

Leroi-Gourhan, a Philosopher of Technique and Evolution

Françoise Audouze¹

With the publication of two volumes on technology—L'Homme et la matière and Milieu et technique in 1943–45, and Le geste et la parole (translated into English in 1993 as Gesture and Speech)—Leroi-Gourhan asserted himself as a major social anthropologist, prehistorian, and the founder of the French schools of the ethnology of technique and of prehistoric ethnology. This paper analyzes the innovative concepts and the content of these original works, which draw their inspiration and data from biology, physiology, psychology, anthropology, and prehistory to study evolution, and technique as its medium, to create a global science of humanity.

KEY WORDS: Leroi-Gourhan; prehistoric ethnology; ethnology of technique; evolutionary theory; origins of techniques and language; history of social science.

INTRODUCTION

André Leroi-Gourhan (Fig. 1) is far from being as famous in the Anglo-Saxon world as his contemporary Claude Lévi-Strauss in social anthropology or even François Bordes in prehistoric archaeology. Yet, Leroi-Gourhan's impact has been much broader and deeper in Old World archaeology. Bordes's work undoubtedly was an essential milestone in prehistoric research. However, his influence is no longer felt to the same extent, whereas the directions explored by Leroi-Gourhan are still evolving and are now spreading to the Anglo-American world (Bleed, 2001; Dobres, 2000).

Several factors explain his relative anonymity: It was only in 1993 that his major work, *Le geste et la parole*, was translated into English as *Gesture and Speech* and made available to British and North American readers. Until that time,

¹Laboratoire d'Archéologie et des Sciences de l'Antiquité (ARSCAN—UMR 7041), Centre National de la Recherche Scientifique, Nanterre, France; e-mail: audouze@mae.u-paris 10.fr.



Fig. 1. André Leroi-Gourhan (standing on the left) with Abbé Henri Breuil looking at Mousterian faunal remains at Arcy-sur Cure in 1951 (photograph by Hélène Balfet).

Leroi-Gourhan was known only for the translation of his *Préhistoire de l'Art occidental* (1965b). In addition, Leroi-Gourhan undertook the construction of a vast theoretical framework into which the actual placement of facts was not always a prime consideration. This typically French perspective is quite different from the empirical nature of North American social sciences.² A third factor is the absence of epistemological definitions and the use of a style full of imagery that combines descriptions rather than definitions and discussions in a dialectic progression, making Leroi-Gourhan rather difficult to read, in spite of the clarity of the concrete vocabulary he used.

Beyond these problems of translation and language, many researchers (including some French authorities) found it difficult to criticize his multidisciplinary approach because of the originality of his thought. Leroi-Gourhan borrowed from

²The 1960s and 1970s had been periods of intensive theoretical development in the social sciences as a whole in France, with the exception of archaeology that remained totally empirical. And, although Anglo-Saxon social science at the same period was characterized by a strong dose of empiricism, Anglo-American archaeology itself was distinguished by its desire to create an approach that was both explicitly scientific and solidly grounded theoretically.

philosophy, social anthropology, prehistory, paleontology, and biology, without adopting the full theoretical framework and practice of any of them.³ As a result, English-speaking functionalists preferred to select Levi-Strauss as an opponent in social anthropology. In archaeology, Binford and the *New Archaeologists* found it more relevant to cross swords with François Bordes, who was interested in cultural evolution rather than to confront Leroi-Gourhan's ideas.

Even more fundamental issues minimized the influence of ideas coming from Europe in the 1960s and 1970s. American archaeologists were preoccupied with their own innovative developments, which powerfully energized both theoretical research and fieldwork. Cultural ecology followed the lead of Julian Steward, then the New Archaeology of Lewis Binford, as well as the application of quantitative methods to the study of formal variables (e.g., Binford and Binford, 1968; Cowgill, 1989; Sackett, 1966; Spaulding, 1960). In Margaret Conkey's view (1989, p. 140), "in the early 1960s (Leroi-Gourhan's approach) was strikingly incompatible with the emergence in the Anglo-American world of the New Archaeology and its denial of 'mind.'"

Leroi-Gourhan's contributions to prehistory were wide ranging, including the development of excavation methods (Leroi-Gourhan and Brézillon, 1966) and his proposed interpretation of cave art (Leroi-Gourhan, 1965b, 1982). But these are not dealt with in any detail here. Instead this essay concentrates on Leroi-Gourhan's fundamental technological and evolutionary works (published from the mid-1940s to the mid-1960s) in order to introduce some of the principal methodological and theoretical directions he explored, and to suggest their relevance for contemporary research.

LEROI-GOURHAN, THE MAN

A Few Elements of Biography

Born in 1911, Leroi-Gourhan came to maturity in 1930s, a very lively period for French sociology and ethnology.⁴ Raised by his grandparents, he lost interest in formal education early. At the age of 14, Leroi-Gourhan left secondary school and began to work in a hosiery and a library. Later in his life, he would always be proud of being a self-taught man and would always claim his independence from all schools of thought.

Despite being self-taught, he actually received more diplomas than did most other academics. Entering the university directly, Leroi-Gourhan obtained a degree in Russian at the age of 20 in 1931, and the next year saw him with a degree in

³Most reviews of *Le geste et la parole* at the time it originally appeared in France seem fairly superficial, as if their authors had encountered real difficulty in coming to grips with the book's subject matter.

⁴For more detailed accounts, see Audouze (1992, pp. 8–12) and Gaucher (1987).

Chinese and in Humanities. In 1945 he defended a dissertation in ethnology for a humanities doctorate.

In 1954 this accomplished scholar submitted a dissertation in paleontology for a science doctorate. His years as a student of Marcel Mauss and Paul Rivet before the Second World War were crucial. Leroi-Gourhan participated in the intense theoretical debates of the times as well as their direct application to the reorganization of the Musée de l'Homme. At the Musée de l'Homme, Leroi-Gourhan followed the seminars of these two great social anthropologists together with a generation of bright students who would later become major social anthropologists, such as Claude Lévi-Strauss, Marcel Griaule, André-Georges Haudricourt, Georges-Henri Rivière, and Jacques Soustelle. In 1937–38, Leroi-Gourhan spent 2 years in Japan, working on Japanese and Ainu material culture, collecting the data that he later used for his research in technology. He began publishing papers and books in 1935. By 1943 and 1945 his two major volumes on technology came out: *Evolution et techniques I—L'Homme et la matière* and *Evolution et techniques II—Milieu et technique*. These books secured Leroi-Gourhan's intellectual notoriety and placed him at the forefront of a new school of the ethnology of techniques.

Leroi-Gourhan held a range of positions during the course of his career. He was successively a researcher at the Centre National de la Recherche Scientifique, an assistant director of the Musée de l'Homme, a curator at the Museum of Far Eastern Art, and a professor of ethnology at the University of Lyon and later at the Sorbonne in Paris. The early 1960s were extremely fruitful years with the publication of his major work, *Le geste et la parole* (Leroi-Gourhan, 1964a, 1965a). He also published *Les religions de la préhistoire* (1964b), *Préhistoire de l'Art occidental* (1965b), and the first monograph on the famous Magdalenian site of Pincevent (Leroi-Gourhan and Brézillon, 1966). With these books, he asserted his position as a major social anthropologist, major prehistorian, and specialist in art.

From 1968 to 1982, Leroi-Gourhan held the chair of prehistory at the College de France in Paris. His teaching there was considered a must for social anthropologists, as much as Levi-Strauss's lectures. Whole generations of students in social anthropology and prehistory attended his lectures and took part in the field training schools that he created, the Training Center for Ethnological Research in 1946 and the Research Center for Prehistory and Protohistory in 1962. In the caves of Arcy-sur-Cure and later at the open air site of Pincevent, he devised new methods for excavating and recording prehistoric living floors. These methods would make the latter site very famous. Indeed hundreds of students from all over the world were trained there.

Leroi-Gourhan died in 1986, author of a dozen major books, several hundred papers; creator of the discipline of cultural technology; and renovator of the study of prehistory with his novel approach to "paleoethnology" or prehistoric ethnology (Audouze and Schnapp, 1992).

An Original Mode of Thinking: Towards a Science of Man

It was never Leroi-Gourhan's intention to become a philosopher. If some of his works are concerned with philosophy, it is because the problems he wanted to solve had to be tackled at a philosophical level. He sought a global approach to the diversity of humanity to seize "the human phenomenon in its totality" (Leroi-Gourhan, 1993, p. 141).

Leroi-Gourhan's originality is manifest in several ways: He stood apart from most other ethnologists with his insistence on inclusion of the diachronic dimension in the analysis of human diversity. For every major question concerning technology, evolution, rock art, or the interpretation of archaeological sites, he devised new approaches and methods that corresponded to his particular point of view. His reasoning often proceeded through the pairing of topics that he considered to be related to complementarity or continuity, rather than in opposition to one another. Thus for him culture replaced nature and supplemented it; technique and language interacted with one another. Leroi-Gourhan sought the complementarity of such concepts through mediators. He was as a consequence mostly interested in grasping the processes of interaction and articulation among different levels (cultural upon natural, functional upon physiological, symbolic upon functional, figurative upon symbolic) (Stiegler, 1992b, p. 34).

Leroi-Gourhan's multidisciplinary research combined methods and approaches from very different disciplines such as biology, technology, paleontology, psychology, and physiology, as well as ethnology, sociology, and the history of art. At a time when other scholars in the social sciences were trying, not without substantial disagreement among themselves, to define the contours and limits of their respective disciplines, Leroi-Gourhan conceived of a single, holistic science of humanity that integrated all the fields of biology and ethnology⁵ (Guille-Escuret, 1994; Leroi-Gourhan, 1952b, 1993, p. 141).

In this vein, he refused either to respect or to erect barriers between disciplines. Biology, psychology, sociology, and ethnology were for him only different ways of apprehending reality at various levels of observation and time scale. In his arguments, he combined perspectives from all these fields as well as ecology or neurology. From the start and without explicitly formulating it, he employed a systemic approach and often referred to systems. But what was probably his greatest original contribution (shared with the Swiss psychologist and epistemologist Jean Piaget) was to construct his arguments through methods and analogies derived from biology (mainly physiology and comparative anatomy) in order to make intelligible processes related to the social realm (Schlanger, 1994). Indeed, Leroi-Gourhan had from the outset a strong intuition for the continuity of living beings and for the relations between the biological and the social realms. He considered the social

⁵He included in his science of man fields concerned with the very long term and the short term, but he excluded history *de facto* because its time span was too short for evolution.

body as “a prolongation of the anatomical body” (Leroi-Gourhan, 1993, p. 20). Organic metaphors constantly appear in his texts, serving as a powerful means to cast a new light on *l’homme zoologique* (zoological man) who is at the very root of evolution (Leroi-Gourhan, 1993, pp. 401–402; Stiegler, 1992b, p. 34).

In the domain of methodology he never felt close to the structuralists, in part because of his diachronic perspective, but also because he could not imagine resorting to a single approach. In his view, each of the major questions that interested him called for its own special methodology, tailored to its own special requirements. Today his approach is often allied to that of structuralism. But this kinship, which he himself denied energetically, was evident neither to him nor to his contemporaries. This point was underlined by Levy-Strauss a year after Leroi-Gourhan’s death, who, in paying tribute to him, said,

Our relations were not as close as they should have been, to the point in fact that we found ourselves perceived as in opposition from time to time. But in rereading his work I am now profoundly struck by the fact that, although working in different domains, he and I were essentially trying to do the same thing. When one rereads his writings on physical anthropology, technology, prehistoric archaeology and art, one sees that the key idea that governed his thinking was always to study the interrelations between things rather than the things themselves, to try to reduce the chaotic diversity of the empirical data to invariant relations and to use . . . a method of transformations (Levy-Strauss, 1988, pp. 203–204).

THE WORK

A New Field of Investigation: Comparative Technology

Leroi-Gourhan’s first goal was to study material culture and techniques insofar as they are characteristic of humankind. He considered techniques to be the only human undertaking that can be traced back to the earliest times and that are present throughout human evolution. He thus needed an analytical method for comparing technical facts, for evidencing their similarity or diversity, for establishing covariations and causal relationships, and for identifying changes in the technical system as a whole and correlated changes in the social system. Such a methodology had to be applicable to past techniques as well as to modern ones. In addressing these themes, Leroi-Gourhan helped establish the new field of comparative technology that is at the origin of the French school of cultural technology or the ethnology of techniques (see the Concluding Discussion below).

The two volumes *L’Homme et la matière* (Man and matter; Leroi-Gourhan, 1943) and *Milieu et technique* (Milieu and technique; Leroi-Gourhan, 1945) are often considered only as a vast encyclopedia of techniques.⁶ It is in fact much more than that since it contains not only an innovative typology and classification of

⁶The two volumes of *Evolution et techniques* were reprinted in 1971 and 1973. Because Leroi-Gourhan made some additions and modifications in the latter edition, I refer to the second edition in this essay.

techniques but also a theory of technique (Lemonnier, 1992). Rather than following most ethnographical classification into types of tools or products, Leroi-Gourhan concentrated on the technical modes of action on matter. This led him to enlightening concepts and theories about technical processes, imitation, and innovation. As already noted, Leroi-Gourhan wanted his classification to encompass complex contemporary techniques and machines as well as simple prehistoric ones.

Drawing on some 40,000 entries (written on manuscript cards, of course, at that time) describing tools and technical processes, his classification was based on (1) the physical properties of matter and the means of action to transform it and (2) a division of techniques according to their finality, e.g., manufacturing and acquisition techniques. The entries in the first classification are physical forces, properties, and actions. They provide a useful grid of analysis. The second classification had entries such as elementary means and forces. Elementary means include prehension, percussions to break, cut, or shape; fire to heat, cook, melt, dry, and bend; water to mix, melt, soften, wash, and to use in different solutions to tan or preserve; and air to dry, clean, or stir up fire (Leroi-Gourhan, 1971, pp. 18–19).

Forces include the force of human and animal muscle, air, and water. These forces create movement that can be directed, amplified by levels or transmissions, or saved by equilibrium. Raw materials are classified as solids, semiplastic solids, supple solids (hide, fabrics, etc.), and fluids. Many other classifications exist, but the utility of such a classification resides in the potential significance of the questions that can be derived from it. By reducing categories to elementary forces and gestures, Leroi-Gourhan was able to divide techniques into their elementary steps. This procedure is still a great help when analyzing a production sequence.

Even more important for us today than his classification are the concepts he introduced to account for the evolution of techniques, their innovation, and their diffusion. He first asserted the universality of technique (Stiegler, 1994, p. 57) and its systemic nature (Leroi-Gourhan, 1973, p. 342). In an important discussion, Leroi-Gourhan presented and put in opposition two types of phenomena: *les faits techniques* (technical facts), which are localized in space and time and which can be observed, and *la tendance technique* (technical tendency), a long-term evolutionary process that accounts for the unending improvement of tools and techniques for better solution tasks, a better response to physical constraints, and higher efficiency. There was, incidentally, no moral connotation here: “No judgement of value can be made about an evolutive process” (Leroi-Gourhan, 1993, p. 253). The technical tendency, in any case, evolves through a number of solutions limited by physical constraints, in a way that is comparable to the pressures of natural selection. By using this concept of technical tendency, Leroi-Gourhan explains the unity of techniques present all over the world and evolving everywhere in a comparable way. He then explains the diversity of technical facts and their relations to the social systems in which they exist (Stiegler, 1994, pp. 61–67).

For Leroi-Gourhan, technical facts (operations or tools) can be classified in two different orders: a chronological order or a logical order. In many cases when a chronological/historical classification was not possible because of the absence of evidence, Leroi-Gourhan turned to a logical classification, on the basis of variation from the essential to the secondary. The corresponding dendrogram illustrates *les degrés du fait* (degrees of specificity) and allows the identification of affiliation or diffusion of traits. If a logical order is chosen, technical facts must be analyzed as a network of a dominant attribute, major attributes, and ancillary ones. In this way, isolated items can be included in a series and can acquire a real comparative value. It also is possible to identify different values for the attributes and to rank them according to *les degrés du fait*. Leroi-Gourhan adds that another useful method would be to compare networks of technical facts (in other words, technical systems or subsystems), but this can be accomplished only through detailed descriptions of the material cultures associated with related ethnic groups. Such in-depth descriptions rarely have been achieved (Leroi-Gourhan, 1971, p. 29).

To clarify these concepts, I take a classic example developed by Leroi-Gourhan in *L'Homme et la matière*—the spearthrower or atlatl. The atlatl is an implement that has existed since prehistoric times and into recent centuries all over the world. Briefly put, its function is to augment the strength, leverage, and precision of the human arm. To work, all spearthrowers must have a body made of a small board or a stick (usually of wood, bone, or antler), an end for holding (a handle), and an end on which the spear or weapon rests.

If we classify all the different types of spearthrowers in a dendrogram, we find a first level, “the first degree of fact,” corresponding to function—an implement devised for increasing the force of a throwing weapon such as a spear or a javelin. All the examples, including the prehistoric ones, fit this definition. In subsequent degrees of fact, varieties are classified according to their ends (active parts) and/or the shape of the board or stick. We can thus create a dendrogram with two to five levels or degrees of facts. From the third degree and beyond, the types become more regionally determined. Regional distributions reflect technical systems related to different ethnic groups (e.g., in Australia). Affiliation and diffusion can be inferred from such a dendrogram if the chronology of the appearance of types is known (Cresswell, 1993; Leroi-Gourhan, 1971, pp. 30–35).

For Leroi-Gourhan, then, tools and implements are the “objectivation”⁷ or concrete expression of *Pa tendance* in technical facts at a specific place in space and time. Among the *degrés du fait*, Leroi-Gourhan gives primacy to function and physical constraints. Choices and style are in his view secondary and relate to ethnicity. In other words, social aspects express themselves in variations of secondary or superficial importance, which are expressed in the last *degrés du fait*.

Today, however, virtually all specialists of style, including the ethnologists from Leroi-Gourhan’s school, would deny any secondary position to the social

⁷This is the philosophic meaning of the term.

dimension of technical facts (Lemonnier, 1993, pp. 1–16; Sackett, 1966). We see here one of Leroi-Gourhan's paradoxes. Although he did create a theoretical framework that should have allowed him to avoid such dichotomies and escape from assigning preeminence to one of its terms, he eventually stood back and adopted a more conformist position.

In the last part of *Milieu et technique*, Leroi-Gourhan sought to analyze technical creations. Transmission, diffusion, and innovation were analyzed through the three concepts of *milieu extérieur*, *milieu intérieur*, and *milieu technique* (Leroi-Gourhan, 1973, pp. 334–346). Leroi-Gourhan insisted that the appropriate level at which to analyze innovation was not that of the individual actor (however original or gifted), but rather, for reasons we will presently examine, that of the group in its entirety. The *milieu extérieur* (external milieu) is a very broad notion that for Leroi-Gourhan includes the natural environment plus the material culture and ideas of other groups. The *milieu intérieur* (internal milieu) is the intellectual capital of a given group, a set of perpetually modified mental traditions and modes of thought that includes as one of its components or subsystems of the *milieu technique* (technical milieu). The evolution of this *milieu technique* proceeds by accumulation, so that its acquisitions never disappear. When an ethnic group transforms itself, the knowledge remains in the new units created from that ethnic group (Leroi-Gourhan, 1973, pp. 331–376).

Technical actions, Leroi-Gourhan argued, can be considered responses to external pressure, but they also are a deliberate expansion of *milieu technique*. The *milieu technique* generates innovation through internal modifications or by borrowing from the external milieu, when favorable circumstances arise. An essential property of the *milieu technique* is its coherence and continuity, resulting from the permanent relationship of each element with the totality of other elements and from their perpetual interactions (Leroi-Gourhan, 1973, p. 344).⁸ Covariations constantly occur; the distribution of basketry made of intertwined twigs precedes that of pottery made with coils. The mill wheel, potter's wheel, wood lathe, hydraulic wheel, spinning wheel, bobbin, and cart usually coexist in the ethnic groups that have one of them. Some groups have the hoe and the spindle, whereas others have the plough and the spinning wheel, etc. (Leroi-Gourhan, 1971, pp. 39–40).

This continuity of the *milieu technique* implies that the techniques included in it are compatible with one another. Strangely enough, and probably because he had decided from the start not to deal at this initial stage with the social dimension, Leroi-Gourhan did not comment on the fact that these techniques also must be socially compatible (Latour and Lemonnier, 1994, pp. 12–16). There are indeed many examples of groups that refused to adopt a potentially useful technique because they found it incompatible with their system of representation (Descola, 1994). This phenomenon was later analyzed in detail by such cultural technologists as Cresswell (1983, 1994) and Lemonnier (1994). Given these premises, borrowing

⁸In other words, Leroi-Gourhan conceived his different *milieux* as systems and subsystems.

from a neighboring group is very similar to inventing since it calls for recombining already existing elements and creating new associations of technical elements. For borrowing to be successful, it must occur in a compatible *milieu*, receive a local imprint, and fulfill the requirements of the local raw materials (even if it retains some of its original cultural attributes).

An accumulation of borrowings leads to a mutation of *milieu technique* and hence to a mutation of *milieu intérieur*. A good example given by Leroi-Gourhan concerns the introduction of reindeer breeding among some Eskimo groups in Alaska between 1890 and 1900. Thus the pertinent level at which to analyze innovation is not the individual, but the collective level, i.e., the *milieu technique*. Invention can occur only if preexisting elements are already in place, if there is what Leroi-Gourhan calls a *technical intention* (usually the desire to establish a new type of control over matter, according to or in agreement with the *tendance technique*).

As in the case of borrowing, the *milieu interieur* also must be favorable. Considered at this general level of technical evolution, the same mechanisms lead to invention and borrowing. The source of technical progress lies in the accumulation of innovations within the *milieu technique* through associations of elements (Leroi-Gourhan, 1973, pp. 351–384).

Leroi-Gourhan had been influenced in this evolutionary view of technology by the philosophy of Henri Bergson in his 1907 *Evolution créatrice* (Stiegler, 1994, pp. 58–59). Although Leroi-Gourhan avoids the concept of Bergson's *élan vital* (life force), it is clear that his *tendance* is very close to it. When discussing "the propensity of technical facts to be endowed with a great force of progression," he refers to the chapter *L'Activité créatrice* (the creative activity) in Bergson's book (Leroi-Gourhan, 1973, p. 95). This dialectic between diverging tendencies and converging states is directly derived from Bergson.

On the other hand, although he has affinities with Teilhard de Chardin's philosophy (they share the view of continuity from zoologic to social), Leroi-Gourhan refuses the teleology of the Omega point (Lemonnier, 1992, p. 14; Martinelli, 1988, p. 77). For him, la *tendance technique* is a trajectory that has no predetermined goal. In a finalist perspective, he sees predetermination as resulting from physical constraints and "natural" selection that act along the trajectory. At the beginning of *Gesture and Speech*, however, Leroi-Gourhan also makes it clear that he is conscious that the finality of evolution is retrospective and thus artificial and that it would be easy, considering other series of facts, to identify other tendencies, other finalities.

La chaîne opératoire

After completing the two volumes of *Evolution et technique*, Leroi-Gourhan continued to search for a better method to analyze technical phenomena. He found it in the early 1950s in the concept of *chaîne opératoire* (operational sequence). At

that time, he became aware of the flintknapping experiments of Francois Bordes, and he also invited an experimental knapper to practice at one of his seminars. This led him to realize just how informative the analysis of a technical process could be when it is considered in terms of a meaningful sequence of operations and actions. This perspective is what would come to be called the *chaîne opératoire*:

Techniques are at the same time gestures and tools, organized in sequence by a true syntax which gives the operational series both their stability and their flexibility. The operational syntax is generated by memory and is born from the dialogue between the brain and the material realm. (Leroi-Gourhan, 1993, pp. 114, 230–234)

As further defined by Lemonnier,

Operational sequences are series of actions which transform a raw material from its natural state to a manufactured state. These operations are made with actions on matter, preparatory phases, phases of rest and they are associated with a knowledge and a know-how. (Lemonnier 1980, p. 8)

Today, the term *chaîne opératoire* refers to a method that is an analytical grid, nothing more. But it is a very complex grid that allows one to relate the different stages of production to each other and to order them along with related factors, including physical and economic ones, terminology, places, social relations, symbolics, etc. For lithics, it is similar to the core reduction sequence. But there is a semantic difference between the reduction sequence and the *chaîne opératoire*. The term “reduction sequence” implies a subtraction of matter, which is appropriate for chipped stone and more broadly for other types of lithics processing. It is inappropriate, however, when dealing with ceramics, basketry, or metallurgy, where adding matter is part of the production process. The *chaîne opératoire* method has proven its efficacy for identifying strategic and tactic choices at every stage of the manufacturing process (as evidenced by hundreds of papers written during the last 20 years) and as a means to approach cognitive problems, including intentionality.

As occurred several times during his life, Leroi-Gourhan had crystallized an idea or a set of ideas that were emerging at the time. This, incidentally, also occurred with the study of prehistoric art, when Leroi-Gourhan published several articles and a book on the structure of prehistoric cave art, just after this hypothesis was taken up by the art historian Max Raphaël and the archaeologist Annette Laming-Empeire.⁹ In any case, the idea of an operational sequence composed of various moments of material transformation is implicit in the technological work of Marcel Mauss (1936). It is even more explicitly presented as a methodology by Marcel Maget in the 1950s (1953). Nevertheless, Leroi-Gourhan was the first to create the concept and to suggest its utility and its implications. Already in the 1940s, Leroi-Gourhan promoted a dynamic concept of tools and techniques: “the tool . . . is only a testimony of the exteriorisation of an efficient gesture . . . it

⁹Acknowledging innovations or ideas of other prehistorians was not one of Leroi-Gourhan’s traits. Bibliographic references are minimal, and he never acknowledged his debt to Mauss, Laming-Empeire, or Raphaël.

is the materialization of the interaction of matter with the means to transform it” (Leroi-Gourhan, 1971, p. 319, 1973, p. 333).

The concept of *chaîne opératoire* was at the heart of his next major work, *Le geste et la parole*, because from this point forward he had a means for investigating the mental processes and representations of prehistoric humans through their manufacture of lithic artifacts. He immediately saw the cognitive perspectives opened by the *chaîne opératoire*. With it he could give up the artificial division he had initially accepted between *Homo faber* and *Homo sapiens* (Leroi-Gourhan, 1952a) and explore instead the continuity he perceived from animal to human in the technological realm. This concept of *chaîne opératoire* proved to be extremely influential in the development of the French schools of comparative or cultural technology and of prehistoric technology and archaeology. In recent years, this concept also has become increasingly influential among several Anglo-Saxon archaeologists (Dobres, 1995; Dobres and Hoffman, 1994, 1999; Enloe, 1991, 1992; White, 1989, 1997), resulting in a welcome broadening of approaches and research questions.

A New Vision: Continuity in Evolution

The two volumes of *Le geste et la parole* were published in 1964 and 1965. They constitute Leroi-Gourhan’s most ambitious work, an essay that encompasses a reflexion on the question of origins but also the development of human societies and even their future. In this book, Leroi-Gourhan intended to create a theoretical framework that would allow him to conceive of human development in continuity with the evolution of the animal kingdom (Akrich, 1994, p. 112). He wanted to show how culture is articulated with nature. It is essential to stress that what interested him were relations, connections, and links, much more than evolutionary stages, categories, or levels—relations between gestures, tools, and language, and between technique, memory, and society. Continuity from the biological realm to the social realm and a search for interactions between the two through the mediation of technique are the main constants of his approach. *Gesture and Speech* also is a vast fresco in which Leroi-Gourhan describes an evolution starting with the first living beings and elaborating upon what we know as its ultimate developments (Groenen, 1996).

Mobility, Liberation, and Exteriorization

To express the continuity existing between animals and humans and at the same time to shed light on the transformations that make humans stand apart from animals, Leroi-Gourhan first sought the origins of technique, speech, memory, and social grouping in the animal realm itself. The modes of reasoning derived from biology prevailed.

The first part of the argument includes a description of various evolutionary changes as analyzed by functional paleontology. Here Leroi-Gourhan drew heavily on his 1954 dissertation in paleontology entitled “The Mechanical Equilibrium of the Vertebrate Skeleton.” He identified the mechanical organization of the spine and limbs, the suspension of the skull, dentition, the hand, and the brain as the significant parameters.

The coevolution of these parameters occurs along six successive stages, each characterized by an acquisition or a liberation. The key concepts of his theoretical framework are mobility, liberation, and exteriorization.

It is possible to regard *mobility* as the significant feature of evolution toward the human state. Locomotion will be considered here as the determining factor of biological evolution. (Leroi-Gourhan, 1993, p. 26)

Within a perspective which starts with the fish in the Paleozoic era and ends with man in the Quaternary period, it is as though we were witnessing a series of successive *liberations*: that of the whole body from the liquid element, that of the head from resting on the ground, that of the hand from the requirements of locomotion and finally that of the brain from the facial mask. In this sequence, the pertinent forms are those that, at each stage of the process, achieve the most perfect balance between mobility and capacity for survival—from the triple point of view of nutrition, locomotion and the organs of responsiveness. (Leroi-Gourhan, 1993, pp. 25–26)

Having reached the vertebrate body, Leroi-Gourhan identified two poles in the anterior field, or the field of responsiveness (*senses*): “a facial pole governed by the actions of the head and a manual pole governed by the actions of the forelimb. The two poles act in close relationship to perform the most elaborate technical operations” (Leroi-Gourhan, 1993, p. 31).

In this manner, Leroi-Gourhan introduced technique as a biological dimension of humanity, in relation to the paleontological concept of *technicality*. It follows then that technical aptitudes were present since the origins of life and developed gradually over the course of time.

A second part of Leroi-Gourhan’s argument in *Le geste et la parole* concerns the evolution of hominids. Much of this discussion is now obsolete because of the very limited knowledge available at the time and the rather simplifying notions that Leroi-Gourhan chose to use. *Homo habilis* was not distinguished from the *Australopithecenes*, which are called *Australanthropians* and personified in the *Zinjanthropus*. *Paleoanthropians* (Neanderthals) were considered intermediate between the *Archanthropians* (*Homo erectus*) and *Neanthropians* (*Homo sapiens sapiens*). But the details and the flaws of this scheme are not really important. What is essential is the way in which Leroi-Gourhan analyzed the mechanism of human evolution, using mobility, liberation, and exteriorization (Leroi-Gourhan, 1993, pp. 25–26).

Unlike other mammals, humans are generalists. Every time a specialization occurs, it is exteriorized outside the human body. Human ancestors evolved in parallel with other mammals until bipedalism, when a drastic change occurred.

It created the conditions for freeing the anterior field—the hand, the mouth, but also the brain, which can, with the migration of the occipital foramen and the opening of the frontal and middle frontoparietal area of the skull, develop the middle cortical area. This results in increasing the complexity of the motor areas and in fully expanding the cortex in a fan-shaped way, connecting it with centers related to the area involving language. Freeing the hand from locomotion brings tools into existence.

The freedom of the hand almost necessarily implies a technical activity different from the apes . . . and commands the use of artificial organs, that is, of implements. Tools appear as a “secretion” of the anthropoid’s body and brain. *Up to this stage, exteriorisation was an evolutive biological tendency. From now on it becomes a technical tendency. . . .* 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)

The concept of exteriorization was used again later in his work in describing the transition from tools to machines, and the “excorporalization” of memory (Stiegler, 1994, pp. 162–182).

Tools and Language: From Paleoanthropians to Neanthropians

Leroi-Gourhan went on to describe the characteristics that define each stage in the evolution of early humans from *Australopithecus* to *Homo sapiens sapiens*, and he also sought to relate the identified novelties to the tendencies evidenced earlier. The chopper and chopping tools of the Australanthropians, as well as the Acheulean bifaces of the Archanthropians, represent for him real “stereotypes,” which correspond to mental pictures and remain identical for hundreds of thousands of years. He concludes with this strong and potentially controversial statement:

Australanthropian seems to possess his tools in much the same way an animal has claws. We might say that with the Archanthropians, tools were still, to a large extent, a direct emanation of specific behaviour . . . Throughout the greater part of our chronological existence, . . . human technicity would thus seem to have been related more directly to zoology than to any other science. (Leroi-Gourhan, 1993, pp. 97–98)

This situation changed with the Paleoanthropians. Leroi-Gourhan endowed them with technical intelligence because of the diversification and specialization of their tools and because of the foresight that their manufacturing appears to require, as evidenced by their *chaîne opératoire*. Leroi-Gourhan also endowed the Paleoanthropians with symbolic intelligence, because of the existence of burials and some incipient aesthetic concerns. He finds parallel evidence for the emergence of language in the development of the cerebral cortex of the brain.

The origin of language in anthropoids preceding *Homo sapiens* thus seems to be closely linked with technical motor function. Indeed the link is so close that employing as they do

the same pathway in the brain, the two main anthropoid functions could be attributed to one and the same phenomenon. (Leroi-Gourhan, 1993, p. 115)¹⁰

Leroi-Gourhan's overall thesis is not, of course, without its weak aspects and unsolved contradictions. Since manufacturing behavior is no longer regarded as genetic, it is not clear whether the development of tools remains based in zoology, i.e., genetics, as he states in several places. Moreover, how does the transition from genetic to social development actually proceed? Recently, a French philosopher, Bernard Stiegler, has proposed to overcome this contradiction by considering this process as an *epiphylogenetic* one, with the evolution of tools acting as feedback on the determination of the corticalization process. It would act by influencing the process of selective mutations "because, unlike non-artificial life, lithic industry is preserved in its form beyond the individuals who manufactured or used it" (Stiegler, 1992a, p. 28, 1994, pp. 183–185).

Concerning *Homo sapiens sapiens*, Leroi-Gourhan identified three major tendencies: a constant increase in *efficiency*, *diversity*, and *specialization*. In an example that became well-known in prehistoric circles, he presented a graph of the ratio of the length of usable cutting edge per kilogram of flint fashioned in tools of a specific form. This ratio drastically increased over time in parallel with an increase in cranial capacity. Once again, Leroi-Gourhan was impressed by this parallelism between the beginning of technological and biological evolution (Leroi-Gourhan, 1993, Tables 64, 65).

From the Upper Paleolithic onwards, he observed another major change. From that point, Leroi-Gourhan argued, biology and technology diverged.

The volume of the human brain has apparently reached its peak, and the (lithic) industry curve, on the contrary, is at the start of its vertical ascent. . . . Human cultural development begins to be dominated by social phenomena. (Leroi-Gourhan, 1993, p. 144)

This diversity of lithic industries had led prehistorians to create Upper Paleolithic "cultures." Although Leroi-Gourhan acknowledged the regional diversity of these cultures, he also warned us that they might not be equivalent to ethnic groups. The greater diversity of tools is, however, not the result of an acceleration of technical evolution, but rather the product of "cultural diversification," which is the main regulating factor in the development of *Homo sapiens (sapiens)* (Leroi-Gourhan, 1993, p. 206).

The analysis of social evolution was the next step in Leroi-Gourhan's argument. He suggested that the roots of social evolution were biological and that there were numerous examples of grouping for mutual benefit among mammals and more widely among vertebrates (Leroi-Gourhan, 1993, p. 206). At the same time,

¹⁰Leroi-Gourhan adopted a very different thesis from Fodor and Mithen, which postulates a modularity of the mind with modules only intertwining in the mind of prehistoric man at the beginning of Upper Paleolithic (Fodor, 1983; Mithen, 1996). His concept of evolution rests upon a progressive transformation of a three-part complex composed of man as an organic being, his knowledge accumulated on different mediums, and tools that he develops, starting as early as Early Paleolithic (Stiegler, 1992a).

Leroi-Gourhan stressed that the development of “social machinery” and technoeconomic organization is closely connected to the evolution of techniques.

His analysis of the evolution of societies through the Neolithic and Metal Ages is less original. But among the familiar or commonplace arguments he advanced, the following is particular to him. As he tried to relate major inventions (such as agriculture and animal husbandry, metallurgy, sedentism and urbanization, mechanization and industrialization) with new forms of society, he observed that from the agricultural stage onwards, the social body included a new element in its constituents: the craftsman or technician, an individual who is engaged in tasks not directly related to food production and who is supported by the group as a whole.

It can be said that the seasonal pauses in agricultural work have created a *milieu favorable* (favorable milieu) for the appearance of this technician. A new liberation occurred—the *freeing of time*. Likewise, stability in space (i.e., sedentism) and the increase of resources through demographic growth induced a new state of the *milieu intérieur* with increasing needs and a strong demand for innovation, resulting in what Leroi-Gourhan calls the “*snowball effect*” of accelerated technical progress (Leroi-Gourhan, 1993, p. 169).

Language and Hand, Motor Skills and Rhythm: The Origin of Writing

Leroi-Gourhan’s thinking was like an octopus, sending tentacles in many directions, but all ultimately connected. At the end of the first volume of *Gesture and Speech*, he introduced into his general theoretical framework the intellectual properties of humans: Language and thought, writing and memory, all evolve in a synchronized way mediated through technique. The two poles he identified as the key poles of evolution—hand/tool and face/language—are the actors in this development. Although he constructed an argument to prove the coevolution of the two poles, Leroi-Gourhan eventually gave dominance to language. It was characteristic of him to modify his concepts and reformulate his conclusions from one chapter to the next, and to involve the reader in the construction of his ideas.

Why are we surprised to see him give prominence to language? Because, according to his own criteria, he should explain why techniques undergo such a rapid evolution when language and thinking do not (Guille-Escuret, 1994, pp. 161–162). Leroi-Gourhan was probably the first to notice that, in the coupling of technique and language, techniques actually evolve much faster and in an uncontrolled way.

Leroi-Gourhan proceeded by associating mental and manual operations he considered deeply rooted in biological characteristics of mammals. These are motor skills and rhythms, which as early as the Upper Paleolithic led to graphics related to initial concepts associated with mythological motifs. This first stage, which he calls primitive thinking, is characterized by a feeling of continuity between

humans and their environment, where space, e.g., radiates from ego. Early traces of engraving and fluting on material surfaces reflect this stage. Another perspective on his hypothesis is provided by the topographical organization of the brain cortex in which motor skills and speech areas are close neighbors and operate together. This leads, as a consequence, to the conjoined development of the material and the verbal (Leroi-Gourhan, 1993, p. 299).

Graphics, which are at the origin of art and writing, are inscribed in the human body through rhythms. For Leroi-Gourhan, rhythms are first expressed biologically in the body (e.g., breathing, heartbeats), then by the body (e.g., singing and dancing), and later exteriorized through repeated use of percussion tools, musical instruments, etc. Progress in hand motor skills, along with the evolution of language and thinking towards reflexive and rational thought, also led to writing. This implies a narrowing of the reasoning mode that ceased to radiate outwards and became linear and rational, as occurred with sedentism and agriculture. For Leroi-Gourhan, writing is part of the agriculturalists' *milieu technique*; associated with a symbolism that is quite distinct from that of hunter-gatherers, writing comes with an increase in techniques and motor skills, as well as specific equipment (clay pottery and tablets) and a need for accounting and for storing capacities (1993, pp. 187–216).

A Programmatology: Memory and Rhythms

Memory

Writing is the means for exteriorizing memory. This part of Leroi-Gourhan's work has attracted renewed attention from several French philosophers. It is mostly his programmatology, as Bernard Stiegler calls it, that has influenced the philosopher Jacques Derrida as well as Stiegler himself (Derrida, 1967; Stiegler, 1994). In brief, Leroi-Gourhan sees memory as a set of programs of operational sequences that are used in different ways according to the kind of memory activated. He distinguishes three kinds of memory that overlap one another. The first kind of memory is a specific or genetic memory present in all living beings, in which programs are shaped by experience but through narrow prespecified species-specific channels. These programs are activated by the central nervous system under physiological impulses and external stimuli.

The second kind of memory is individual memory that accumulates programs through experience and education. It exists at a certain level in higher mammals, but is quantitatively and qualitatively different in humans, in whom memory is totally channeled by knowledge and transmitted and preserved by language in every ethnic group. With this knowledge, the individual has access to the third kind of memory: a virtual memory that is the ethnic or social memory and that belongs as a whole to the ethnic group.

According to the type of operational behavior involved, the individual calls upon or activates one of these three memories. Automatic behaviors related to one's biological nature, such as feeding or sexual behaviors or body attitudes, call for the genetic memory. A second level of behavior is concerned with operational sequences acquired through education and experience, but which take place in a "semiautomatic" mode; brushing your teeth and putting on your clothes do not require full attention. However, as soon as an incident or interruption occurs (e.g., accidentally injuring oneself during such activity), semiautomatic behavior is replaced by lucid behavior, which introduces a confrontation between the present situation and experience through language symbols.

The third level is lucid behavior in which language takes a dominant part, whether for repairing an accident in an operational sequence or for creating a new one. Periodical operational sequences and exceptional operational sequences require lucid behavior. But most of our lives are filled with semiautomatic stereotyped operational sequences that are transmitted through the family unit or youth peer groups. They form the basis of individual behavior within the ethnic group and give the strongest ethnic imprint to the individual. They are the necessary counterpart to freedom of behavior in exceptional circumstances (Leroi-Gourhan, 1993, pp. 227–233).

The Exteriorization of Memory

With memory, humanity experiences a double exteriorization. One is the transfer of the largest segment of knowledge outside the individual to the social or ethnic memory. The second is part of the evolutionary trend outside the human body. Memory was first orally transmitted and then fixed in writing that initially reproduced oral lore. Libraries were created to preserve written memory. By the nineteenth century, memory was fixed in a new multidimensional system with files and indices that permitted the sorting of data in different ways (by subject, geography, chronology, etc.). Files can be considered a manual machine of some kind. The next step was realized only in the midtwentieth—sorting machines and perforated cards. Leroi-Gourhan observes that although very similar in their technical structure, these files appeared only a century after the Jacquard loom (the first mechanical loom).

The next step occurred with computers and artificial intelligence, implying not only memory but also human reflexive thought (another dimension of exteriorization). This may seem commonplace today, but when Leroi-Gourhan was writing in the early 1960s, it was quite innovative.

To refuse to see that machines will soon overtake the human brain in operations involving memory and rational judgment is to be like Pithecanthropus who would have denied the possibility of the biface, the archer who would have laughed at the mere suggestion of the crossbow, most of all like the Homeric bard who would have dismissed writing as a mnemonic trick without any future. We must get used to being less clever than the artificial

brain that we have produced, just as our teeth are less strong than a millstone and our ability to fly negligible compared with that of a jetcraft. . . . We already know, or will soon know how to construct machines capable of remembering everything and of judging the most complex situations without error. What it means is that our cerebral cortex, however admirable, is inadequate just as our hands and eyes are inadequate; that it can be supplemented by electronic analysis methods; and that the evolution of the human being—a living fossil in the context of the present conditions of life—must follow a path other than the neuronically one if it is to continue. Putting it more positively, we could say that if humans are to take the greatest possible advantage of the freedom they gained by evading the risk of organic overspecialization, they must eventually go even further in exteriorizing their faculties. (Leroi-Gourhan, 1993, p. 265)

Symbolism and Aesthetics

Leroi-Gourhan was convinced that humans were distinct from animals or machines, and he sought evidence for this in two directions—symbolic activities and aesthetics. He thought that the conquest of tools and language represented only part of human evolution and that what he called “aesthetics” in our ascent has been as important. But aesthetics was much more difficult to document because “at first glance, it left no traces in skeletons and tools” (Leroi-Gourhan, 1993, p. 274).

Indeed, Leroi-Gourhan made a very original contribution in the field of aesthetics, which was carried further by French ethnologists (Bromberger, 1987). Instead of directly analyzing style—for him an essential component of ethnicity and ethnic identity—he preferred to analyze aesthetics, a much broader field that is not limited to creating images materialized in artistic production but extends to living as a whole through rhythms, forms, and flavors. Leroi-Gourhan wanted to take into account not only auditory and visual representations but also the totality of the sensory apparatus. Within this framework, style became the means through which ethnic groups put their imprint on forms, values, and rhythms.

Leroi-Gourhan was interested more in analyzing the internal characteristics of art production than in their ideological meaning (although he was also interested in the latter aspect). In this he differed from the main trends in social sciences both then and now. In the many previous examples I have noted, he also intended his analysis to encompass all aesthetic manifestations from biological aesthetics to the most refined figurative art or abstract painting.

He worked at three different levels—physiological, technical, and social. Thus he identified three kinds of aesthetics. Physiological aesthetics are deeply rooted in living beings through symmetry and rhythms. Functional aesthetics are present in all human productions, such as tools and instruments, and they correspond to a true mechanical determinism related to laws of matter. (Functional aesthetics are associated with the search for objects whose forms are perfectly adapted to their function.) Reflexive aesthetics are embodied in figurative and nonfigurative representations (Leroi-Gourhan, 1993, pp. 281–311).

The ethnomorphological analysis derived from these concepts was thus based on different dimensions of artistic representations: mode of expression (from pure

geometric to analytical figurative), shaping of forms (from elementary outlines to exuberant ornamentation), composition (including perspective, spatial distribution, movement), and construction (framing and creation of intervals creating rhythms).

Leroi-Gourhan applied this method to the analysis of African and prehistoric statues and figurines. He showed how these figurines were constructed according to repetitive intervals, the length of which was related to the width of the adze used on wood or to the size of the hand. But at the same time he also indicated how the choice of intervals and their overlapping were deeply rooted in ethnic style. It was thus possible “to isolate ethno-stylistical characteristics which [could] be defined as infrastructural” (Leroi-Gourhan, 1970, p. 676).

This particular example makes it clear that artistic productions were for him mostly determined by material and technical constraints and only subsequently by ethnic style within the narrow margin allowed by functional requirements. However, we find here one of the paradoxical situations he created by changing his perspective or the manner of his discourse. In some paragraphs, style is a superstructure resting on the infrastructure of material constraints, but it is also a comprehensive expression that imprints all aspects of an ethnic group’s culture. In a few illuminating pages, he succeeded in connecting aesthetics to symbolism. For example, he demonstrated that the aesthetics of clothing were rooted in symbolism and that the symbolic role of clothing was as important if not more so than its function (Leroi-Gourhan, 1993, pp. 350–353).¹¹

Leroi-Gourhan attempted to demonstrate how city plans from origins down to the eighteenth century were symbolic representations of the universe, linking space and time through solar or stellar mythology and calendar. He also recognized that industrialization had introduced a break in town evolution, leading to specialization and decentralization of towns and cities, and to the growing importance of networks. In this he foreshadowed much later urban geography studies.

In this last part of *Gesture and Speech* he also introduced his analysis of prehistoric cave art that he thoroughly developed in *Prehistoire de l’art occidental* published the same year (Leroi-Gourhan, 1965b).¹²

The Future of Human Evolution

The vast theoretical framework constructed by Leroi-Gourhan in the two volumes of *Le geste et la parole* ends with a tentative prospective view of human

¹¹Much earlier, he had argued how the Japanese costume was totally conditioned by its symbolic function to the point of being rather unpractical (Leroi-Gourhan, 1946).

¹²Leroi-Gourhan’s work on prehistoric art is well known to Anglo-Saxon readers and has been the subject of many comments (Conkey, 1989). It is not analyzed here. While his theory of cave paintings organized according to structural rules is still valid, his stylistic chronology is obsolete. The Chauvet cave (dated to around 30,000 and 26,500/25,000 B.P.) brought the final documentation that Aurignacian art was in no way only schematic and that there was no evolution from schematics to realism.

evolution, built as a musical fugue in which themes associated by pair or triplets recur in different associations as parts of an intricate network—hand/face, hand/tool, technique/language, memory/rhythms, tool/language/rhythmic creation, function, form, and aesthetics. From the beginning of his first volume, Leroi-Gourhan wanted to study ethnic groups. He thought that this was the typical form of human grouping and a significant unit of analysis. Individuals found their identity as members of an ethnic group and in sharing its characteristics as much in automatic behavior as in reflexive behavior. In a large section of *Technique et langage*, he studied “the social organism” (Leroi-Gourhan, 1993, pp. 145–183) or “the social body” (i.e., ethnic groups or social groups) as the place where social evolution replaces or takes over biological evolution.

However, in the course of his research Leroi-Gourhan came to reconsider his belief that ethnic groups were indeed the basic social components of humanity. Humanity was evolving towards what he called a “megaethny,” in a process that we would call globalization today—the globalization of the economy and of information, the standardization of modes of life and of culture. He saw that as part of social evolution. While developing other themes, he wrote on occasion several lines on his expectations and concerns about this evolutionary trend. He devoted an entire chapter to this subject—concerns about physical Man overcome by the acting and thinking machines he had devised, about the degradation of motor and technical skills, concerns about diminishing participation in the production of symbols replaced by access to virtual leisures organized by a few specialists in charge of creation (Leroi-Gourhan, 1993).

Extrapolating from the evolutionary trajectory he designed, he expressed concerns that are now at the heart of the interrogations of the twentieth century.

“The technical liberation unquestionably reduces the technical freedom of the individual” (Leroi-Gourhan, 1993, p. 253). Industrialization adapts the worker to the machine, so that “the liberation of a faculty always leads to accelerated improvement, not of the individual as such but of the individual as an element of a supermechanism.” The technical liberation

has led to the exteriorization of tools, . . . of muscle, and eventually of the nervous system of responsiveness. The exteriorization of time took place simultaneously but along different lines; time became the grid within which individuals became locked at the moment when the system of responsiveness reduced the period required for transmission to hours, minutes, and eventually to seconds. In sectors where the limit has been reached, the individual functions as a cell, an element of a collective program, within a network of signals that not only control his or her gestures, or effective mental activity but also regulate his or her right to absence, that is to rest or leisure time. (Leroi-Gourhan, 1993, p. 317)

Our electronic culture is barely 50 years old and is supported by a physiological apparatus which itself is 40,000 years old. While we have to trust our adaptive potential, the distortion still exists and there is some contradiction between a civilization with nearly unlimited powers and man’s aggressivity which has remained unchanged from the time when killing reindeer? meant survival. (Leroi-Gourhan, 1993, p. 402)

In his sober assessments, Leroi-Gourhan rejected the fear of an atomic apocalypse as well as Teilhard de Chardin's vision of an ascent towards a utopian Omega point. He also dismissed the hypothesis of a totally artificial world in which human beings would only be the cells of a megaorganism. Instead Leroi-Gourhan preferred to imagine that humanity will consciously decide to remain *sapiens sapiens*.

In such an event, the problem of the individual's relationship with society will have to be completely rethought: we must face up squarely to the question of our numerical density and our relations with the animal and plant worlds. (Leroi-Gourhan, 1993, p. 408)

CONCLUDING DISCUSSION

Leroi-Gourhan's teaching had as much influence on his students as his writings, or even more. This impact explains why his former students have insisted on the social role played by techniques while this emphasis is strangely missing in his written work. This short and slender man, with the sharp face of a fox, shy and secret, this slow speaker who avoided most of his colleagues because of his shyness, was a fascinating and charismatic teacher. Listening to him, you were captivated in an exciting intellectual adventure. His lectures reflected not only his intellectual trajectory but also his way of conducting excavations. As Guille-Escuret recalls, Leroi-Gourhan was such a prodigious professor because, in his approach, observation and theory were associated in an insoluble whole. Each served to correct and consolidate the other as the work progressed (Guille-Escuret, 1994, p. 10).

As soon as students discovered Leroi-Gourhan, they wanted to continue with him. The scientific approach was there, the rigor, the imagination. During the spring of 1964, the Magdalenian open-air site of Pincevent was discovered and began to be destroyed by a quarry. All shyness forgotten, Leroi-Gourhan pulled all the academic and political strings he could to stop the destruction and called his students to the rescue. More than 50 students answered, interrupted their university courses, and spent 4 months, digging with him until Malraux, the author and then minister of culture, had the land purchased by the state.

Digging with Leroi-Gourhan was an exciting adventure. Every morning, he put forth new hypotheses, and everybody was entitled to comment or question. Over the next 20 years he spent 2 months in the field every year, and anyone could sit with him at meals and engage in discussion (a very uncommon situation in French academic life at the time). Leroi-Gourhan was an intelligent man in the etymological meaning of the word.

From the 1950s on, Leroi-Gourhan had a considerable, and even decisive, influence on French prehistorians and on some French social anthropologists, as well as on German, Swiss, and Spanish prehistorians. His innovative excavation methods at Pincevent, involving the horizontal *decapage* of living areas (Leroi-Gourhan

and Brézillon, 1966), were further developed and refined to become standard procedure for open-air sites in the Old World. His influence extended to French archaeologists working on living floors and settlements in Mesoamerica, Central America, and the Near East.

Equally importantly, Leroi-Gourhan, together with knapping experiments developed in Jacques Tixier's laboratory, was at the origin of the school of prehistoric technology that developed from the practice of flint conjoining (or refitting) at the site of Pincevent. These two research groups, which joined forces in the 1980s, have been accumulating a very important body of theoretical knowledge on techniques and cognition, using the powerful concept of the *chaîne opératoire*. Technology is now as essential a component of Paleolithic or Neolithic research projects as typology. Prehistorians such as Jacques Tixier and collaborators, Claudine Karlin, Nicole Pigeot, Sylvie Ploux, Pierre Bodu, Jacques Pelegrin, Jean-Michel Geneste, and Eric Boëda, have brought important theoretical or methodological contributions to prehistoric technology and cognition (Boëda, 1991; Geneste, 1991; Karlin *et al.*, 1991, 1992; Karlin and Julien, 1994; Pélegrin, 1993; Pélegrin *et al.*, 1988; Pigeot, 1987, 1990; Ploux *et al.*, 1991; Tixier, 1988).

A school of comparative ethnology and cultural technology was created directly under the influence of *Evolution and Technique*, Leroi-Gourhan's first major work. Major figures of this movement are Robert Cresswell with his journal *Techniques & Culture* (1993), Balfet (1991a,b), Bromberger (1987), Digard (1979), Lemonnier (1980, 1992), and Martinelli (1988). Many of these researchers have shown a deep interest in understanding the reciprocal influences of social organization and techniques. Some French social anthropologists also having been influenced by Leroi-Gourhan, try to relate the rationality inscribed in the evolution of techniques to the analysis of the Marxist "productive forces" and to link together technical and social or production processes (among them, Digard, 1979). But here, alongside Leroi-Gourhan, one must also mention the influence of Haudricourt, his contemporary in social anthropology with an agronomic and a linguistic background. Haudricourt created the ethno-science approach in France (Haudricourt, 1968, 1987; Sigaut, 1991). Much more than Leroi-Gourhan, Haudricourt stressed the social and cultural aspect of techniques (Bonte, 1992). A member of the ethno-science school, and from a much younger generation, Georges Guille-Escuret also acknowledges a direct connection to Leroi-Gourhan in his theory of the social fact (Guille-Escuret, 1994).

It took much longer for Leroi-Gourhan's influence to be felt in the United States and Great Britain, where language and an altogether different set of scientific priorities had established almost insurmountable barriers. It was at the time of the translation of *Préhistoire de l'art occidental* (Treasures of Prehistoric Art) that rock art specialists such as Andre Rosenfeld and Peter Ucko became interested in his work, but then only in a very critical fashion. They were able to perceive the weaknesses but not the innovative aspects of his work (Ucko and Rosenfeld, 1967).

Another dozen years intervened before the influence of Leroi-Gourhan was felt in the United States, even among Old World specialists. This took place at the moment when postprocessualism had begun to weaken the thrust of the New Archaeology and when a spirit of intellectual renewal was in the air. Margaret Conkey's work in the late 1970s and early 1980s seems to have been the first to regard Leroi-Gourhan's structuralist approach to art as one capable of offering new perspectives. Among other things, it informed her work on engraved bone and antler assemblages from Magdalenian sites of north-coastal Spain (Conkey, 1978, 1980, 1989). By 1985, Randy White recognized the methodological potential of the *chaîne opératoire* as he began his analysis of personal ornaments from the Aurignacian.

Although they themselves lacked firsthand knowledge of his writings, Americans working in the Near East were kept constantly up-to-date on the progress of Leroi-Gourhan's school, thanks to Jacques Tixier, the well-known prehistorian and expert on technology. Beginning in the 1980s, reference to the *chaîne opératoire* and French thinking on the subject appeared in the bibliographies of Angela E. Close (2000) and James L. Phillips (1991). Ofer Bar-Yosef, a Harvard professor working in Israeli with French prehistorians at Kebara, not only kept up-to-date on *chaîne opératoire* research but in fact incorporated it into his own approach, where it was allied with refitting analysis and the morphometric study of tool supports (Bar-Yosef, 1991; Bar-Yosef *et al.*, 1992). For still other prehistorians, it was as a direct result of working in France that they became familiar with the intellectual heritage of Leroi-Gourhan (Simek, 1994); all the more if they worked at Pincevent as Enloe did for his PhD. Since then, his excavation methods for uncovering living floors and his field school at Verberie in northern France have retained much of Leroi-Gourhan's method (Enloe, 1991, 1992).

The belated translation *Gesture and Speech* in 1993 provided a wider American audience with access to Leroi-Gourhan's major theoretical work. His ideas also were diffused to English readers through the works of Marcia-Ann Dobres. Apart from a PhD dissertation applying the *chaîne opératoire* to the manufacture and subsequent rejuvenation of bone tools (Dobres, 1995), her articles and book furnish a critical synthesis of the history of French thought on technology from the time of Marcel Mauss to the present (Dobres, 1999, 2000; Dobres and Hoffman, 1994, 1999). Leroi-Gourhan's work now seems to reach a wider audience in the Anglo-Saxon world (Bleed, 2001).

About the same time as in the United States, an interest in technology emerged at the University of Cambridge in England. This interest bore fruit with the appearance of an entire number of the *Cambridge Archaeological Review* (edited by Nathan Schlanger) devoted to "Techniques as Human Action" in 1990. In this, several French prehistorians were given the opportunity to review the major theoretical and methodological advances made in this field in the 1980s. In the same year Mark Edmonds brought his understanding of *chaînes opératoires* to bear on

his study of the production of polished axes in northern England (Bradley and Edmonds, 1993; Edmonds, 1990).

After its translation into English, *Gesture and Speech* also found an echo in Great Britain among social anthropologists such as Tim Ingold (personal communication, 1998), as well as prehistorians such as Clive Gamble who—while not adopting his ideas—have found their own thought to be greatly stimulated by Leroi-Gourhan's distinctive manner of defining and attacking the issues that now engage their own concerns (Gamble, personal communication, 2001).

Because it was translated into Japanese not long after its publication in France, *Gesture and Speech* is part of the archaeology readings at the university in Japan, but this did not lead to real influence. Although Japanese prehistorians practice lithic refitting (Aita *et al.*, 1991), they have closer affinities to Bordes's approach. But there is interest in Leroi-Gourhan's earlier work on Japan that resulted in the recent publication of two volumes of Leroi-Gourhan's photographs from his 1937–38 mission in Japan (Yamanaka 2000, 2001).

Leroi-Gourhan's influence today does not rest solely on his printed works. Indeed, thanks to the massive contribution made by his many students and younger associates, his work and thought no doubt enjoy much greater currency today than they ever did in his own lifetime. When Leroi-Gourhan's major work was published, it was received not only with admiration but also with some perplexity. Thirty years earlier, when Marcel Mauss read Leroi-Gourhan's first book on the *Civilization of Reindeer* (1936), he had told him in jest that he felt like a hen that had hatched a duckling. The same comment applies to *Le geste et la parole*. What was one to do with such an enterprise, which constantly referred to methods from other fields and which displaced primary questions? Biologists could not use it in their discipline, and neither could psychologists, social anthropologists, nor for that matter prehistorians. For several years, *Gesture and Speech* was ignored as an intimidating monument. Leroi-Gourhan operated at three levels of reasoning: a concrete analytical level for observing facts and manipulating data; a highly abstract level involving vast questions such as origins or evolution that could only be approached through philosophical investigations; and an intermediate level of abstraction, the most original, where he constructed the networks of biological, psychological, and social relations that established the technical realm as the mediator of evolution.

Thirty years later, prehistorians and social anthropologists have retained the analytical methods and, most of all, the acquisitions at the practical level: the *chaîne opératoire*, the analysis of techniques, and the excavation methods have all been adopted, refined, and enlarged. At the abstract level, French philosophers such as Foucault or Derrida have been interested or even inspired by Leroi-Gourhan's concepts. There is today a school of philosophers of science and techniques, centered on Bernard Stiegler, that stresses again the importance of Leroi-Gourhan. His vision of the evolution of technique, his "programmatology," seems to them highly

inspiring. Leroi-Gourhan's real originality, his ability to combine in a unique approach a science of man, biology and social sciences, has not yet found followers.¹³

Upon reading *Le geste et la parole*, one may note that his description of early humans is now inaccurate, that his chronology and structural interpretation of prehistoric art needs to be revised, that his sweeping reconstructions are at times far too ambitious, and that some of his terminology would now be considered to be "politically incorrect." All of this is true, but it is far more important and worthwhile to remember that in his work Leroi-Gourhan provides an extraordinarily powerful theoretical framework for thinking about techniques and their evolution and that he furthermore expresses very contemporary insights and concerns about aesthetics and ecology, about freedom and politics. There is no doubt that Leroi-Gourhan's work constitutes a major contribution in both French prehistory and social anthropology. Yet those aspects of his work that have not been assimilated still offer a potential source of insights and interrogations. If we want to know more about early prehistoric societies, technology, and evolution, we shall have to deal with fundamental questions at the level at which Leroi-Gourhan formulated and addressed them.

ACKNOWLEDGMENTS

This paper originated in public lectures that I presented while a George A. Miller visiting professor at the University of Illinois, Urbana-Champaign, in fall 1996, and in a class that I taught at the University of California, Berkeley, in spring 1998. I express my gratitude to Janet Keller, Olga Soffer, and Margaret Conkey for giving me those opportunities and providing useful comments. In preparing this paper, I am very much in debt to H el ene Balfet, Anick Coudart, Georges Guille-Escuret, Pierre Lemonnier, Bernard Stiegler, and Nathan Schlanger, whose writings on Leroi-Gourhan helped me clarify my own views. Meg Conkey, Marcia-Ann Dobres, and Randy White helped me sort through the ins and outs of American archaeology. I am also extremely grateful to Anick Girard and Elizabeth Dinan for correcting the imperfect English of the first version of this text, to Nathan Schlanger for his constructive critiques, and to Jim Sackett for translating the additions to this text. I use this opportunity to express my gratitude to him for introducing me to American archaeology 30 years ago. Last, I warmly thank Douglas Price for the final editing.

REFERENCES CITED

Aita, Y., Kato, M., and Yamanaka, I. (1991). Le remontage des pi eces lithiques: une illustration des diff erentes techniques du Pal eolithique sup erieur au Japon. In *25 ans d'Etudes technologiques en*

¹³However Guille-Escuret has attempted in *Le d ecalage humain* (1994) to explain the origin of the social fact by drawing on biology, ecology, ethology, and the social sciences.

- Préhistoire, Bilan et perspectives, Actes des XIèmes Rencontres Internationales d'Archéologie et d'Histoire d'Antibes (18–20 octobre 1990)*, APDCA, Antibes, France, pp. 305–317.
- Akrich, M. (1994). Comment sortir de la dichotomie technique/société. Présentation des diverses sociologies de la technique. In Latour, B., and Lemonnier, P. (eds.), *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris, pp. 105–130.
- Audouze, F. (1992). Essai de portrait. In Audouze, F., and Schnapp, A. (eds.), *Un homme, une oeuvre: Leroi-Gourhan (dossier), Les Nouvelles de l'Archéologie* **48/49**: 5–54.
- Audouze, F., and Schnapp, A. (eds.) (1992). Un homme... une oeuvre: André Leroi-Gourhan. *Les Nouvelles de l'Archéologie* **48/49**: 5–54.
- Balfet, H. (ed.) (1991a). *Observer l'action technique. Des chaînes opératoires pour quoi faire?*, Ed. du CNRS, Paris.
- Balfet, H. (1991b). Chaînes opératoires et organisation sociale du travail: quatre exemples de façonnage de poterie au Maghreb. In Balfet, H. (ed.), *Observer l'action technique. Des chaînes opératoires pour quoi faire?*, Ed. du CNRS, Paris, pp. 87–95.
- Bar-Yosef, O. (1991). The search for lithic variability among Levantine Epi-Paleolithic industries. In *25 ans d'Etudes technologiques en Préhistoire, Bilan et perspectives, Actes des XIèmes Rencontres Internationales d'Archéologie et d'Histoire d'Antibes (18–20 octobre 1990)*, APDCA, Antibes, France, pp. 319–335.
- Bar-Yosef, O., Vandermeersch, B., Arensburg, B., Belfer-Cohen, A., Goldberg, P., Laville, H., Meignen, L., Rak, Y., Speth, J. D., Tchernov, E., Tillier, A. M., and Weiner, S. (1992). Excavations at Kebara, Mt. Carmel. *Current Anthropology* **33**: 497–550.
- Binford, L. R., and Binford, S. R. (1968). *New Perspectives in Archeology*, Aldine, Chicago.
- Boëda, E. (1991). Approche de la variabilité des systèmes de production lithique des industries du Paléolithique inférieur et moyen. Chronique d'une variabilité attendue. *Techniques et Culture* **17/18**: 37–39.
- Bonte, P. (1992). Après Leroi-Gourhan: tendances et problèmes d'une approche ethnologique des faits techniques. *Les Nouvelles de l'Archéologie* **48/49**: 18–22.
- Bradley, R., and Edmonds, M. (1993). *Interpreting the Axe Trade: Production and Exchange in Neolithic Britain*, Cambridge University Press, Cambridge, MA.
- Bromberger, C. (1987). André Leroi-Gourhan et l'esthétique. In *André Leroi-Gourhan ou les voies de l'homme, actes du colloque du CNRS, Paris 1987*, Albin-Michel, Paris, pp. 157–168.
- Close, A. E. (2000). Reconstructing movement in prehistory. *Journal of Archaeological Method and Theory* **7**(1): 49–77.
- Conkey, M. (1978). *An Analysis of Design Structure: Variability among Magdalenian Engraved Bones From North-Coastal Spain*, Ph.D. Dissertation, Department of Anthropology, University of Chicago, Chicago.
- Conkey, M. (1980). Context, structure and efficacy in paleolithic art. In Foster, M. L., and Brandes, S. (eds.), *Symbol as Sense*, Academic Press, New York, pp. 225–248.
- Conkey, M. (1989). The structural analysis of Paleolithic art. In Lamberg-Karlovsky, C. C. (ed.), *Archaeological Thought in America*, Cambridge University Press, Cambridge, MA, pp. 135–154.
- Cowgill, G. L. (1989). Formal approaches in archaeology. In Lamberg-Karlovsky, C. C. (ed.), *Archaeological Thought in America*, Cambridge University Press, Cambridge, MA, pp. 74–88.
- Cresswell, R. (1983). Transferts de techniques et chaînes opératoires. *Techniques et Culture* **2**: 144–159.
- Cresswell, R. (1993). Tendances et faits, logique et histoire. *Techniques et Culture* **21**: 5–37.
- Cresswell, R. (1994). La nature cyclique des relations entre le technique et le social. Approche technologique de la chaîne opératoire. In Latour, B., and Lemonnier, P. (eds.), *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris, pp. 275–289.
- Derrida, J. (1967). *De la Grammatologie*, Editions de Minuit, Paris.
- Descola, P. (1994). Pourquoi les Indiens d'Amazonie n'ont-ils pas domestiqué le pécarì? Généalogie des objets et anthropologie de l'objectivation. In Latour, B., and Lemonnier, P. (eds.), *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris, pp. 329–344.
- Digard, J.-P. (1979). La technologie en anthropologie: fin de parcours ou nouveau souffle? *L'Homme* **19**: 73–104.
- Dobres, M.-A. (1995). *Gender in the Making: Late Magdalenian Social Relations of Production in the French Midi-Pyrénées*, Unpublished Ph.D. Dissertation, Department of Anthropology, University of California, Berkeley.

- Dobres, M.-A. (1999). Technology links and chaînes: The processual unfolding of technique and technician. In Dobres, M.-A., and Hoffman, C. R. (eds.), *Making Culture: Essays on Technological Practice, and World Views*, MIT Press, Washington, DC, pp. 124–146.
- Dobres, M.-A. (2000). *Technology and Social Agency*, Blackwell, Oxford.
- Dobres, M.-A., and Hoffman, C. R. (1994). Social agency and the dynamics of prehistoric technology. *Journal of Archaeological Method and Theory* 1: 211–258.
- Dobres, M.-A., and Hoffman, C. R. (1999). *Making Culture: Essays on Technological Practice, and World Views*, Smithsonian Institution Press, Washington, DC.
- Edmonds, M. (1990). Description, understanding and the chaîne opératoire. *Archaeological Review From Cambridge* 9: 55–70.
- Enloe, J. G. (1991). *Subsistence Organization in the Upper Paleolithic: Carcass Refitting and Food Sharing at Pincevent*, Ph.D. Dissertation, Department of Anthropology, University of New Mexico, University Microfilms, Ann Arbor.
- Enloe, J. G. (1992). Subsistence organization in the early Upper Paleolithic: Reindeer hunters of the Abri du Flageolet. In Knecht, H., Pike-Tay, A., and White, R. (eds.), *Before Lascaux: Complex Record of the Early Upper Paleolithic*, CRC Press, Boca Raton, FL.
- Fodor, J. (1983). *The Modularity of the Mind*, MIT Press, Cambridge, MA.
- Gaucher, G. (1987). André Leroi-Gourhan, biographie. *Bulletin de la Société Préhistorique Française* 84: 302–315.
- Geneste, J.-M. (1991). Systèmes techniques de production lithique; variations techno-économiques dans les processus de réalisation des outillages paléolithiques. *Techniques et Culture* 17/18: 1–35.
- Groenen, M. (1996). *Leroi-Gourhan. Essence et contingence dans la destinée humaine*, De Boeck Université, Bruxelles.
- Guille-Escuret, G. (1994). *Le décalage humain*, La Découverte, Paris.
- Haudricourt, A.-G. (1968). La technologie culturelle. Essai de méthode. In Poirier, J. (ed.), *Ethnologie Générale I*, Gallimard, Paris, pp. 731–882.
- Haudricourt, A.-G. (1987). *La Technologie science humaine. Recherches d'histoire et de technologie des techniques*, Edition de la Maison des Sciences de l'Homme, Paris.
- Karlin, C., Bodu, P., and Pélegrin, J. (1992). Some socio-economic aspects of the process of lithic reduction among groups of hunter-gatherers of the Paris Basin area. In Berthelet, A., and Chavaillon, J. (eds.), *The use of Tools by Humans and Non-Human Primates* (symposia of the Fyssen Foundation No. 3), Clarendon Press, Oxford, pp. 318–340.
- Karlin, C., Bodu, P., and Pigeot, N. (1991). Processus techniques et chaînes opératoires. Comment les préhistoriens s'approprient un concept élaboré par les technologues. In Balfet, H. (ed.), *Observer l'action technique. Des chaînes opératoires pour quoi faire?*, Edition du CNRS, Paris, pp. 87–95.
- Karlin, C., and Julien, M. (1994). Prehistoric technology: A cognitive science? In Renfrew, C., and Zubrow, E. (eds.), *The Ancient Mind: Elements of Cognitive Archaeology*, Cambridge University Press, Cambridge, MA, pp. 152–164.
- Latour, B., and Lemonnier, P. (eds.) (1994). *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris.
- Lemonnier, P. (1980). *Les Salines de l'Ouest, logique technique, logique sociale*, Edition de la Maison des Sciences de l'Homme, Paris.
- Lemonnier, P. (1992). Leroi-Gourhan ethnologue des techniques. *Les Nouvelles de l'Archéologie* 48/49: 13–17.
- Lemonnier, P. (1993). Introduction. In Lemonnier, P. (ed.), *Technological choices. Transformation in Material Cultures Since the Neolithic*, Routledge, London, pp. 1–35.
- Lemonnier, P. (1994). Choix techniques et représentation de l'enfermement chez les Anga de Nouvelle-Guinée. Ethnologie et technologie. In Latour, B., and Lemonnier, P. (eds.), *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris, pp. 254–270.
- Leroi-Gourhan, A. (1943). *Evolution et techniques I—L'Homme et la matière*, Albin Michel, Paris.
- Leroi-Gourhan, A. (1945). *Evolution et techniques II—Milieu et techniques*, Albin Michel, Paris.
- Leroi-Gourhan, A. (1946). Symbolique du vêtement japonais. *Rythmes du Monde* 4: 31–40.
- Leroi-Gourhan, A. (1952a). Homo faber—Homo sapiens. *Revue de Synthèse* 30: 79–102.
- Leroi-Gourhan, A. (1952b). Sur la position scientifique de l'ethnologie. *Revue philosophique. Paris octobre-décembre*: 506–508.

- Leroi-Gourhan, A. (1964a). *Le geste et la parole I—Technique et langage*, Albin Michel, Paris.
- Leroi-Gourhan, A. (1964b). *Les religions de la préhistoire*, Presses Universitaires de France, Paris.
- Leroi-Gourhan, A. (1965a). *Le geste et la parole II—La mémoire et les rythmes*, Albin Michel, Paris.
- Leroi-Gourhan, A. (1965b). *Préhistoire de l'Art occidental*, Mazenod, Paris.
- Leroi-Gourhan, A. (1970). Observations technologiques sur le rythme statuaire. In *Exchanges and communications (Mélanges offerts à C. Lévi-Strauss)*, Mouton, La Hague, pp. 658–676.
- Leroi-Gourhan, A. (1971). *Evolution et techniques I—L'Homme et la matière*, 2nd edn., Albin Michel, Paris.
- Leroi-Gourhan, A. (1973). *Evolution et techniques II—Milieu et techniques*, 2nd edn., Albin Michel, Paris.
- Leroi-Gourhan, A. (1982). *The Dawn of European Art*, Cambridge University Press, Cambridge, MA.
- Leroi-Gourhan, A. (1993). *Gesture and Speech* (translated by Anna Bostock Berger), MIT Press, Cambridge, MA.
- Leroi-Gourhan, A., and Brézillon, M. (1966). L'habitation magdalénienne n° 1 de Pincevent, près Montereau (Seine-et-Marne). *Gallia-Préhistoire* 9(2): 263–385.
- Lévy-Strauss, C. (1988). Nous avons lui et moi essayé de faire à peu près la même chose. In *André Leroi-Gourhan ou les Voies de l'Homme (Actes du colloque du CNRS—mars 1987)*, Albin Michel, Paris, pp. 201–206.
- Maget, M. (1953). *Guide d'étude directe des comportements culturels*, Edition des civilisations du Sud, Paris.
- Martinelli, B. (1988). Après André Leroi-Gourhan: les chemins de la technologie. In *André Leroi-Gourhan ou les voies de l'homme, actes du colloque du CNRS, Paris 1987*, Albin-Michel, Paris, pp. 61–89.
- Mauss, M. (1936). Les techniques du corps. *Journal de Psychologie*, 32(3/4): 271–293.
- Mithen, S. (1996). *The Prehistory of the Mind*, Thames and Hudson, London.
- Pélegrin, J. (1993). A framework for analysing prehistoric stone tools manufacture and a tentative application to some early industries. In Berthelet, A., and Chavaillon, J. (eds.), *The Use of Tools by Humans and Non-Human Primates* (symposia of the Fyssen Foundation No. 3), Clarendon Press, Oxford, pp. 302–314.
- Pélegrin, J., Karlin, C., and Bodu, P. (1988). Chaînes opératoires: un outil pour le préhistorien. In Tixier, J. (ed.), *Technologie préhistorique*, Editions du CNRS, Paris, pp. 55–62.
- Phillips, J. L. (1991). Refitting, edge-wear and chaînes opératoires: A case study from Sinai. In *25 ans d'Etudes technologiques en Préhistoire, Bilan et perspectives, Actes des XI^e rencontres internationales d'archéologie et d'histoire d'Antibes (18–20 octobre 1990)*, APDCA, Antibes, France, pp. 305–317.
- Pigeot, N. (1987). *Magdaléniens d'Etiolles; économie, du débitage et organisation sociale. XXVe suppl. to Gallia-Préhistoire*, Editions du CNRS, Paris.
- Pigeot, N. (1990). Technical and social actors: Flintknapping specialists at Magdalenian Etiolles. *Cambridge Archaeological Review* 9: 126–141.
- Ploux, S., Karlin, C., and Bodu, P. (1991). D'une chaîne l'autre: Normes et variations dans le débitage laminaire magdalénien. *Techniques et Culture* 17/18: 81–114.
- Sackett, J. R. (1966). Quantitative analysis of Upper Paleolithic stone tools. *American Anthropologist* 68: 356–394.
- Schlanger, N. (1994). Piaget et Leroi-Gourhan. Deux conceptions biologiques des connaissances et des techniques. In Latour, B., and Lemonnier, P. (eds.), *De la préhistoire aux missiles balistiques, l'intelligence des techniques*, La Découverte, Paris, pp. 165–183.
- Sigaut, F. (1991). Un couteau ne sert pas à couper mais en coupant. Structure, fonctionnement et fonction dans l'analyse des objets. In Tixier, J. (ed.), *25 ans d'études technologiques en préhistoire, actes des XI^e Rencontres internationales d'Archéologie et d'Histoire d'Antibes 1991*, APDCA, Antibes, France, pp. 21–34.
- Simek, J. F. (1994). The organization of technology and evolution: Notes from the continent. In Carr, P. J. (ed.), *The Organization of North American Prehistoric Chipped Stone Tools Technologies*, International Monographs in Prehistory, Ann Arbor, MI, pp. 118–123.
- Spaulding, A. C. (1960). Statistical description and comparison of artifact assemblages. In Heizer, R. F., and Cook, S. F. (eds.), *The Application of Quantitative Methods in Archaeology*, Viking Fund Publications in Anthropology 28, Quadrangle Books, Chicago, pp. 60–92.

- Stiegler, B. (1992a). Leroi-Gourhan, part maudite de l'anthropologie. *Les Nouvelles de l'Archéologie* **48/49**: 23–30.
- Stiegler, B. (1992b). La programmatologie de Leroi-Gourhan. *Les Nouvelles de l'Archéologie* **48/49**: 31–36.
- Stiegler, B. (1994). *La technique et le temps, I. La faute d'Épiméthée*. Galilée/Cité des Sciences et de l'Industrie, Paris.
- Tixier, J. (ed.) (1988). *Technologie préhistorique*, Editions du CNRS, Paris.
- Ucko, P., and Rosenfeld, A. (1967). *Paleolithic Cave Art*, McGraw-Hill, New York.
- White, R. (1989). Production complexity and standardisation in early Aurignacian bead and pendant manufacture: Evolutionary implications. In Stringer, C., and Mellars, P. (eds.), *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, Edinburgh University Press, Edinburgh, Scotland, pp. 366–390.
- White, R. (1997). Substantial acts: From materials to meaning in Upper Paleolithic representation. In Conkey, M. W., Soffer, O., Stratmann, D., and Jablonski, N. (eds.), *Beyond Art: Upper Paleolithic Symbolism*, California Academy of Sciences, San Francisco, pp. 93–121.
- Yamanaka, I. (2000). *Le Japon vu par André Leroi-Gourhan, 1937–1939, Vol. 1*, Osaka Culture Association, Kyoto, Japan.
- Yamanaka, I. (2001). *Le Japon vu par André Leroi-Gourhan, 1937–1939, Vol. 2*, Osaka Culture Association, Kyoto, Japan.

BIBLIOGRAPHY OF RECENT LITERATURE

- Audouze, F. (1999). New advances in French prehistory. *Antiquity* **73**: 167–175.
- Bleed, P. (2001). Trees or chains, links or branches: Conceptual alternatives for consideration of stone tool production and other sequential activities. *Journal of Archaeological Method and Theory* **8**: 101–127.
- Boëda, E. (1997). *Technogenèse du système de production lithique au Paléolithique inférieur et moyen en Europe occidentale et au Proche-Orient*, Habilitation, Université de Paris X-Nanterre.
- Coudart, A. (1999). Is post-processualism bound to happen everywhere? The French case. *Antiquity* **73**(279): 161–167.
- Inizan, M.-L., Roche, H., and Texier, J. (1999). *Technology and Terminology of Knapped Stone*, CREP, Nanterre, France.
- Michelson, A. (1986). In praise of horizontality: André Leroi-Gourhan, 1911–1986. *October* **37**: 3–5.
- Pélegrin, J. (2000). Les techniques de débitage laminaire au Tardiglaciaire: critères de diagnose et quelques réflexions. In Valentin, B., and Bodu, P. (eds.), *L'Europe centrale et septentrionale au Tardiglaciaire. Confrontation des modèles régionaux de peuplement*, APRAIF, Nemours, pp. 73–86.
- Pétrequin, P., Pétrequin, A.-M., Jeudy, F., Jeunesse, C., Monnier, J.-L., Pélegrin, J., and Praud, Y. (1998). From the raw material to the Neolithic stone axe. Production processes and social context. In Edmonds, M., and Richards, C. (eds.), *Understanding the Neolithic of North-Western Europe*, Cruithne Press, Glasgow, Scotland, pp. 277–311.
- Valentin, B. (1995). *Les groupes humains et leurs traditions au Tardiglaciaire dans le Bassin Parisien*, Ph.D. Dissertation, Université de Paris, Paris.