Chapter 13
Leroi-Gourhan: Technical Trends and Human Cognition

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Abstract The work of Leroi-Gourhan (1911–1986) has had a strong impact on twentieth century French thought. To account for the origin of our human capacities of memory, anticipation and language, Leroi-Gourhan builds on a "Technology" understood as the study of the functional linkage between the organisms and their environment. In continuity with the biological world, without sudden event (by miracle or by chance), it is to explain the gradual separation of social memory by the interplay of technical innovations that will allow free thinking detached from the immediate situation. The fulcrum of this liberation is the *tool*: both a biological fact and a movable organ, it permits the passage from the biological world to the human world.

Keywords Anticipation · Embodied cognition · Externalism · Cognitive science · Hominization · Leroi-Gourhan · Paleoanthropology · Social memory · Technology

The work of André Leroi-Gourhan has had a strong impact on twentieth century French thought. His work covers a vast spectrum, ranging from the history of technology to prehistoric art, prehistory, ethnology, paleontology and anthropology,[1] all

[1] Leroi-Gourhan (1911–1986), after studying Russian and Chinese and a mission in England to the British Museum (1933–4), worked on organizing the Far East and Arctic collections of the Paris *Musée de l'Homme* for its opening in 1937. After a mission to Japan in 1936–1938, during the war he was Assistant Curator at the *Musée Guimet*; at this time he wrote *L'homme et la matière* (*Makind and Matter*), a vast synthesis centered on human technologies, as well as a first thesis in ethnology, *L'Archéologie du Pacifique Nord* (*The Archeology of the North Pacific*), defended in 1946 under the supervision of Marcel Mauss (1873–1950). He then conducted a series of excavations (at Arcy-sur Cure, then at Pincevent) and prepared a second thesis, in paleontology, *Les tracés d'équilibre mécanique du crâne des Vertébrés terrestres* (*Traces of mechanical equilibrium in the skulls of terrestrial vertebrates*). Professor at the Sorbonne University, replacing Marcel Griaule in 1956, he published an essay on *Les religions de la préhistoire* (*The religions of prehistory*) (1964); and then

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linked and mutually embedded in an over-riding project: to try and understand the "human phenomenon" at all time-scales, in continuity with the biological world, and through a "Technology,"[2] i.e. the study of functional couplings between the organisms and their environment. The approach of Leroi-Gourhan is of great interest today, and it can offer cognitive science some fruitful and original hypotheses. To Leroi-Gourhan, cognitive faculties are not explained by the brain, but by an evolutionary process in which the brain is one of the consequences. Thus, in his masterwork *Le geste et la parole* (*Gesture and Speech*) (1964–1965), Leroi-Gourhan proposes an explanation, ranging from the biological process of hominization to the freeing of social memory, which accounts for the specificity of our cognitive capacities of anticipation and language. The fulcrum of this liberation is the *tool*: both a biological fact and a movable organ, it permits the passage from the biological world to the human world.[3]

In order to follow Leroi-Gourhan's approach, it is first necessary to grasp the originality of his study of technology in his ethnological works. I will then explain how he approaches paleontology, and provide several elements elucidating his conception of anthropological evolution. Several preliminary comments are in order.

First, it is important to insist on the fact that the work of Leroi-Gourhan is characterized by rigorous empirical investigations and great prudence with respect to philosophical generalizations; yet at the same time it opens up vast theoretical perspectives of great originality. In these pages I will restrict myself to this theoretical dimension, whose originality has not escaped a number of French philosophers (Georges Canguilhem, Gilbert Simondon, Michel Foucault, Gilles Deleuze, Jacques Derrida or more recently Bernard Stiegler). (Guchet 2015)

Second, in this chapter I consider only a part of Leroi-Gourhan's work. I will refer neither to the schools of ethnology and history of technology which have been inspired by his work, nor to his work on cave paintings, nor to his methods which have largely contributed to renewing prehistory (excavations by horizontal strata for historical, statistical and topographic analysis). Many discoveries have been made since the 1960s when Leroi-Gourhan published his main work in anthropological paleontology (for example the discovery of 'Lucy' and the characterization of *Homo habilis*), but there is nothing which seems to put into question the set of theoretical intuitions I shall present.

Finally, let me mention that I adopt a naturalistic reading of Leroi-Gourhan against certain hasty assimilations of his evolutionary perspective with a teleology of technology tinged with spiritualism, even though certain passages in his texts do seem to motivate such interpretations. The feature which marks the singularity and

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his most important work of synthesis *Le geste et la parole* (*Gesture and speech*) (1964–1965). He subsequently devoted most of his time to excavations, and to a general reflection on the arts of prehistory. He was nominated professor at the Collège de France in 1969.

[2] Which he often writes using a capital "T" to distinguish the discipline from the operations, tools and systems constituting its object of study.

[3] In this Leroi-Gourhan extends an intuition of Marcel Mauss (Mauss 1936).

the interest of Leroi-Gourhan's approach is that by openly assuming a naturalistic posture with respect to the phenomenon of technology, he makes it possible to grasp the irreducibility of the human phenomenon… while at the same time avoiding a sharp break with the biological world.

13.1 Technological Trends and Technological Facts

Leroi-Gourhan began his career by a considerable amount of work in ethnology. In order to arrange the collections for the opening of the *Musée de l'Homme* in 1938, he undertook the construction of a terminology and a system of classification that allowed for the study of technologies from pre-historical times up to the industrial period. This work is presented in the two fascinating volumes of *Evolution and Technology* (Leroi-Gourhan 1943, 1945). The first thing that is striking is that such an undertaking is even possible. By taking into account the types of material, the basic means of action, and the forces which can be mobilized, it turns out that only a limited number of techniques are possible, and so they can be subject to a systematic description. Three central concepts are forged by Leroi-Gourhan in order to perform this scientific research into technology: the concepts of "trend," "degrees of factuality," and "technical milieu." (Leroi-Gourhan 1943: 325)

The term "trend" (*tendance*) does not designate any sort of final causation, but rather the determinism stemming from the limited number of possible modes of coupling between living organisms and matter.[4] According to the laws of geometry and rational mechanics, there are only a limited number of ways in which a given function can be realized. It is normal that roofs should have a double slope, that axes should have a handle, and that arrows should have a balance-point at one-third of their length. This being so, for the technical principles which are thus defined, it is possible to *construct* a series of objects and to speak of "progress," for instance, from the first flint choppers to copper knifes to steel swords (Leroi-Gourhan 1964a: 91).[5]

However, trends are not to be confused with the *facts*, i.e. the concrete local and historical observations of objects and practices. Leroi-Gourhan distinguishes several "degrees of factuality," i.e. for each object observed at different levels of description, starting from its function described in very general terms (which amounts to a materialization of the trend), followed by determinations which are

[4] The "trend" is "a simple abbreviation to characterize in one word the whole set of potentialities which only becomes realities under favorable conditions of the environment, symbolizing the penchant which is followed in the living world by all the needs for survival according to modalities which are increasingly complex." (Leroi-Gourhan 1943: 326)

[5] "In zoology as in ethnology, (…) *everything seems to happen as if* an ideal prototype of a fish or a flint blade evolved according to preset lines from the fish to the amphibian to the reptile to the mammal or bird; from the rough flint chopper to the finely hewn blades, to the knife of copper, to the sword of steel. Let there be no misunderstanding: these lines of evolution are simply the result of an aspect of life, that of the limited and inevitable choice that the milieu offers to living matter." (Leroi-Gourhan 1943: 14) My emphasis.

more and more complete up to the designation of the tool of a precise ethnic group at a given moment of its history. The trends are only abstract principles whose concrete realization is perturbed by multiple external and internal conditions. The external milieu comprises the physical environment as well as the ethnic environment. Contacts between ethnic groups (movements of men, of objects, of practices) can induce the appearance of new techniques. And above all, each ethnic group is characterized by a *technical milieu* which determines the changes it can accept. The adoption of a new technique, either by internal invention, or by reception during contacts with other ethnic groups, depends on the capacity of this technical milieu to reproduce the innovation in question. From this point of view, "between the autonomous invention and the straightforward borrowing from a neighbor, the difference is not very great" (one and the other both result in the creation of the same technical milieu). "In other words one only invents the spinning-wheel, or one only borrows it, if one is in condition to use it." (Leroi-Gourhan 1943: 320) But conversely, one should not read into the facts a descent or an origin without taking into account the existence of universal trends which produce similar technical inventions quite independently in different ethnic groups, separated in space and time.

> The search for improvements in the technique of throwing is in the order of the most natural technical trends, its simultaneous realization at several points of the globe or its diffusion from a unique source are of the order of facts which admit of only one demonstration: putting a sufficient number of instruments of propulsion into concordant geographical and chronological series. (Leroi-Gourhan 1945: 62)

The great difficulty in ethnological studies is thus to unravel what derives from the diffusion of technologies or practices, and what derives from convergent independent inventions (Leroi-Gourhan 1945: 95).

13.2 Functional Palaeontology

When Leroi-Gourhan turns to biology to follow the evolution of the mechanical structures of vertebrate skeletons, he deploys a similar logic. The bodily conformations of each species are considered as technical devices destined to ensure the survival of the organism by functions such as the acquisition of food, movement or defense against predators.[6] The stereotypic nature of an anatomical structure, its constancy or its distribution among species is not determined only by heredity or phylogeny. It is also the product of constraints in the coupling of living organisms and matter with respect to particular functions. Like the trends, these stereotypes can be theoretically described, and accounted for independently of factual phylogenetic considerations concerning the filiation of species. This is demonstrated by the

[6] "Technical action is found in invertebrates as much as in human beings and should not be limited exclusively to the artifacts that are our privilege." (Leroi-Gourhan 1965: 237)

cases of convergence, both in the case of living organisms from various phyla and in that of techniques from various ethnic groups.

> One can show by dragging a plastic mass in water, that any solid whatsoever in displacement in a liquid medium necessarily takes on a particular fusiform shape, and that the tuna fish, the ichthyosaurus, the whale and the ship could not have had any other general plan than the one that is imposed by physics. (Leroi-Gourhan 1945: 337)

In the same way, the general technical principle of a mechanism of prehension, such as the hand, crops up repeatedly in the most diverse lineages, both for the anterior limb of rodents or primates, and for the posterior members of birds.

> The case of birds is of interest because it proves that the possibility of intervention by the "hand" not only exists in a limited number of zoological groups on the direct line of evolution from the crossopterygian fish via monkeys to humans, but is even to some extent independent of any specific anatomical area. (Leroi-Gourhan 1964a: 33)

This functional paleontology makes it possible to account for the courses of evolution that are open to a given species (Leroi-Gourhan 1964a: 31). In the same way that the technical milieu of an ethnic group can only select among a limited repertoire of certain possible changes, so the functional situation of the species only offers certain directions in which selective pressures can operate. The functional situation predates the course of evolution that it generates. Leroi-Gourhan does not go into the details of the biological mechanisms of variation and selection which modify the genetic memory. Here, we will restrict ourselves to the "Darwinist" perspective that he claims elsewhere (Leroi-Gourhan 1982: 18).

If we turn to the development of the nervous system, we observe the same logic. The general structure of the organism determines the range of possible actions in the world. It is only afterwards that this functional situation selects the evolution of a brain which is best able to control the actions that are available.[7] There is thus an "*advance*" of the technical situation over the development of the control system, which combines the operational sequences that the situation allows.

> The progressive enrichment of the nervous system is an evolutionary fact of the same order as the perfectioning of *automatic controls of machines* with respect to the evolution of mechanical organs. (Leroi-Gourhan 1983a: 29, my emphasis)

In the series of mammals, one witnesses the development of the diversity of operations that are accessible. This diversity is already great among the carnivorous animals and primates; and in the phylum of hominids, it will progressively increase further. Cortical development then materializes the necessary increase in the capacity to complexify the relations between perception and action in complex operational sequences. The capacity to think depends strictly on the power to act.

[7] "We cannot cite a single example of a living animal whose nervous system preceded the evolution of the body, but there are many fossils to demonstrate the brain's step-by-step development within a frame acquired long before." (Leroi-Gourhan 1964a, b: 47)

13.3 The Question of Hominization

A general account of the development of the nervous system is not in itself an explanation of hominization. One has still to explain how this is related to the emergence of human experience comprising memory, anticipation and language. It is not so much a question of establishing factual lines of filiation between species, but rather of rendering intelligible the trends explaining human evolution. For that, Leroi-Gourhan takes on and resolves the paradox of a biological *determinism* of technical evolution that in the end accounts for a *liberation* from that determinism.

He first of all spells out the particular sequence of trends which, in the burgeoning patterns of evolution, explains the paleontological succession of functional types which led to the first hominids (Leroi-Gourhan 1964a: 36). To summarize briefly, the trend of animals to mobility leads to a functional type with bilateral symmetry; a fundamental type which itself defines a trend to the development of an anterior field devoted to relations with the environment, which will take various forms including those where the "relational field" is shared between the face and the forelimbs; and this in turn will define a trend to a vertical stance and the freeing of the hand. Among the organisms which are able to grasp, there are still two possible trends. On one side grasping may be only intermittent, limited to certain bodily postures (for example rodents in a sitting posture). On the other side, the grasping may be constant, continuing while the animal is in movement, as with the Australopithecus. This second solution, which is specific to our phylum, leads to a vertical posture having two further corollaries: the free hand, and the short face.

> Freedom of the hand almost necessarily implies a technical activity different from that of apes, and a hand that is free during locomotion, together with a short face and the absence of fangs, commands the use of artificial organs, that is, of implements. (Leroi-Gourhan 1964a: 19)

From a paleontological point of view, the general and sufficient criterion to distinguish our phylum from all other primates is thus present very early in the Australopithecus lineage. Amongst them, Leroi-Gourhan gives the name Zinjanthropus (*Zinjanthropus boisei*, now *Paranthropus boisei*) to the first hominids equipped with a few very simple tools more than two million years ago (today we rather attribute the first tools to *Homo habilis*). It is then shocking to find that these beings, whose general posture is so similar to our own, had such tiny brains.

> This uneasy feeling is due to the fact that the Australanthropians are really not so much humans with monkeys' faces as humans with a braincase that defies humanity. We were prepared to accept anything except to learn that it all began with the feet! (Leroi-Gourhan 1964a: 65)

There is still a long evolutionary path to be trodden to reach the "Neanthropians" of which we *Homo sapiens* are part. In the absence of direct traces of creative intelligence equipped with language, all we can do is to follow the transformations of the material traces of techniques of coupling between living organisms and their environment. In order to evaluate this slow evolution, Leroi-Gourhan proposed to measure, for each stone industry, the number of different tools and the length of cutting edge obtained per kilo of flint.

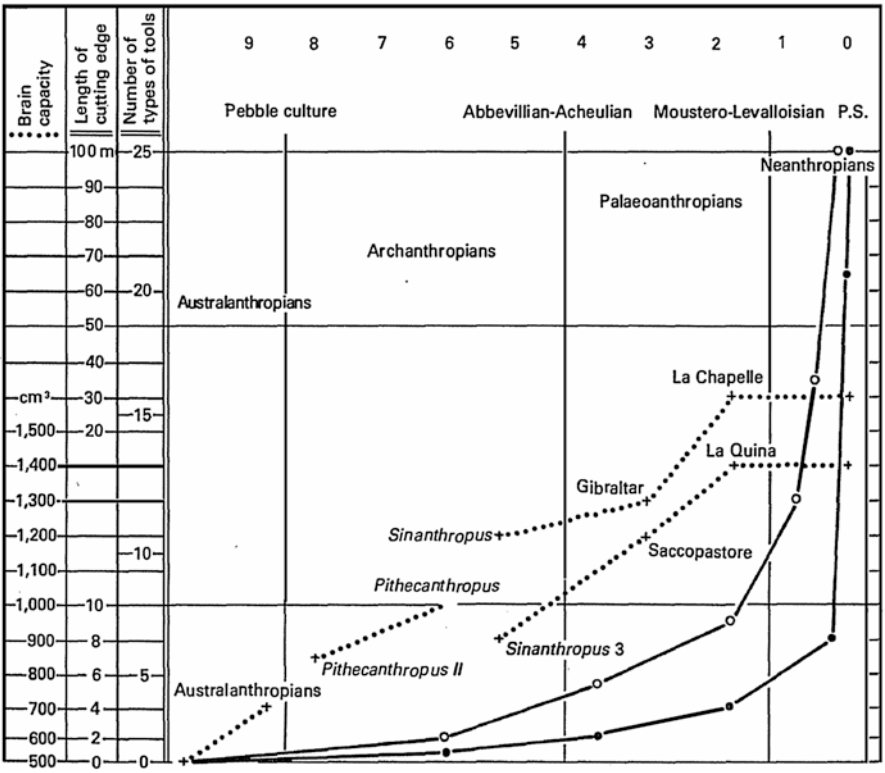

Fig. 13.1 The relationship between increase in brain volume and technical evolution during the Quaternary Period of the Cenozoic era (relative length of blade per kilogram of material and diversity of tool types). Australanthropians (*Zinjanthropes*); Archanthropians (*Homo Erectus*); Palaeoanthropians (*Neanderthal*); Neanthropians (*Homo sapiens*). (Leroi-Gourhan 1964a: 138)

If we compare these curves with that of the volume of the brain cavity (Fig. 13.1), two striking features appear. First, the extremely slow evolution of the stone industry. Technical progress and biological evolution advance at the same slow rate, "a fact that confers a curiously biological character to the prehistory of sharp-edged objects." (Leroi-Gourhan 1964a: 134) Then, with the Neanthropians (Sapiens), there is such an acceleration of technical evolution that it seems to become completely independent of new biological transformations: "from being governed by biological rhythms, human cultural development began to be dominated by social phenomena." (1964a: 141) Nevertheless, throughout this evolution, the general formula of hominid anatomy does not change much. One only observes a lightening of the bony structure of the skull, and a filling by a brain that increases in volume.

Classically, the development of the nervous system is considered the relevant explanatory feature, and one starts from the forms of intelligence and culture in animals to account for the origin of our cognitive faculties and our socio-technical systems (Tomasello et al. 2005). This supposes an evolutionary scenario in which

the faculties of learning and social transmission of the first hominids would carry a trend towards their complexification. Hereditary variations in the brain which went toward increased cognitive faculties would constitute in themselves an adaptive advantage. An increasingly complex technical system would follow from an increase in these cognitive abilities.

For Leroi-Gourhan, these "brain-centred" approaches, which one finds in the myth of "a monkey ancestor of man," do not correspond to the facts and are quite unable to account for the specificity of human evolution. Rather, one must recognize that the advance of technical situation over the development of the control system observed in the whole of the living world, is found again here. The development of the nervous system can only represent an adaptive advantage if it is related to a repertoire of possible actions. There is an advance of the general anatomical structure that defines the concrete living conditions of the organisms over the cortical variations which can take advantage of the new possibilities offered by these conditions.

At the start of the process of hominization, the tool was a biological fact which derived from the upright posture and the freeing of the hand. Just like any other organ, it would be an *obligatory* product of zoological ontogenesis, systematically produced, under normal conditions, quite independently and prior to an encounter with a situation in which it can be exploited. The first forms of tools were in a way "exuded" by the organism, and hence could not evolve more rapidly than their biological bearer could.[8] The constancy of their forms over hundreds of millennia proves this.

Now the presence of tools signifies a functional situation for the species in which increasingly complex operational sequences are possible. This complexity defines the conditions of selection for the development of a brain apt to coordinate the behaviors in this new space of possibilities. In turn, this evolution allows for the production of richer technologies… which themselves will induce further developments of the brain. This process leads to a progressive deployment of the "cortical span," i.e. a strong development of the associative zones in the cortex which control actions and their succession in complex operational sequences.

In order for this coupling between tools and the evolution of the brain to function, it is necessary to admit a biological determination of the first tools. This is the essential difference with the behavior of certain monkeys. Since the time of Leroi-Gourhan, our knowledge of primate behavior has been enriched. There can already be tools for infant monkeys. For example, there have been observations in nature of the differentiated ways in which techniques for cracking nuts with a percussive instrument diffuse in various primate populations (Wrangham et al. 2005). However, if we follow Leroi-Gourhan, these premises of cultural transmission remain limited, contained within the repertoire of actions accessible to the species. Even if they bear witness to remarkable cognitive and social capacities, these new behaviors do not

[8] "Australanthropians (…) seem to have possessed their tools in much the same way as an animal has claws (…) as if their brains and their bodies had gradually exuded them." (Leroi-Gourhan 1964a, b: 106)

have the potential to initiated novel directions of biological evolution. They do not impose a constant selective pressure on other characters of the species precisely because they adapt on the spot in function of the circumstances. When chimpanzees assemble a perch by fixing together several sticks in order to catch a bunch of bananas otherwise out of reach, they are only responding to a momentary problem in function of the data present in their environment. Such inventions of monkeys do not determine an evolutionary trend, because the monkeys do not have to adapt to tools that are already there. The human tool poses a *problem* for the ancestors of humans; whereas the perch of the monkey is a *response* to a contingent situation. Thus, paradoxically, it is because the human tool is not so much the product of intelligence, but rather the intelligence that is the product of the tool, that the biological evolution of the human brain is justified.

13.4 The Problem of the Externalization of Memory

If this is so, how is it possible to account for the appearance of a social memory that has the capacity to register technical innovations much more rapidly than the genetic memory of heredity? Two explanatory options are open:

– Either the appearance of this social memory was the secondary consequence of the evolution of the cerebral cortex, which would have passed a somewhat mysterious threshold with the appearance of the Neanthropians (*Homo sapiens*);
– Or else the social memory was the product of a process of externalization that is specific to human technologies.

Certain formulations of Leroi-Gourhan seem to favor the first option.[9] However, as Bernard Stiegler has pointed out, this would mark a serious regression (Stiegler 1994). Instead of a co-invention of mankind and technologies, humanity, in the modern sense of the term, would suddenly appear with the Neanthropians, by the inexplicable means of a mutation. In order to avoid this disappointing backsliding, Bernard Stiegler grants the very first tools of the Zinjanthropes the status of "external memory"; but this amounts to admitting that from this stage on, there is a genuine autonomy of the history of technical differentiation.[10]

Nevertheless, another reading of Leroi-Gourhan is possible, which avoids any sudden appearance of mankind either at the level of the Zinjanthropes or that of the Neanthropians. According to this reading, mankind appeared *progressively*, by means of a *gradual* detachment of social technical memory. This would be more consistent with the general project of explaining human evolution by the play of definite trends. Between the incomprehensible event of a random "accident," and a

[9] "It does seem as though the 'prefrontal event' had marked a radical turning point in our biological evolution as a zoological species governed by the normal laws of species behavior." (Leroi-Gourhan 1964a, b: 137)

[10] Bernard Stiegler speaks of an "epiphylogenetic memory." (Stiegler 1994: 185)

mysterious "predestination," there is a third way, a paradoxical "human solution of the problem of our origin." (1964a: 94) If we admit that "humanity" begins as soon as the upright vertical stance is established, it is a question of maintaining the principle of an "advance of technical situation" over cortical development, so as to account for the progressive genesis of the way "the system that provides human society with the means of permanently preserving the fruits of individual and collective thought came slowly into being." (Leroi-Gourhan 1964a: 187)

13.5 A Human Solution to the Problem of Mankind

The tools that accompanied hominids more than two million years ago are challenging our contemporary human reason. The very simple tools of the Zinjanthropes are the products of a single gesture, the perpendicular shock between two flints. They show no rapid or spectacular progress, no visible differentiation of techniques over hundreds of thousands years. Notwithstanding, that does not preclude from conjecturing that, already at this stage, fortuitous or deliberate variations in an external tool might favor their own reproduction.

Leroi-Gourhan admitted the existence of capacities for individual learning of know-how even in the simplest animals. There is a technical intelligence in all prehensile organisms (a perception of the forms to be grasped and used, a mastery in the combination of actions in action-sequences). Leroi-Gourhan describes "instinct" in the animal world, not as a behavior inscribed in the nervous system, but as the determinate result of a coupling "located at the intersection of the means specific to that individual and the external causes for deploying those means in action sequences." (1965: 221)

As in *situated cognition*, the solving of a problem corresponds to the transformation of the environment, a transformation that includes the participation of the agent just as much as the initial material milieu (Gallagher 2009; Hutchins 1995; Clark 1997).[11] A certain form of memory of learned behaviors must thus have existed in the first hominid societies. These populations must already have been able to transmit behavioral novelties according to different "traditions." Nevertheless, Leroi-Gourhan does not propose to explain the liberation of human history from its biological basis as an effect of the social organization of the first anthropoids. What is lacking are the concrete conditions for learning the reproduction of new techniques. A new tool enriches the range of possible operations, but there is no assurance that it contains precisely the operations for making this new tool (nothing ensures that the new tool can participate recursively in its own reproduction).

Nevertheless, with the movable tools of the first anthropoids, there is already a radical novelty compared with organs that are attached to the organism. By its exter-

[11] We are very close to the notion of "stigmergy" developed at the time by zoologist Pierre-Paul Grassé (1959) who presided in the 1955 the jury of the thesis in natural science of Leroi-Gourhan.

nality and its material permanence, it allows for intergenerational exchanges. The tool is "already there" in the environment of the next generation. By grasping it, the young individual receives from the outside a new power to act, that she has not necessarily produced herself. The coupling between the abilities of the organism and its environment now takes place in a milieu comprising movable tools, exchangeable material inscriptions, which surpass the lifetime of an individual. This new situation bears a *trend* towards an external memory.

With the Archanthropians (*Homo erectus*), there is essentially a second series of gestures: tangential blows, which results in the fabrication of the famous bifacial tools. The progressive complexification of the set of tools is realized in a context where the activity related to a certain tool can be dedicated in part to the fabrication of other tools.[12] The reproduction of a tool can mobilize a social transmission of techniques. The external transmission of tools which can be given and received defines a richer technical milieu. However, the transformation of the technical milieu by learning new tools remains confined in the field of situations of possible fabrications. The simple transmission of an innovation does not directly entrain its reproduction. There is not yet a fully-blown autonomy of the external technical history, but still only a displacement in a fixed field of possibilities.

With the Palaeoanthropians (Neanderthal), the technical milieu becomes still more complex. The operations of fashioning comprise several steps, marked by changes in the tools and the operations (rough fashioning of the original block to give it an appropriate shape; productive chipping and flaking; refashioning the block; pursuit of the productive chipping…). (Pellegrin 1990) The tools are successively grasped and put down, fashioned and used. We may even speak of a sort of technical *syntax*, insofar as the fabrication of the tools proceeds by ordered sequences of operations, and a different arrangement would produce different products.

> 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. (Leroi-Gourhan 1993: 114)

As soon as the conditions of the fabrication of technical objects become recursively themselves transmissible external techniques, the field of possibilities is vastly enriched. There is a genuine external memory when the introduction of a new technique can be the cause, direct or indirect, of its own reproduction. Externalization renders possible a spatial deployment of the syntax of operational action sequences, which in its turn allows for a process of external reproduction of these conditions of learning. The externalization of the movable tool is thus duplicated into an externalization of the conditions of its reproduction.

The creation of new tools and new situations of coupling is no longer the product of a heritable variation, but results from a modification by the organisms of their technical environment. The capacities of reproduction of this social memory

[12] "The lump of stone initially intended to become an almond-shaped tool became instead a source of flakes of predetermined shape, and it was these flakes that were eventually used as tools." (Leroi-Gourhan 1964a, b: 100).

participate in the definition of the functional situation of the species. In the game of mirrors between cortex and silex there are now *two* memories which respond to each other, genetical and sociotechnical. To the extent that the possibilities for external reproduction remain limited, this situation can still lead to further biological evolution.

We can understand why the process by which a social memory independent of biological determinism arose was so extremely slow – hundreds of thousands of years! It is because this process was contingent upon a complexification of the specific techniques for the reproduction of tools sufficient for them to be able to progressively encompass an ever increasing diversity of new possibilities.

In a final phase, that of Neanthropians (*Sapiens*), the movement which was thus set in motion accelerates and amplifies. There is no longer time, nor any need, for a selective effect of the technical milieu on biological genetic memory. There is no longer time, since the recording of technical variations in the social memory is infinitely more rapid than that of biological evolution, which must wait for relevant mutations in the genetic memory.[13] There is no longer any need, since the creation and the fixation of innovations can be accomplished directly as a function of their success in this social memory, even if they are useless from the point of view of the biological species. The dynamics of the evolution and differentiation of human productions is thereby profoundly altered. Just as species separate into a diversity of phyla according to their histories inscribed in the genetic memory, so human populations will diversify into different ethnic groups according to their histories inscribed in the social memory.[14]

This explanation of hominization as the product of a trend towards the externalization of social memory allows for an original approach to the evolution of cognitive capacities.

13.6 Intentions and Anticipation

Ever since the first stages of hominization, Leroi-Gourhan admits that the fabrication of tools supposes a form of *technical consciousness* with capacities for prediction and anticipation.[15] These capacities will continue to reinforce themselves progressively, since for the fabrication of tools such as the bifacial flint, there is clearly the aim of a stereotype in spite of the infinite variations in the initial form. Now, as we have seen, Leroi-Gourhan maintains at the same time that at this stage

[13] "In *Homo sapiens* technicity is no longer geared to cell development but seems to exteriorize itself completely – to lead, as it were, a life of its own." (Leroi-Gourhan 1964a, b: 139)

[14] "If it is true to say that the species is the characteristic form of animal grouping and the ethnic group of human grouping, then a particular form of memory must correspond to each body of traditions." (Leroi-Gourhan 1964a, b: 221).

[15] "The Australanthropian making a chopper already foresaw the finished tool because the pebble chosen had to be of suitable shape." (Leroi-Gourhan 1964a, b: 97, personal translation).

technical objects cannot transform themselves independently of a biological evolution.

> Thus the first anthropoids' technicity [implies a state] of technical consciousness to which, however, we must not apply our own yardstick. It is undoubtedly less of a risk to see human technicity as a simple zoological fact than it would be to credit *Zinjanthropus* with a system of creative thought. The countless millennia during which his industry remained unchanged – conditioned, as it were, by the shape of his skull – disproves the latter hypothesis. (1964a: 92)

Leroi-Gourhan thus invites us to delve into the strange realms of a technical consciousness capable of certain sorts of learning but incapable of innovation; which has the power to aim at certain archetypes amidst the myriad diversity of perceptual situations, but remains destitute of the capacity for free creation… An effort of this magnitude to try and imagine the obscurity of the most archaic forms of thought seems to us nevertheless absolutely necessary if we wish to grasp the "stages in which the link between the zoological and the sociological has become progressively more tenuous." We are invited to admit that, at the very beginnings of humanity, there was the capacity to aim at a goal without there being the capacity to discover new goals.[16] If one tries to elaborate a conception of intentionality which can fit this specification, we must first of all reject the idea of an intentional behavior guided by the representation of a perceived model. That would be to give ourselves what it is our task to discover, since the perception of a novel form is not sufficient to set in motion the learning of a way of making it. We must rather look for a conception of intentionality in a technical consciousness that is directly anchored in the living world.

There was a time when the stability and the constancy of the forms within any given species induced biologists to invoke the notion of a "final cause" which, like a causally effective intentionality, would operate to direct the processes of ontogenesis. By doing so, the scheme of the conscious productions of a craftsman was projected into biological explanations. Nowadays, however, a complex causality regulated by genetic memory is considered sufficient to account for the appearance of final causation. If there is still some resistance to recognize a similar process in the case of the fabrication of the first tools, it is merely because their ontogenesis is external: it mobilizes the organs of perception (choice of materials, adjustment of the gestures) and of action (finding the materials, controlled gestures).[17] This makes it difficult not to attribute to the makers of these tools the same conscious intentions that we would have for the same work.

> There is little reason to distinguish between the Palaeoanthropian technician's attitude and that of any technician of a more recent age – at any rate in strict terms of technical intelligence. (Leroi-Gourhan 1964a: 102)

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[16] At least in the domain of the production of stone tools that we can observe, because in the case of woodworking there are few if any observable remains.

[17] "It is logical that the standards of natural organs should be applied to such artificial organs: They must exhibit constantly recurring forms, their nature must be fixed." (Leroi-Gourhan 1964a, b: 91)

If we follow Leroi-Gourhan in his search for a *continuity* between biological causality up to human cognition for which the capacity to aim at a goal has to be admitted, a reversal of the terminology is possible. Rather than renouncing the idea of an intended form from the moment when an explanation in terms of memory is available, one could say that the aim derives from a memory construed as a capacity to produce the same forms in a diversity of material situations. However, as long as this memory is genetic, even if one admits a form of consciousness of the intended forms, this consciousness is limited to a choice within a repertoire which is biologically fixed and limited.

Any form of memory involves a temporal lag, a retention programing future action, in other words an anticipation. For Leroi-Gourhan, an essential characteristic of human tools is that their production occurs in a situation that is independent of the context of use: "the operations involved in making a tool anticipate the occasions for its use and the tool is preserved to be used on later occasions." (1964a: 114) The production of a tool involves a preparation for a situation, which is absent and merely possible, where the tool will be used. In this way Leroi-Gourhan attributes to the first hominids a *concrete* capacity of anticipation in the fabrication of their tools. The organism "foresees" without *choosing* what it foresees. It is only to the extent that this anticipation contributes to the survival and the reproduction of the organisms in question (and hence to the reproduction of the biological memory) that it is conserved. The biologically specified tool *concretely* anticipates its future use, in the same way that an organ produced in the course of ontogenesis anticipates its future use, just as the nest of a bird anticipates its function of protecting the future nestlings. The anticipation is *concrete* by its biological determinism, and by the biologically functional nature of the situation that is anticipated.[18] However, with the externalization of the tool, there is already an externalization of the anticipation. With progressive enrichment of this external memory, new forms can be aimed at. Their number and complexity increase ever further as this memory becomes autonomous.

At the stage of the Archanthropians, when certain tools served the production of other tools, we find ourselves in a situation where the initial tools anticipate the situation of the fabrication of subsequent tools. The operations follow on from each other in action sequences which become highly complex, which "implied a good deal of foresight on the part of the individual performing the sequence of technical operations." (Leroi-Gourhan 1964a: 97) A system of embedded anticipations comes into play: the initial forms anticipate a number of subsequent forms, which are themselves produced with a view to future use. Nevertheless, the meaning of the possible anticipations derives from their origin in a biological memory of feasible operations, and corresponds to their adaptive utility.

> Operating behavior remains completely rooted in lived experience, for projection can only take place once operations have been freed from their materiality and transformed into sequences of symbols. (Leroi-Gourhan 1964a: 226)

[18] The "concrete" character of the anticipation on which I insist here is not justified by the concrete character of the tool or the organ bearing the anticipation. We will see that a "symbolic anticipation" can be based on substrates that are just as concrete.

This freeing is only attained at the succeeding stage. As we have seen it is with the Paleanthropians that a veritable external social memory develops. Tooling up reaches the stage of becoming a means of producing new tools. It is in this reflexivity that it acquires immense capacities, and in particular the power to reproduce innovations. The variation and the reproduction of anticipations can occur following their success in social interactions, independently of the concrete character of the situation. This is what Leroi-Gourhan calls "liberation from lived experience." (1964a: 33) In this way, an external memory opens the way to creative anticipation, a full anticipation that is no longer derived from a biological determinism and a utilitarian content. Leroi-Gourhan speaks of *externalizing a symbolic representation*, which is the beginning of an intelligence that is no longer *strictly technical*, that is to say the possibility of thinking, of reflecting about the future, in the absence of concrete actions in the environment. Just as reproduction in biological memory specifies the aim of constant forms in the behavior of living organisms, so reproduction at the level of social memory makes it possible to specify the aim of constant forms in technical behavior. The anticipations henceforth available and produced are now the fruits of a social history, and they are related to the development of language.

13.7 The Development of Language

In the absence of material traces we are reduced to hypotheses. Leroi-Gourhan proposes to imagine that language develops in the same way technical artifacts do, in the same movement and following the same basic logic.[19] The proximity of the brain areas involved can be read as a result of their functional proximity.[20] During the initial stages (Zinjanthropes then Archanthropians), although there were probably already exchanges of auditory and gestural signals, these exchanges were limited, as were the anticipations, to the context of actions in concrete situations.[21] However, following through on the analogy between language and techniques, in the same way that tools came to be made and rendered available independently of the situation of use that they anticipated, the "verbal forms" came to be reproduced and available *before* their use in concrete situations. With the complexification of the

[19] "Technics and language are not two distinct typically human facts but a single mental phenomenon neurologically based on contiguous areas and expressed jointly by the body and by sounds." (Leroi-Gourhan 1965: 403)

[20] "This leads us to conclude, not only that language is as characteristic of humans as are tools, but also that both are the expression of the same intrinsically human property, just as the chimpanzee's 30 different vocal signals are the precise mental counterpart of its use of several sticks to pull down a banana hanging overhead – in other words, no more a language than fitting the sticks together is, properly speaking, a technique." (Leroi-Gourhan 1964a, b: 114)

[21] "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." (Leroi-Gourhan 1965: 365)

techniques and a veritable syntax of action sequences, one can very well imagine that there was an equivalent structuring of language, even if it was still limited "to the expression of concrete situations."

> If language did indeed spring from the same source as technics, we are entitled to visualize language too in the form of operating sequences limited to the expression of concrete situations, at first concurrently with them and later involving the deliberate preservation and reproduction of verbal sequences going beyond immediate situations. (Leroi-Gourhan 1964a: 116)

It is only when an external memory became fully autonomous that a truly symbolic language was able to make its appearance. For Leroi-Gourhan, the faculty of symbolization consists of producing a distance between the human and the milieu (both internal and external) in which it is immersed: "a detachment, which expresses itself in the separation between tool and hand and between word and object." (1964a: 235) When the forms thus produced (tools, vocal or gestural expressions) are no longer linked to biological memory and utility, they come to depend only on their reproduction in social interactions. Language can then be applied to "areas beyond that of purely vital technical motor function," and so "used for *post facto* transmission of the action symbols in the form of narration." (Leroi-Gourhan 1964a: 115) It is then that one observes the development of activities of figuration,[22] which can take on an esthetical-religious character as with signs of the anticipation of death (sepultures) and a taste for the unusual (fossils, pyrites). (Leroi-Gourhan 1964a: 107; 1964b)

With language, there is also the development of "reflective thought" at the level of the individual (Leroi-Gourhan 1964a: 195). The system of social memory allows, up to a certain point, a personal liberation with respect to biology and to the social dimension itself (Leroi-Gourhan 1965: 227). By appropriating the reproducible forms that are available, each individual can construct on her own account a specific memory, the last degree in ethnic differentiation. The mastery of the concepts born by the social memory allows her to construct her own anticipations.

13.8 Conclusion

The perspectives opened up by Leroi-Gourhan in his work on paleo-anthropology are potentially fruitful for inspiring novel lines of research in cognitive science, in particular for the "enactive, embodied, embedded" approaches which refuse the facility of simply giving themselves the capacities of a representational computational system. Taking "technology as anthropologically constitutive" (Stiegler 1994)

[22] "Figurative behavior cannot be dissociated from language: It forms part of the same human aptitude, that of reflecting reality in verbal or gestural symbols or in material form as figures. Just as the emergence of language is connected with that of hand tools, figurative representation cannot be separated from the common source from which all making and all representation spring." (Leroi-Gourhan 1965: 363)

makes it possible to propose an explanation for the passage from the instinctual capacities of the biological realm (which Leroi-Gourhan conceptualizes in terms of a coupling between the organism and its milieu), to the symbolic capacities of creation, reflexivity and free anticipation, that are commonly associated with an internal representational system, but which here are realized secondarily by the individual reappropriation of external symbols embedded in the social memory.

"Technology" is not only the object of Leroi-Gourhan but the very method he systematically follows, and which could be referred to as "*the principle of concrete operations*": Accounting first for the functions and properties of the coupling between living organisms and their environment *before* examining the possible transformations that they imply for the organism (either taken up by selection in the hereditary memory, or taken up by reproduction in the technical milieu of social memory, or yet again taken up by learning in the cerebral system of the individual). Following this principle, the existence of reproducible external forms is the precondition for any learning of their internal reproduction. Every "symbolic representation," whether individual or collective, presupposes that a process for the reproduction of concrete external forms (tools or symbols) has *already* been set up. In this perspective, cognitive activity and individual memory are not encased within the organism, but are rather constitutively related to material technical inscriptions that are *external* (Lenay 2012).

If we admit that there is an "advance of technical situation," it is necessary to systematically take into account the repertoires of concrete operations in order to define the conditions of possibility for mental operations. Rather than explaining extended cognition as the external deployment of cognitive capacities that are already there, it is a question of understanding how the technical environment is the very condition which makes these capacities possible. Individual thought does not happen in the brain alone, but *with* a brain as it is coupled – via the rest of the body and a set of tools – to the technical and social milieu. This perspective may help to evaluate the contemporary transformations resulting from the development of digital technologies of collective memory.[23]

In the second volume of *Gesture and speech* (not analyzed here), Leroi-Gourhan pursues by an analysis of the techniques of social memory, systems of writing and figuration. He thus prolongs his reflection towards the future, and anticipates many of the developments of cybernetics. Thus, by his conception of technical systems, he helps us to escape from the reduction of cognitive activities to a simple question of information processing; he offers us instead a vision of cognitive activities as stemming from a dialogue between *life* and *matter*.

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[23] "Saying that we are currently being overwhelmed by technical innovations is thus a false problem: technical systems are *always* 'overwhelming', this is quite normal; the real worry is probably elsewhere," Said Leroi-Gourhan in *Le fil du temps* (1983b: 87).

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