Chapter 22

The Social and Cultural Context of Stone-knapping Skill Acquisition

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Modern human technological practice is an inherently social phenomenon saturated with cultural meaning. Research among the stone-adze makers of Langda village in Indonesian Propinsi Papua (Irian Jaya) (Stout 2002) illustrates the integral role that culturally-constructed values and relationships play in the acquisition and performance of sophisticated stone-knapping skills, suggesting new perspectives on prehistoric lithic technologies. The emergence of increasingly skill-intensive stone technologies over the course of human evolution implies change in the social context of skill acquisition and constitutes important evidence of hominin social cognition and cultural origins.

> …there is no such thing as human nature independent of culture. (Geertz 1973)

Humans live and act in culturally-constructed environments. This construction is embodied, not merely in extensive modifications of the physical environment, but more fundamentally in the mapping of meanings and values to that environment (Ingold 1996). The historically-evolving cultural environments in which humans live shape our opportunities for action and learning at a fundamental level, providing a cumulative 'ratchet effect' that may underlie many of the distinctive cognitive skills of modern humans (Tomasello 1999). Understanding the origins and history of this uniquely human mode of cultural existence is a central question for human-evolutionary studies.

One potential source of insight into this question lies in the physical traces of proto-human behaviour, and particularly in the durable stone artefacts that dominate the archaeological record. In order to be useful, however, these artefacts must be carefully interpreted using *actualistic* models based on observable phenomena in the modern world. Artefact replication and other experimental approaches have provided valuable insights into knapping techniques, tool functions and site formation processes (review in Toth 1991) and are even beginning to elucidate the neural foundations of knapping skill (Stout *et al.* 2000; Stout this volume). However, experimental approaches are ill suited to exploring the cultural dimensions of stone knapping. For this, an ethnographic perspective is needed.

Figure 22.1. *The adze makers of Langda.*

Research among the stone-adze makers of Langda village (Fig. 22.1) in the central mountains of Indonesian Propinsi Papua (Irian Jaya) (Stout 2002) provides an opportunity to employ such a perspective. Obviously these modern craftsmen do not provide a direct window on the past, but they do offer a valuable example and source of inspiration for new perspectives on prehistoric stone knapping. In particular, the Langda craftsmen illustrate the pivotal role of social context in stone knapping skill acquisition. Appreciation of the social and cultural foundations of modern human knapping skill is an essential reference point when assessing the cognitive significance of prehistoric lithic technologies.

Technological practice

Although anthropologists often drawn a sharp distinction between social and technological phenomena (Ingold 1993), this is a false dichotomy. As argued by Dobres (2000, 96–7), 'Technologies are always and everywhere socially constituted' and, in fact, 'the production of matter and the production of meaning are instantiated by each other'. Technology is more than just a static collection of external objects (tools) and the internal rules (technical knowledge); it is an ongoing process of dynamic interaction between people and their social and physical environment.

Technological proficiency is a skill acquired over time through engagement with this environment. Although it is conventional to speak of the social 'transmission' of technical knowledge, this is a misnomer. Knowledge and skills are not objects to be passed around, but rather abilities to be developed. Social interaction helps to provide a supportive context (Vygotsky 1978) or *scaffolding* (Wood *et al.* 1976) for the emergence of abilities which are themselves stable and adaptive modes of interaction with the environment.

Research on the subject of *distributed cognitions* has underlined the fact that people routinely 'think in conjunction or partnership with others and with the help of culturally provided tools and implements' (Salomon 1993, xiii). In human technological practice, these 'tools and implements' may be conceptual as well as physical, including ideas regarding the potential or appropriate uses of objects (cf. Ingold 1996). Technological practice is a property emergent from the dynamic interaction of individuals in environments over time, rather than the simple expression of some set of transmitted rules.

Work on distributed cognitions generally emphasizes the flow of information between individual and environment, for example in the 'off-loading [of] mental reasoning processes as action constraints of either physical or symbolic environments' (Pea 1993, 48). However, human cognition is more than just the dispassionate processing of information and is intimately tied with somatic sensations and emotional states (Damasio 1994; Greenspan 1996). Behavioural strategies and abilities are *situated* (Brown *et al.* 1989) in particular environmental contexts, often in ways that have more to do with emotional investment, meaning and motivation (e.g. Perret-Clermont *et al.* 1991; Fogel 1997, 417–22; and the 'mindful engagement' of Salomon *et al.* 1991, 4) than with classically 'cognitive' constraints.

As outlined in Damasio's (1994) *somatic marker hypothesis* of human cognition, emotions and associated bodily sensations help to organize experience by providing a fast and reliable system of affective categorization. So-called 'visceral reactions' to a situation drastically reduce the number of potential behavioural responses that need to be considered, and provide an affective 'weighting' to available options. When the ability to form associations between emotion and experience is compromised (as, for example, in patients with damage to the ventromedial prefrontal cortex of the brain), social skills, planning, and decision-making abilities are all drastically impaired.

Although emotion and motivation are often considered to be private and individual, they arise like other mental phenomena from the encounter with the lived-in world. In humans especially, emotional associations are shaped by social experiences and the negotiation of cultural meaning. Emotional interaction is essential for healthy mental development (Greenspan 1996), and in tragic cases where children are deprived of nurturing emotional experiences, mental health, social skills, and learning abilities are all jeopardized.

For both children and adults, the acquisition of technical skills is an evolving form of membership in a community of practice (Lave & Wenger 1991). The development of new knowledge and skills is just one part of a more general process of changing interpersonal relationships and identity that is emotionally charged and motivated. In other words, human technical learning is *meaningful* process. For this reason, the cultural construction of meaning and its influences on task-related emotional valences and attitudes must be considered as central features of human technological practice. In Langda, these and other elements may be investigated in the context of a traditional stone-knapping industry.

Skill and meaning in the Langda adze industry

Prior to the introduction and spread of metal tools, ground-stone axes and adzes were the primary heavy-duty tools of the New Guinea Highlands. These implements were used primarily to clear land, but also as all-purpose cutting tools for tasks ranging from woodworking and fiber processing to butchery. Simply put, the horticultural lifestyle of the Highlands would not have been possible without ground stone axe/adzes (Pétrequin & Pétrequin 1993). Stone axe/adzes were also of great symbolic and ceremonial importance as items of ritual exchange and bride-wealth payments, war trophies, and sacred objects (Pétrequin & Pétrequin 1993; Hampton 1999).

Figure 22.2. *The head adze maker of Langda evaluating roughouts following a communal quarrying trip to the Ey River. He is responsible for redistributing these roughouts to the men who participated.*

Currently (as of October 1999) in Langda, metal tools have replaced stone adzes for most everyday tasks. However, this transition has been a relatively recent one, and the use of stone adzes was more common as little as 10–15 years ago (Toth *et al.* 1992). Stone adzes remain an important part of the culture of Langda, for example in their continued role as an expected part of bride-wealth payments and in the contribution they make to local identity. Nevertheless, traditional patterns of production, use and exchange are clearly changing. The role of stone adzes and of their makers in Langda is in flux, but, for the time being, elements of traditional arrangements are preserved in both current practice and recent memory.

Even today and much more so in the past, the traditional value of stone adzes makes involvement in their production a potential source of both prestige and wealth. In the non-stratified societies of the New Guinea Highlands, personal stature derives from a combination of personality and social networking. Exchange is central to the development of such networks, including the expression and maintenance of group ties through ceremonial *moka* exchange (Strathern 1971) and of individual relationships through semi-formal 'exchange partnerships' (Fiel 1987). Among other things, the value of stone adzes as exchange items has allowed their makers to maintain extensive social networks, contributing to their personal prestige, wealth and influence.

Due to the great value of stone adzes, the skills and raw materials needed for their production are closely regulated. Adze making is an exclusively male occupation entered through a semi-formal system of apprenticeship that is generally open only to the 'sons' of established adze makers (kinship in Langda follows a bifurcate merging or 'Omaha' system that does not distinguish between sons and nephews). The craftsmen themselves report that adze-making skill is too valuable to teach to anyone outside close family, and each adze maker is able to recite a pedigree of past masters through whom they have inherited the tradition. The longest such list includes fourteen names stretching back to a semi-mythical progenitor of the craft, *Menminy Malyoman Balyo*.

The adze makers of Langda recognize the authority of a 'headman' who controls access to the quarry sites near the village and presides over production in general. For example, the headman regulates the distribution among the other craftsmen of blanks and rough-outs produced during communal quarrying expeditions to the river (Fig. 22.2). Hampton (1999) attributes this authority to a system of hereditary ownership over the quarry sites. Such ownership over quarries, blanks and even hammerstones is jealously guarded, even (within living memory) to the extent of using deadly force.

Apprenticeship

Traditionally, adze-making apprenticeship began at the age of 12–13. Apprenticeship typically lasted for several years, although it might take ten years or more for the highest level of skill to be achieved. According to informants, a boy might express his interest by accompanying the adze makers on quarrying trips, bringing them food while they worked and by attending to them in general. For his part, the potential master would evaluate the seriousness and commitment of the prospective student, perhaps asking him

Figure 22.3. *Adze making is a great source of pleasure for the men who participate in the craft.*

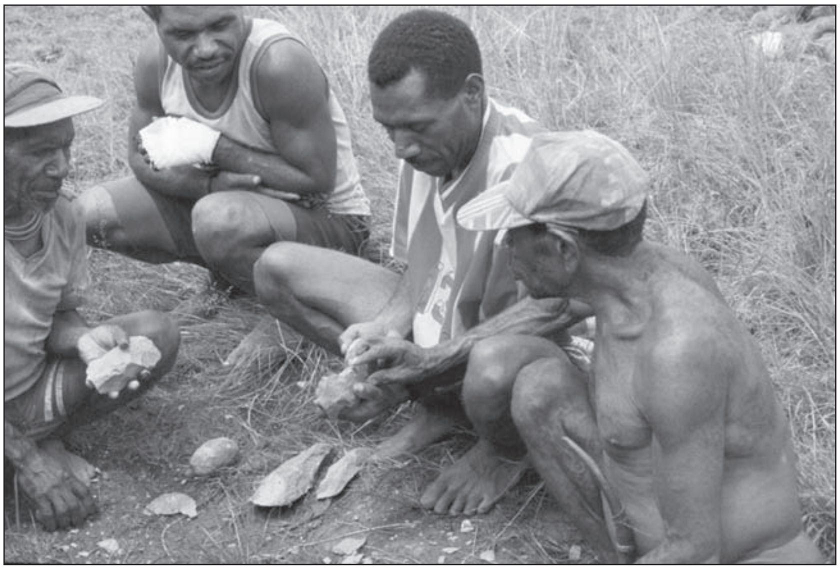

Figure 22.4. *An experienced craftsman offering advice to an apprentice.*

to do some flaking in order to gauge his potential. Acceptance might be indicated, among other things, by the gift of a hammerstone.

In Langda today, this pattern has changed and most apprentices appear to be in their mid-twenties (birth records and exact ages are generally not available). Many children are enrolled in a primary school that has been established in the village, and the decision to pursue an apprenticeship now seems to be more commonly made later in life. Despite decreasing everyday usage, adze making continues to be a source of pride and identity for its practitioners, and motivations for entering into apprenticeship may have changed in a way which appeals more to older individuals.

Although motivation for participation may have changed somewhat, the adze makers make it clear that commitment and devotion to the craft remain highly valued. For example, one man explained that his (deceased) father was an exceptional knapper because, for him, adze making always came first. He would make time for it despite the work required by his gardens, and work long hours without eating or resting. Other adze makers similarly speak of forgetting their wives, gardens and everything else while knapping, and emphasize that a man's hand will 'grow heavy' and lose its skill without continual practice. Commitment to the craft is more, however, than just a duty or virtue. Knapping is also a great source of pleasure (Fig. 22.3), and craftsmen often call out in excitement after successful flake removals. Adze making, which is always conducted as a group exercise, is an enjoyable and meaningful social activity.

This social dimension is central, not only in the everyday conduct of the craft, but also in learning and skill acquisition by apprentices. Although each apprentice has a special relationship with his nominal 'master', he actually learns to make adzes through participation and interaction with the entire community of adze makers. In the words of one man, learning to make adzes is 'not like in school' but rather involves 'sitting together'. Overt instruction, both verbal and gestural, is commonplace but forms only one component of the social scaffold that supports skill acquisition.

Because they are participating in a group endeavour, apprentices are able to gain experience with aspects of production that would be inaccessible for them individually: they are able to participate in the quarrying of suitable materials even if the they could not locate these on their own, they gain experience roughing-out blanks even if they have difficulty producing them, and they are able to practise finer knapping even if they themselves produce few usable roughouts / preforms (the Langda adze makers recognize only one intermediate stage between the blank and the finished form, covering a wide range of reduction). It is also common for more experienced knappers to help apprentices by giving advice (Fig. 22.4) about where to strike the core (and why), or even by taking and working the piece through difficult points themselves. These various forms of facilitation allow apprentices to perform beyond the unassisted level, in the optimum learning situation Vygotsky (1978) refers to as the *zone of proximal development*. At the same time, the social contexts and cultural meanings associated with adze making help to provide emotional value for practice and participation, influencing motivational, attentional and decision making processes (Damasio 1994).

Skill

Differences in knapping ability between experienced and novice craftsmen in Langda are evident in the size and proportions of adze heads (Fig. 22.5) and waste flakes produced, as well as in the strategic organization of knapping operations. As detailed elsewhere (Stout 2002), experienced knappers achieve superior results by: 1) removing longer and relatively thinner flakes allowing greater control over evolving core form; 2) manipulating local elements of core morphology (e.g. ridges, flake scars) to facilitate desired flake removals; and 3) employing more consistent and effective overall reduction strategies. The acquisition of knapping skill thus occurs at multiple levels, from the discovery of effective movement synergies for individual flake removals to perception of the affordances of changing core morphologies and the emergence of stable reduction strategies.

As illustrated by the work of Roux *et al.* (1995; Bril *et al.* 2000) with the stone-bead knappers of Cambay, India, higher-order knapping skills must emerge from mastery of elementary knapping gestures. In Cambay, superior craftsmen display a greater homogeneity of movement arising from their achievement of an optimized and stable motor state. This achievement, which takes years of practice, facilitates successful flake removals and allows for the development of more sophisticated reduction strategies that are flexible rather than stereotyped. Conceptually, less-skilled craftsmen 'know' about the necessary stages in the production of high-quality beads, but they do not comprehend them in the same experiential way as more skilled craftsmen.

A similar situation exists in Langda. Waste-flake data reveal that skilled knappers deploy more precise and effective motor synergies, reliably delivering a large amount of force to a small target. Such effective

Figure 22.5. *As illustrated by these examples, adze heads produced by skilled craftsmen (left) are longer, relatively narrower and more regular in plan form than those produced by apprentices (right).*

knapping is a specialized kind of 'action-for-perception' that allows for the discovery of otherwise inaccessible affordances of core morphology. For example, there is the dorsal ridge of the adze-head. Apprentices are aware of the need to shape this ridge but avoid working it because of the difficulty of the large platform angles typically involved. Until they have developed sufficient elementary flaking skills, apprentices are unable to gain a practical understanding of the role of the dorsal ridge in overall reduction strategies. Apprentice strategies are demonstrably less uniform and coherent than expert strategies (Stout 2002) because apprentices lack the control needed to experience and stabilize larger-scale relationships in evolving core morphologies.

Conventional approaches to stone tools and cognition (Gowlett 1992; Robson Brown 1993; Karlin & Julien 1994; Wynn 2002) generally focus on abstract planning, conceptualization and the 'imposition of arbitrary form' (Holloway 1969) rather than on the perceptual-motor skill needed for effective flake removal. Ultimately, however, the former must emerge from the latter and the strategic understanding of a skilled knapper bears little resemblance to an abstract recipe or algorithm. Preliminary investigations of brain activity during stone knapping (Stout *et al.* 2000;

Stout this volume) corroborate the predominance of externally-directed perception and action over internally-directed conceptualization. Examples from Cambay and Langda similarly illustrate the fact that, for modern humans at least, it is much more difficult and time consuming to achieve actual knapping skill than it is to develop a theoretical knowledge of the appropriate stages of reduction.

Meaning

The description of prehistoric stone-knapping technologies in terms of abstract concepts (e.g. Wynn 1989) or rule systems (e.g. Gowlett 1996) is a useful heuristic but does not address the effortful process of behavioural exploration through which actual knapping skills emerge. Much of the cognitive sophistication involved in prehistoric and pre-modern lithic technologies probably had to do with involvement in social contexts that allowed or facilitated such exploration rather than with the comprehension of a particular target form or procedural recipe.

In Langda, an elaborate system of cultural meanings provides the context for skill acquisition and execution. Adze making is a social process involving relationships between masters, peers and apprentices as well as resource owners, ancestors, mythical figures and even the personified stones themselves, not to mention the social exchange networks into which finished adzes enter. Technological practice occurs in a historically-evolved cultural environment that includes craft-related values, expectations, terminology and techniques as well as physical artefacts and locations.

As described above (p. 33 'Apprenticeship') and in Stout (2002), the social and cultural context of adze making in Langda provides an important scaffold for skill learning. Participation in the craft, and particularly movement from apprenticeship to mastery, involves changes in identity, relationships and prestige that can provide powerful motivation for practitioners. The community of adze makers also structures the learning process by providing materials and occasions for practice while restricting apprentices to tasks of appropriate difficulty. This scaffolding affords apprentices the opportunity to participate to some extent in all stages of production and to benefit from the commentary, demonstration, discussion and assistance of fellow craftsmen. Adze-making activities are conducted in social groups that provide opportunities for focused individual practice and a meaningful and enjoyable form of interaction. Situated in this context, apprentices have the opportunity and motivation to devote many hours over a period of years to the acquisition of adze-making skills that include both the shaping of stone and negotiation of the cultural environment.

Obviously, Langda provides an extreme example of an elaborate and skill-intensive stone-knapping technology. Certainly many prehistoric knapping technologies were less technically demanding, and many were probably implemented by less elaborate systems of craft-related cultural meaning and social relations. The stone-scraper technology used by hide workers in southern Ethiopia (Clark & Kurashina 1981; Brandt 1996; Weedman 2000) provides one modern example of a more 'casual' approach to stone knapping.

When it comes to the stone-tool behaviours of extinct hominin species, there is little evidence of skill and sophistication anywhere near the level seen in Langda. It is even debatable whether such behaviours were 'cultural' in the fully modern sense. Study of the modern adze-making industry of Langda will not resolve this debate but, in conjunction with studies of non-human primates, such examples of modern human skill do provide an essential point of comparison.

Stone knapping and the origins of culture

The impressive stone-knapping skills of senior adze makers in Langda are reflected in physical attributes of the tools and *debitage* that they produce. In particular, adze heads that are long but thin and narrow and waste flakes that are large and thin reflect the exercise of knapping skills acquired over years of practice (Stout 2002). Experimental replication can begin to provide similar insights into the skills indicated by proto-human stone artefacts (e.g. Callahan 1979, 35; Schick 1994, 584), and more such work is clearly needed. Future experimental research might benefit from explicit attention to the processes of knapping-skill acquisition, and from focused archaeological case studies that take raw material and technological variability fully into account.

To the extent that the knapping skills of ancient hominins can be divined, possible social and cultural implications may be considered. For example, experienced experimental knappers generally agree that the production of refined later Acheulean bifaces requires a level of skill that, even for modern humans, is attained only after substantial practice (Callahan 1979; Bradley & Sampson 1986; Edwards 2001). Contemporary Western knappers acquire this skill within academic, craft and recreational cultures (see Whittaker 1994, 60–63; Olausson 1998) that create opportunities, meaning and motivation for participation. What social (cultural?) situations might have attended the acquisition of comparable skills in archaic *Homo*?

In all prehistoric technologies, social arrangements would have had to provide sufficient opportunity for participation by learners. At a bare minimum, this requires social tolerance among conspecifics: the simple opportunity to share activity space without conflict. In fact, varying degrees of social tolerance do seem to influence the distribution of tool use across modern ape populations (van Schaik *et al.* 1999; Russon 2002). Even in the nut-cracking chimpanzees of Bossou, Guinea, a lack of adult tolerance for juveniles may inhibit skill learning beyond infancy because only infants are afforded 'opportunities to freely access stones and nuts' (Inoue-Nakamura & Matsuzawa 1997). A relatively high degree of social tolerance would have been important prerequisite for the development of increasingly diverse and skill-intensive tool behaviours during hominin evolution.

Modern human learning involves more than simple tolerance, however. In Langda, apprentices participate in a structured and meaningful community of practice that provides scaffolding and motivation for the learning process. Participation is a question of identity, and its value to the learner 'lies in *becoming* part of the community' (Lave & Wenger 1991, 111). Chimpanzee societies also scaffold learning, as in the *stimulation* and *facilitation* of infant nut cracking described by Boesch (1991), but they do not possess the same *regulative* (Ingold 1996) dimension of cultural meaning that specifies identities like teacher, learner or craftsperson.

In chimpanzees, learning is facilitated by a combination of adults' affective response to infants (tolerance) and infants' emotionally-motivated tendency to attend to, interact with and generally stay close to adults. These mechanisms of facilitation tend to break down with maturation, however, and are never elaborated into the system of meaningful social relationships and culturally-mediated identities that support human technical learning. Inoue-Nakamura & Matsuzawa (1997), for example, report that infant chimpanzees frequently emulate the nut-cracking behaviour of adults but receive little or no feedback or 'social reinforcement'. Juveniles, on the other hand, are actively denied opportunities for participation and are often chased away if they try 'to get stones and/or nuts at the side of the adults'.

Nevertheless, wild apes do engage in a range of skilled foraging activities (e.g. Byrne & Byrne 1993; Matsuzawa 1996; van Schaik *et al.* 1999) that have been loosely compared to human skills in terms of the timing, duration, and social 'transmission routes' of learning (Russon 2002). For example, many everyday human skills, like ape foraging skills, are acquired during childhood through interaction with parents (Hewlett & Cavalli-Sforza 1986). In the case of more specialized technical skills, the ten years it takes nut-cracking chimpanzees to reach 'refined' adult levels of proficiency (Matsuzawa 1996) is at least superficially reminiscent of the general '10-year rule' in human expert skill learning (Ericsson & Lehmann 1996) and the specific estimates of time to mastery provided by the Langda craftsmen. Closer consideration of such expert skill learning, however, reveals important differences between ape and human conditions.

As observed by Ericsson & Lehman (1996, 278), the fact 'that [human] experts in most domains attain their highest level of performance a decade or more *after maturation* points to the importance of extensive preparation' (italics added). Kaplan *et al.* (2000), for example, have shown that, unlike chimpanzees, human foragers do not achieve their maximal production until at least 10–15 years after maturation. In Langda adze-making apprenticeship traditionally did not even begin until around age 12. This is in striking contrast to ape skill learning, which is typically concentrated in infancy due to the changes in social relations (tolerance) that occur with maturation (Russon 2002).

Another critical difference between ape and human skill learning lies in the structure and intensity of practice. Ericsson & Lehman (1996) argue that many everyday human activities show only a weak correlation between experience and performance because such activities 'afford few opportunities for effective learning and improvement of skill'. Expert learning, in contrast, is characterized by highly-structured *deliberate practice* (Ericsson *et al.* 1993) that is often designed by a coach or teacher and requires an individual's full concentration. Such deliberate practice is exemplified in the process of knapping skill acquisition seen in Langda and is afforded by the presence of extensive social and cultural scaffolds for learning. Research is needed to better characterize the investments made by apes during foraging skill acquisition, but it seems clear that ape skills, acquired during infancy in relatively unstructured social learning environments, are more analogous to 'everyday' human skills than to expert performance.

Clear continuities thus exist between ape and human skill learning, but also important differences. Most salient of these differences is the presence in humans of intensive, socio-culturally supported expert skill learning by adults. Insofar as human intelligence is itself a form of developing expertise (Sternberg *et al.* 2000), any account of human mental evolution must deal with the emergence of this uniquely human mode of expert skill acquisition. Comparison of modern human and ape skills with those evident from prehistoric stone tools is one important method by which this question may be addressed.

Nut cracking, for example, is one of the most difficult perceptual-motor skills acquired by chimpanzees in the wild and is supported by both stimulation and facilitation of infant learning. In the absence of cultural mechanisms supporting deliberate practice and expert skill learning (as seen, for example, in 'enculturated' apes in captivity), efficient nut cracking may approximate the upper limit of skill acquisition afforded by chimpanzee societies. Research explicitly comparing chimpanzee nut-cracking and human stone-knapping skill acquisition would thus be extremely valuable.

Modern actualistic research, whether experimental, ethnographic or ethological, clearly cannot reveal the details of prehistoric social organization, but it can provide insight into some of the necessary conditions underlying particular kinds of behaviour. For example, evidence that particular pre-modern stone technologies required investments in skill acquisition appreciably beyond the levels seen in wild apes would be strongly indicative of hominin cultural elaboration. Exactly what early hominin 'proto-cultures' might have looked like is open to question. Donald (1991), for example, has suggested a pre-linguistic stage of *mimetic culture*, in which representational physical action (*mimesis*) supported 'collectively maintained customs, games, skills and representations' that served 'as the collective definition of society' (p. 173). What is clear is that the (proto) cultural foundations of expert skill acquisition would have necessarily involved the establishment of routinely *intersubjective* (Quine 1960) social relations.

Intersubjectivity, or the understanding of others as intentional agents, is the foundation of human culture and creates a medium for joint attention and action, including true pedagogy (Rogoff 1990). Intersubjective awareness transforms simple social interactions into meaningful social relationships and has been characterized by Tomasello (1999) as *the* key adaptation underlying the emergence of modern human cognitive sophistication. The constitutive sociality supported by intersubjectivity does not necessarily imply the abstract normative framework of rules and expectations seen in modern human regulative sociality (Ingold 1996), but it does offer a shared mental space for intentional learning and teaching. It is the saturation of everyday social interactions with intersubjective meaning that is lacking in modern ape societies, and which would have allowed for the invention of distinctly hominin proto-cultures and skill-intensive technological practices.

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