In perspective, an integration of the approaches represents a necessary condition for a prolific research on cognitive abilities and for an actual communication between more or less contiguous disciplines. The creation of a common semantic (for example, the concept of modularity and the concept of choice of production) could encourage this purpose. In this regard, a recent book by Roux and Bril (2005a) collects contributions from archaeologists as well as scholars from other disciplines: neuroscience, psychology, ethology, and science of movement.

The cognitive domain represents an elaborated process of interaction: individual and social, implicit and explicit. Lithic technology, by itself, is not able to provide definitive answers. We would ponder whether cognitive theories can help the archaeologists find those answers.

CHAPTER 9

Cognition and the emergence of language: A contribution from lithic technology

Jacques Pelegrin

Attempting to understand the development of hominid cognitive capacities based on their technical productions is not a new approach. André Leroi-Gourhan (1964, 1993) laid the foundations in the 1960s when he first proposed the idea of a concomitant evolution of language and techniques based on the proximity and parallelism of the cerebral zones and paths implied in both motor functions and language. At that time, however, the study of prehistoric lithic industries was essentially limited to a typological approach and the inferences thus drawn concerning the mental capacities of their authors were rather general (e.g., Alimen & Goustard 1962; Bordes 1971).

Several other approaches have since been proposed (e.g., Toth 1993; Wynn 2002). In France, in particular, a new approach to knapped stone artifacts was developed whereby these objects were no longer seen solely as "fossil directors" of periods and cultures, but also as evidence of so-called operational sequences (*chaînes opératoires*) and thus technical (and economic) behaviors. This notion of operational sequence was also introduced by Leroi-Gourhan in 1952 (Schlanger 2004, 2005). Its full potential was then developed through the practical expertise of Bordes and Tixier (Tixier 1967). Tixier then played a major role by systematizing principals of the operational sequence through the "technological reading" of lithic objects, coupled with a stabilized and enriched terminology. In particular, Tixier (1967) proposed the very pertinent distinction between *technique* and *method*, thus distinguishing, respectively, the modes of flake detachment and the organization (spatial and chronological) of the removals during a knapping operation (debitage or flaking, shaping, retouch, preparation; see Inizan et al. 1999).

It is useful to recall these two distinct levels implied in hard stone knapping (knapping being defined as intentional fractioning by conchoidal fracture, other than exceptions). The word *technique* refers to the physical modes of executing flake detachments. They are associated with several parameters: the nature of the application of force (direct percussion, indirect percussion, pressure); the nature and morphology of the knapping tools (hard stone, soft stone, wood billet, etc.); and the manner in which the knapped object is held and the body position of the knapper (on an anvil, other support, freehand, etc.). The word *method* refers to the spatial and chronological organization of the removals from a knapped object. When this organization is repeated in an archaeological assemblage – which is often the case – a knapping method is identifiable. It then corresponds to a procedure that is at least systematized and more or less reasoned.

This distinction between technique and method is also relevant from a methodological point of view. Techniques, on the one hand, are identified through analogical comparison with experimental data (analysis of modern knapping products). This comparison is strengthened by a mechanical understanding of certain stigmata, which are related to certain parameters of the technique. For example, the degree of diffusion or concentration of a point of percussion is directly related to the hardness of the hammer used.

Methods, on the other hand, are identified through a technological reading of all of the archaeological material. A particular method – and its variants – within an operational sequence is "reconstructed" through a synthesis of all observations of the spatial and chronological organization of the flake scars visible on each piece (diacritic scheme).

For readers lacking experience in the study of knapped stone objects, it is also useful to emphasize the excellent so-called visibility of the knapping actions produced on a piece. Knapped stones being nearly inalterable, their technological characteristics (point of origin, dimensions, orientation, and order of preceding removals) are completely, or nearly completely, preserved in a redundant manner. Each removal produces a double equivalent trace: on the object from which the flake was removed (its negative), and the flake itself (its positive). Therefore, a piece shaped by the removal of numerous flakes shows the negative scars of the last series of flakes removed, which are themselves identifiable as such. The same is true for a core and its products. This visibility allows us to associate (and classify) corresponding pieces and, if there are many pieces in an assemblage, to refit them like a puzzle, and thus to totally objectify the method applied.

In this way, by clearly demonstrating that the knapping method(s) identified in a prehistoric industry are related to a "procedure," Tixier opened the possibility of more psychological analyses – meaning cognitive rather than only descriptive – of the organization of removals from a piece. This introduced the notions of selection, intention, and predetermination, which were then further developed by his followers.

At the same time, this analysis was facilitated by the development of modern, experimental stone knapping under the impetus of Bordes and Tixier, themselves experienced knappers like Crabtree in the United States. Indeed, this type of analysis of knapping methods – once they have been identified on the archaeological material – requires particular competencies. First, it is necessary to have practical knapping experience, which is either direct, by knapping oneself, or indirect, through numerous observations and discussions with a knapper who is preferably an archaeologist. Second, and most importantly, one must have experience with variable archaeological cases.

To illustrate, we can compare a knapping method with the transcription of a game of chess. A chess expert can psychologically analyze a game (or better, a series of games between two players): He or she will be able to evaluate the skill level of the opponents (stereotyped sequences, simple reactions or one or several moves planned in advance), their intentions and priorities (central development, outgoing of pieces, attack, defense), and their knowledge (strategies for opening or closing – and possibly ending – the game). The same is true for the study of stone knapping methods, in which an experienced analyst can recognize stereotyped sequences that may be repeated (simple methods based on monotonous formulas of organization; Pelegrin 1993, 2004, 2005), appreciate different degrees of predetermination (predetermined removal or predetermining removal; cf. Boëda 1994, 1995), or analyze elaborate methods based on planning by objective (Pelegrin 1990, 2005).

Appreciated in this way, prehistoric knapped stones can provide relevant evidence of some of the cognitive capacities of our hominid ancestors. On this basis, we can now address the subject of this chapter,[1] which can

1 This chapter was translated and corrected by Magen O'Farrell; it includes some passages from an earlier text (Pelegrin 2005), the translation of which was corrected by Marcia-Ann Dobrès, whom I thank. I also thank the editors of this volume: Sophie de Beaune, who invited me to participate, as well as Fred Coolidge and Thomas Wynn. The Master's thesis of Frédérique Bresson (synthesis and references in Bresson 1992) also contributed to this

be formulated by the following question: According to this procedure for analyzing knapping methods, what cognitive capacities can we distinguish in hard stone knapping that could be related to certain prerequisites of language?

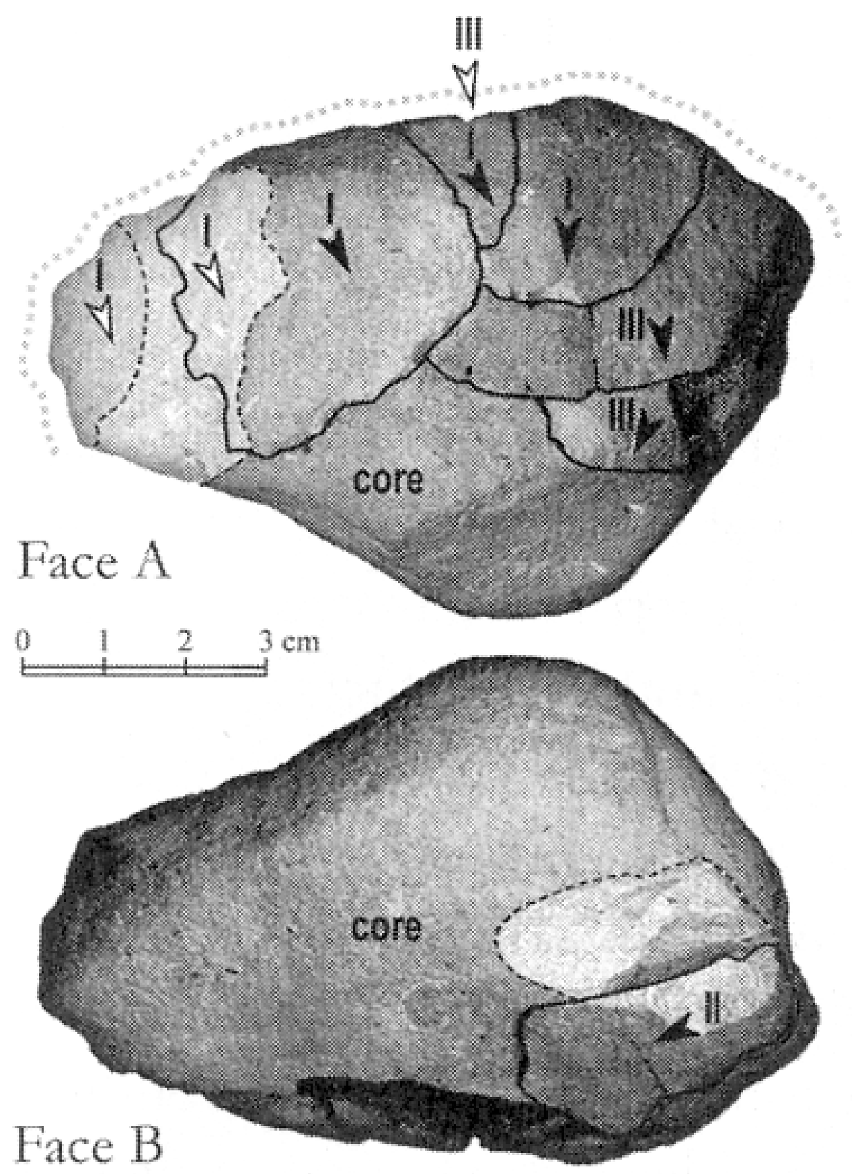
A first tempting approach, proposed by some anthropologists and prehistorians, concerns the nature of the transmission of the so-called art of knapping to children. In other words, starting from which stage or method would language have been necessary for elders to explain to young learners what to do and how to do it? This approach is not very convincing because, in general, psychomotor skills are not acquired through verbal instruction. This is true in traditional apprenticeships, and in the case of flint knapping, we know people who have learned to knap without observing a skilled knapper and without documentation. Even if language, once acquired, certainly participated in the technical education of learners, it is not a condition for the transmission of techniques. This approach, which we could call the "short route," is thus inoperable.

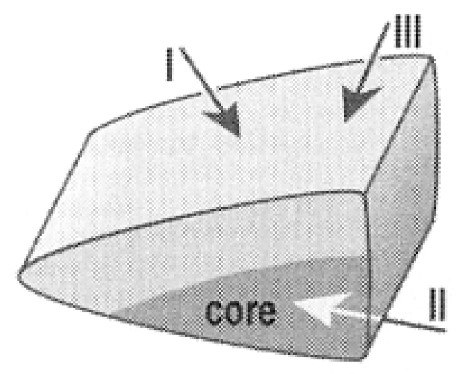
What remains is the "long route," which consists of identifying the neuropsychological elements in technical productions, at the level of thought and technical reasoning, which may be significant prerequisites of language.

The notions of specified intention and skill

We long considered the oldest stone tools to be the result of sensory-motor actions performed without conscience – meaning two cobbles or pieces of stone, chosen at best for their form, were knocked against one another until one or several fragments were detached and then selected for their cutting edge. However, the recent discovery by Hélène Roche (Roche et al. 1999; Roche 2005) of the Kenyan site of Lokalalei 2C considerably modified this perception. At this site, dated to 2.3 million years ago, around 50 blocks or large fragments of volcanic stone were knapped to obtain flakes by conchoidal fracture. Refittings (replacement of the flakes on their block or original core) show that from one to several dozen flakes were detached from each core. These removals were organized by small, subparallel, or convergent series, at the expense of a favorable morphological configuration,

chapter. The figures were computerized by Gérard Monthel (UMR 7055 Centre National de la Recherche Scientifique).





Series	Refitted pieces (*fragments*)	Missing pieces	Total of refitted and missing pieces
I	3 (*3*)	2	5
II	1 (*1*)	0	1
III	2 (*3*)	1	3
core	1 (*1*)	0	1
TOTAL	**7** (*8*)	**3**	**10**

direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms

FIGURE 9.1. Photographs and drawing of a refit core and its flakes from Lokalalei 2C, showing the process (I) after five flakes, (II) the removal of a flake to correct the striking platform, and (III) continue the debitage process. (Figure is after Delagnes & Roche 2005; photograph and copyright are from the Mission Préhistorique française au Kenya, director H. Roche, by permission of Hélène Roche.)

meaning a nonobtuse dihedron forming the striking platform on one side and the relatively wide debitage surface on the other.

Although this operational sequence appears globally reducible to a simple formula, that is, "detach a series of adjacent flakes from a favorable dihedron," several of the cores indicate a more complex process. When the striking platform of these latter cores became inadequate, it was repaired by the removal of a small flake struck from the flaking surface before the principal flaking operation was continued (Figure 9.1). In other words, faced with the inadequacy of the striking platform, the individual was capable of correcting this fault by a removal not intended as a product, but rather adjusted for its effect on the configuration of the striking platform.

We thus see the first evidence of a technical "skill" in stone working (meaning knowledge that goes beyond a simple sensory-motor action), objectified by a true specification of the intention: although the flakes normally removed have the value of potential products, other removals are conceived for their expected effect on the core. The same elementary action, an adjusted percussion to detach a flake adjusted to the situation, can thus be deliberately performed to satisfy different intentions, which we are tempted to say have different meanings.

We should also emphasize the absence of hammering or useless strikes, which would be easily visible on the material as crushing at impact points. This shows that the knappers did not attempt to detach flakes when the angle was inappropriate, as well as the precision of their strikes, which necessitates knowing where and how to strike and having the ability to do so. Moreover, the lucidity of the author(s) is shown by his or her aptitude to reorient the core to preserve or recreate a morphological configuration combining the striking platform and debitage (flaking) surface.

Before 2 million years ago (by *Homo habilis*?), we are thus tempted to see in this first degree of knapping control (the capacity to improve possibilities, demonstrated by a specific solution) an initial level of what we could call "technical conscience."

The shaping of symmetrical bifaces: Evidence of conceptualized mental images

The first bifaces (also called handaxes) appear in Africa around 1.7 million years ago. These tools were at least partly shaped to form a point and at least one lateral cutting edge by the removal of flakes (waste products) from each of their two faces. The form of bifaces, which are often found during surface collections and thus impossible to date, seems to become gradually more specific, indicating that they indeed represent a particular tool.

In contrast, the stratified site of Isenya in Kenya (excavated by Roche) has yielded several hundred bifaces, dated to around 700,000 years ago, whose elongated almond shape is repetitive, regular, and symmetrical in both plan and profile view (Figure 9.2). Although their dimensions vary slightly, their form is repeated, demonstrating that their authors had a mental image of this form. Although the numerous shaping removals were adjusted according to a highly variable spatial and chronological organization, the objective was always to produce this preconceived form (Roche & Texier 1996).

Roche had already considered that, during the Acheulean period, we passed from stereotyped actions to stereotyped forms (Roche 1980, 193), which is in agreement with Bordes, who discerned the progressive stabilization of tool forms throughout this long period (Bordes 1970, 199).

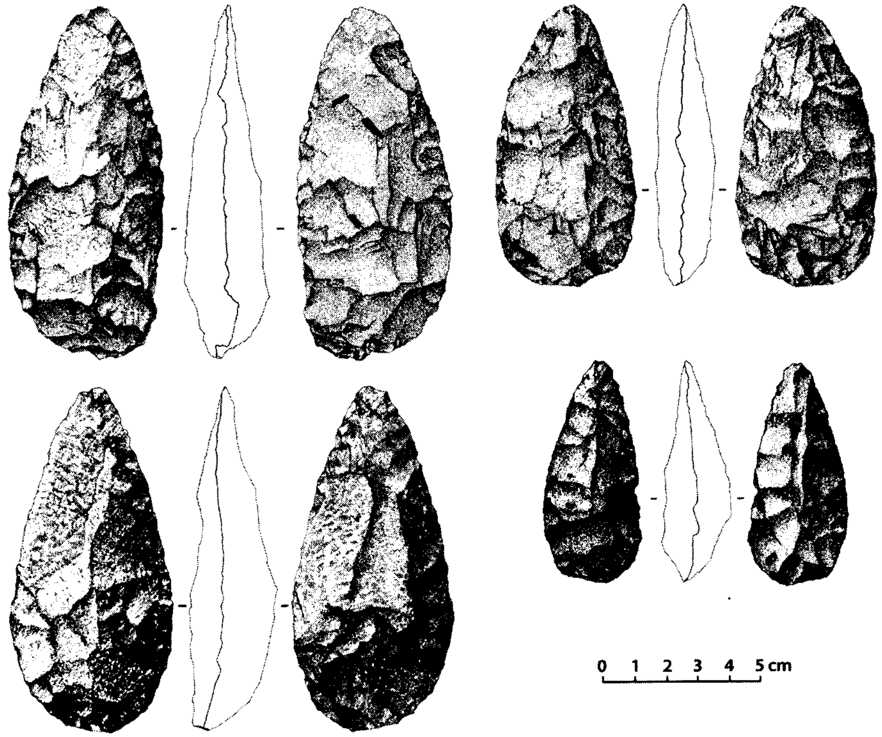


FIGURE 9.2. Bifaces from Isenya. (Figure is after Roche 2005; drawings are by M. Reduron, copyright Mission Préhistorique française au Kenya, director H. Roche, by permission of Hélène Roche.)

This standardized form of the Isenya bifaces is not strictly governed by production or use constraints; it is deliberate. Unless we can imagine that our ancestors moved around with a set of models, in the form of roughouts and preforms at different stages, this form must be associated with a specified mental image, meaning a concept of "their" biface (different forms exist in other geographic or chronological contexts). This means that the authors of these objects were capable of conceptualizing these tools, which thus constitute a true type.

To understand what this signifies, we can refer to a major distinction in psychology between percept and concept.

A percept refers to the capacity to recognize something present to our senses. I see a pen, I touch a spoon, and I recognize these objects as a pen and a spoon. Animals are perfectly capable of percepts; a dog recognizes its leash and wags its tail at the prospect of taking a walk.

A concept refers to the capacity to evoke a mental image in the absence of the object, an image for which we can formulate commentaries and even imagine, mime, and describe its actions. Think of an orange, even though you do not have one visible to your eyes; you see it mentally, describe it, and even describe or mime how you would peel it according to your family tradition, and how your African neighbor would do the same, peeling it in a spiral.

It is extremely difficult to know if animals are capable of such operational conceptualizations. We know they are capable of perceptual recognitions and responses adapted to these percepts, but nothing indicates that they possess an operational mental imagery such as our own.

The production of shaped bifacial tools with a standardized shape attests to the capacity of their authors (probably *Homo erectus*, predecessors of Neanderthals, who themselves fabricated symmetrical bifaces) to conceptualize certain tools, which could be seen as a prerequisite to their denomination.

Levallois debitage: Planning by objectives, temporality of mental imagery, and propositional reasoning

The Levallois debitage method (Levallois method of flaking) was discovered in Europe, on the banks of the Seine near Paris, and identified by Commont (1913) nearly a century ago. Although it may be older in Africa or Asia, it is considered to appear in Europe around 250,000 years ago at the beginning of the Middle Palaeolithic period, produced by Neanderthals. It consists of predetermining the general form of one or several flake products by a preliminary or subsequent (ensuing) preparation of the core (Boëda, Geneste, & Meignen 1990; Boëda 1994, 1995). Figure 9.3 shows a Levallois core and flake from Ault, a knapping site in northern France that yielded several hundred Levallois cores. On nearly 300 cores, the last flake scar removes an average of 70% of the flaking surface (Perpère 1999), proving that this last predetermined flake was intentional. The flake shown in the figure was probably abandoned because of its dull, hinged distal edge; it does not come from the core shown, but corresponds very closely. The position of the flake on the core reveals the faceted preparation of the striking platform. The upper face of the flake presents a large flake scar of

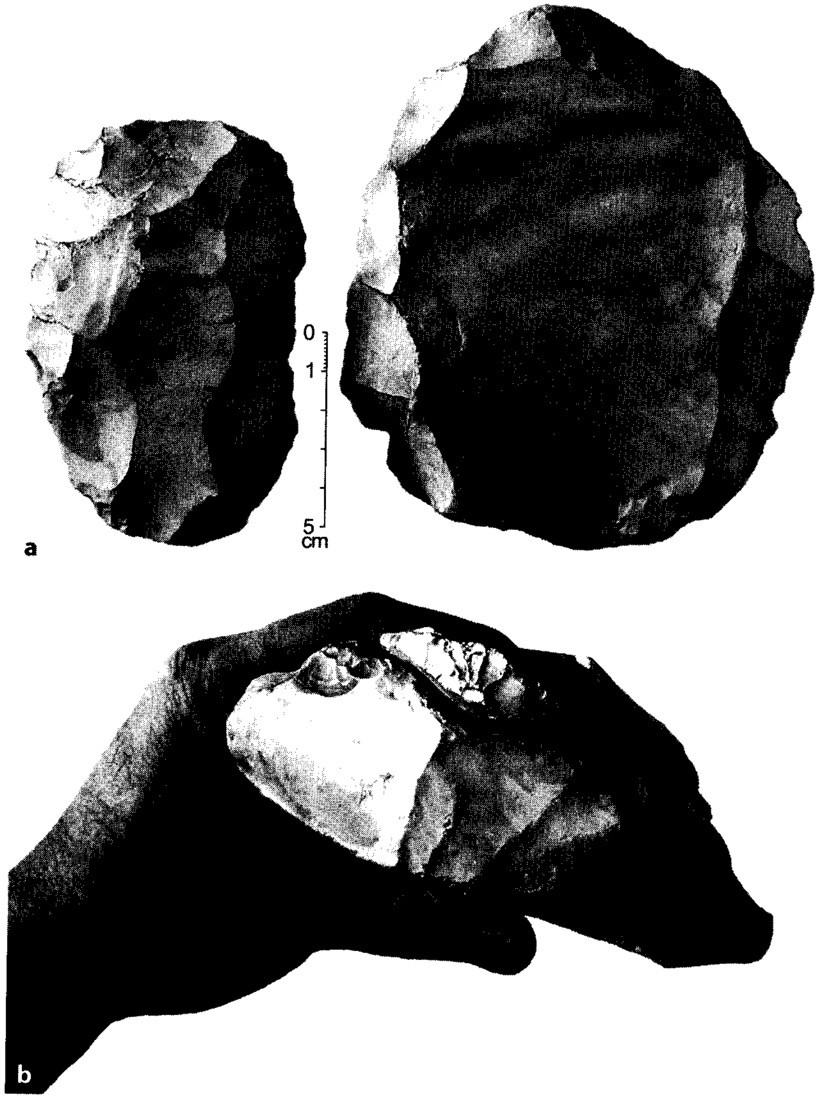


FIGURE 9.3. Levallois method of flaking: a, Levallois core (right) and flake (left) from Ault; b, the position of the flake on the core reveals the faceted preparation of the striking platform in a *chapeau de gendarme* shape, explained in figure 9.4. (Photograph by J. Pelegrin.)

a probable preceding Levallois flake in the same direction, after which the core was reprepared to allow the production of a second Levallois flake, shown in the figure.

Levallois debitage also includes several steps marked by changes in operation ("opening" of the roughout, initial shaping out, striking platform preparation, detachment of one or several flake products, reshaping out of the core, new preparation of one or more striking platforms, etc.) or technique (hammerstone change, use of an "abrader" to prepare the striking platform). They result in normalized, or even standardized, products independent of the initial morphology of the block. Figure 9.4 shows a diagram of the Levallois method with a preferential (intended) flake and *chapeau de gendarme* striking platform. Part a shows the preparation flakes on the debitage surface to create an adjusted convexity; part b indicates that preparation of the striking platform first consists of detaching two convergent flakes, separated just enough to create a small triangle in relief. Part c shows that a few fine bladelets are removed by a small, abrasive percussion to round off this triangle by faceting (if the bump thus formed is asymmetrical, too high, or too low relative to the plane of the debitage surface, the Levallois flake removed will be skewed, too thin, or too thick). Finally, part d shows that, if the strike is delivered with a correct oblique incidence, the hammerstone will attain the summit of the bump, determining the depth of the fracture plane, which will then cut through the prepared convexity of the debitage surface, all predetermining the thickness, width, and general form of the flake with a peripheral cutting edge.

Although the shaping of a rough biface can be interpreted as a progressive reduction, nonetheless requiring a strike-by-strike adjustment of the removals, Levallois debitage implies true planning according to objectives (giving a precise form to the debitage surface and to the platform, recreating an adequate convexity on the core, etc.), and not a chaining together of actions through a "recipe" or formula (detach a series of alternate or adjacent flakes, such as with the cores from Lokalalei 2C). In other words, the knapping procedure is guided by a series of specified forms to be obtained before passing to the next state, which must again be adapted to the preceding state. In this way, the technical modes (elementary actions) are clearly subordinated to the specified intentions or objectives, which correspond to knowledge.

An essential point is, therefore, that the details of the passage from one of these specified forms to another is highly variable: What counts is the

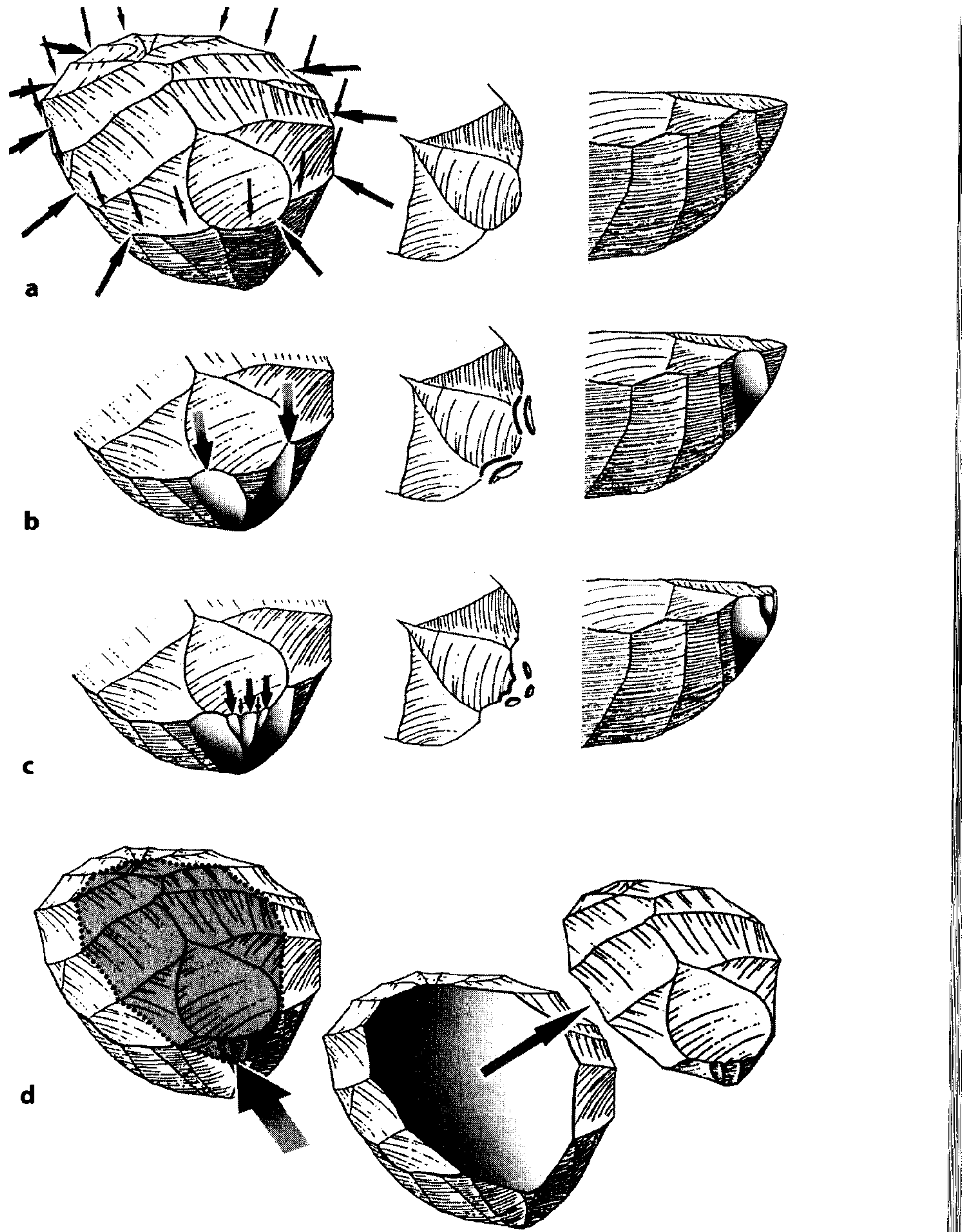


FIGURE 9.4. Diagram of the Levallois method with a preferential (intended) flake and *chapeau de gendarme* striking platform (after Pelegrin in Boëda and Pelegrin 1979–1980): a, surface preparation flakes to create an adjusted convexity; b, detachment of two convergent flakes, creating a small triangle in relief; c, removal of a few fine bladelets to round off this triangle by faceting; d, with correct delivery, the hammerstone will attain the summit of the bump. (Drawings by J. Pelegrin, DAO G. Monthel.)

result in terms of the form obtained, when the order and placement of these removals to maintain the debitage (flaking) surface are variable from one object to another, decided ad hoc. Based on a critical monitoring of the evolution of the piece, this flexibility shows the capacity to imagine solutions – how to organize the few flakes to follow, how to create a local striking platform to detach an important flake, and so on. These solutions are mentally evaluated as both possible (technically realizable) and desirable to advance toward the next intended state.

We have called this capacity "ideational know-how" in reference to ideational or constructive apraxia: motor disorders in which the combination of elementary actions is affected, whereas the capacity for individual actions is preserved.

Such reasoning thus activates a capacity to recall rules and anterior experiences in comparison to the present situation and to imagine what the piece can or will become following a given sequence of action. In these knapping productions, we are thus tempted to see the capacity to chronologically connote operational mental images; those that were memorized from experience, those present and evaluated, that of the ideal form that the object or part of it must obtain, and also those possible or virtual, requiring one operation or another in terms of the causes and consequences recalled and pondered.

This first illustrates the capacity of modern humans, us, to connote information, mental images, and events in time (capacity for temporality). This corresponds to our verbal "time" and the host of adverbs that allow us to recount what happened in the past and to distinguish what is happening now from what will happen next, using our past, present, and future tenses. We do all this without mixing the temporal connotations of these events or images, which could result in mental confusion or spatiotemporal disorientation.

This capacity for temporality is a powerful characteristic of language. Saying "I see a lion eating a gnu," in the same way as an animal who signals an immediate situation, is of limited use because the person to whom you are talking can also see it, or turn his eyes to a simple signal. However, after a morning excursion, saying "I saw a lion that was eating a gnu behind the hill" is much more useful because this statement can initiate a collective decision, such as "at the hottest time of day, when the felines are sleeping, we will go to take the carcass."

Second, we propose that the capacity to imagine what the piece will become following the imagined solution or action equals a form, or

beginning form, of propositional reasoning: "if I do this, the piece will become like this, if I do that, the piece will become like that."

The capacity for propositional thinking, expressed by two propositions linked by *if* and *then*, apparently extends that of temporality: an initial event must first be connoted as anterior to that which follows. We consider it to be crucial in the technical sphere because it allows the emergence of conceptualized technogeometric rules (e.g., "it is the depth of the point of impact relative to the debitage surface that determines the thickness, and thus width, of the removal"). Being considered as conditional to the second, the first fact or event is seen as the cause of the second, which itself is seen as the consequence. Expected and verified by experience, this consequence becomes predictable, and even imaginable if the causal fact or event can itself be imagined, thus taking the value of reason. Reasoning can thus occur and be transmitted in the absence of the events in question in order to give supporting arguments for an intention and motivate collective decisions. In this case, it is the verbal form of the so-called conditional that is used: "if we watch the lions, [then] we will be able to take the carcass" and "if he had not left alone in the evening to drink, [then] he would not have been attacked."

Whether or not it was fully conscious, the reasoning underlying Levallois technology by Neanderthals seems to have a propositional structure (Parker & Milbrath 1993) and is implicated in all knapping parameters. I refer here to the geometric parameters of knapping (for instance, the fact that given the convexity of the flaking surface of a core, the width of a flake is tied to its thickness), as well as to the dynamic parameters (effect of excessive or insufficient force and incidence; optimal relation between the mass and size of the expected flake and mass and hardness of the hammerstone, which also depends on the mass of the core).

Therefore, in my opinion, in terms of the cognitive capacities required for stone knapping, the essential points were already in place: the later realizations of *Homo sapiens*, in a given time or region, consist only of a diversification of performances permitted by the accumulation of innovations (new knapping techniques, new hafting methods, etc.).

What can we conclude?

It would be tempting to imagine a first use of "names" as early as the Acheulean, and a fully constructed language, with diverse tenses and propositional expression, for Neanderthals and contemporary *Homo sapiens*, both of whom employed the Levallois or equivalent debitage methods. But, I prefer to conclude more modestly: far from being a language specialist, I contribute here only a few technological observations and neuropsychological inferences that can participate in the debate concerning the origins of language. These inferences should be compared with those of other approaches, such as that of Coolidge and Wynn (2005), and then critiqued by linguists, neuropsychologists, and ethologists (Gibson & Ingold 1993).

In summary, I would like to make just one more remark concerning the chimpanzee Kanzi, who despite numerous knapping demonstrations and motivations (Toth et al. 1993; Schick, Toth, & Garufi 1999) never learned the basic principals of conchoidal fracture, which was already practiced by *Homo habilis* 2.6 million years ago (Roche 1980; Pelegrin 2005). A detailed examination of the "flakes" and actions produced by Kanzi indeed shows that his knapping skills extend no further than more or less violent and random hammering, which produces only splinters (detached by vertical blows, that is, by hardly controllable split fracture), and no true flakes by conchoidal fracture. In contrast with their excellent locomotor dexterity, the disappointing technical capacity of chimpanzees thus strongly indicates that the "technical" domain is much more an affair of conceptualization than one of motor dexterity, as language, also, is much more an affair of cognition than one of phonatory capacities.

CHAPTER 10

Language and the origin of symbolic thought

Ian Tattersall

To the best of our knowledge the possession of symbolic reasoning marks *Homo sapiens* as unique in the living world, both past and present. Until rather recently, though, our hominid precursors appear to have been nonsymbolic, nonlinguistic creatures. That is to say, in certain very significant ways they more closely resembled other primates than they did modern human beings in the ways in which they perceived, and communicated information about, the world around them. This is not to say that earlier hominids were unsophisticated in their perceptive and communicative abilities, or even that they were necessarily *inferior* to us in those qualities. It is to say that they were *different*. Indeed, it is just this difference that may well in the end have made them lose out in the grand competition among hominids for ecological space and economic resources that took place in Africa, Europe, and Asia toward the close of the last Ice Age.

Prior to the dramatic spread of modern *Homo sapiens* at some time in the period centered at around 50,000 years ago, it had been routine for several different species of hominid to coexist in some manner throughout the Old World (see Figure 10.1; also see Tattersall 2000). However, in the few tens of millennia following the emergence of behaviorally modern *Homo sapiens*, all of our species' hominid competitors rapidly disappeared, in a process that certainly tells us more about the special nature of behaviorally modern *Homo sapiens* than it tells us about what it means to be a hominid in general. The abruptness and synchronicity of this Old-World-wide elimination of competing hominid forms suggests that, whatever it was about *Homo sapiens* that suddenly positioned our species as the sole hominid on the planet, it cannot simply have been an extrapolation of preexisting evolutionary trends in the human lineage: For a simple incremental addition to those trends, if

Cognitive Archaeology and Human Evolution

Edited by

SOPHIE A. DE BEAUNE

Jean Moulin University – Lyon 3 and CNRS

FREDERICK L. COOLIDGE

University of Colorado, Colorado Springs

THOMAS WYNN

University of Colorado, Colorado Springs

2009

CAMBRIDGE
UNIVERSITY PRESS