The Archaeology of Teaching: A Conceptual Framework

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Studying the emergence of teaching in our lineage entails identifying learning strategies among human and non-human groups, understanding the situations in which they occur, evaluating their performance, recognizing their expression in the archaeological record, identifying trends in the way knowledge transmission changed through time, and detecting the key moments in which members of our lineage complemented pre-existing transmission strategies with those that led our species to develop cumulative culture and eventually 'teaching' as we know it. Here we explore how learning processes function in spatial, temporal, and social dimensions and use the resulting situations to build a tentative framework, which may guide our interpretation of the archaeological record and ultimately aid our identification of the learning processes at work in animal and past hominin societies. We test the pertinence of this heuristic approach by applying it to a handful of archaeological case studies.

Introduction

The goal of this paper is to propose an analytical framework that may allow us to interrogate and categorize present-day instances of animal and human cultural transmission. By applying this framework to the archaeological record, one should be able to propose and test best-fit scenarios for the emergence and complexification of teaching. If one accepts the view that pedagogy and teaching are capacities unique to our species that exist only in very rudimentary and non-comparable forms among our present-day closest relatives and hominin ancestors, an inquiry into the emergence of these capacities would be restricted to studies of developmental psychology among extant human populations and the archaeological record created by anatomically modern humans (AMH) since their emergence in Africa *c.* 200,000 years ago. Such a viewpoint would rest upon the assumption that no 'teaching' existed prior to 200,000 years ago, or even after that date among archaic populations present in and outside Africa. Furthermore, all changes we infer in pedagogical practices since 200,000 years ago would simply reflect the complexification and amount of cultural and social information being transmitted between generations rather than any significant change in the manner in which this process transpired.

Enhanced social learning, language, imitation and prosociality are certainly key behavioural features that allow our species to produce cumulative culture (Boyd & Richerson 1985; Dean *et al.* 2012; Laland & Galef 2009; Tomasello *et al.* 1993; Want & Harris 2002; Whiten *et al.* 2006). However, this observation alone does not explain how and when these capacities and behaviours arose or how they led to the emergence of 'teaching' as we know it. We argue here that the emergence of 'teaching' cannot be understood if it is assumed to be the outcome of a stochastic event associated with the origin of our species.

Studying the emergence of such a complex phenomenon in our lineage represents a much broader endeavour. From an archaeological perspective, this entails identifying learning strategies among human and non-human groups, understanding the situations in which they occur, evaluating their performance and creating frames of inference that may allow us to recognize and interpret their expression in the archaeological record. The application of such a heuristic tool to behavioural patterns implicit in artefacts produced and used by hominins during the last three

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million years may allow us to identify trends in the way knowledge transmission changed through time and detect the key moments in which members of our lineage complemented pre-existing transmission strategies with those that led our species to develop cumulative culture and eventually 'teaching' as we know it.

Archaeologists have long been puzzled by stability in material culture over long spans of time, often referred to as an archaeological 'tradition', which represents the transmission of information and behaviours with a degree of fidelity that has no modern-day equivalent. However, it has not been until recently that we witness an interest in understanding how in some cases such fidelity can be maintained and, in others, can lead to shifts in material culture. Following Cavalli-Sforza and Feldman's seminal work (1981), researchers have intensively theorized about the mechanisms of cultural transmission in human societies (e.g. Boyd & Richerson 1985; 1996; Shennan 2002). However, this research was not primarily concerned with the potential variety of 'teaching' practices and cognitive settings that may have served to transmit cultural content between individuals. Information pertaining to those settings has come from work in the fields of primatology, comparative psychology and ethology with the goal of documenting how human and non-human species acquire knowledge and skills in social contexts (Tomasello 1994; Whiten *et al.* 2009a; 2009b). Recent work (Hoppitt *et al.* 2012) has created a method to formalize and analyse different learning processes that underpin inter-generational knowledge transfer in wild animal populations (their focus was on wild meerkats) and that theoretically can be applied to other species in natural settings.

Ethnographic and ethnoarchaeological studies have also contributed, particularly through the application of the *chaîne opératoire* concept (Lemonnier 1986; Leroi-Gourhan 1964; Sellet 1993), to our understanding of how skills and knowledge are transferred between individuals in non-industrial societies (Roux & Bril 2005; Roux *et al.* 1995). Detailed analyses of rare, high-resolution archaeological site components have been integrated with experimental studies and spatial analyses to infer learning processes at work in the late Upper Palaeolithic of Western Europe (Pigeot 1987). Recently, a more theoretical attempt has been made to formalize the steps through which apprentice flint-knappers might pass in order to acquire the skills necessary to produce finished artefacts that conform to lithic technical traditions (Tostevin 2012).

By building on concepts such as emulation, imitation and 'formal teaching', a number of recent studies have tried to create explicit theoretical frameworks with which one can identify the importance of each of these learning mechanisms in past cultural transmission and build predictive models to establish which archaeological outcome one might expect by the predominant use of a particular transmission process or combination of processes (see Tehrani & Riede 2008 for a synthesis).

Despite these valuable efforts, we still lack a comprehensive heuristic approach that might combine concepts and analytical tools from a variety of disciplines into an operational framework that can be used to identify and study all of the potential means and mechanisms of transmitting cultural information. Ideally such an approach must be applicable to non-human, ancient hominin, archaeological modern human, pre-industrial and industrial societies. Obviously, cultural transmission is not a simple business involving interactions and the transfer of information between two or more individuals. An effective approach must be able to take into account the various dimensions (spatial, temporal and social) in which such transmission occurs.

Our aim here is to explore how learning processes may function in each of these dimensions and use the resulting situations to build a tentative framework, which may guide our interpretation of the archaeological record and ultimately aid our identification of the learning processes at work in animal and past hominin societies. We also aim to test the pertinence of this heuristic approach by applying it to a handful of archaeological case studies.

Spatial dimension

This dimension explores the possible forms that interactions may take between a practitioner and a learner (or novice) during the transmission of knowledge. We define a practitioner as the individual (or individuals) who possesses a certain body of knowledge and uses that knowledge to perform a task that has the purpose of reaching or attaining a specific goal. Such a task may take the form of a physical action, or sequence of actions, and/or some type of knowledge transfer via communication (gestural, verbal, etc.).

We envisage eight situations in which such interactions may take place within differing spatial frameworks (Fig. 1). The first, which we term **distant observation**, entails the learner observing a practitioner's actions from a distance that cannot be considered as close proximity. In this situation, the practitioner has no intention to transmit information to the observer, and one can even conceive of instances in which the practitioner has no willingness to transmit information and thus attempts to mask or conceal his/her

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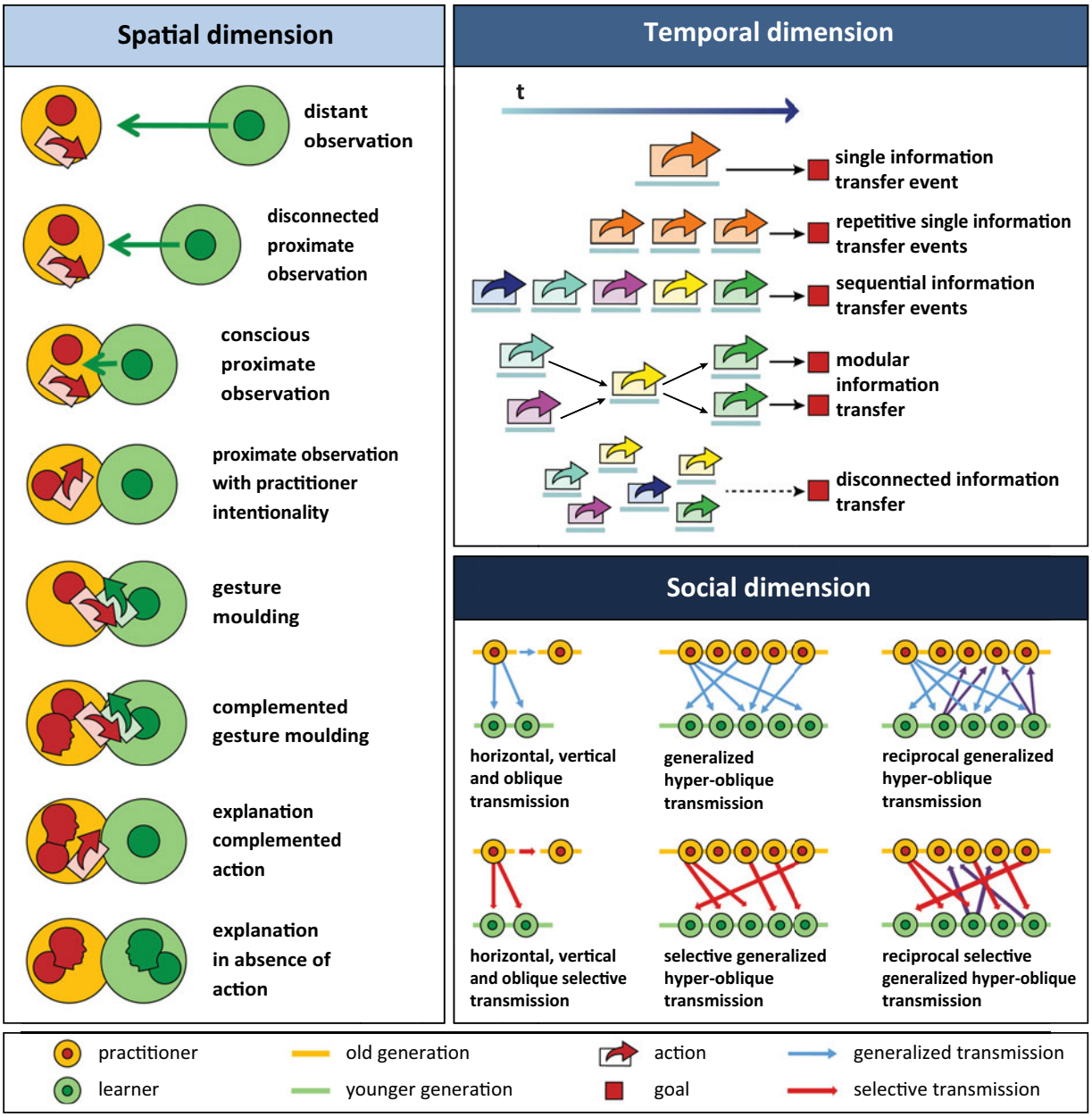


Figure 1. *Diagram illustrating the different dimensions and situations in which information transfer may occur in both human and non-human contexts (see text for details).*

actions. In another scenario, **disconnected proximate observation**, the practitioner accepts the proximate presence of the observer and is not concerned with the fact that the observer is there and wishes to learn. In the case of **conscious proximate observation**, the practitioner is also aware of the observer's presence and accepts this proximity, but knows, or has some indication, that the observer is there to acquire knowledge necessary to perform the same task on their own. In other words, the practitioner sees the observer as a learner or a potential learner. Next, we envisage a scenario, **proximate observation with practitioner intentionality**, in which the task and its actions are intentionally performed in such a way, for example by slowing down gestures, that the learner may more effectively register information in a way that would facilitate its acquisition and later use. This strategy may come at a certain cost, since in slowing down some or all gestures the efficacy of certain actions is potentially reduced because the focus has been partially shifted

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from that of completing a task to that of transmitting how to accomplish it. **Gesture moulding** describes instances in which the practitioner, through physical contact, guides the actions of the learner so that the two of them together are performing the action(s). Thus, the learner is able to integrate the *know-how* via direct and shared experience. In **complemented gesture moulding** the previous scenario is accompanied with positive or negative non-verbal feedback on the part of the practitioner. With **explanation-complemented action**, the practitioner complements his/her actions, or representations of these actions (e.g., mimicking, drawing, etc.), with verbal explanations (or in situations that involved the use of a proto-language, modes of verbal expression that served to provide positive or negative feedback) allowing the learner to understand better the mode and sequence of the actions, as well as, possibly, the goals behind them. In the final scenario, knowledge is only transmitted either verbally, with a coded representation of the spoken language (e.g. written text), or via other coded forms of communication (e.g. mathematical formulas, computational script, etc.) in the absence of any physical actions; we term this **explanation in absence of action**.

Each of these scenarios holds different potentials for the use of emulation or imitation as the means with which an observer or learner can accomplish a specific task and associated goal on their own. For instance, in the case of **distant observation**, not being able necessarily to identify and break down all the skills and actions involved in the given task, the observer would be more limited to emulation rather than imitation (*sensu* Whiten) when attempting to accomplish that task on their own. Imitation only becomes possible in situations in which the observer/learner is in closer proximity to the practitioner and even more so when the practitioner plays an active role in providing the potential for actions to be perfectly duplicated by the learner. Thus, imitation has the potential to become more accurate as one moves from **disconnected proximate observation** to either **complemented gesture moulding** or **explanation-complemented action**, depending on whether the know-how necessary to accomplish the task is oriented more towards gestures or conceptually oriented actions, respectively. **Explanation in absence of action** represents a special case, in that imitation can be severely compromised when the task is comprised of a sequence, or sequences, of complex gestures. It follows, then, that strictly explanatory teaching strategies, generally considered as among the more significant achievements of *sapient* cognition, may not necessarily have led to the long-term maintenance of many key technical innovations that were an inherent part of subsistence strategies of a large number of pre-industrial cultural traditions.

Temporal dimension

Learning takes time, and any attempt to model learning processes should consider this dimension (Fig. 1). Knowledge necessary to accomplish a task may be transferred to a learner in a **single information transfer event** or session. This does not imply that the learner may be able subsequently to accomplish the task perfectly, but he/she nonetheless has acquired all of the knowledge necessary to increase his/her skill progressively through repetitive trial and error. The acquisition of knowledge needed to accomplish a certain task may be of such a complexity that multiple or **repetitive single information transfer events** are required. A more complex situation is represented by instances in which reaching an ultimate goal entails learning how to accomplish a number of different, potentially complex, tasks that must be performed in a given sequence, and we term this scenario **sequential information transfer events**. Some behavioural adaptations incorporate tasks that are used by different but intertwined *chaînes opératoires*. In such situations, the know-how required to accomplish a task represents a 'module', the acquisition of which, at a given moment in time, will be instrumental to accomplish a comparable task at a different point in time and to reach a different goal. Such **modular information transfer** is key in the acquisition and maintenance of complex cumulative culture, in that the most complex of goals can only be reached when multiple modules are acquired and combined. It should be pointed out that each module may be learned or acquired in an order that does not follow the actual sequence of tasks necessary to reach the final goal (e.g. learning how to make a mastic to haft a projectile point before learning how to manufacture the point itself). The temporal dimension becomes even more significant, from both cognitive and social standpoints, when any of the above teaching scenarios is accomplished with the awareness that the task, or tasks, at hand will need to be carried out to reach a goal at some future point(s) in time (e.g. in coming days, months, years, or even an as yet undetermined future point in time) by the learner. We term this **disconnected information transfer**.

Social dimension

Already in earlier attempts to describe and model the transfer of information across generations, distinctions have been drawn between **horizontal transmission** describing transfers that take place between

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individuals of the same generation, **vertical transmission**, in which information is passed directly from parent to offspring, and **oblique transmission**, which describes the transfer of knowledge to someone of a younger generation by any member of an older generation (Cavalli-Sforza & Feldman 1981). Building on this and later attempts (e.g., Boyd & Richerson 1985; Shennan 2002) we envisage a number of situations that may be observed in the field or inferred, to some extent, by material culture remains recovered from the archaeological record (Fig. 1). We would argue that within oblique transmission one can potentially differentiate between different modes of cultural transfer. The first is small-scale **oblique transmission**, in which information is passed to the novice by individuals that are closely related, genetically or socially, to the novice's parents. A more complex form, which we term **generalized hyper-oblique transmission**, describes situations in which all members of a group belonging to a single generation can pass information on to any member of the younger generation. This closely corresponds to the definition put forth by Cavalli-Sforza and Feldman (1981). Such generalized forms are instrumental in cultural systems that rely on a high degree of transmission fidelity and social cohesion. This may take an extreme form in contexts in which the individuals are completely surrounded by complex, culturally determined and culturally maintained environments that continually reinforce an individual's feeling of belonging to that culture. We term this situation, which became common in historically known complex societies, redundant **generalized hyper-oblique transmission**.

Information transfer can also be **selective** in nature, with respect to the learner. This may concern horizontal (e.g. sharing knowledge only with particular peers), vertical (e.g. a parent transmitting knowledge to the first-born child, or to children of a specific gender), as well as oblique transmission (e.g. a shaman passing his/her knowledge onto a chosen and unrelated member of a younger generation). **Selective vertical transmission** is not only dependent on the number and gender of descendants, but is also influenced by the parent-teacher's expertise or body of knowledge. By allowing the transmission and maintenance of knowledge to specific learners, **selective generalized hyper-oblique transmission** potentially allows for greater degrees of social complexity to exist (e.g. the creation of a social class consisting of 'priests' or religious experts, craftsman, warriors, etc.). Finally, we envisage the case of reciprocal transmission, which entails the transfer of new knowledge (e.g. innovations) from learners back to teachers within a short span of time (less than a single generation). This happens in cases in which the learners act in contexts that permit them to use what they have learned in order to develop novel ideas or behaviours that, once transmitted back to the older generation, play a role in that generation's decision-making. Arguably, this is something that can only occur in the context of selective hyper-oblique transmission in which some learners acquire specialized expertise. In theory, this situation could exist in a number of cultural contexts, but one must wonder whether **reciprocal selective generalized hyper-oblique transmission** was present prior to the emergence of industrial or even post-industrial societies.

Methods for inferring past learning scenarios

Inferring which of the above described scenarios was at work in past human and non-human groups is not straightforward and requires the integration of methods from a variety of research fields. Archaeology, ethnoarchaeology and human and animal ethology are clearly the most appropriate disciplines, when used in combination, to acquire the data necessary to infer past teaching scenarios. Experimental archaeology and technological studies (e.g. reconstruction of past *chaînes opératoires*) can identify behavioural patterns preserved in material culture remains and evaluate their level of correspondence to the various scenarios envisioned above. Comparisons of such results with field observations made on human and non-human actors allow for the verification, to varying degrees, of inferences derived from archaeological analyses.

Discerning past teaching strategies

It has been effectively demonstrated that results obtained from studies of primate ethology and archaeology (Haslam *et al.* 2009) can serve to make inferences pertaining to early hominin tool use. Such observations can also be used to infer how the information behind such behaviours may have been transferred between past individuals and correspond to one or multiple scenarios described above. However, our ability to infer potential teaching/learning strategies improves greatly with the appearance of the Oldowan stone tool industry. Recent discoveries have shown that, since its beginning, the Oldowan encompassed a variety of knapping strategies certainly requiring different modes of information transfer. At Lokalalei, Roche *et al.* (1999) and Delagnes and Roche (2005) performed refitting analyses to demonstrate that, at 2.34 million years ago, cores were reduced with an organized reduction strategy that relied upon foresight and planning and, equally as important, allowed cores

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to be maintained through the correction of knapping errors. They also demonstrate that a fine-grained raw material was selected for the use of this relatively advanced Oldowan knapping strategy. Furthermore, relatively coeval and neighbouring sites have revealed Oldowan industries that display less complex knapping strategies. This suggests that a variety of teaching/learning scenarios were already at work when the first stone-tool industries appear in the archaeological record. While disconnected proximate observation may be sufficient to acquire the skills necessary to knap the most simple Oldowan tools, those recovered at Lokalalei most likely involved 'complemented gesture moulding', at the very least and, in all likelihood, 'explanation-complemented action', as recently suggested by Morgan *et al.* (2015). From a temporal standpoint, simple Oldowan technology could have been acquired via 'single event communication' followed by subsequent trial and error. It may instead be argued that the *chaîne opératoire* observed at Lokalalei likely relied upon, at a minimum, 'sequential information transfer' in order to be fully integrated and used. As for the social dimension, the teaching/learning process needed to master this *chaîne opératoire* may have taken place through vertical or even perhaps oblique transmission. It is reasonable to assume that transmission was not selective in nature.

A technological adaptation observed in the African hominin record somewhat later in time (*c.* 1.8–1.0 million years ago) is the use of weathered bone fragments and horn cores as digging tools to extract termites from their mounds, most likely by *Australopithicus robustus* populations (Backwell & d'Errico 2001; d'Errico & Backwell 2003; Lesnik 2011). Some of these tools, particularly those made from horn cores, exhibit signs of having been modified at their tip through grinding in order to enhance their capability to penetrate termite mounds. Furthermore, the use wear observed on many of these tools indicates that they were used repetitively and most likely curated. Conscious proximate observation, perhaps complemented with practitioner intentionality, would likely have been sufficient to transmit the technological know-how necessary to procure the appropriate bone blanks and modify, use and re-sharpen such tools. Single information transfer events are likely sufficient for acquiring knowledge about the basic use of such tools. However, repetitive single information events, and perhaps even sequential information transfer events, may have been needed for an individual to observe, understand and learn all the potential manufacturing, use and eventual modification procedures included within such tools' complete *chaîne opératoire*. Vertical transmission is likely to have been involved in the teaching/learning of this technological adaptation, but the fact that such knowledge can be obtained through disconnected proximate observation makes it probable that oblique transmission processes could have been at work.

Moving to more recent and complex material culture remains, what types of inferences can we make with respect to teaching/learning settings? Based on detailed analyses of Aurignacian and early Upper Palaeolithic personal ornaments, it has been proposed that such assemblages are regionally differentiated and likely reflect distinct ethno-linguistic traditions associated with the early presence of anatomically modern humans in Europe (Vanhaeren & d'Errico 2006). Such a complex pattern, consisting of some personal ornaments being unique to distinct regional populations and other ornament types shared between neighbouring populations, can only be maintained through time in contexts characterized by cultural transmission mechanisms governed by explanation in absence of action. One could also argue that we are witnessing a complex array of technical competences (different acquisition strategies dependent on raw material types, complementary techniques necessary for modifying a variety of raw material types, etc.) that can only be acquired, from a temporal standpoint, via modular and disconnected information transfer. Socially, we are most likely, at a minimum, in a situation of generalized hyper-oblique transmission. Selective hyper-oblique transmission can be argued when considering that many types of Aurignacian carvings used as ornaments, for example those made from ivory and found in the Swabian Jura (Conard 2003; 2009), require an expertise likely to have been restricted to specialized 'craftsmen', meaning that only certain individuals had the knowledge needed to produce such items and share that information with select members of a younger generation.

Conclusions

When viewed from an evolutionary perspective, teaching appears as a vague concept that may serve to obscure the complex processes and variety of teaching/learning strategies that led some members of our lineage to develop particularly effective means for transmitting, maintaining and even expanding knowledge across generations. We do not consider what we have presented here to be the last 'lesson' on the subject of teaching. Furthermore, there is always a danger with comprehensive classification systems that some categories may not exist in real world. Future studies will need to evaluate the system that we propose here with detailed ethnographic examples in

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order to fine tune our inferential framework (see, for example, Lombard's paper in this volume). Such 'in the field' testing of our proposed inferential framework can serve to make interpretations of the archaeological record more pertinent and help us to understand better the cognitive and teaching implications of each case. Clearly, there exists a great deal of work that remains to be done. Nevertheless, our attempt, and those similar to it, may be instrumental when it comes to constructing evolutionary perspectives on teaching that rely on material culture recovered from archaeological contexts. Admittedly, we may be confronted with archaeological records that might be ambiguous and thus fit within more than one of the described scenarios or be situated somewhat in between them.

The proposed framework may, however, be useful for evaluating such cases, in that it can help guide their interpretation and eventually lead to refinements of the theoretical approach itself. Through a process of gradual improvement, this framework will become more effective for interpreting archaeological situations. Once such a stage is reached, our improved ability to infer past 'teaching' strategies may identify long-term trends in their evolution and perhaps even instances in which major behavioural thresholds were crossed.

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