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HUNTING AND HUNTING TECHNOLOGIES AS PROXY FOR TEACHING AND LEARNING DURING THE STONE AGE OF SOUTHERN AFRICA

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Abstract

Human hunting represents one of the most difficult foraging activities. It is a skill-intensive pursuit with an extended learning process. Different from other animals, Stone Age hunter-gatherers used complex strategies and technologies to outsmart and pursue their prey. Such strategies and technologies were grounded in extensive knowledge that facilitated context-specific solutions during different phases of weapon production and hunting. Apart from subsistence behaviour, Stone Age hunting technologies also inform on a suite of associated skills, behaviours and levels of cognition. At least since the start of the Holocene in southern Africa, and probably much earlier, behaviours associated with hunting permeated almost every sphere of hunter-gatherer life, and I argue that the theme is a suitable angle from which to explore broader aspects of the evolution of teaching and learning. I provide a brief overview and broad timeline of the 'evolution' of hunting technologies associated with the southern African Stone Age record and present some ethnographic hunter-gatherer examples of teaching and learning associated with hunting. The aim is to start situating the archaeological and ethnographic data within a theoretical framework of teaching and learning evolution.

Introduction

Human hunting has been described as "arguably one of the most difficult activities common to foraging peoples now and in the past" (Gurven et al. 2006, 454). Southern Africa is a region with a Stone Age record spanning ~2.5 million years. Well-developed foraging communities roamed the landscape from at least ~100,000 years ago, and signatures for increasingly complex behavioural systems are also more-or-less contemporaneous with fossil and DNA evidence that indicate the appearance of early anatomically modern *Homo sapiens* on the sub-continent (e.g., Lombard et al. 2013). Knowing how to hunt well would have had direct fitness consequences for such early hunter-gatherer groups. Our increased ability to reconstruct and understand Stone Age hunting technologies also informs on a suite of associated skills and behaviours including hafting technologies, weapon systems, and levels of complexity in cognition (e.g., Lombard & Haidle 2012; Wadley 2013; Williams et al. 2014). Through time, all of these ancient knowledge systems culminated into behavioural systems as observed in recent times, wherein human behaviours associated with hunting permeates almost every sphere of hunter-gatherer life. Realms of Kalahari hunter-gatherer behaviour with deeply embedded reference to hunting include, for example, child play, coming of age, sex and marriage, storytelling, myth and spirituality. I suggest that, because some hunting technologies and behaviours are relatively accurately traceable through deep time, because knowledge about hunting technologies transcends subsistence behaviour, and because we have a rich, local ethnographic hunter-gatherer record, the evolution of stone Age hunting in southern Africa is an ideal angle from which to explore aspects of the evolution of teaching and learning through time. Using what we know about the development of hunting technologies in southern Africa, we can also hypothesise about minimum time estimates for when certain teaching and learning behaviours were in place.

Evolution of Stone Age hunting technologies in southern Africa

Our hominin ancestors were fairly weak and vulnerable in a landscape filled with large and dangerous predators. We may thus assume that the first 'weapons' were not used for hunting, but for defence, perhaps wielding sticks or throwing stones at predators, or chasing co-scavengers from carcasses or water. Such behaviour is difficult to trace in the archaeological record, but primates have been observed to throw objects (Boesch & Boesch 1990; Osvath 2009), and the ability to throw with precision and force came early in our evolution with the hand of *Australopithecus afarensis* already adequately adapted to this function by ~4-3 million years ago (e.g., Isaac 1987). In human evolution such an ability was probably pivotal in subsistence behaviour and in fighting, shifting the emphasis from brute force to skill, and encouraging the brain to cope with three-dimensional objects in relation to space in an exacting manner, pre-adapting it for increasingly complex functions (e.g., Darlington 1975).

Stone tool butchery marks on faunal remains from Afar Rift, Ethiopia, with age estimations of 2.6-2.5 million years ago, have been suggested to represent "the earliest evidence of hominid meat-eating and, by extension, hunting" (Pickering & Domínguez-Rodrigo 2010, 107). A more parsimonious interpretation is probably that the tools were used for scavenging, because direct evidence for hunting at the time remains elusive. Recently, it was suggested that stone points, possibly hafted and used for spear hunting, could date to ~500,000 years ago at Kathu Pan, South Africa (Wilkins et al. 2012), but the interpretation has been questioned (Rots & Plisson 2014). Also, because of the geomorphology of the site, the context of the artefacts needs further verification and similar tools from other sites should be dated to a similar age before the results can be accepted as a wholesale age for stone-tipped spear hunting. Across sub-Saharan Africa, Middle Stone Age points are firmly contextualised from

~300,000 years ago, and some have traces of being used to tip hunting spears or javelins, for example the stone points from Gademotta, Ethiopia, at ~279,000 years ago (Sahle et al. 2013). This age for hunting with weaponry is consistent with that of the Shöningen spear from Germany, which is clearly associated with hunting and with *Homo heidelbergensis* (Thieme 1997).

There is direct evidence that by ~100,000 years ago, *Homo sapiens* were hunting large, dangerous game with stone-tipped spears at Klasies River, South Africa (Milo 1998). From ~77,000-70,000 years ago people produced a range of stone points, currently lumped under the Still Bay technocomplex, but with clear stylistic variation. Use-traces on Still Bay points show that whereas some were used to tip spears, others could have been hafted as knives (e.g., Lombard 2006). From at least 70,000 years ago hafting technologies that included ochre-loaded, compound adhesives were used at Sibudu Cave, South Africa, and Lyn Wadley suggested that:

> "It is difficult to imagine how the expert glue maker could train an apprentice to make compound adhesives without explaining, in abstract terms, attributes and conditions such as stickiness, viscosity, workability, consistence, plasticity, texture, particle size, temperature, concretization, water solubility, hydroscopic, dehydration, reversible process, irreversible process, shrinkage, homogeneity, creep, and shrinkage. The concept of the irreversible transformation had to be explained using language as we understand it, for example, incorporating recursion, abstraction, and words to describe both the past and the future" (Wadley 2010a, S116).

At the same time and at the same site, there is circumstantial evidence that people were using snares to acquire meat (Wadley 2010b). The concept of harnessing the latent energy in a bent branch, and the ability to manufacture rope with adequate tensile strength, such as that used in the setting of snares, probably lead to the innovation of the hunting bow in southern Africa (Lombard & Phillipson 2010) (Fig. 1). This invention is, arguably, one of the most important technological inventions in our human history – 'a machine that changed the world' (Denny 2007; Barham 2013). Evidence for bow hunting, with bone- and stone-tipped arrows, has been traced back to more than 60,000 years ago at Sibudu and Umhlatuzana in KwaZulu-Natal, South Africa (Backwell et al. 2008; Wadley & Mohapi 2008; Lombard & Phillipson 2010; Bradfield & Lombard 2011; Lombard 2011) (Fig. 2). A more tentative indication for bow hunting could be the bladelet technology from Pinnacle Point 5-6 on the south coast of South Africa dating to ~71,000 (Brown et al. 2012), but no corroborating use-trace studies have been reported for these artefacts. The knowledge of how to produce 'super glue', together with the variable use of small geometric stone tools, such as those probably used to tip arrows, imply a cognitive ability for mental rotation and a flexible way of thinking about objects at more than 60,000 years ago (Wadley et al. 2009). Some of the larger geometric stone pieces could have been used as spear insets (Lombard 2008; 2011), and, at the same time, small quartz points from Sibudu Cave were also used for hunting (de la Peňa et al. 2013), providing hunters with an array of weaponry to choose from – not unlike recent hunter-gatherers of the Kalahari. The diversity of hunting weapons implied by Sibudu's backed stone tools, a possible bone arrowhead, the quartz bifacial points, and circumstantial evidence for snares, suggests a range of weaponry design more than 60,000 years ago not recorded for earlier industries (de la Peňa et al. 2013).

Between ~58,000-40,000 years ago, there seems to be a ‘gap’ in human behaviour, but this is perhaps more an artefact of research focus than past reality. Nonetheless, based on current data, people apparently ‘revert back’ to stone-tipped spear hunting. Yet, this behavioural trend does not automatically imply ‘non-modern’ minds, instead it might reflect shifts in environmental adaptation and demography (e.g., Lombard & Parsons 2010; see Riede 2010 for European example), and a wider range of hunting technologies for this period probably remains to be discovered. Generating archaeological evidence for hunting strategies, such as snaring and bow hunting, is difficult and time-consuming, requiring long-term research attention and exceptional preservation conditions (e.g., Wadley 2010b; Lombard 2011), aspects thus far lacking for the period in question. Recent examples of organic arrow tips, that might not preserve over time include those made of wood (e.g., Lebzelter 1996), or porcupine quill (Fig 2). Experimental work also shows that wooden arrows perform as well as those tipped with stone (e.g., Waguespack 2009), so that the current lack of stone or bone arrow tips cannot be considered as evidence for the absence of bow hunting.

From ~40,000-35,000 years ago bone points from sites such as Border Cave, South Africa, and White Paintings Shelter, Botswana, closely resemble recent hunter-gatherer arrow tips (d’Errico et al. 2012; Robbins et al. 2012). It has also been suggested that a ‘poison stick’ from Border Cave of ~24,000 years old, on which traces of possible ricin poison were detected, currently indicates the oldest evidence for hunting with poisoned arrows in the Stone Age (d’Errico et al. 2012). From ~18,000 years ago, assemblages across southern Africa trend towards small, blade-based technologies generally associated with stone-tipped bow hunting across the globe. Wooden arrow shafts and bone arrow points dating to 7610±110 BP were excavated at Pomongwe Cave, Zimbabwe (Cooke 1963, 1975), and reed arrow shaft fragments from Melkhout Boom Cave, South Africa, originate from contexts with dates of 6980±65 BP (Pta-668) and 5900±90 BP (Pta-680) (Deacon 1976). A single, perfectly preserved, transversely hafted, stone-tipped arrowhead, dating to 1760 ± 50 BP (Pta-6418), was excavated by Johan Binneman (1994) at Adam’s Kranz Cave, Eastern Cape, South Africa (Fig. 2). This artefact represents what is accepted as run-of-the-mill hunting equipment for the Holocene in southern Africa, and was probably in use until the introduction of iron.

Hunting and hunting technologies as proxy for aspects of teaching and learning

When considering the evolution of teaching behaviour, it is suggested that ‘teaching’ should be reserved for the transfer of skills **and** the transfer of concepts, rules and strategies that allows the ‘learner’ to solve problems in multiple situations and in multiple ways (Leadbeater et al. 2006). Such an inclusive characterisation of human teaching and learning that insists on the interplay between skills, concepts, rules and strategies does not only impart knowledge, it also facilitates creative problem solving, and provides the scaffolding for reorganising and playing with ideas until they produce an unexpected outcome (Dehaene 2005). Thus far, the outcomes of non-human animal teaching and learning seem to seldom result in novel activities or innovative applications of knowledge and technologies across generations. Thus, the strategy of interplay between taught and learned elements, and subsequently playing with these elements creatively, is probably uniquely human, and I propose that the evolution of, and variation in hunting technologies in southern Africa demonstrates these criteria at least from ~77,000 years ago.

To actively teach, we first need theory of mind, and then the intention to teach. We, therefore, need to recognise a knowledge gap in another person, and understand how and when best to fill that gap (e.g., Strauss 2005). Skill teaching and learning seems to be facilitated, in part, by mirror neurons (neurologically ‘storing’ observations regarding the physical actions of others enabling the learner to imitate them). But, unlike primates, humans are able to further describe both the goal of an action, and the movements necessary to achieve it, by using language (Rizzolatti 2005). Human language produced a fundamental shift in our cognitive environment, so that no other animal is able to teach as we do. Amongst us, concepts can be introduced by definition, avoiding overexposure to real-life experiences or concrete examples (Battro 2010). Such a strategy dramatically cuts down on learning time, and would have had direct fitness consequences for Stone Age hunter-gatherer groups.

All known chimpanzee populations have been observed to hunt small mammals for meat (mostly without weapons). Amongst those with the highest levels of cooperation and meat-sharing behaviour, the hunting and sharing roles require elaborate coordination with other hunters (Boesch 2010). Learning these roles takes long. Taï chimpanzees begin hunting monkeys at about 10 years old. But, chimpanzees of 20-25 years of age remain uncertain about their predictions, and fully grown males still learn the elaborate hunting and sharing roles (Boesch 2010). This lengthy learning period is also evident in hunter-gatherers, endorsing the challenge that human foraging and hunting represents (Boesch 2010). High levels of knowledge, skill, coordination, and strength are required to exploit the suite of high-quality, difficult-to-acquire resources that humans consume. Thus, reaching the necessary levels in skill and technology production requires time, energy and a strong commitment (Kaplan et al. 2000). Phases of learning may ratchet with times in a person’s life based on levels of cognition, growth and strength, leading to the long-term, punctuated development of skills (MacDonald 2007). This extended learning phase, during which productivity is low, is compensated for by higher productivity during the adult phase and an inter-generational flow of food from old to young (Kaplan et al. 2000).

Complex imitation and teaching may be more common in humans than in other animals, and language makes social learning easier and quicker (Blurton Jones & Marlowe 2002). Motor procedures, however, tend to be learned primarily through relatively time-consuming processes of imitation, demonstration, and repeated practice (Gibson 1999). Most hunter-gatherer children start gaining experience in using hunting weapons at a young age. In many cases, adults or older children provide hunting tools for the young ones to play with. These weapons are often scaled-down versions from those of adults. Larger, more powerful versions are provided as the children grow older (MacDonald 2007). In Kalahari hunting communities, parents, grandparents, other adults in the group and/or older children will occasionally teach toddlers how to shoot the bow and arrow through demonstration and explanation. But most skill is gained through play-hunting in and around the camp. From as early as three, a boy plays with a little bow, shooting at still targets or dung beetles and grasshoppers. As he grows older, he will hunt lizards, mice and small birds, studying their behaviour and gaining experience in stalking for hunting large animals (e.g., Liebenberg 1990). These frequent teaching, learning and imitation activities continue throughout childhood (MacDonald 2007).

The young thus acquire hunting skills without being ‘on the job’ or exposed to its dangers. This behaviour keeps children safe, and hunting parties unencumbered with their safety, until they are able to contribute effectively. Kalahari hunter-gatherer boys of about 12 years old start to accompany their fathers, uncles or older brothers on hunts. By this time, they have gained much knowledge of animal behaviour through hunting small animals and listening to hunting stories (Liebenberg 1990). Young Kalahari hunters of 15 to 22 years old usually work hard at hunting, killing their first buck between the ages of 15 and 18. (Lee 1979). There are strong social incentives for this effort, because, with his first successful killing of a large antelope, a boy assumes adult hunter status and becomes a potential partner in marriage. A hunter's career reaches a peak at 30-45 years old. During this time, he has an optimum combination of physical fitness, skill, wisdom and experience, yet, even after his prime, his skill and experience grows with age (Lee 1979).

Children initially attempt to manufacture the most common, and least dangerous, hunting equipment such as traps or snares – first by observation, then by helping with specific aspects of production (apprenticeship). Later they will try to make snares themselves, but they can expect some advice and criticism from peers, older children or adults, but usually not much. Many ethnographers suggest a limited role for ‘teaching’ (and the use of language) in the acquisition of weaponry and hunting skills. But, perhaps, such observations are biased towards the recorders’ perceptions of how teaching should be structured. It is abundantly clear that the social context is an important part of the teaching and learning process in hunter-gatherer societies (e.g., MacDonald 2007), and it cannot/should not be separated from the greater social context of hunter-gatherer societies. Within such societies, and particularly for Kalahari hunter-gatherer groups, children are rarely excluded from adult activities. Even when performing potentially dangerous tasks, such as making a fire or spear and arrow tips, adults do not attempt to exclude them. Grappling with the perception that 'teaching' is almost absent in hunter-gatherer societies, I recently asked Chris Low, who spent much time with Kalahari peoples, to share some of this thoughts on the topic:

- Although teaching in a didactic, formal manner does not exist, parents and probably more importantly grandparents, will say 'when I am gone you need to know these things so that you can survive'. Then, depending on the knowledge and personality of the parent/grandparent, they will deliberately show their children plant and animal resources, medicines, hunting skills, etc. I suspect the idea of 'they do not teach' is overplayed. For me, personality of adult and child are really underplayed here.
- Folk stories are undoubtedly a moral and practical form of teaching, they set the barometer of what is normal. More subtly, they serve as the backdrop to understandings of how the world works.
- The adults are always being overheard by children, and this must be considered very important to ideas of education (Low pers. comm. July 2014).

Observations such as these emphasise how the education of children are deeply imbedded in the everyday life of these communities, and how the concept of 'teaching' weaponry and hunting skills cannot be extracted from their rich oral traditions.

The Kalahari cameo below further illustrates the interplay between bow hunting, language, theory of mind and flexible problem solving. Biesele and Barkley (2001) reports how a Ju/'hoan husband and wife team tracked animals. Moving together, but about 10 metres apart, they remained close enough to each other to share information, but far enough apart to observe a large area. The strategy provides a range of animal trail options to follow. The couple would communicate, often using only hand signs, about the most promising tracks. Thus, as a smoothly communicating unit, the team changed tracks at least 20 times in four hours while rapidly moving through the African veld. They continuously assessed variables, and jointly processed large amounts of current information across a long distance. When they approached a family of warthogs that became their ultimate target, the wife fell back for her husband to get a good shot with his bow and poisoned arrow. Although the man made the kill, the cerebral part of the stalking had been a collaborative activity, made more effective by joining the skills and observations of both hunters working together, communicating and making decisions seemingly as one (Biesele & Barkley 2001). Here the interplay between skills, concepts, rules and strategies resulting in creative problem solving is evident. It is also easy to see how the aim of hunting in such an effective team requires theory of mind and could have co-evolved with early forms of complex communication including the use of meaningful hand signs, a strategy still used by Kalahari hunters.

Salado (2011) suggested a 'pre-hunt discussion' stimulus for his model on early language use in which information exchange about previous hunts, whereabouts of prey, and the planning of future hunts are important parts of hunter-gatherer life. This model is supported by the ethnography of recent hunters. For example, graphic description of hunts, both recent and in the distant past, constitute an almost nightly activity around the campfire (Lee 1979). Even at daytime, Kalahari hunters talk endlessly about hunting as they sit together repairing their equipment or poisoning their arrows. They repeatedly recount episodes of past hunts, hear each other's news about recent hunts, and plan future hunts (Marshall 1976). Apart from oral and sign language, hunting may also have played a motivating role in the ultimate evolution of 'reading' and 'writing'. Liebenberg (1999) argues that selection for an ability to read tracks and signs (i.e., interpreting animal spoor the way that current Kalahari hunter-gatherers do in the context of bow hunting) may have played a significant role in our cognitive and behavioural evolution. Tracking animal spoor might be linked to early symbolic and abstract thinking, because the spoor 'stands for something else' (the type of animal, the direction in which it was travelling, how long ago it was created, the age and condition of the animal, whether it was alone or in a herd, etc.). Davidson (2013) suggests that although all mammals leave spoor, only humans are known to track prey by interpreting these visual clues, and that the ability to recognise such indexical signs is key to the evolution of our understanding and using symbols (Fig. 3).

Simple tracking involves following a trail of clear track prints, but, speculative tracking, as practiced by Kalahari bow hunters, involves a completely new way of thinking. It requires the creation of a working hypothesis, involving knowledge of animal behaviour and terrain, with a combination of inductive and deductive reasoning (Liebenberg 1990, Biesele & Barkley 2001). Yet, when asked by ethnographers, the hunters themselves find the notion of 'teaching' someone to track slightly amusing and claim that even when signs are pointed out by an experienced tracker, it is necessary to self-analyse them, carefully and critically, to understand them (Liebenberg 1990). Yet, it is well known that older men will work with the younger ones, who do the killing whilst making the most of their elders' wisdom and experience when they interpret the spoor (Lee 1979). Detailed abstract knowledge about the age of a spoor, the interpretation of an animal's condition, the speed it was travelling at, its age, activities and predictions about its movements (all gleaned from reading the spoor) cannot be learned easily without sharing information and previously acquired knowledge – teaching. In fact, observation of hunter-gatherers show that general conversation provides much information about animal behaviour and cultural attitudes toward animals, such as which prey are preferred, the sharing of meat, etc. (Fig. 3).

Most Kalahari hunters also delight in lengthy, detailed and very gripping narrations of their hunting experiences, often using non-verbal expression or imitation to dramatize their stories. Although they do not take licence with the facts, artistic expression is used to relate events in an entertaining, memorable way, ensuring a continuous, lasting flow of information (Liebenberg 1990). Storytelling thus acts as a medium for the shared group knowledge of a hunting band (Biesele 1993). Although, superficially, there seems to be relatively little direct transmission of information or 'formal teaching' of hunter-gatherer children, much knowledge is gained indirectly in a relaxed social context.

Knowledge gained informally is often assimilated more easily than knowledge gained under direct instruction (Liebenberg 1990). Before they actually go on a hunt, young hunters have listened to countless hunting and tracking encounters, described in minute detail during storytelling around the campfire. This is a major component of their socialisation as hunters. The stories and myths represent a vast body of knowledge and a treasure house of lore and information about animals and how to kill them. And children listen intently (Szamado 2011). Thus, the notion that language-based teaching plays a minor role in hunter-gatherer children gaining hunting knowledge should be rejected.

Concluding thoughts

Unlike other animals, we are able to teach (and learn) flexibly, and in many different contexts (e.g., Thornton & Raihani 2007). This short contribution demonstrates how a suite of teaching and learning processes are involved in acquiring hunting skills and hunting technologies. Active teaching and demonstration perhaps take up less time than observation and practice, probably indicative of a learning theory that suggests that motor procedures require practice to acquire adequate skill sets (MacDonald 2007), and/or a philosophy whereby informal ways of knowledge transmission are considered more effective than structured, formal 'education' (e.g., Liebenberg 1990). Yet, information about animal behaviour is often acquired with relatively efficient and fast teaching and learning processes. These activities usually continue into adulthood and involves observation, imitation and instruction, as well as exposure to useful information in linguistic forms, such as hunting stories and animal-related myths (MacDonald 2007). Our capacity to develop new techniques for extractive foraging and hunting allowed us to exploit a wide variety of different foods and to colonise the globe. Hunting is the hunter-gatherer activity that requires the longest period of learning before maximum return is achieved, but provides the highest return once maximum skill is reached (Kaplan et al. 2000). It has been suggested that a species-typical life course evolved in response to the demands of a hunter-gatherer way of life. Broad and flexible enough to allow successful exploitation of most environments, yet, specialised toward the acquisition of learned skills and knowledge to obtain high rates of productivity later in life (Kaplan et al. 2000). The evolution of human hunting and the ways in which we learn and teach is therefore inextricably linked.

For hunting to serve as proxy for human teaching and learning, there should be no genetically inherited mental models of technology-assisted hunting in humans. Thus, even contemporary hunters will have to learn both the use of weapons and the tactics of the hunt throughout their life history. Moreover, they have to learn it from each other. I.e., there should be a cultural inheritance of hunting tactics and prey preferences (Szamado 2011). The rich, and increasingly better understood, southern African archaeological record of hunting technologies, as well as studies of contemporary hunter-gatherers coupled with their deep genetic roots in the region, support this prediction. Here I was able merely to scrape the surface of developing knowledge about technology-aided hunting as potential proxy for the evolution of human teaching and learning strategies. Considering evidence for the early use of traps and bow hunting, however, complex ways of teaching and learning, unique to our species, were already in place by ~70,000-60,000 years ago.

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