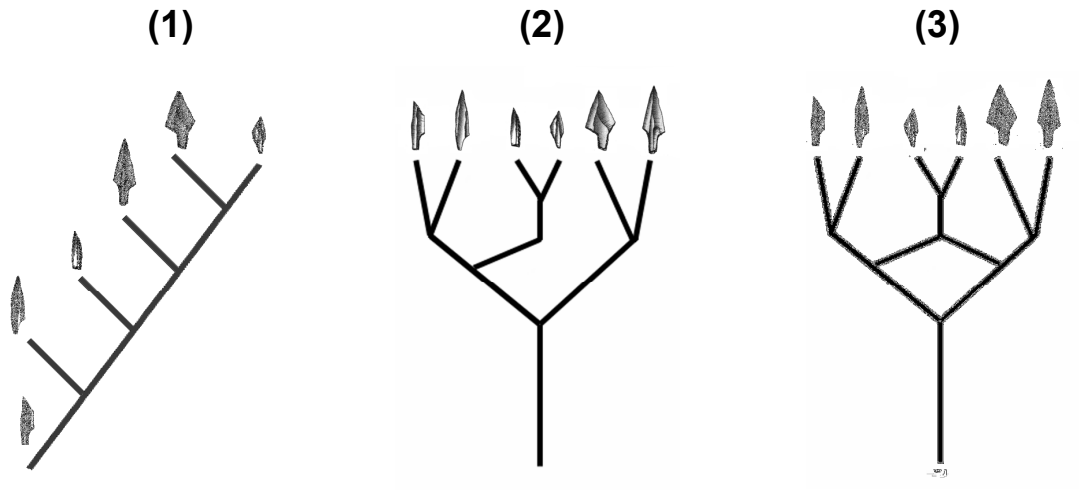

Figure 1.

Continuities among artefacts are often clearly manifested in the material culture record, and can frequently be traced back to one or more ancestral assemblages (e.g. Mace et al. 2005; Lipo et al. 2005). Here, three kinds of lineages are shown. In (1),the evolution of a lithic projectile point technology is represented as a linearly ordered set of ancestor-descendent relationships, whereby each form is derived from a single predecessor and gives rise to a single successor ('anagenesis'). In (2) the relationships among the points are shown as a 'family tree' that resulted from ancestral assemblages splitting into new ones. In this model of evolution, each form is derived from a single predecessor but can potentially give rise to more than one successor ('phylogenesis'). In (3) an even more complex evolutionary history is represented. Not only can ancestral forms have more than one descendent, but descendent forms can be traced back to more than one ancestor, as seen in the two points in the middle of the diagram ('ethnogenesis').

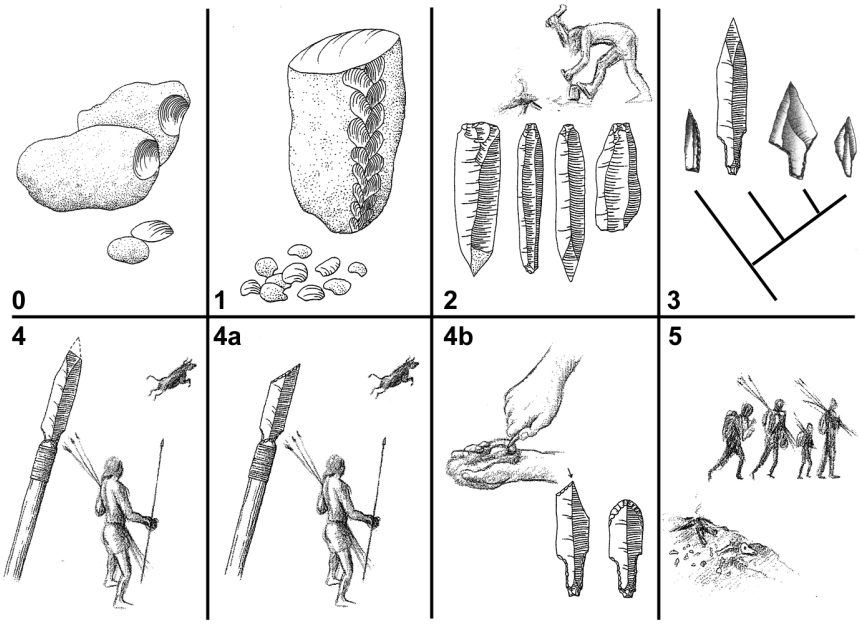

Figure 2.

The chaîne opèratoire *process from raw material (0) procurement to discard (5). Of particular relevance here are the manufacturing steps (1) to (3): The finished artefact in (3) clearly bears the traces of its manufacture and can so be discriminated from other craft traditions. The – often opaque – manufacturing technique itself is a complex learned procedure for which ethnographic evidence suggests a strong pedagogical component (e.g., Stout 2005). Putting artefacts into the context of other similarly socially transmitted craft traditions allows us to trace learning lineages in the past. Adapted from Eriksen (2000).*

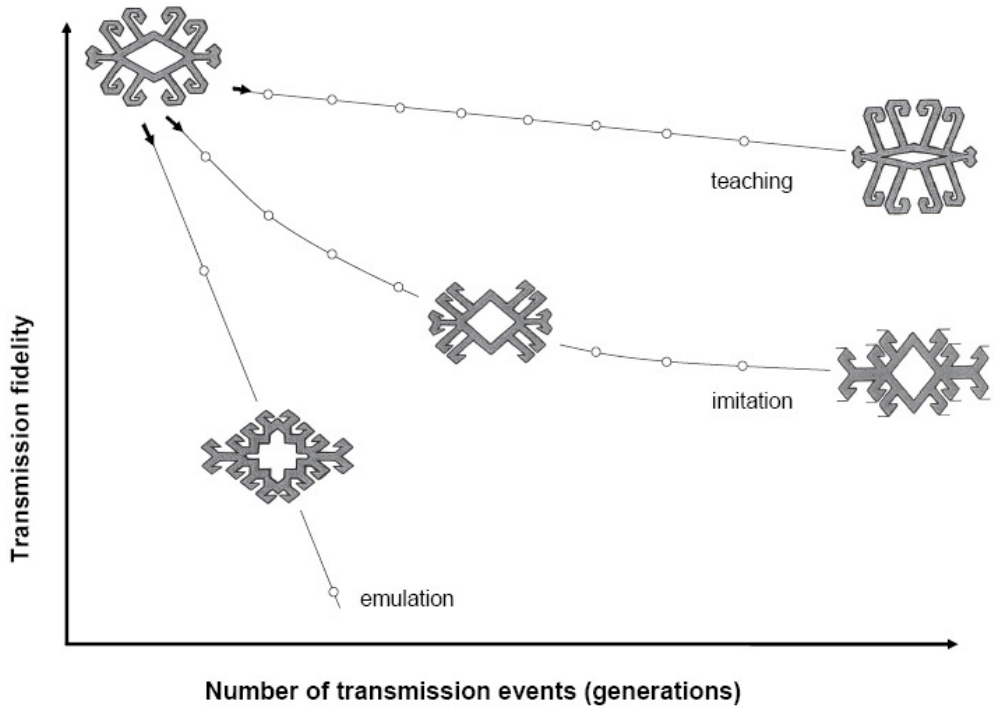

Figure 3.

This schematic model shows some basic expectations regarding the fidelity with which complex cultural forms (such as Central Asian rug ornaments) are reproduced over multiple generations under different modes of social learning. Under emulation learning, observers copy a set of goals or affordances demonstrated by a role model, allowing improvisation of techniques and procedures and a high rate of change in a craft or tool-making tradition. Under imitation, learners attempt to reproduce the exact repertoire of the demonstrator. Initially, copying error might be quite high for complex tasks, but as the tradition evolves into more easily remembered and 'copy-able' forms, it stabilises and is transmitted between generations with a high degree of fidelity. Under teaching, difficulties of copying complex and/or arbitrary forms are ameliorated by the intervention of an expert, ensuring that skills are passed on accurately to the next generation. However, even under teaching, there is scope for transmission error and innovation and hence for the accumulation of modifications in a given craft lineage.