This is the published version of a paper published in *Childhood in the Past: An International Journal*.

Citation for the original published paper (version of record):

Children, Teaching and the Evolution of Humankind.
*Childhood in the Past: An International Journal*, 8(2): 113-121
http://dx.doi.org/10.1179/1758571615Z.00000000033

Access to the published version may require subscription.

N.B. When citing this work, cite the original published paper.

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Social learning is essential for human evolution. To achieve such learning, cultural processes which trigger the development of active teaching and intergenerational transmission and accumulation of knowledge are needed. The understanding of how such systems and processes were developed over a long time is essential for our understanding of human evolution. The identification of children’s learning activities in the archaeological record is crucial for how we may develop this understanding.

KEYWORDS children, teaching, learning, stone tools

Introduction

Teaching and social learning are important in hominin evolution. Fogarty et al. (2011: 2768) emphasize that in comparison with other animals, human cooperation is distinctively extensive as a result of cumulative culture. Such cooperation may be uniquely reliant on an important mechanism – the human ability to teach our children – that is less frequently observed in other species. In this article we proceed from the simple fact that the way children have learned and been taught during millions of years has had a direct impact on how we act and think as humans. From a theoretical background of how teaching changes the human brain in a long-term perspective, we exemplify by analysing the learning and teaching of early stone tool
technology. We conclude that the identification of children and their teaching and learning events in the archaeological record is crucial for how human evolution is to be understood.

Each Generation Changes the Brain of the Next

Recent research in neuropsychology has clearly shown that genetic influences on behaviour are not something fixed and predetermined from birth. Genetic and environmental influences on behaviour are inextricable (Solms and Turnbull, 2002) and work in dynamic interaction with regard to the way that the mind evolves. The human mind cannot come into existence on its own. It is wedded to a collective process, and filtered through culture and the social environment (Donald, 1991, 2012; Gamble et al., 2014). How intimate the link between genetic and environmental influences is varies for particular periods in the developmental process. The years up to about twenty are particularly crucial for how the behavioural parts of the brain develop (Wasserman and Zambo, 2013).

This means that behaviour must be seen as something that emerges gradually from early infancy onwards, not in a linear and irreversible evolutionary development by leaps, but as a behavioural development shaped in social interaction between nature and nurture. Sterelny has described this as a ‘positive feedback loop’ between social complexity and individual cognitive capacity (2012: 8). It is an interaction based on the brain’s genetic ability to be shaped behaviourally by the environment and its increased complexity in relation to social interactions. As long as the complexity is maintained, the brain’s behavioural functions develop, and as long as the brain is stimulated in this respect, there is also a potential for the complexity of the behaviour in the surrounding environment to be maintained and extended (Solms and Turnbull, 2002). A consequence of this reasoning is that if the interaction between the brain’s behavioural functions and the environment changes, the complexity of behaviour can also change. By changing the social environment, each generation changes the brains of the next (Mithen and Parsons, 2008).

Hence, brain-culture co-evolution postulates an evolutionary feedback loop between culture and mind that triggers human cognitive evolution. As Donald has written:

Culture changes the mind, and vice versa. Both sides of this interaction affect selection pressure and influence the direction of evolution. Because culture is unpredictable, and accumulates new knowledge rapidly at the group level, this co-evolutionary scenario would select for greater plasticity and improved learning capacity [...] a co-evolutionary process tethered neural epigenesis to culture, and made the human brain subject to radical functional reorganization by cultural forces. (Donald, 2012: 272)

One way this is constituted is by the transmission of knowledge and know-how between generations (Dean et al., 2012). The processes of learning and teaching through verbal instructions, gestures and imitations, matching the actions of others and facilitating learning in others, together with pro-social acts of feedback, are unique characteristics for human social exercise (Gärdenfors, 2003).
Consequently, studying children is important. They are and have for a long time in human evolution been the ones that learn and are taught. And if brain-culture co-evolution in the long term is what made *Homo* what it is today, childhood and children as learners must be seen as important driving forces in evolution (see Nowell, 2010; this issue, for discussion). In this sense it is not just what children have done during prehistory, but childhood itself that has been fundamental to the development of the human mind as we understand it today (Nielsen, 2012).

**Teaching Someone to Learn to Make Stone Tools**

The analogy between sign and tool (cognitive technologies) is well established within archaeology (Hodder, 1982). Vygotsky argued that tools are ‘outer directed’, transforming the ‘outer world’, while signs are ‘inner directed’, transforming mind and behaviour (Vygotsky, 1962). Still a pabulum, this dualism of mind and matter is theoretically questionable. Tools materialize intentionality and are in a broad sense cognitive (Miller, 1998), and social life and culture (cognition) are asymmetrically entangled with tools (Latour, 2007). Hence, tool making consists of complex knowledge and know-how systems, embedded in social networks of teaching and learning practices (Donald, 2012). To be taught how to make tools is a way to understand the world.

A central empirical question is what archaeological evidence can support different levels of teaching in the hominin line. If we assume that evolution goes hand in hand with some form of change in the production of synapses and maturing brain structures, i.e. brain-culture co-evolution (Donald, 2012; Solms and Turnbull, 2002), then it is essential to study material evidence from social life, such as lithic technological teaching and learning processes and intergenerational transmission of knowledge (Read and van der Leeuw, 2008). The archaeological record with stone tool production known from c. 2.6 million years ago and throughout the whole Stone Age makes up an outstanding database for the study of the evolution of social learning (Roux and Bril, 2005). From this database it is possible to identify and analyse archaeological contexts relevant for the study of teaching and learning. Here we exemplify this by using examples from ape and early human tool use (see Haidle, 2010 for discussion).

**Pre-Homo Hominid and Oldowan Tool Making**

Even if apes in captivity have learned to knap stone from human teachers, they have never been observed to do it in the wild (Whiten et al., 2009). What has been observed is apes using a hammer stone and a stone anvil to crack nuts open. Excavations at chimpanzee nut cracking sites show that hammer stones and anvils were handled by some individuals as tool-kits and that a site can be used recurrently over long periods of time (Carvalho et al., 2008). This suggests that nut cracking was transmitted by social learning from one generation to the next (Fragaszy et al., 2013; Wynn et al., 2011).

The question is what kind of teaching this involves. For a young chimpanzee to learn tool use in nut cracking, it must observe how members of the group select
suitable stones and how they place them in an action setting. The young chimpanzee must also watch other individuals when they work and experiment with holding position and ways to move the arm holding the hammer. A demonstrator facilitates the nut cracking site for the learner and makes the learner understand that it is a site where nuts are cracked recurrently.

Nut-cracking can be learned by non-intentional teaching as emulation, i.e. the learner observes the outcomes of the model’s actions and tries to reach the same outcome (Tomasello, 1999), and facilitation, for example by the demonstrator providing a working space. No intentional teaching is necessary, i.e. teaching with the goal that the teacher act in a way that the learner understand that here is something to learn and that the teacher understands that the learner does not know something and needs to be taught (Gärdenfors, 2003). The data presented here come from studies of modern Pan sites. Several researchers have postulated that the patterns of tool use equals a pre-

Oldowan is the earliest known stone tool industry. It is associated with Homo habilis and early Homo erectus, but other hominin species might have been involved in the creation and use of this industry as well (Plummer, 2004). The knowledge needed to master this technology is limited to two techniques: knapping with a hammer stone using direct percussion or bipolar percussion with an anvil; and a few methods: raw material acquisition, finding a place to knap, splitting up a nodule, detaching a flake, twisting the core to detach another flake and repeat twisting the core and detaching a flake until the core is exhausted (Stout et al., 2009).

But although the range of techniques and methods needed is limited, the Oldowan technology required an interrelated set-up of raw material choice, controlled flake detachment, maintenance of platform angles and core adjustments (Morgan et al., 2015). To understand this set-up, teaching is required. It involves social learning that includes where to find and how to use suitable rock types for the core and the hammer stones. This can be learned by the learner copying what others do and the demonstrator approving or disapproving what the learner does. Methods to produce what is needed, e.g. using a hammer stone to apply proper force to the platform and recognizing a suitable platform after splitting up a nodule by rotating the stone, may be learned through imitation, i.e. the learner observes the sequence of the model’s actions and tries to perform the same actions (Tomasello, 1999). How to maintain the core within a reduction sequence of several flakes must also be learned. A teacher can intentionally convey this by drawing attention to something relevant, for example, pointing out a suitable area on the core to use as a striking platform. Intentional teaching may also be used when demonstrating a holding position of the core or the movement of the arm and hand holding a hammer stone when detaching a flake. The intentional teaching involved in learning Oldowan technology means that the teacher acts in such a way as to make learning easier by drawing attention to or demonstrating something, and that the learner understands that there is something to be learned.

Wynn et al. (2011) have argued that the Oldowan technology should not be defined as a new ‘proto-human technology’ (p. 195), but as a variation on an older technology. By this they mean that there is nothing unique about the technology in comparison with technologies used by apes:
Apes had been very successful and very varied for millions of years before the advent of flaked stone technology, and it is likely that several were tool-users. It is within this context that the Oldowan should be understood. (Wynn et al., 2011: 195)

Wynn et al. make a convincing argument when demonstrating archaic features in the Oldowan technology. But there are fundamental differences between Oldowan and apes using stone tools. In ape lithic tool use, a hammer stone is used to hit a nut that has been placed on another stone, an anvil. This means that a stone tool-kit is used to achieve an immediate result: a nut to eat. In Oldowan, a hammer stone is used to hit another stone, a core, to produce a tool (a flake or a core tool). This tool will subsequently be used for something, e.g. butchering (Lemorini et al., 2014,) and then create results: meat for food. The teaching involved in Oldowan stone technology needed to have been set up to facilitate this process of basic future planning (Osvath and Gärdenfors, 2005), which is not necessary for learning ape stone tool use.

By changing perspectives from the world of the adult stone tool user to children’s world of learning and being taught, one can illustrate differences involved not only in tool use but also in the way ape and Oldowan use stone tool technologies. Hominins can voluntarily self-direct and supervise the performance of learned skills, other primates cannot (Donald, 2012: 283).

Concluding Discussion

Evolutionary studies are significant for how human teaching and learning processes are apprehended (Pinker, 2002). But the way human evolution is understood has significantly changed in recent years. Thirty years ago, a consensus existed on how to explain the evolution of modern humans: the ‘Human Revolution’ was considered to have taken place approximately 150,000 years ago in East Africa, generating humans of behaviourally modern origin, who eventually dispersed and replaced Eurasian archaic humans. The ‘Upper Palaeolithic Revolution’ was considered to have taken place approximately 35,000 years ago, at the time when modern humans entered Europe and replaced the Neanderthals in a ‘survival of the fittest’ competition of adaptation (Mithen, 1996). With these explanations also followed understandings of human abilities in terms of teaching and social learning.

These ‘revolution paradigms’ are now out of date. Studies have shown that early modern humans evolved in sub-Saharan Africa >200,000 years ago (Mellars et al., 2007), that anatomical and behavioural modernity do not necessarily go hand in hand (Henshilwood and Marean, 2003), that modern humans and Neanderthals existed simultaneously >10,000 years in Europe (Higham et al., 2011), that modern behaviour, i.e. modern cognition shared by all Late Stone Age hunter-gatherers, is to be seen as developed by environmental and social processes among both archaic and modern humans and not as a species-specific attribute of modern humans (d’Errico, 2003; Shea, 2011; Zilhão, 2011), and that present-day non-sub-Saharan African humans have a percentage of their DNA that derives from the Neanderthal, indicating that modern and archaic humans interbred (Green et al., 2010).
Evidently, we know more today than we did thirty years ago. However, we do not know much about how to interpret this new knowledge. Few studies have been conducted that focus, in an interdisciplinary and global manner, on the essence of that which creates, maintains and develops modern behaviour, i.e. teaching and social learning and intergenerational transmission of knowledge. More research is needed. This is not a matter of research about new evolutionary models of strategies involved in cultural evolution (Morgan et al., 2012) but rather about when, where and how teaching and social learning came about, what artefacts and technologies were handled, how knowledge of these was preserved, transmitted and further developed in the form of innovations from one generation to another and what evolutionary consequences this has had (Akazawa and Kenichi, 2013; Dean et al., 2012).

Additionally, we do not know much about what consequences such a new evolutionary understanding of teaching and social learning will have for how we look upon present-day theories of education and learning processes. If the evolution of teaching and learning is understood in new ways, this will have an impact on how we interpret typical education and learning within ordinary schools, within special pedagogy as well as within learning processes for persons with non-typical cognitive abilities caused by, for example, handicap or trauma.

**Put Children in Focus**

To accomplish this, it is essential to study children and childhood. The way children have learned and been taught during millions of years has had a direct impact on how we as humans act and think (Nowell, 2010). *Homo sapiens* cannot avoid learning and teaching. We do it by reflex. Even young children have a natural capability to teach (Strauss et al., 2002). If the emergence of childhood as a life-history stage is foundational to the development of modern behaviour (Locke and Bogin, 2006), when did childhood become childhood? And how did learning evolve not just from learning something new, but also to the ability to develop what has been learned into new knowledge? And when did learning transform from a cumulative addition of information to the ability to reflect and balance what is at hand and what previously was learned and from this stake out a direction for the future, and act according to that?

To be able to elaborate on the perspectives presented here, archaeological studies on human evolution must learn to take infants’, children’s and adolescents’ learning and teaching experiences into account: What is meant by teaching, learning and knowing in various contexts and periods? What do we theoretically put into our interpretations of what teaching is? And what roles might teaching have had throughout the evolution of the *Homo* line?

For a learner to become a proficient stone tool knapper, a massive number of stones must have been shattered, generating huge amounts of waste. If we consider that a great number of learners have been knapping stone during every year since more than 2.5 million years ago up till very recently, the amount of waste generated in teaching and learning processes throughout prehistory is unimaginably large.

Hence, a reasonable suggestion is that a significant quantity of the lithic debris excavated by archaeologists at sites coming from Oldowan and onwards most
definitely was produced by children (Shea, 2006; Stapert, 2007). This suggests that an understanding of the role of children and childhood is not only essential for how we comprehend human evolution, but also essential for how children’s learning activities have formed the lithic assemblages we excavate. If we accept that children might be the creators of most of the debris at sites, then this ought to have a fundamental impact on the way we do lithic analysis and the significance we ascribe to typological methods we use to make sense of lithic assemblages. In accordance with Lillehammer (this issue): It is time to place the archaeological child at the heart of archaeology.

Acknowledgement

This research is funded by the Swedish Research Council (Dnr 721-2014-2100). Both authors also received funding and support from the Stellenbosch Institute for Advanced Study (STIAS) in the form of fellowships.

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**Notes on contributors**

Anders Högberg, Linnaeus University, Faculty of Arts and Humanities, School of Cultural Studies, Archaeology, SE-391 82 Kalmar, Sweden. Email: anders.hogberg@lnu.se; and Stellenbosch Institute for Advanced Study (STIAS), Wallenberg Research Centre at Stellenbosch University, Marais Street, Stellenbosch 7600, South Africa.

Peter Gärdenfors, Lund University, Cognitive Science, Department of Philosophy, S-221 00 Lund, Sweden. Email: Peter.Gardenfors@lucs.lu.se; and Stellenbosch Institute for Advanced Study (STIAS), Wallenberg Research Centre at Stellenbosch University, Marais Street, Stellenbosch 7600, South Africa.