Gesture and Speech

André Leroi-Gourhan's theory of the co-evolution of manual and intellectual activities

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The role of gesture in Leroi-Gourhan's theory of the origin of language is portrayed in its historical context and in view of recent research to allow a balanced appraisal of his contribution to the debate. Written in the mid-1960s, his *Gesture and Speech* offers a vivid contrast to Chomsky's contemporary mentalist view of language that espoused Cartesian rationalism with its barriers between man and beast, and between body and mind. On the contrary, Leroi-Gourhan takes an integrated approach to human evolution: gesture (conceived of as 'material action') and speech are seen as twin products of an embodied mind that engendered our technical and social achievements. His explanation of the evolutionary association between the hand and the face provides a biological basis for cognitive as well as communicational aspects of gesture, with culture emerging as an extension of our zoological foundation. He asserts that the liberating of the hand from locomotion led to the liberating of the face from prehension, thus creating the duality of instrument and symbol whereby human beings physically and mentally grasp the world in which they live.

Keywords: gesture, speech, manual action, mind, paleontology, human evolution

Introduction

To begin with, let us distinguish between two kinds of origin that Trabant (2001) identifies and that inevitably become intertwined in the debate about how language first began. Firstly, the 'eternal' origin of language is always present in every speech act since every speaker uses the language he or she has

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inherited in a unique situation and in a new way every time he or she speaks. It is not only observable in speakers today but it has also been captured in the concrete form of writing, of which the oldest surviving records date back to about 5,500 years Before Present (BP). Fathoming how language actually and continually regenerates itself encompasses a wide range of heterogeneous research. The traditionally linguistic side of this enterprise includes investigating linguistic taxonomies (Ruhlen, 1994a and b), pidgins, creoles (Bickerton, 1981) and language change (Aitchison, 2001b). In the wake of the pioneering work of William Stokoe (1960) sign languages began to gain acceptance as real languages. This revived interest in the nature of gesture and in the relationship between gestural and verbal forms of communication in the hope that more knowledge about the language faculty could be gained. The issues at stake became increasingly apparent in the mid 20th century as the technological revolution began to open a window into the biology of the mind. It inspired the search for innate Universal Grammar (a set of syntactic rules that underlie all languages and are independent of meaning) that Noam Chomsky (1957) proposed we are all equipped with at birth and that resides in a genetically determined Language Acquisition Device hard-wired in our brains. Precisely where such a language module is located and which grammar genes encode for it (Pinker, 1994) is unknown. The failure to find this mental organ has led to the quest to track down distributed language circuitry that involves scanning the brains of people engaged in linguistic activity, often using language impairment as a guide (Deacon, 1997; Lieberman, 1998). Exploring the linguistic potential of non-human primates provides insights into which features of our language faculty are shared with our closest biological relatives and what makes it exclusively human. Research projects with this aim have their roots in the work of R. Allen and Beatrice Gardner (1969). This sparked ideas about how gesture may relate to language evolution because teaching non-human primates to communicate with us manually has been relatively successful, whereas efforts to get them to speak have failed miserably.

Secondly, the 'historical' origin of language was the birth of the language faculty in our hominid ancestors who lived somewhere in the empirically inaccessible past at least 50,000 BP. The paleontological and archeological records deliver a few of their bones, tools and cultural artifacts that attract controversial interpretation and, at best, only provide enticing pinholes of illumination into the mystery of who spoke first, where, when, why and to whom — or if he or she was alone, listening to the first lexical thoughts in their mind. Furthermore, "language not only does not fossilize, but there are no

living intermediate forms either" (Maynard-Smith & Szathmáry, 1999, p.153) to enlighten us. Faced with the impossibility of ever knowing what really happened so long ago, theorists project their research into the eternal origin of language back in time and use their findings to deduce what might have taken place in those mysterious creatures poised at the threshold of possessing language as we know it. Jean Aitchison maintains the validity of this approach by affirming Lass's (1997) 'general uniformity principle' that language follows principles that have changed little since it came into existence, and his 'uniform probabilities principle' that "the likelihood of any linguistic state of affairs has always been roughly the same as it is now" (Aitchison, 2001a, p.135). Furthermore, analogies between children (whom we can readily observe) and hypothetical pre-humans (whom we can never observe) are made by theorists who imagine that growing children whizz through the major changes which occurred in human evolution over the course of millennia. Technically speaking, this line of inquiry assumes that "ontogeny is the short and rapid recapitulation of phylogeny" (Aitchison, 1996, p.93). Although Aitchison rejects the idea of a total recapitulation, she proposes two instances in which this might occur: the lowering of the larynx, and the onset of the naming insight, i.e. when children discover that "the sounds coming out of people's mouths might be names for things" (Aitchison, 1996, p.94).

The debate about the historical origin of language in the Western tradition goes back to Plato's *Cratylus* (that leaves the issue of whether the nature of words was primordially iconic or arbitrary undecided) and to the Biblical account of Adam giving names to animals in *Genesis* (where Man creates the first words through his God-given language faculty). Gesture has persistently featured in some of the theories proposed, and Gordon Hewes (1975, 1976 & 1977) provides a very comprehensive overview of its main proponents. The 18th century marked a period of intense discussion, especially in France where Condillac (1746) provided gesture studies with a seminal text by arguing that language began as a hybrid of sound and movement: *langage d'action*. But the topic lost credibility in most academic circles concerned with language in 1866 in the wake of the decision of the newly founded Société Linguistique de Paris to outlaw all discussion of it. The ban coincided with the advent of Darwinism. It marked a watershed that shifted the arena of the debate from speculative philosophy towards the biological sciences in which the debate is now predominantly located. Since language is considered to be one of the essential characteristics of being human, its origin is pertinent to the natural history of man, and the branch of linguistics that investigates it has been transformed into a natural science.

The academic taboo was broken by the conference 'Origins and Evolution of Language and Speech' at the New York Academy of Sciences in September 1975, a breakthrough that Stevan Harnad (Harnad et al., 1976) in his 'Opening Remarks' partly attributes to Hewes. In the section 'Formulating the Target (II)', the first speaker was Chomsky. He maintained his (1957) argument that an innate human capacity for syntax could explain the ease with which all children learn their native tongue and produce novel sentences just by exposure to fragmentary utterances. The question of what exactly is due to genetics (nature) and to learning (nurture) in the ontogenesis of language in modern humans forms a corollary: how did the language faculty come about phylogenetically, i.e. in the history of the human species? Addressing this question requires reconciling language origin scenarios with evolutionary theory. The apparent discontinuity between articulate speech and non-human vocalization implies that Darwinism alone cannot account for the human language faculty. Conceiving of what a structureless 'protolanguage' (Bickerton, 1990) was like and how the gap to a rule-governed system of arbitrary *signes linguistiques* (Saussure, 1916) was bridged (Aitchison, 2001a), either gradually, incrementally or by a huge evolutionary leap, poses a challenge that has yet to be adequately met.

Chomsky (1972) favours the spontaneous emergence of language via genetic mutation requiring no Darwinian explanation of natural selection to account for its success, but he has not until recently involved himself directly in the biological issues emanating from his work. His most recent paper, co-authored with Marc Hauser and William Fitch, is a product of the "interdisciplinary cooperation" (Hauser et al., 2002, p.1569) that he now advocates in order to further our understanding of the language faculty and its evolution. Nevertheless, his prime interest continues to be in the human brain conceived of as a computational system equipped with language algorithms that generate almost unlimited sentences as an independent cognitive task. Chomsky's universalistic conception of 'deep-structure' language reduces human language primarily to the "core computational mechanisms of recursion" underlying "narrow syntax" (Hauser et al., 2002, p.1573) that all other forms of animal communication appear to lack. In doing so, he relegates the semantic and phonological aspects of words to secondary systems with which syntax interfaces, linking them in the process. In keeping with the Aristotelian tradition, he still appears to view different languages as different material expressions of universal concepts. Steven Pinker (1994) furthers this abstraction with his notion of wordless 'Mentalese' in which we all supposedly think pre-verbally the same, and that he believes can be explained as an 'instinct' acquired through

gradual Darwinian adaptation. Both these authors frame linguistics as a cognitive science in which the communicative aspects of language have been marginalized. Although Chomsky now has recourse to compare animal and human communication (and 'computation') to provide empirical data that he believes may enlighten the theoretical debate about language evolution by establishing which linguistic traits are uniquely human, his influential mentalist position has created a polarity with gestural theories of language origin since communication is central to them all. Furthermore, they all affirm the continuity between body and mind, refuting the gap between them inherent in Cartesian thought, by including a gestural stage prior to or concurrent with glottogenesis.

At the New York conference, Hewes and Stokoe were among those who presented the case for gestural origin theories, which were allotted their own section on the agenda. Hewes delivered an extensive survey of the ideas abounding at that time, and built on his argument "that a preexisting gestural language system would have provided an easier pathway to vocal language than a direct outgrowth of the 'emotional' use of vocalization characteristic of nonhuman primates" (Hewes, 1973, p.12). Also at the conference was Philip Lieberman, a linguist and cognitive scientist, whose team has reconstructed vocal tracts from hominid fossil remains to evaluate their phonetic capabilities. According to Lieberman (1998) the earliest complete skulls of anatomically modern humans that he estimates were able to produce the full range of speech sounds are about 100,000 years old. Given the archeological evidence of cultural artifacts that our more ancient ancestors have left behind, he believes that gestural communication was never the exclusive medium of language but that it probably played a role in earlier stages of hominid evolution. More recently, the conference 'Origins of Language' at the Berlin-Brandenburgische Akademie der Wissenschaften in December 1999 continued its tradition as the first prominent forum for the language origins debate that goes back to its founder, Gottfried Leibniz (1710). The conference brought together Lieberman and a new generation of debaters that includes Terrence Deacon, a neuroscientist and evolutionary anthropologist. Deacon (1997) takes Peirce's semiotics as the foundation of his theory that language originated from a multi-modal mix of vocalizations, gestures, activities and objects ritually used as symbols to establish social contracts. He argues for the co-evolution of cognition, gesture and speech during which vocal language imposed itself as a relatively independent and closed system as alternative modes for expressing symbolic information competed. More recently, the 'Fourth International Conference: 'Evolution of

Language', held at Harvard University in March 2002, brought together Chomsky, Lieberman, Hewes, and new theorists who showed that gesture theories are maintaining their place on conference agendas dealing with this issue. The next conference in this series will be held at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany from March 31st to April 3rd, 2004.

Given the long Western tradition of the discussion and the exciting possibilities that technological advances put at our disposal for testing hypotheses, it is appropriate to reconsider the contributions of past prominent figures in their historical context. Not only is it instructive to acknowledge their originality, but it is also useful to recognize recurring ideas and polarities. One such figure is André Leroi-Gourhan (1911–86), an eclectic scholar whose influence has been profound across disciplines in France. Equipped with a remarkably broad academic foundation in linguistics, anthropology, ethnology and archeology, his innovation as a theorist was firmly rooted in empirical fieldwork. In 1946, in tandem with Claude Lévi-Strauss, he was nominated assistant director of the Musée de l'Homme, where he had begun work as a voluntary librarian in 1929. He became a professor of ethnology and prehistory at the Sorbonne University and later at the Collège de France, and he initiated several centres for prehistoric studies in France.[1] Among monolingual Anglophones who only have access to the fragments of his work that are available in English, Leroi-Gourhan is known mostly for his analyses of paleolithic art. His methods of seeking to reveal the inner structure of enigmatic paleolithic paintings on European cave walls, and his conclusion that these images are symbolic representations of religious systems, may have led to him being dismissively labelled a 'structuralist' largely out of ignorance.[2] Undoubtably less well known outside of France is *Le Geste et la Parole* (Leroi-Gourhan, 1964) that appeared while Chomsky, on the other side of the Atlantic, was revolutionizing linguistics into a cognitive science that disembodies language. Lucidly illustrated with the author's own drawings, this seminal work explicates Leroi-Gourhan's synthetic theory of "hominid biocultural evolution" (White, 1993, p.xvii) which underpins his interpretation of paleolithic 'art' viewed in the wider context of 'figurative behavior'. Drawing upon evidence from the fields of paleontology, anthropology, ethnology, archeology, art and technology, his tenet is that the co-evolution of manual and intellectual activities in our remote ancestors shaped our humanity. The title of his book hints at a revival of Condillac's (1746) idea that gesture and vocalization jointly constituted the origin of language although, as we will see, Leroi-Gourhan's understanding of the term 'gesture' differs essentially from Condillac's as well as from that of

current researchers and theorists. However, like Condillac, Leroi-Gourhan sees language as vital to the process whereby our ancestors crossed the threshold from nature to culture. Since words dissipate after speech and the organs of speech production and reception do not fossilize, he focuses on the concrete evidence that their hands have left behind, in particular tools and cave imagery, to fathom our linguistic roots. From this legacy he pieces together conjectures on the parallel emergence of technology and language that drove, and continues to drive, social and esthetic development. Translated into English, *Gesture and Speech* first appeared in 1993 but this well-established French classic has yet to be internationally appraised. This article aims to help redress the balance. Admittedly, as both White (1993, p.xxi f.) and Graves (1994, p.439) point out, major advances in the research of prehistory, paleontology and cognitive science since 1964 do expose flaws and weaknesses due to outdated knowledge. Nevertheless, the historical importance of this work should also be recognized outside the French scientific community, where its broad interdisciplinary scope remains an enduring source of inspiration. For example, Geneviève Calbris' theory (2003) of how 'cutting gestures' could be preconceptually linked to a wide variety of verbal expressions appears to be very much in keeping with this traditon. Leroi-Gourhan's theory of the co-evolution of manual and intellectual activities is presented here under three headings:

1. 'Principles' gives an outline of natural laws that in his view drive evolution.
2. 'Liberations' depicts evolutionary stages towards the human anatomy in which he sees these principles at work.
3. 'From nature to culture' follows his proposed transition from speciation to ethnic diversity.

Principles

Structure evolves in accordance with function

Leroi-Gourhan could be considered a partisan of the French structuralist movement in the 1960s in that he takes a functional approach to paleontology. His guiding theme is the interrelation between anatomy and physiology. He sees the research of biological facts that are linked to behavior as complementing the systematic approach of mapping out evolutionary branches by classifying anatomical features and chronologically ordering their emergence. The beauty of his functional paleontology is that it views fossilized life forms as

living creatures and opens up a dynamic perspective on the human metamorphic journey through time. He singles out five principal "functional elements" (Leroi-Gourhan, 1993, p.36) of each successive type that were, and still are, integrally linked during the course of our evolution:

1. Mechanical organisation of the vertebral column and limbs (locomotion)
2. Suspension of the skull (brain development)
3. Dentition (capture, defence, food preparation)
4. Hand (technical integration)
5. Brain (coordination)

To assist orientation in this evolutionary story that spans millions of years, Aitchison's (1996) diagrammatic overview of the evolutionary branching that led to the emergence of humankind is reproduced below. This provides an update of the paleontological evidence on which *Gesture and Speech* is based. As White (1993, p.xxi) indicates, in the 1960s our species, *Homo sapiens sapiens*, was thought to have evolved around 35,000 years ago. This is much later than current estimates of the emergence of 'anatomically modern humans'. Aitchison's (1996) date of 150–200,000 years ago represents the average consensus (Figures 1 and 2). New finds continue to fill huge gaps in the hominid fossil record. It should be borne in mind that important fossils representing intermediate stages, such as *Homo habilis* and the famous *Australopithecus afarensis* named 'Lucy', had not been discovered when Leroi-Gourhan wrote *Gesture and Speech* (White, 1993, p.xxi).

First the body then the mind

Central to Leroi-Gourhan's hypothesis is the idea that the birth of language was enabled by a series of 'liberations', i.e. the releasing of mechanical constraints on the body architecture which had powerful cognitive consequences. This fits into his general theoretical framework whereby physiological adaptation (technical means) to a habitat drives brain development (organisational means) which in turn promotes further evolution of the body. This 'body-brain cycle' is expressed schematically in Figure 3.[3]

The chances of evolutionary development are seen to depend on how well a body structure lends itself to behavioral remodelling through the activity of a more developed brain. Thus, the brain commands evolution but it remains inescapably subject to the possibilities of selective adaptation that are open to the skeletal framework. This 'body first' principle places human evolution in a

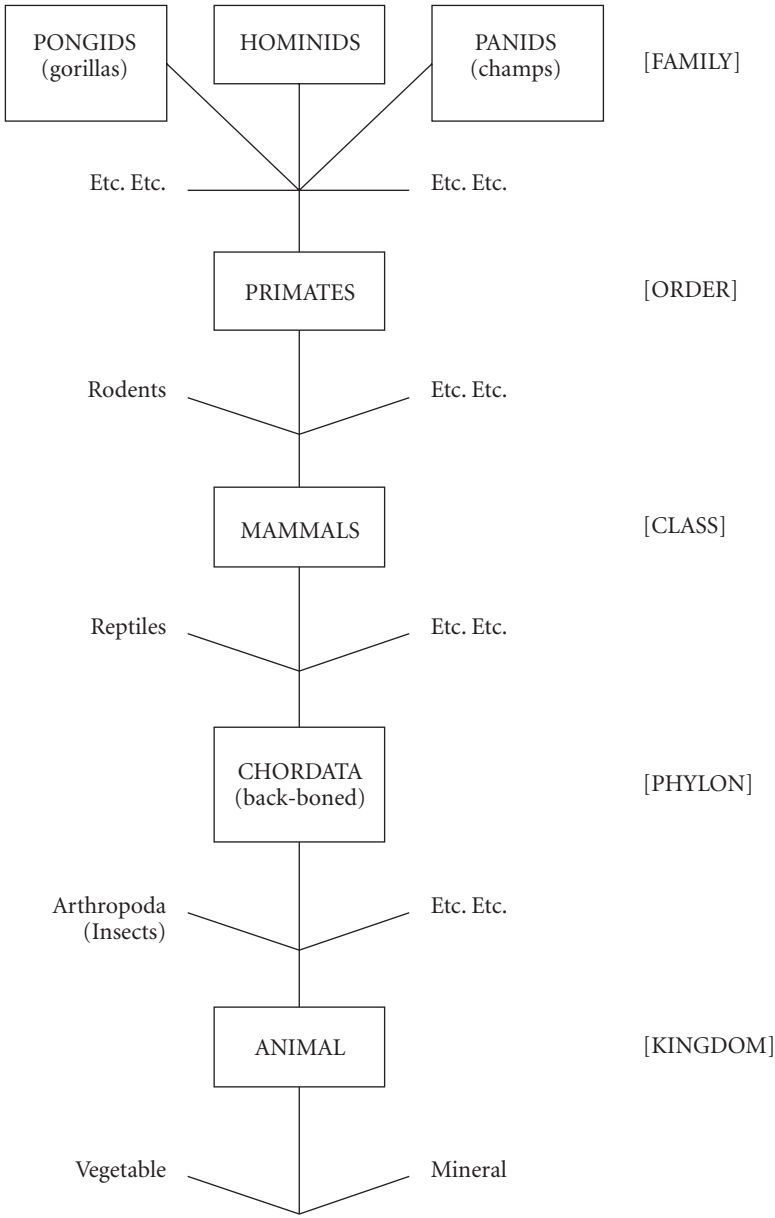


Figure 1. The primate bush (Aitchison, 1996, p.51)

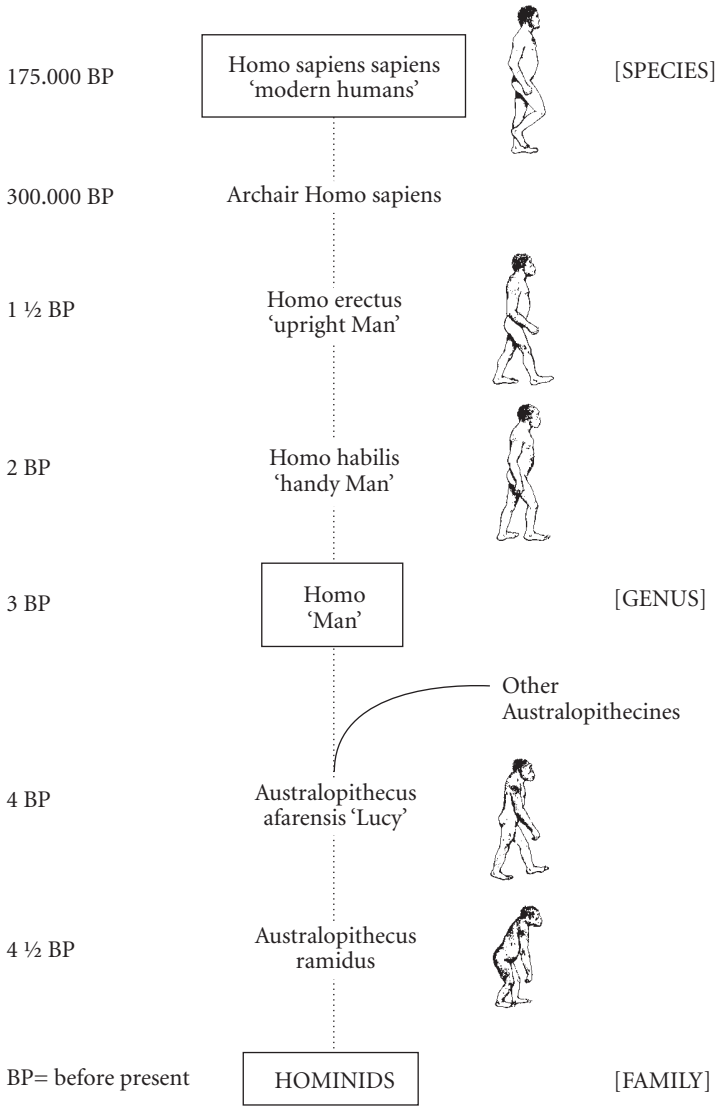


Figure 2. The genus *Homo* (Aitchison, 1996, p.52)

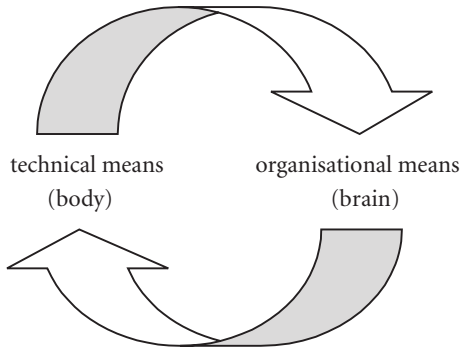


Figure 3. "For each species a cycle is established between its technical ability (its body) and its ability to organize itself (its brain). Within this cycle, through economy of design, a way opens up toward increasingly pertinent selective adaptation" (Leroi-Gourhan, 1993, p.60).

continuum with that of animals built according to the same architectural principles and, consequently, subject to the same mechanical constraints. It allows Leroi-Gourhan to establish conditions for development without which cerebral evolution would remain for him an abstract phenomenon. It frames the question of why only humans talk primarily as a physiological one. Since we move to 'capture' our food, a basic condition for survival, he argues that mobility, not intelligence, is the significant trait of human evolution: "there would seem to be sufficient documentation to demonstrate that the brain was not the cause of developments in locomotory adaptation but their beneficiary" (Leroi-Gourhan, 1993, p.26). His theory aims to reveal how locomotion is "the determining factor" (ibid.) of both biological and cultural evolution.

Mobility determines organ distribution

Leroi-Gourhan's theory rests on demonstrating how successive 'liberations' could have shaped the bodies that gave rise to our minds — how they channelled our hominid ancestors through a series of irreversible choices down the evolutionary path to humanity. Each liberation correlated with physiological adaptations to changes of habitat, delineating a progression from living in a watery medium to breathing air and occupying the land — from swimming to walking upright and talking. These evolutionary moves involved the successive liberations of

1. the whole body in relation to water
2. the head in relation to the ground

3. the hand in relation to locomotion
4. the brain in relation to the facial mask.

Leroi-Gourhan asserts that all animal species can be divided into two dynamic organisational types according to their body plan: bilateral / radial symmetry. He correlates body plan with another major evolutionary choice that determines functional type: mobility / immobility. He sees the extremities of physiological adaptation to habitat as represented by humans (mobility + lateral symmetry) and jellyfish (immobility + radial symmetry), and considers these disparate species to be equally successful in biological terms. Reaching down the (admittedly very sporadic) fossil record, he selects specimens that demonstrate how behavioral patterns and physical adaptations to habitat are intimately linked. His starting point are jawless fish called 'ostracoderms' (Figure 4). These lived about 360–410 million years ago during the Devonian period, which is called the 'Age of Fishes' because of the great proliferation of fish species throughout the oceans of the world. In common with all vertebrates ('Chordata' in Figure 1), ostracoderm fish had a bilaterally symmetrical body plan ordered by the axis of displacement.

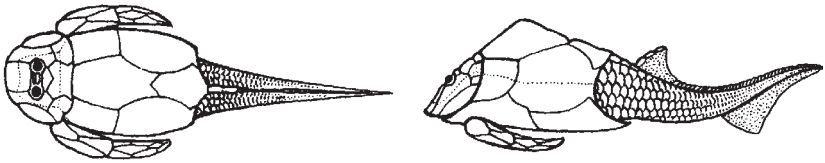


Figure 4. Ostracoderm fish of the Scottish Devonian, from Traquair (Leroi-Gourhan, 1993, p.28).

Moving forwards to capture their food, their bodies were polarized with the organs specialized for feeding facing the direction of movement. Thus, they had the body plan that mobile animals normally possess, i.e. with a mouth and prehensile organs at the front of the organism. Moving to the food source also caused the anterior polarization of the organs of responsiveness (*organes de relation*) involved in spatial orientation and in the coordination of the prehensile organs and food preparation. Leroi-Gourhan calls this concentration of organs vital to life processes at the front of the organism the 'anterior field' (*champ antérieur*) which was encased in bone. Since the function of the posterior part of the body was propulsion, it tapered off into a tail enclosing a spinal cord that coordinated muscular activity. He asserts that movement is

clearly the reason why this same general structure became the common blueprint for subsequent superior life forms. What is not clear is the precise process that gave rise to fish **with** jaws. This marked a decisive evolutionary moment since it gave the head, which essentially contained the mouth and the control centre for the nervous system, a new function: mechanical food processing. Consequently, the mechanical constraints of locomotion and the constraints of jaw functioning came to dominate the entire evolution of the skull. In accordance with Leroi-Gourhan's 'body first' principle, skull evolution sets limits on cognitive development in that it determines the volume available for the brain it houses. He views the nervous system as the most apparent beneficiary of this evolution: culminating in the human brain, the nervous system gives evolution an 'extraorganic direction' (*sens extraorganique* — '*sens*' could also be translated as "dimension" [Leroi-Gourhan, 1993, p.31] or 'sense'). This cognitive pinnacle originated in a very broad biological base of generally favorable conditions that gradually became more restricted as humans evolved.

Face and hand act together

Leroi-Gourhan maintains that the constitution of the anterior field is the first condition that favored the evolution of most animals and all vertebrates. He proposes that a second condition that favored human evolution was the subsequent polarization of the anterior field into a facial and a manual pole. He defines these as complementary territories: the facial pole is delimited by the action of the head, and the manual pole by the action of the forelimbs, or more precisely, by the action of the facial organs and the tips of the forelimbs. Generally, the forelimbs are situated at the junction of the cerebral and motor sections of the body. This makes them "functionally somewhat ambiguous" (Leroi-Gourhan, 1993, p.31) in that they can be used for locomotion and / or to capture and prepare food. The realization of this potential dual-functioning can be observed in relatively low life forms, e.g. fish that use their front fins not only to swim but also to fan through sediment on the sea floor and uncover nutrients. Leroi-Gourhan places vertebrates into two functional categories depending on how they use their forelimbs:

1. Walking mammals (*marcheurs*) that use their forelimbs exclusively for locomotion, e.g. all hoofed animals. They are mostly herbivores with long heads and teeth adapted for biting off and grinding cellulose-rich vegetation. There is no functional association between their face and forelimbs, which are specialized for locomotion.

2. Grasping mammals (*préhenseurs*) whose forelimbs intervene in the anterior field for the purpose of feeding, e.g. rodents, insectivores, carnivores and primates. They have an anatomy oriented towards eating flesh or vegetation or both. The action of grasping food in order to get it into the mouth has established a functional link between the face and the forelimbs.

Humans belong to the second group, the grasping mammals, characterized by a bipolar anterior field. However, we are the **only** living species with this liaison between the facial and manual poles that does not use its forelimbs for locomotion. The fact that we use our arms and hands to eat, but not to move our bodies, distinguishes us from our closest primate relatives. It also gives biological clues to resolving the evolutionary puzzle of why we talk and they do not. Echoing an intuitive insight of the 4th century philosopher Gregory of Nyssa, Leroi-Gourhan theorizes that the fact that we use our face to speak is directly related to our dexterity. He considers this relationship between language and the hand not as a 'banal' participation of the gesticulating hand accompanying speech, "but as an organic one, manual expertise corresponding to the degree of freedom of operation of the facial organs thus made available for speech." (Leroi-Gourhan, 1993, p.36) This already implies that Leroi-Gourhan's concept of 'gesture' (*geste*) is broad and quite unique: it encompasses all 'material action', the gloss for '*geste*' proposed by White (1993, p.xvii) and endorsed by Graves (1994, p.440). Through gesture the human hand creates material evidence of culture. As we will see, Leroi-Gourhan uses this concept to explain how tools emerged as 'secretions' of our bodies, and then goes on to establish an intimate biological link between our technical and cultural evolution. But first, let us follow him back to the roots of this organic relation between language and the hands, as he traces our path from the depths of the fossil record up through the series of liberations that gave rise to it.

Liberations

Liberation of the whole body in relation to water

Anatomically, the dynamic organisation of fish has not changed much since jawed fish, ichthyomorphs, evolved 360 million years ago (see Figure 5). They swim by beating their tails from side to side. This movement is generated by the rhythmic action of antagonistic muscles supported by the vertebral axis and complemented by fins. The head cannot move independently of the rest of the

Figure 5. "Ichthyomorph — *suspension in an aquatic medium, no cervical mobility, long homodont tooth row*" (Leroi-Gourhan, 1993, p.38).

Figure 6. "Amphibomorph — *crawling on the belly, lateral mobility of the head, long homodont tooth row*" (Leroi-Gourhan, 1993, p.38).

body to which it is attached by muscles. Since buoyancy is assured by the watery medium which they inhabit, their vertical column does not play any role in supporting body structures. It simply houses their spinal chord which terminates in a small brain.

The first four-legged amphibians underwent decisive adaptations about 286–360 million years ago when they moved from a watery habitat to dry land and made the biological choice between absorbing oxygen from water or respiring it from air in favor of the latter. The amphibian solution is a partial one since their cutaneous balance and their reproduction depend on a watery environment. The skeletal architecture of all higher vertebrates is recognizable in their body plan (see Figure 6). On land, the first amphibians crawled on their bellies with the aid of four limbs equipped with fingers. The head, no longer suspended by water, was poised unstably at the tip of the body, bringing new mechanical factors into play. They could move their heads from side to side but not lift it up from the ground. This restricted the action of the mouth which opened by raising the head with the lower jaw resting on the ground. Leroi-Gourhan explains how the tip of the face (*prosthion*), the articulation point of the head on the vertebrale column (*basion*) and the top of the neck (*inion*) became intimately related with dentition and posture through the force of gravity (see Figure 7).

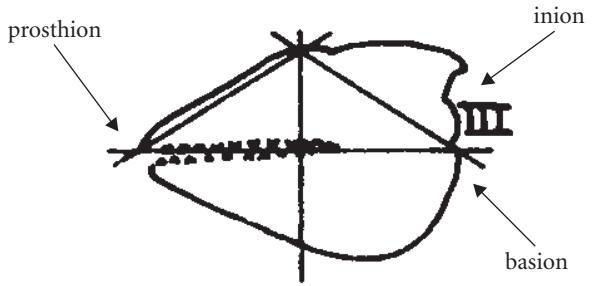


Figure 7. Cranial structure of an amphibomorph: "Weight is now exerted upon a lever that runs from the tip of the muzzle (*prosthion*) to the point at which the skull articulates with the backbone (*basion*). The skull is kept horizontal by the set of muscles and ligaments that pull on the upper part of the nape of the neck (external *inion*), following an inion-basion lever arm that counterbalances the effect of weight. The reconciliation of mandibular and suspensional stresses is a thread that runs through the entire cranial evolution of all vertebrates, including humans. Dentition and posture are closely linked from the outset." (Leroi-Gourhan, 1993, p.42)

Liberation of the head in relation to the ground

When the first lizards, sauromorphs, evolved in the Permian period about 200 million years ago, they not only completely adapted to respiring in a gaseous environment. They also embodied a more efficient solution to the mechanical problems of moving in a terrestrial habitat (see Figure 8). Their vertebral column curved to fulfil a supportive function. It served as a central beam in which the head and limbs were anchored, enabling the entire body to lift from the ground during locomotion. The shoulders gained mobility and the head moved more freely on a real neck, 'liberated' from the ground. This mechanical adaptation had the effect of enlarging the cranial volume, although the brain inside it remained relatively small. The volume of cranial dome was determined by the action of the lower jaw, unobstructed by the ground, and conditioned by

Figure 8. "Sauromorph — *crawling partially off the ground, free neck, tooth row in the front half of the skull*" (Leroi-Gourhan, 1993, p.38).

the mechanics involved in holding the head up. Its development complied with what Leroi-Gourhan claims is a law of constant proportions that holds for all terrestrial vertebrates, including humans:

> The distance between prosthion and basion (the front and back of the skull) is divided into two equal halves, one dental and the other cerebral. The halfway mark between the prosthion and the basion therefore corresponds to the last tubercle of the last tooth, and constitutes the geometrical center of the cranial structure. (Leroi-Gourhan, 1993, p.46)

As animals increased their mobility and range of postural positions, their skulls developed through the mutual conditioning of the dental and the cerebral zones. Thus, the bodily mechanics of coming to terms with gravity during locomotion and feeding created a larger cranial volume, offering the potential to be filled by a larger brain — a potential that the evolution of higher vertebrates eventually realized.

Liberation of the hand in relation to locomotion

Primitive mammal-like reptiles, theromorphs, evolved about 150–200 million years ago. With their arrival the basic skeletal architecture common to all superior vertebrates was established, although the advent of warm-blooded mammals still lay on a horizon in the distant future.

Figure 9. "Grasping theromorph — *occasionally free hand, heterodont tooth row*" (Leroi-Gourhan, 1993, p.38).

About 50–60 million years ago, the mammalian ancestors of currently living species truly walked upon the earth on four vertical limbs tipped with digits. During this period, the division into Leroi-Gourhan's two functional categories occurred, giving rise to walking and grasping mammals. The skull architecture of modern grasping mammals, such as lions, is the same as that of theromorph reptiles, "gradually modified by postural development" (Leroi-Gourhan, 1993,

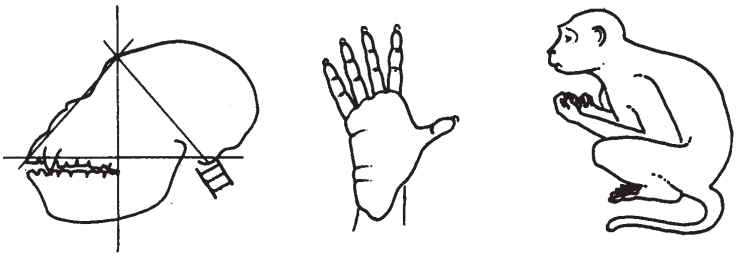


Figure 10. "Pithecomorph — *hand free when seated, opposable thumb, back part of the skull freed by the vertebral column*" (Leroi-Gourhan, 1993, p.38)

p.51; Figure 9). Unlike the hoofs that evolved in walking mammals, the digits of grasping mammals have not undergone any profound modification, and "many can sit and so free their hands" (ibid.).

The ability to liberate the hands by sitting is a distinctive feature of ancestral monkeys, pithecomorphs, and their modern descendants (Figure 10). It allows them to manipulate objects. Whereas most mammalian tree dwellers have claws, monkeys have four hands (they are quadrumanous as opposed to quadrupedal), each with an opposable thumb. This enables them to grip branches as they swing from tree to tree. Alternating between prehensile locomotion and sitting, they are the only mammals that possess constant grasping ability.

Liberation of the brain in relation to the facial mask

Leroi-Gourhan explains how the postural behavior that monkeys display is responsible for the shape of their heads: at the *basion* (junction of the vertebral column and the skull), the hole in the *occipital bone* (through which the spinal cord joins the brain) opens obliquely downward (Figure 11). This results from their postural ability both to sit upright and to move on all four limbs.

Compared with animals that cannot sit, e.g. lizards,

- their *prosthion-basion* base is shorter — hence, the face and teeth are shorter.
- their *basion-inion* lever is lower — hence, "for the first time in the animal kingdom" (Leroi-Gourhan, 1993, p.58), the cranial dome is partially liberated from mechanical constraints involved in holding the head up. Simultaneously, the base of the skull is liberated from mechanical constraints involved in clenching the jaw.

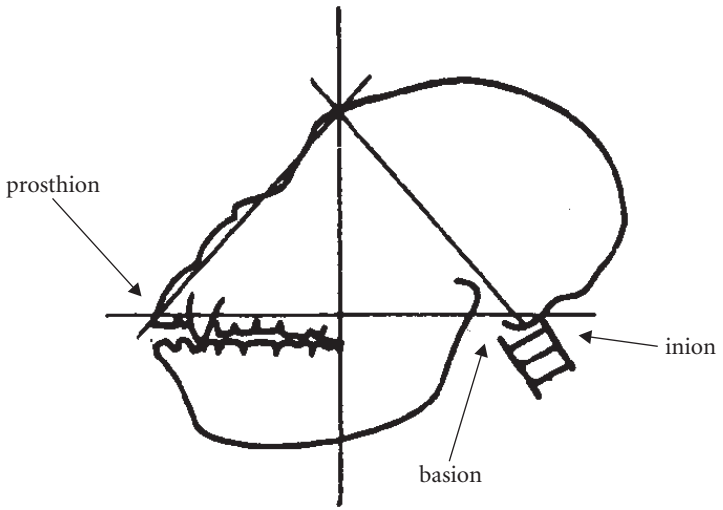


Figure 11. Cranial structure of a pithecomorph

Consequently, the facial bloc gained autonomy in relation to the cerebral zone of the skull. This allowed the skull to expand. The primate face took shape along the lines of a triangle which joins the *prosthion*, the *basion* and the orbital bloc formed by the eye sockets. This explains the "visor" (Leroi-Gourhan, 1993, p.58) above the eyes of primates. "The disengagement of the cranial dome is thus achieved from the back of the skull; the prefrontal area in all primates, as

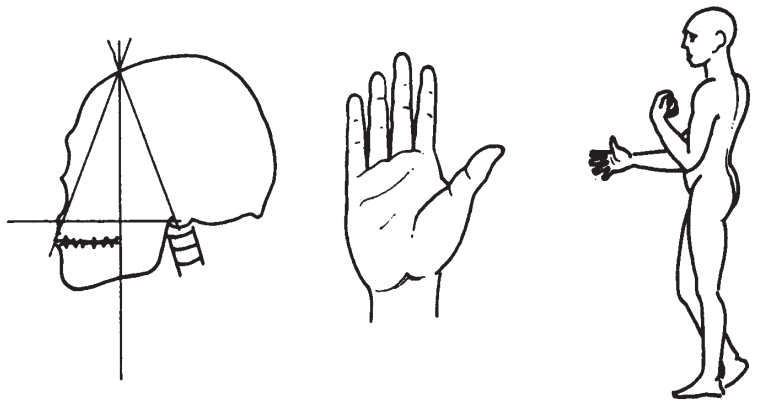


Figure 12. "Anthropomorph — *hands completely free, erect posture, mechanical disengagement of the convexity of the skull*" (Leroi-Gourhan, 1993, p.38)

in the primate anthropoids, is **locked** in position by the eye sockets (the orbital bolc)" (ibid.) (my emphasis).

The achievement of walking upright by our hominid ancestors, *anthropomorphs*, was decisive. One consequence of this was that, unlike all four primate hands, the human foot does not have an opposable big toe that would facilitate grasping. This implies that a common ancestor linking humans and other primates lived in the extremely remote past.[5] Erect posture liberated the hands entirely from locomotion, allowing our hominid ancestors to gain skills in manipulating objects, skills that are required for making tools and using them. This in turn liberated the face from prehension, so that it was free to materialize the output from the articulated-sound system for symbolizing that we call language. Erect posture also optimized the cranial tendencies already evident in monkeys: face and teeth were further reduced and the cranial dome became completely liberated from mechanical constraints. Balanced on a curved (but effectively vertical) vertebral column, the head was free to expand — opening up like a fan towards the back and sides.

Leroi-Gourhan sees this expansion as posing the most important problem confronting paleontology: "the freeing of the forehead in *Homo sapiens*, a phenomenon correlated with a thoroughgoing reshaping of the face in the course of which the forehead, the cheekbones, and the chin make their first appearance" (Leroi-Gourhan, 1993, p.71). He asserts that the reduction of the roots of the teeth triggered this remodelling. Furthermore, these mechanical liberations, these physiological adaptations (technical means) to walking in a terrestial habitat, drove the enhancement of the nervous system (organisational means), especially in its control centre, the brain. The hominid brain progressively filled the entire cranial cavity, folding in on itself as new formations covered previous ones that continued to play their roles. The most recent feature in this layering process of one brain on top of another is the neocortex. It covers the largest part of the human brain, the cerebrum, that is divided into the right and left cerebral hemispheres that are linked by a series of neural bridges. Each hemisphere receives sensory input from and controls movement in the opposite side of the body. The development of specific functions, such as language, in predominantly one hemisphere is known as lateralization. It has been demonstrated that the left hemisphere, as viewed from the back of a person, is dominant for language in most right-handed people, and even in the majority of left-handed people.[6] This localization hinges on the interrelation between ontogeny, the development of an individual, and phylogeny, the development of a species. Deacon maintains that "lateralization is almost

certainly an effect and not a cause of brain-language co-evolution" and "largely an effect of language development in an individual's lifetime" (Deacon, 1997, p.309). He also stresses the importance of not just assuming that a bigger brain is necessarily a smarter one: the brain / body ratio must be taken into account too. We have a much bigger brain than would be expected for our body size. It also seems that the human development pattern from gestation to maturity is quite exceptional in the animal world. "The human pattern of brain growth is appropriate for a gigantic ape, while the pattern of body growth is appropriate for a large chimp" (Deacon, 1997, p.214).

Writing in the 1960s, Leroi-Gourhan was aware of the groups of brain cells then known to be involved in language processing (see Figure 13). He describes the sensory motor cortex of the left cerebral hemisphere that occupies the borders of the fissure of Rolando (also called the 'central fissure') separating the frontal lobe from the parietal lobe. Brain cells on the frontal side of the fissure govern movement and those on the parietal side are linked to sensation. They pair up so that movement and sensation are integrated in the body parts to which they are connected. Areas known to be involved in speaking, listening, reading, writing and signing are located around the sensory-motor areas that are linked to the face and the right hand.

Leroi-Gourhan reproduces one of Penfield and Rasmussen's (1950) *motor homunculi*, that maps out areas of the cerebral cortex involved in motor activity, in order to show how a neuromotor image of the human body is reflected in the brain (see Figure 14). Brain cells involved in voluntary motor control of the head and neck are located at the bottom of the frontal lobe, and those linked to the feet are at the top. Viewed in this upside down neurological mirror, the size of each group of cells reflects the relative amount of voluntary motor control that can be exercised over each part of the body. The neural areas that control the hands and the face are contiguous, and they occupy considerably more space than those that correlate with other body parts, e.g. the feet. Leroi-Gourhan holds that this neurological adjacency in the brain indicates that the interrelation of the movements of the hands and face was established deep in our evolutionary past, and that the distinction between the facial and the manual zones in the sensory motor cortex is present in all grasping mammals and tailored to their particular range of movement and sensorial ability. He compares the topography of the human brain with that of monkeys in order to look for neurological clues that might lead to discovering why only humans talk. He points out that cortical areas associated with language processing are either absent or undeveloped in non-human primates because, locked inside a

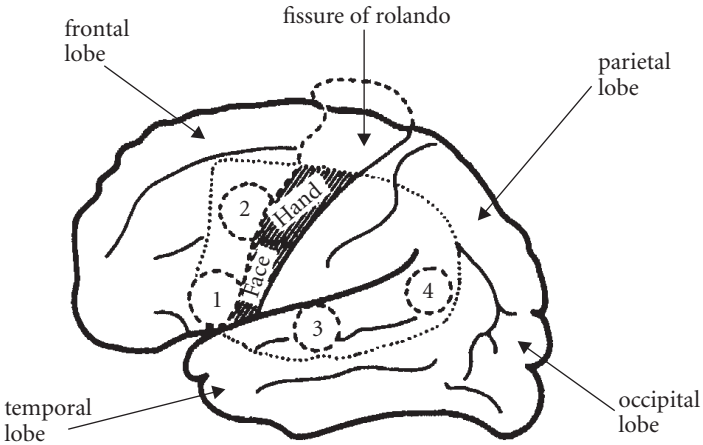


Figure 13. The area of voluntary motor function is shaded; the dots indicate P. Marie's quadrilateral area of aphasic lesions — anarthria [inability to form coherent articulated sounds] *(1), agraphia* [inability to write] *(2), word deafness* [inability to identify spoken words] *(3), word blindness* [inability to read] *(4)* (Leroi-Gourhan, 1993, p.87).

skull that never 'fanned out', these areas never had room to grow. However, apart from other distinguishing features that are due to different modes of locomotion — bipedal as opposed to quadrumanous — he notes that both man and monkey have an equal neural representation of the face and hands but that these are used in different ways:

> In the monkey this link is primarily related to feeding and the same is, to a lesser extent, true of the human, but in the latter case coordination between the face and the hand is equally pronounced in the exercise of speech. This coordination, which is reflected in the use of gesture as a **commentary** to speech, reappears in writing as the transcription of vocally emitted sounds. (Leroi-Gourhan, 1993, p.85) (my emphasis)

Leroi-Gourhan clearly sees this neurological link as supporting a theory of the origin of language in which gesture played an active role. Although he does not clarify how gesture 'comments' on speech in modern man, he does picks up the thread of its evolutionary role in transcribing speech into writing. First of all, he deals with the 'biological vocation' (*vocation d'organe*) of the human hand: manufacturing tools. By tapping the roots of technology he sets out to reveal why man alone uses his hand to make things and his face to make words. With the biological foundation for the evolution of gesture, i.e. 'material action', and

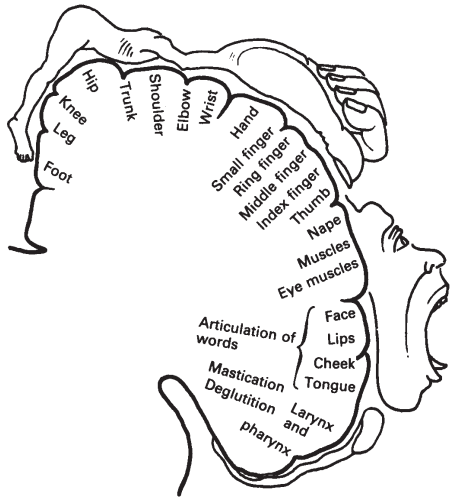


Figure 14. Cortical picture of voluntary motor function in [...] a human (after Penfield and Rasmussen) (Leroi-Gourhan, 1993, p.82).

speech in place, his hypothesis takes a decisive cultural turn that hallmarked our ancestors as human beings. A modern, admittedly very approximate and brief, prehistory of culture is provided by Douglas (2001, p.45; Figure 15 below). Her schema integrates more recent paleontological and archeological evidence into a chronology that allows us to identify the stages at which Leroi-Gourhan places his stepping stones. Of course, discrepancies do occur as his time timescale was based on evidence available in the 1960s, but the order of events has remained the same since then.

From nature to culture

Terminology

How does the emergence of language fit into Leroi-Gourhan's evolutionary story? On the cognitive side of the linguistic coin, the dividing lines between of his three key terms are somewhat blurred:

1. language (*langage*)
2. reflective thought (*pensée réfléchie*)
3. reflective symbolism (*symbolisme réfléchi*)

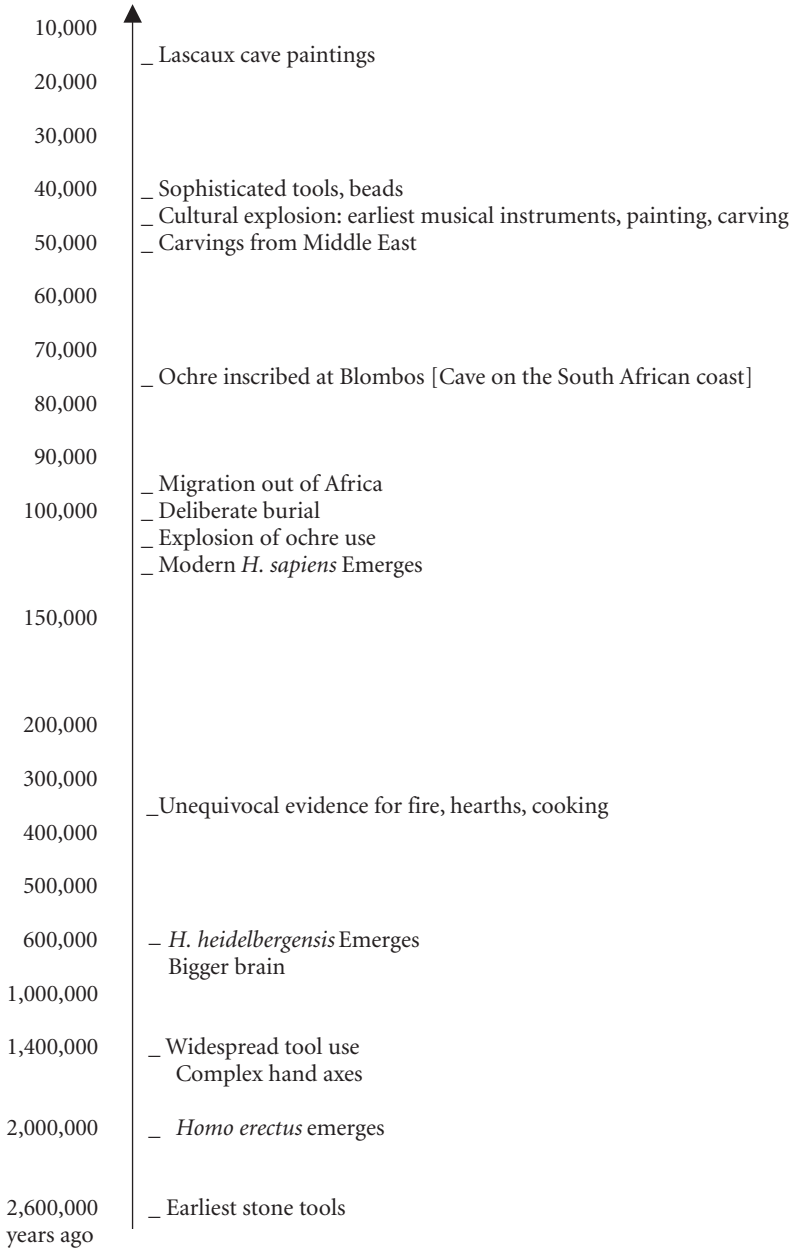


Figure 15. A brief history of culture (Douglas, 2001, p.45)

These terms tend to overlap in his linguistic conception in that thought extracts symbols from reality to create language and, thereby, we get a mental grip on the world. On the communication side of linguistic activity, Leroi-Gourhan conceives of language as a form of symbolization that is externalized and materialized first through the face (in transient speech), and subsequently through the hand (in more permanently fixed mythological symbols that gave rise to writing). The term '*parole*' is unambiguously reserved for the spoken word, which he conceives of as a "phonic symbol" (Leroi-Gourhan, 1993, p.412, n.10). The role of the face in communication is not restricted to speech. He recognizes the communicative importance of facial expressions, but reserves the term '*geste*' for the technical activity of the hand and for its symbolic activity in figurative manifestations, such as paleolithic 'art', and in writing.

Tools and talking

According to the most recent finds, the first stone tools appear in the archeological record about 2,600,000 years ago (see Figure 15). Rather than putting a date on such artifacts, Leroi-Gourhan attributes the earliest examples known to him to *Zinjanthropus* and other *Australopithecines* belonging to the African Pebble Culture that thrived at the transition from the Tertiary to the Quarternary era, i.e. about 1,800,000 years ago.[7] Acknowledging the difficulty of distinguishing between the regular stone forms made by hominids and those produced by natural processes, he considers the first stone tools as "a 'secretion' of the anthropoid's body and brain" (Leroi-Gourhan, 1993, p.91) — each chopper, scraper or blade evolving towards total functional efficiency of form is seen as an 'artificial organ' that extended the technical range of the hand that held it. He proposes that tools appeared at this point in hominid evolution as an anatomical consequence of hands and teeth having become "completely useless as weapons" (Leroi-Gourhan, 1993, p.90), coupled with advances in brain organization that enabled complex manual operations. Making and using stone tools required conscious intention and careful attention. The first toolmakers needed an inner vision of what the tool should look like and what it could do once it had been made. They had to find a suitable stone and administer the right blows at the correct angles to make a stereotyped form. The mental vision coupled with rhythmic body movements produced the intended result. Striking stone against stone to chip away fragments of particular shapes and sizes demanded highly-tuned visual and kinetic skills (Figure 16).

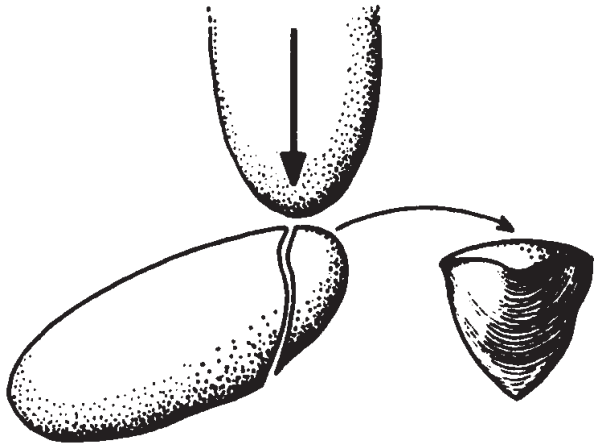


Figure 16. Industry in the first stage. The operating sequence is confined to a single action (Leroi-Gourhan, 1993, p.93).

Since the movements of the hands and face are coordinated in the same cortical region of the brain, the same fundamental mental equipment and processing were employed to make concrete tools and language. Leroi-Gourhan considers both to be expressions of the same essentially human characteristic. Both extend the means to 'grasp' the world. Tools do this materially. Words perform this action cognitively. Lexicalized metaphors that express the conceptual link between 'grasping' and 'understanding' have not gone unnoticed by linguists. Not only do we 'catch' and 'grasp' what someone is saying in English, but equivalent expressions are also available in other languages. For example, Blank (1999, p.72) points out that the Italian word *capire* 'to understand' stems from *capere* (Lat.) 'to catch', and that *afferare* 'to grip, to grasp' is also used to mean 'to understand'. Trabant (1998, p.105 ff.) expands on the relation between the German words *Griff* meaning 'grip' or 'grasp' and *Begriff* meaning 'concept' or 'term' that are merely distinguished by a prefix. In his view, the ear plays a major role in this transformation of our mental grip on the world into the words that end up in our mouths.

In the French philosophical tradition, ideas about the interplay between the senses abounded in the 18th century debate about the origin of language that was inspired by Locke's (1690) essay.[8] In Condillac's (1746) essay, an explicit reply to Locke's, not only is the intimate relation between hands and words fundamental to his semiogenetic scenario in which gestural and verbal expression amalgamate in 'action language' (*langage d'action*). The relationship

between hands and knowledge acquisition also features in his treatise (Condillac, 1754) in which a hypothetical statue first discovers the world through the hand. Touch is proclaimed to be the only sense that can judge external objects alone, enabling the statue to distinguish between what is inside and outside of itself. The hand gives form to the expanses of colour that filter through the statue's eyes, instructing the other senses to spread their perceptions over the mental scaffolding it creates. The spatial awareness of volume afforded by the tactile sense lays a tangible foundation for the temporal sense of linearity produced by successive impressions of all sensorial kinds. This cognitively frees the statue from here and now, but it remains enclosed in a wordless world because it is alone: communication is a prerequisitive for language in Condillac's view.

Leroi-Gourhan also places the origin of language in a communicative situation. He even provides a biological foundation to Condillac's semiogenetic scenario, in which the feeding function of the hands and face — the common neurological ground between humans and other primates — extend towards the language function. Condillac's portrayal of our ancestors reaching up and crying out towards inaccessible fruit in a tree fits in nicely with the neurological hand-face relation that Leroi-Gourhan explicates. In his biologically informed view Leroi-Gourhan sees language evolution more as a neural problem rooted in the brain (organisational means) than as a somatic one (technical means) in the face: "The point at issue is neuromotor organization and the quality of cerebral projections" (Leroi-Gourhan, 1993, p.112). Armed with the disclaimer that before writing first appeared it is impossible to prove the existence of language, he tentatively explores the extent to which one can project current linguistic behavior back to its prehistoric roots.

The essence of his hypothesis is that language was possible from the moment that tools emerged because of the neurological link between the face and the hands, and because language and tools are inseparable in the social structure of humanity, past and present. He speculates that the hominids who produced the first simple tools would have had "language at a level corresponding to that of their tools" (Leroi-Gourhan, 1993, p.114). Although this level would have been very low compared with language as we know it, it would nevertheless have surpassed the vocal calls of modern non-human primates. He classes vocal calls as signals. To distinguish them from words, he draws a parallel with tools — the only concrete evidence of reflective thought before the hand delivered concrete evidence of reflective symbolism in figurative representation, and language in writing. He argues that modern non-human primates

are characterized by the spontaneous production of signals and 'techniques', such as using sticks to hook bananas down from trees, only in response to external stimuli. In contrast, hominids produced durable concepts and tools that presupposed an intended future use: "The making and using of choppers or bifaces must be ascribed to a very different mechanism since the operations involved in making a tool anticipate the occasions for its use and the tool is preserved to be used on later occasions" (Leroi-Gourhan, 1993, p.114).

Leroi-Gourhan believes that the foresight required to make the first stone tools implies that concepts were already captured in symbols that were not totally determined. He proposes that these symbols were stored in a mental lexicon and, like stone tools, were available to be applied when needed. He introduces his central notion of 'operational sequences' (*chaînes opératoires*), drawing a parallel between the linear organisation of tool and language production. Both employ memory and 'syntax':

> Techniques involve both gestures and tools, sequentially organized by means of a 'syntax' that imparts both fixity and flexibility to the series of operations involved. This **operating syntax** is suggested by the memory and comes into being as a product of the brain and the physical environment. If we pursue the parallel with language, we find a similar process taking place. (Leroi-Gourhan, 1993, p.114) (my emphasis)

Here, Leroi-Gourhan is comparing the cognitive processing involved in creating products of two different orders — and not just the purely physical (stone tools) with the essentially cognitive (language) that nevertheless does have material aspects for the purpose of communication (speech and writing). Tools are spatially concrete, whereas words are temporally fleeting. They "exist only the moment when we think and understand them" (Aarsleff, 1982, p.297). Furthermore, manual gestures produced stone tools by a process of subtraction, chipping away fragments to reveal a final form that retained the same function(s) in different circumstances. In contrast, language produces meaning by a process of addition, creating networks of reference between linguistic elements and the unique extralinguistic context in which they are embedded. In modern brains, the processing time required to string together linguistic units into a meaningful sequence is many times quicker than it would take to sequence movements to create a stone tool. However, since we are dealing here with hominid brains poised on the watershed between immanent humanity and the rest of the animal kingdom, the speed of their thoughts is beyond our

comprehension. Despite these discrepancies, Leroi-Gourhan's analogy between the production of stone tools and language does present interesting comparisons:

1. The success of each tool would have depended on how efficiently its form fitted its function. From a pragmatic point of view, the success of utterances, signed or written text is also a matter of how fittingly they suit their intended purpose.
2. A particular tool was the result of a kind of recipe determined by its 'operating syntax': the type and sequence of blows subjected to raw material with particular properties. Syntactic flexibility enabled innovation to occur. The chopper recipe, for example, could have been adjusted during materialization to produce a variant or something quite novel. The linguistic equivalent of the operating syntax produces utterances. These are 'born' between the brain and the situational environment, the equivalent of the material milieu, as linguistic components recalled from memory are strung together. The stored syntactic recipes for stringing words together to create meaning do seem to be fixed in some ways, but supple enough in others to allow for variation and innovation. They order stored lexical items sequentially, adjusting their morphological form in an 'on-line' manipulation as they are spoken or written down. Thus, syntax weaves patterns out of words morphemes, each consisting of phonological sound patterns phonemes, to produce semantic patterns within a particular linguistic environment (co-text) and situational environment (context) (Aitchison, 1996). The 'duality of patterning' (Martinet, 1965) that interlocks the levels of morphemes and phonemes to create sense out of sounds sets language apart from other activities involving pattern (re)cognition and (re)production that humans engage in, e.g. music.
3. Since syntax can be considered to be "less accessible to consciousness than semantics, but more so than phonology" (Aitchison, 1996, p.203), it operates at the interface between unconscious cognitive processes and intentional, controlled behavior — just like the operating syntax that produced stone tools. Chomsky invingtly leaves the door open to theorists who propose that syntax is an adaptation that may have been "exapted away" (Hauser et al., 2002, p. 1570) from previous adaptive functions such as toolmaking. His view of syntax, singled out as the unique and essential property of human language, boils down to "the core computational mechanisms of recursion" (Hauser et al., 2002, p. 1573). Applied to a finite set of elements these are seen to yield a potentially infinite range of discrete expressions that are subsequently mapped on to the "sensory-motor" and

> "conceptual-intentional" (Hauser et al., 2002, p. 1571) interface systems, which are assumed to have been "given" (Hauser et al., 2002, p. 1578) before syntax evolved to link them, and some features of which may not be exclusively human. Thus, the semantic dimension inherent in duality of patterning is relegated to secondary processes rather than seen as integral to the core functioning of the language capacity.

Leroi-Gourhan correlates the generation of language and stone tools according to degrees of complexity and richness of concepts: the more complex the operating syntax required to produce the tool, the higher the level of language in use at the time. Thus, he envisions an evolutionary progression in which tools and language developed in synchrony. Deacon cautions us about the assumption that "simple tools mean simple minds" (1997, p.368) with particular reference to the apparent lack of technological change during the *Homo erectus* epoch of human evolution (see Figure 2). He believes that the language capacity and tools could have developed out of sync: "Their brains and their symbolic forms of communication were undoubtedly co-evolving together, even if the tools they were using were not progressing at a comparable pace" (Deacon, 1997, p.369). He supports his position by pointing to the vast range of habitats, from subtropical to subarctic climates, to which *Homo erectus* adapted whilst retaining a relatively stable repertoire of stone tool recipies that needed little modifiction to promote their survival. He also warns that "we cannot assume that all tool users were our ancestors" (Deacon, 1997, p.347) because stone toolmaking "is not passed on genetically" (ibid., p.346). Tool use is a learned behavioral adaptation and, therefore, could have spread across species.

In Leroi-Gourhan's discussion of the language of the Neanderthals,[9] who lived about 50–100,000 years ago, he reveals what he considers to be the primary function of language: "It was reserved essentially for concrete situations and used for the purpose of communication during the performance of activities, a prime function in which language and technical behavior are closely combined" (Leroi-Gourhan, 1993, p.115). Although he uses the term 'language' (*langage*) rather than 'speech' (*parole*) in this instance, spoken words are implied because he sees the primordial function of language as solving a communication problem between toolmakers in action. Since their hands would have been tied up in the technical action being applied to materials, gestural signs could have played a role before and between stages of manufacture, but not during them. Speech, in this instance, would therefore have been more efficient since it could run uninterruptedly in parallel with tool production.

Leroi-Gourhan does not exclude the possibility of a purely gestural technical education since it would have triggered symbolic processes in both communication partners. However, he does not speculate further on the semiotic potential of manual gestures at this primeval stage of language evolution. The role of gesture in his story of the origin of language is primarily a technical one: verbal expression began by communicating symbolic sounds referring to the actual manipulation of concrete matter.

Technical and social memories

Taking the technical relation between gesture and tools a step further, Leroi-Gourhan incorporates his theory of how rhythm, that has a deep zoological foundation, underlies many facets of humanity, past and present. Stone tools were the result of repeated hammering, sawing and scraping. These rhythmic gestures created forms out of inert matter that were then ready to be animated. Without the technical operation in which they are employed, tools are mere skeletons of tools. The only "real significance of tools is in the gesture, which makes them technically effective" (Leroi-Gourhan, 1993, p.237). For example, arrows only exist in the steady drawing of the bow that sends them flying to their target. The "operational synergy of tool and gesture presupposes the existence of a memory in which the behavior program is stored" (ibid.), i.e. how to make and use a tool. Animals have a technical memory integrated into their biological behavior, e.g. how to make a nest, and their technical operations have an instinctive character. Leroi-Gourhan maintains that in human beings the removability of tools and language led to the externalization of operational programs linked to group survival. What distinguishes animal from human memory is that the former is contained in the species (*espèce*) whereas the latter is contained in the ethnic group (*ethnie*) and dominated by language. Thus, language not only solved a communication problem between stone toolmakers, but also enabled cultural values to be stored within a speech community. The emergence of tools, in parallel with language, marks the transition to humanity: "The emergence of tools as a species characteristic marks the frontier between animal and human, initiating a long transitional period during which sociology slowly took over from zoology" (Leroi-Gourhan, 1993, p.90).

About 150–200,000 years ago anatomically modern man, *Homo sapiens sapiens*, appeared in the paleontological record (see Figure 2). The archeological record delivers evidence that very few stone-tool recipes with little variation had been 'handed down' for over a million years until about 30–35,000 years ago,[10]

when an abundance of new tools appeared. Regional variations emerged within 20,000 years and, in Western Europe alone, 20 basic types of tool have been found in more than 200 varieties. Leroi-Gourhan holds that this rapid wave of innovation not only equates with increased cognitive ability due to brain development, but that cultural differentiation, "the main regulating factor in the development of *Homo sapiens*" (Leroi-Gourhan, 1993, p.144), must also have been a vital factor. Since the brain seems to have reached its maximum volume with the arrival of anatomically modern humans,[11] he argues that biological evolution gave way to cultural evolution dominated by social phenomena, and that there is always a direct link between technological development and social forms. Equipped with a fully 'liberated' brain, tools and language, our ancestors bridged the evolutionary gap between nature and culture. Language played the vital role of capturing and externalizing memory — the repository of technical know-how, social organisation, religious customs and esthetic traditions. Leroi-Gourhan's hypothesis echoes Condillac's emphasis on the role of memory as pivotal in the passage from nature to culture: memory enabled our ancestors to establish conventional signs (*signes d'institution*) and to do with *réflexion* what they had formerly done by *instinct* alone (Condillac, 1746, p.195, §3). It also recycles Plato's weaving metaphor in *Cratylus*: it makes language into "an instrument of teaching and of separating reality" (Plato, p.23) — a tool that tailors reality according to the social needs of the ethnic group using it to weave their thoughts into text.

Three primary linguistic functions

Leroi-Gourhan proposes a chronology of functions that correspond to increasing linguistic abilities in the course of hominid evolution:

1. Communication during technical activities, e.g. making and using tools, whereby he equates the level of technical progress with that of linguistic complexity.
2. Progressive emergence of "post facto transmission of the action symbols in the form of narration" (Leroi-Gourhan, 1993, p.115), which built up technical and social memories in the course of time.
3. Surpassing of the primary link with the concrete world and its narrated reflection: the expression of "sentiments of a less precise nature" (Leroi-Gourhan, 1993, p.115) which entered into the supernatural domain of religious sentiment.

Thus, he theorizes that language slowly became detached from the concrete world of toolmaking and created a world of abstract concepts. Calbris' theory (2003) would appear to support his view.

The original art of writing

Leroi-Gourhan conceives of a reintegration of the hand and face in writing. The hand that was employed to make and manipulate tools subsequently took on the function of symbolizing exercised by the face. "Before writing, the hand was used principally for making and the face for language, but with the invention of writing the balance between the two was restored" (Leroi-Gourhan, 1993, p.113) in that both speech and writing materialize thought. Leroi-Gourhan sees the seeds of writing in the first traces of figurative imagery in caves. Both employed the hand in order to capture thought in material symbols. The eyes that guided tools to process material in order to sustain body functions, e.g. food preparation, began to guide tools to materially fix cognitive activity. Referring to the two functional couples he has established, "hand/tools, face/language" (Leroi-Gourhan, 1993, p.187), he suggests that graphic symbols created a new, exclusively human relationship between the face and hands: "face/reading" and "hand/graphic sign" (ibid., p.188), in which vision occupies the predominant place. Bypassing the ear-oriented relationship that binds communication partners, this functional redistribution creates an eye-oriented relationship between a writer and the writer's text, and between a reader and the writer who is only present in the text. The visual word brings the objective, semantic, cognitive aspects of language to the fore: "The sharp division is thus created between denoting the world, 'talking about', and 'talking with', both of which are connected in every spoken utterance (in which 'talking about something', on the contrary, can be completely missing)" (Trabant, 1998, p.111).[12]

Rhythmic gestures

Leroi-Gourhan asserts that all graphic expression has its roots in abstract rather than realistic representation, that it began with signs which appear to have expressed rhythms and not forms. In this respect, his view differs from Condillac's despite otherwise striking parallels. Leroi-Gourhan theorizes that it originated from the same source as speech, i.e. reflective thought that abstracts symbols from reality by analysis in order to get a mental grip on the world. He holds that reflective thought was first expressed in "vocal language and mimicry"

(Leroi-Gourhan, 1993, p.195). Without saying what the first iconic gestures may have conveyed — rhythms or forms — he speculates that two languages developed synchronously from these prime sources:

1. Auditory language in the facial pole
2. Visual language in the manual pole

Leroi-Gourhan links the development of visual language with the evolution of the cerebral areas where gestures, "translated into graphic symbols" (Leroi-Gourhan, 1993, p.195), were coordinated. He proposes that the parallel development of symbolizing abilities in both the facial and the manual pole would explain why the oldest known graphics are "stark expressions of rhythmic values" (ibid.). His argument rests on the increasingly precise process of analysis and abstraction underlying reflective thought. This may tally with Condillac's (1746) theory of the evolutionary ascent of the mind to the heights of reason through increasing analytic abilities that optimized the process of 'transforming sensations'. But their conclusions diverge: Condillac envisions mental images, that gestures had traced in the air, materializing as simple pictures of concrete referents in the first form of writing. Realistic representation then became increasingly abstract as his examples of Egyptian hieroglyphs, Chinese characters and alphabetic letters are called upon to demonstrate (Condillac, 1746, p.252, §127).

Highlighting the importance of communication, emotions play a major role in Leroi-Gourhan's conception of intellectual development. He conceives of figurative behavior as an emotional language that is indissociable from verbal language. It originates from the same human aptitude "of reflecting reality in verbal or gestural symbols or in material form such as figures" (Leroi-Gourhan, 1993, p.363). Indeed, he sees the whole palette of artistic expression — dance, mime, theatre, music and the visual arts — as biologically linked with tools and language. They all use the same 'routes' (*voies*) through the body and the hand, the eye and the ear. Tools, language and figurative representation may spring from the same source, but they delineate two complementary rhythmic poles: the technical one that humanizes brute matter (tools), and the figurative one that humanizes behavior (language and art). What distinguishes figurative behavior is that it belongs to the realm of the imagination. It is biologically based in the perception of rhythms and values. The progressive intellectualization of sensations led to the conscious production of these, and to symbolic codes of ethnic significance, i.e. art forms that are biologically akin to the material and relational grip on the world that tools and language create:

> But whereas the purpose of verbal figures — words and syntax — is, like the purpose of tools and manual gestures, their equivalents, to provide an effective hold on the world of relationships and of matter, figurative representation belongs to a different biological field, that of the perception of rhythms and values, which all living beings have in common. Thus we see that tools, language, and rhythmic creation are three contiguous aspects of one and the same process. (Leroi-Gourhan, 1993, p.365 f.)

This biologically based contiguity opens up the question of the origin of language to the possibility of the simultaneous emergence of diverse forms of human expression that huddle under the umbrella term of 'art', and their interaction in a common genesis. Figurative behavior is an emotional language for Leroi-Gourhan since it forges common values between the artists (*figurants*) who are emitting images and their audience who responds with fitting emotions. Although one can only speculate about prehistoric figurative behavior involving sound and movement, one is reminded of Rousseau's party scene at a well in his (1781) essay, written in response to Condillac's (1746) essay. There, lovers from different families meet (previously incest was the norm) and speech, or rather sung language, emerges for the first time — humanizing them, binding their hearts as "their feet were joyfully leaping" (Rousseau, 1781, p.123).[13] Unfortunately, just as spoken words do not fossilize, neither do dances, although some musical instruments have survived about 45,000 years (Douglas, 2001, p.45). Therefore, Leroi-Gourhan anchors his speculation about the origin of language in concrete prehistoric traces left by figurative gestures. He identifies the first of these as series of equidistant lines engraved in bones and stones that were made towards the end of the Mousterian culture, i.e. 35–40,000 years ago. According to his knowledge, their appearance coincided with the first known use of dyes, e.g. red ochre, and body ornaments, as well as the first habitations. Douglas (2001) reports that current evidence suggests that red ochre was widely used in Africa as early as 100–120,000 years ago (see Figure 15). But the dates she quotes for the first evidence of body ornaments and habitations are similar to those proposed by Leroi-Gourhan. Since repetition is the essence of rhythm, he views these engravings of parallel lines as the first "proof of the earliest rhythmic manifestations" (Leroi-Gourhan, 1993, p.188; Figure 17). Although he pushes aside interpretations as to their meaning, e.g. "hunt tallies" (ibid.), as unfounded, he speculates that they could have been associated with rhythmic incantations.

Deacon (1997) reminds us that artifacts made of material other than stone perish relatively quickly and are therefore rarely present in the archeological record. Furthermore, "artifacts are not reliable indicators of mental abilities"

Figure 17. Paleolithic incisions on bones, known as 'hunting tallies' (Leroi-Gourhan, 1993, p.189). (Solutrean culture 16–19,000 years ago.)

(Deacon, 1997, p.367) and "most of the symbol use in a society, even excluding language, is not even embodied in any material, but only in ceremonies, habits, and rules that govern everyday life" (ibid.). He attributes the origin of language to the need to create common value systems through the use of symbols. Like Condillac (1746), he entertains the possibility that speech and gestural communication formed a "more complete hybrid" (Deacon, 1997, p.356) than the "symbiosis" (ibid.) we observe today, before language eventually gained autonomy as a closed symbolic system as speech abilities increased. He envisions a heterogeneous mix of multimodal symbolic communication that could have involved handling objects, perhaps like the one illustrated in Figure 17, as well as making symbolic sounds and gestures during the course of symbolic rituals that evolved to meet increasing communication demands. He suggests this may have occured when meat became a critical food source (requiring stone tools to process it), placing unprecendented demands on social group organization. He explains that most mammals are polygynous and typically live in groups in which the females alone raise offspring sired by the fittest males. Alternatively, pair-bonding typically occurs in species that favor social isolation, thus maximizing the probability of sexual fidelity, and in which both males and females care for their young. Human societies have a unique and "highly volatile social structure" (Deacon, 1997, p.388) that incorporate both models. They comprise "cooperative, mixed-sex social groups" (ibid.) in which long-term (mostly) monogamous arrangements are formed and the upbringing of

children is shared by both parents. Deacon theorizes that our ancestors went through a "shift from polygyny to pair-bonding" (Deacon, 1997, p.392) that coincided with the emergence of *Homo habilis* (the toolmaker), the introduction of meat into the hominid diet, increased brain size and reduced sexual dimorphism, i.e. difference in body size between males and females. Hunting required social cooperation, and not just among the hunters: while they were out catching meat, their females were exposed to other potential mates back home. Conversely, males on hunting trips could have found new mates and given them the meat they caught. Deacon proposes that the cognitive feat of symbolic processing was the answer to the communication problem that cooperation posed. Symbolic rituals evolved to regulate sexual relations and establish kinship alliances vital to survival. Enabling mental representations to be shared, signs were invented to mark exclusive pair-bonding within the group. They represented the "promises and obligations that link a reproductive pair to the social groups of which they are a part" (Deacon, 1997, p.400), and the rituals in which they were used "still echo" (ibid., p.407) in the public exchange of rings in a festive setting of traditional words and music that we all recognize today: in Deacon's view, the origin of language was marriage.

The correlation of evidence that the fossil and archeological records deliver is a source of continuing controversy among evolutionary anthropologists seeking to explain the emergence of social cooperation and monogamy among our ancestors. For example, Douglas (2001) outlines the theory of Leslie Aiello who believes that the need for cooperation was driven by expanding hominid brains. In a similar vein to Deacon, she argues that as offspring with increasingly larger brains took longer to reach maturity, an energy-rich food source such as meat became essential and females would have benefitted from having mates who went hunting to feed them and their children. However, this cooperation would have conflicted with the evolutionary interests of males, i.e. to mate with many females and produce offspring that they did not raise themselves. Douglas highlights a recent development of Chris Knight's (1991) theory that female coalitions may have formed to punish uncooperative males, i.e. by collectively agreeing to refuse to mate during menstruation and until their mates returned home from a successful hunt, females could have gained power over reproduction: no meat, no sex. Camilla Power, a student of Aiello's, builds on Knight's idea by suggesting that females may have faked the natural signs of menstruation by painting their bodies with red ochre. Their symbolic "Stone Age make-up" (Douglas, 2001, p.42) — a cultural sign of their fertility — could have been used to signal their unavailability for sex until the meat arrived. Knight (2000)

discusses Power's idea of how speech may have arisen "out of long-term strategies of reciprocal altruism between *females*" (Knight et al., 2000, p.22) to counteract the threat posed to pregnant and nursing females of losing male attention in favor of local rival females. Both Knight and Power refer to extant traditional societies that enact initiation rituals linking hunting, menstruation and the lunar cycle. They note that these cultural connections have natural foundations: the light of the full moon provides the optimal conditions for hunting, and the lunar and menstrual cycles are approximately the same length.

Abstract and realistic forms

Symbols of human sexuality and animals provide Leroi-Gourhan with the material for his story of the birth of graphism. According to him, the oldest European remains of graphic forms inscribed on cave walls about are 30,000 years old.[14] They depict symmetrically grouped animal heads and, in his interpretation, humans are represented by very abstract sexual symbols (Figure 18).

Figure 18. Engraving from Aurignacian I, cellier shelter (Dordogne). One of the earliest figurative records that can be dated with certainty. We see a head (probably a horse's), a female symbol, and some regular incisions (Leroi-Gourhan, 1993, p.193).

In his terminology, 'to abstract' means to "isolate mentally; to consider a part by isolating it from the whole" (Leroi-Gourhan, 1993, p.373). He theorizes

that this process corresponds exactly to the genesis of the first prehistoric art forms "in a logically consistent manner" (ibid.): expressive features (phallus, vulva, animal head) of what was to be figured were selected and reassembled to translate a myth into symbols. Hence, "the tip of symbolizable thought appeared first, long before any realistic organization of figures was possible" (ibid.). Leroi-Gourhan sees these abstract beginnings of art as the root of the long, slow development of efforts to manually translate a content that had already been verbalized. Although their execution was still 'stuttering' (*balbutiante*), he finds that their content implies a convention that was inseparable from concepts that had already been highly organized by language. Since Paleolithic figures appear to be stereotyped, he concludes that figurative expression was originally directly linked more to writing than to art, that it symbolically transposed reality before it sought to mirror it. As time went by, the technical skills of 'artist-writers' increased, and simple outline sketches were gradually superceded by more polished representations of basically the same content. Whereas images of animals became increasingly realistic about 15,000 years ago, those of humans tended towards extreme abstraction (triangles, rectangles, dotted lines). A more realistic portrayal of humans surfaced about 11,000 years ago, and both currents persisted in parallel until about 8,000 years ago, when a transition from hunter-gatherer to agricultural societies was evidently occurring in the Old World. Leroi-Gourhan concludes that art and writing had a common source in the graphic expression of rhythm. Whereas art tended to develop towards realistic representation, writing eventually overcame the temporal limitation of speech by fixing it spatially. He goes on to describe a cycle of maturation which repeats itself, whereby art returns to its primordial abstract roots.

Mythographic content

Leroi-Gourhan proposes that the enigmatic figures and designs inscribed on the cave walls of Lascaux (one of which is shown in Figure 19) about 17,000 years ago were the translation of whole mythologies into figurative symbols, i.e. mythograms (*mythogrammes*) that are "closer to ideograms than to pictograms and closer to pictograms than to descriptive art" (Leroi-Gourhan, 1993, p.191). Whereas pictograms provide a recognizable picture of what they represent, ideograms have an abstract or conventional meaning that no longer has a clear pictorial link with external reality. Despite the realism of the Lascaux frescos, Leroi-Gourhan relates them directly to ideographies since most pictographies

are of relatively recent origin. He describes the organisation of a mythogram as "radial" (Leroi-Gourhan, 1993, p.196) in that specific kinds of animals seem to be systematically arranged around others. However, this grouping would have been perceived as a linear organization by visitors to the cave who walked through the galleries of images and 'read' them. Indeed, when discovering the Lascaux images by lamplight one sees that the figures are not organized in blocks but unfold thematically along a thread. This correlates with two human ways of perceiving the world that he links with vision:

1. Dynamic: a linear world-view produced by journeying though it.
2. Static: a concentric world-view radiating out from the central viewer to the limits of the unknown, integrating the images of two opposing surfaces: "sky and earth meeting at the horizon" (Leroi-Gourhan, 1993, p.326)

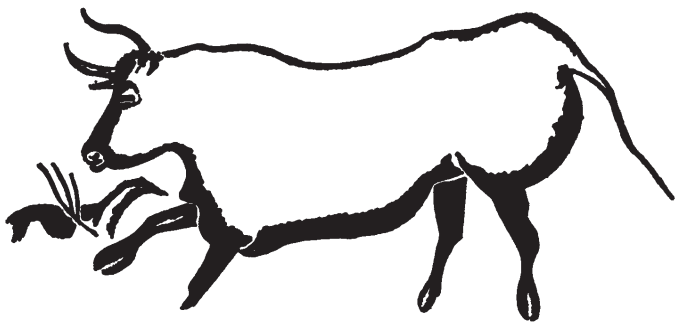


Figure 19. Aurochs […], style III. Cave paintings, Lascaux, Dordogne, France (Leroi-Gourhan, 1993, p.379)

Leroi-Gourhan correlates such Paleolithic cave images with the linear world-view of the nomadic hunter gatherer who mentally 'captured' the surface of his territory by walking across it, and who is known to have begun wandering the earth at least 30,000 years ago. Today, the heaps of animals and signs do not show us any actions or tell us any stories. Either we cannot read these 'texts' or they really are void of such content. However, Leroi-Gourhan sees a figurative syntax in their composition which is inseparable from that of words. Whatever their meaning may have been, he is convinced that their creators spoke because language would have been necessary to make sense of the content of the mythograms they created:

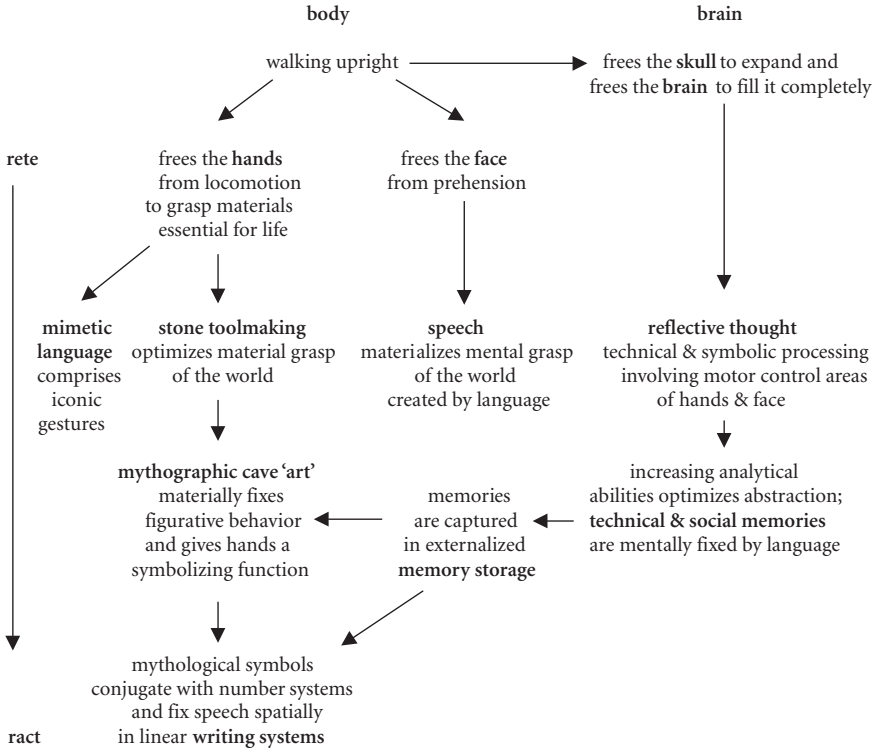
> The best proof — were it still necessary to supply one — of the existence of language in the Upper Paleolithic is precisely that words had to exist for the figures to be intelligible. It is therefore very important to note that as far back as 20,000 years before our era, figures could depart from realism of even the most relative kind and assume the form of signs as conventional as those used in writing (Leroi-Gourhan, 1993, p.384).

Neither writing nor painting, Paleolithic cave 'art' shows that thought had reached a degree of abstraction corresponding to that of language. Even if fossils have left no trace of Paleolithic language, the hands of those who spoke it have left unambiguous evidence of their symbolizing activities that were "inconceivable without language" (Leroi-Gourhan, 1993, p.215).

Towards the end of the Paleolithic era, about 10,000 years ago, the domestication of plants and animals led to the settled village existence that characterizes the Neolithic concentric world-view of the settled farmer who "constructed the world in concentric circles around a granary" (Leroi-Gourhan, 1993, p.327). Leroi-Gourhan sees this world-view reflected in the Biblical *Genesis*, which portrays a world centred around Eden, in which Adam names things, giving them a symbolic existence. In contrast to the Paleolithic stereotyped figures, real scenes depicting habitations, hunting, crop and animal farming adorn the walls that Neolithic people inscribed. Leroi-Gourhan proposes that linear writing grew as a hybrid of old mythical symbols and the emerging number systems for elementary bookkeeping "at a certain moment in time, which was not the same moment in different parts of the world" (Leroi-Gourhan, 1993, p.200). This 'moment' coincides with the invention of metallurgy and the rise of commerce in urban settlements, which occurred in Europe around 5,500 years ago. Ancient Sumerian and modern Chinese provide his examples of how linear writing originated since both contain a large number of ideograms evolving towards the phonetic transcription that alphabets eventually achieved.

Summary

The milestones in Leroi-Gourhan's hypothesis of the co-evolution of manual and technical activities are summarized in the schema below.



These milestones conform to his 'body first' principle — whereby physiological adaptation (technical means) drove the brain development (organisational means) that gave birth to the language capacity — demonstrating how the mind could have been produced by the body. They are stepping stones in a biological story that increasingly becomes a cultural (and a political) one, marking the progress in the human ability to symbolize. Semiogenesis coincides with glottogenesis in Leroi-Gourhan's story in which language includes speech (communication) and thought (cognition). Although his conception of symbolization encompasses many forms of figurative behavior, language underpins them: it stores their interpretation in the ethnic memory of a speech community. His conception of gesture includes technical (toolmaking and usage), figurative (art making) and linguistic (writing) use of the hands, as well as their 'commentating' synchronicity with speech (gesticulation). By anchoring his speculations in the concrete evidence that the paleontological and archeological records have bequeathed us, he avoids the pitfalls of considering any prehistoric gesturing in the air that may have disappeared as the first words

reached into silence. The key role of gesture in the evolutionary emergence of speech is simple but central: "The hand that liberates the spoken word, that is exactly what paleontology culminates in." [15]

Conclusion

Although tremendous advances have been made in linguistic research since Plato wrote *Cratylus*, at the turn of the 21st century we still do not really know what language is: "Cognition or communication? Or both? Or something else?" (Trabant, 2000, p.2). This series of questions reveals just one of the recurring dichotomies in the language origin debate that is particularly relevant to the role of gesture in glottogenetic theories: gesture is clearly communicative, but its relation to cognition far more obscure than that of speech. We hear our thoughts as words that unwind, but our gestures border on the edge of consciousness as we move seamlessly in and out of them.

Leroi-Gourhan's novel understanding of the term 'gesture' is yet another variant that would find a place in the wide-ranging inventory that Armstrong, Stokoe and Wilcox (1995) draw up: hand movements, upper-limb movements, lip movements, facial expressions, postural behaviors and "not only in humans but in all moving creatures" (Armstrong et al., 1995, p.38). One crucial feature of the 'material action' that Leroi-Gourhan identifies with gesture is its syntactic potential to transform a whole mental vision into a concrete reality: a tool with an intended future use is the result of 'operating syntax'. Although his conception of syntax may not withstand current knowledge about the complexities of syntactic systems, evidence of stone tools is widely accepted as an implication of the existence of the language faculty in their makers. For example, Deacon (1997) and Lieberman (1998) hold this view. Leroi-Gourhan's understanding of gesture would probably differ essentially from that of many gesture researchers addressing the evolutionary puzzle of the origin of language. They usually consider gesture in relation to its role in transmitting units of thought rather than in creating a material product. For example, Armstrong, Stokoe and Wilcox assert "that embryo sentences are already inherent in simple visible gestures" (Armstrong et al., 1995, p.161). The idea that gesture may help to explain how the hiatus between words (or symbols) and sentences as units of meaning was bridged is not new. Condillac (1746, 1775, 1780) explored how the supposedly most 'natural' word order, Subject-Verb-Object (SVO), may have emerged from the analysis of synthetic gestures equivalent to sentences. He ventured that this evolutionary development may have laid down the cognitive

basis for the analytic ability required to juggle words into grammatical categories and build sentences (and eventually 'reason') out of them. The problem of what gave rise to *double articulation* (duality of patterning) as formulated by André Martinet (1965) — an arguably unique universal property of spoken and written language since equivalents may have been identified in signed languages[16] — still remains a major stumbling block at the heart of the matter and therefore offers the potential to catalyse progress in the debate.

Language has been singled out as a feature that distinguishes us from the rest of the animal kingdom. This claim depends, of course, on how we define language, and inquiry over the centuries has provided many useful ways of describing and analysing it. By comparison, finding clear definitions and a conceptual framework to inform inquiry into gesture is still in its infancy. David McNeill's (2000) continua, first outlined in 1992 and based on Adam Kendon's (1988) definitions of gesticulation, pantomime, emblem and sign language, are notable landmarks. Having the appropriate means of describing how gesture creates meaning alone and in concert with speech is crucial. Since primate studies reveal that gesture is more 'natural' to our nearest biological relatives than speech, gesture is bound to remain on the language origin agenda. As Chomsky (2002) points out, it is a task for interdisciplinary research to show where the continuities and discontinuities between human and animal 'language' lie. Whatever combinations of new and old disciplines are involved, their participants will have to work towards finding a common language in order to share and compare their knowledge. The potential for Babylonian confusion is great. Traditional linguists rarely have a sufficient understanding of the biological sciences that are spearheading the debate but their contributions would be of great value. Input from gestural specialists is equally vital to the quest. At a bare minimum, they can counteract the dangers of language being reduced to sets of parameters or of disappearing entirely down a maze of neural circuitry.

Notes

1. See Graves (1994, p.439) and White's (1993) *Introduction* to Leroi-Gourhan (1993, p.xiii-xxii) for further biographical details.

2. Leroi-Gourhan developed these 'structuralist' methods in collaboration with Annette Laming-Emperaire, and he was possibly influenced by the art historian Max Raphael (White, 1993, p.xvii). Both Graves (1994, p.438 f.) and White (1993, p.xiii f.) emphasize the centrality

of Leroi-Gourhan to the French academic tradition in contrast to the mostly uninformed criticism that stigmatizes his reputation abroad.

3. My diagram. All the other figures in this article are attributed to Leroi-Gourhan unless otherwise indicated. My attempts to identify the owner of the copyright for the images in *Gesture and Speech* have failed. All rights are reserved by default.

4. Lieberman (2001, p.39) estimates that this ancestral 'missing link' between humans and other primates lived about 5 million years ago.

5. Aitchison (1995, p.55) provides statistics demonstrating the dominance of language processing activity in the left hemisphere in both right-handed and left-handed people.

6. Leroi-Gourhan (p.89 f.). His reference to eras here rather than dates is typical. Deacon (1997, p.346) indicates the problem of identifying the first toolmakers because of the difficulty of correlating artifacts with hominid fossil remains.

7. See Aarsleff (1982) for a discussion of Locke and Condillac's views on the role of the senses in knowledge acquisition.

8. Leroi-Gourhan estimates that Neanderthal language would not have sounded much different from our modern languages. Lieberman, who is famous for his assessment of the phonetic capabilities of Neanderthals based on his reconstructions of their vocal tracts, believes that they could have produced almost all human speech sounds: [i] and [u] being the notable exceptions. For further details see Lieberman (1998).

9. Leroi-Gourhan (1993, p.139). This date refers to archeological finds in France showing dramatic advances in technology and culture. Douglas (2001, p.45) and Aitchison (1996, p.53) indicate that this acceleration may have begun earlier around 40–50,000 years ago.

10. See Deacon (1997, p.343 f.) for current data on the increase in size in hominid bodies and brains from 3,000,000 years ago to the present day, showing a slight decrease in *Homo sapiens* in relatively recent times.

11. My translation of: "Es entsteht so die scharfe Trennung zwischen dem Bezeichnen der Welt, dem Sprechen-über, und dem Sprechen-mit, die beide aber in jedem mündlichen Sprechen verbunden sind (in dem gerade im Gegenteil das Sprechen-über-Etwas durchaus fehlen kann)" (Trabant, 1998, p.111).

12. My translation of: "les pieds bondissoient de joye" (Rousseau, 1781, p.123).

13. Douglas (2001, p.42) pushes the date of the emergence of cave painting back to around 50,000 years ago (see also Figure 15). Hogan (2003, p.8) points out the difficulty of determining the age of cave paintings and how radiocarbon dates can vary widely from those suggested by stylistic features.

14. My translation of: "La main qui libère la parole, c'est exactement ce à quoi aboutit la paléontologie" (Leroi-Gourhan, 1964, I, p.40) that has been omitted from the beginning of Ch. 2 in *Gesture and Speech*.

15. See Armstrong, Stokoe and Wilcox (1995) for current views on how the equivalents of phonemes, morphemes and sentences can be found in sign languages, and how the template for the double articulation inherent in spoken / written language may have evolved gradually through gesture.

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