8 Gesture and Program

A study of technics limited to classifying different types of tools and analyzing different stages of manufacturing processes would bear the same relation to ethnology as systematic zoology does to animal biology. In such a study tools exist only as part of the operating cycle. They provide evidence of the cycle because they generally carry significant traces of it, but no more so than a skeleton of a horse does of the swift herbivore to which it once belonged. Systematic technology, which forms the subject of the two volumes of my Evolution et techniques, is an indispensable basis, yet the real significance of tools is in the gesture, which makes them technically effective.

The concept "tool" itself needs to be reviewed with reference to the animal world, for technical action is found in invertebrates as much as in human beings and should not be limited exclusively to the artifacts that are our privilege. In animals, tool and gesture merge into a single organ with the motor part and the active part forming an undivided whole. The crab's claws and jaws are all of a piece with the operating program through which the animal's food acquisition behavior is expressed. The fact that human tools are movable and that their characteristics are not species related but ethnic is basically unimportant. The sociocultural divisions that make a particular technical operation typically New Caledonian in terms of both the method and the tools employed have simply taken the place of the psychozoological divisions that make certain operations and a certain physical apparatus typical of particular species of animals.

The operational synergy of tool and gesture presupposes the existence of a memory in which the behavior program is stored. With animals, this memory forms part of organic behavior as a whole, and the technical operation becomes, in the popular sense, "instinctive." We saw earlier that in humans, the mobility of tools and language has determined the exteriorization of operational programs related to the

survival of the group. What we must now do is to trace the stages that have led to a liberation so great in present-day societies that both tool and gesture are now embodied in the machine, operational memory in automatic devices, and programming itself in electronic equipment. Most of what needs to be said about tools is already to be found in earlier chapters. Gesture, however, has not often been considered by a method in which animal behavior and the deliberate motor activities of humans are viewed from the same perspective

Elementary Analysis of the Gesture

The osteomuscular apparatus of primates is similar enough to the human's for its mechanical properties to be considered largely equivalent to ours. Human movements are no doubt more finely differentiated than those of monkeys, but the anatomical differences are negligible compared with those of the neuromotor apparatus. Ordinary monkeys, anthropoid apes, and the human can therefore be considered to have the same anatomical and gestural possibilities

The essential traits of human technical gesticulation are undoubtedly connected with grasping. We saw earlier that grasping actions are characteristic of a whole category of mammals starting with rodents and carnivores, which show varying degrees of the same aptitudes. The distinction between operations in which hand actions are combined with actions of the face, particularly of the lips and the front teeth, and operations in which hand actions, bilateral or unilateral, are performed without facial participation is evident at different levels. We became aware of the importance of this distinction when we analyzed the formation of the anterior field. To it we must add another that is particularly important when analyzing the technical behavior of humans: the mode of action peculiar to the hand. Action peculiar to the hand consists in the potentially wounding effect of fingernails, in grasping operations involving the fingers and the palm (digitopalmar prehension), and in grasping between the fingers (interdigital prehension). Since movements of transmission or rotation determine both our manner of holding a hand tool and the impetus we apply to it, a fourth term descriptive of the leverage exercised by the forearm and the arm is needed in order to analyze human gestural behavior in the technical field. A full analysis would have to be based on the whole of the body, but here we need go no further than to suggest a method of ordering the main categories of the gestural behavior of the higher mammals and the human.

The interest in defining the common capital of monkeys and the human being does not lie in finding human elements in the monkey but in analyzing the elements of physiological anatomy common to both. Figure 106 shows the technical behavior of primates and human technical capital from the earliest beginnings until the dawn of Homo Sapiens.

The elementary behavior of monkeys and anthropoid apes involves coordinated or isolated action of the forelimb and the face against the moving background of the body mass in operations relating to the acquisition and consumption of food, to aggression or defense, and to associative behavior through facial or manual contact. Unlike the rodents, which almost exclusively seize or palpate by grasping with the lips and teeth, primates use the hand by preference.l6 This reversal of the proportion between the respective uses of the hand and the face in a number of actions not basically different from those performed by rodents having a prehensile hand is in itself sufficient to set the primates apart from the rest of the mammals. It marks the beginning of human operational behavior processes.

From primate to human being, grasping operations do not change in nature but develop in terms of the variety of ends pursued and the delicacy of execution (figure 106).

		Dental percussion	Manual percussion	Percussion with the nails
	Aggression / Acquisition / Feeding	Crushing Sectioning	Hammering	Scraping Digging
Grasping: labio-dental	Relationship	——	Tearing ——	
Digito-palmar	Brachiation, seizing Affective contact Kneading Cupping Snuggling, protection	Crusher Knife Awl Spike	Chopper, hammer, club Spatule	Notcher Digging-stick, pick, hoe
Interdigital	Peeling Grooming Molding	Graver Punch Needle		Scraper
Projection		Spear	Stone, projectile Bola	

106. Elementary connections between actions and primitive tools.

Digitopalmar grasping operations, affectionate or hostile contact, kneading or using the hand as a receptacle remain fundamental in bare-handed tech piques, while the interdigital operations performed by primates for the purpose of grooming or peeling assume considerable importance in techniques requiring some delicacy of execution, such as spinning yarn. The fact that our brain as it is today was the human being's most recent acquisition emerges more clearly from the study of technical gestures than from any other form of research because the result of a technical gesture does not require any part of the osteomuscular apparatus that is not already present in the higher monkey: The difference is one of nervous apparatus alone.

The borderline between the primate and the first toolmaker is not a matter of technical possibilities: The great apes can grasp, touch, pick, knead, peel, and handle; they tear food apart using fingers and teeth, crush with their molars, cut with their incisors, hammer with their fists, scratch and dig with their nails. The list of what primates can do includes every one of the operations attested by Archanthropian or Palaeoanthropian tools.

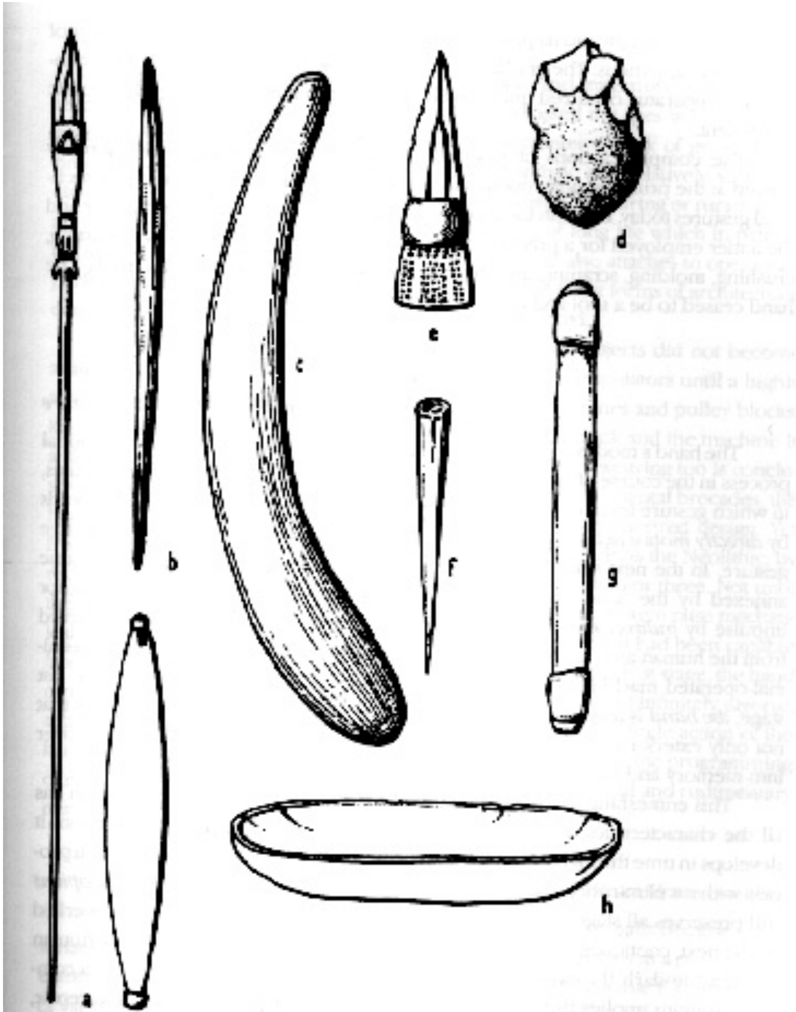
In an earlier chapter we arrived at the impression that tools were "exuded" by humans in the course of their evolution. A moment came when the lineage was mature enough to produce the free-handed biped to whom the first part of this book is devoted, a biped who emerged without losing touch with the continuum of living organisms, totally different, even in his most elementary humanity from the most advanced of the monkeys but carried along on the same tide. An identical impression

[Table goes here]

106. Elementary connections between actions and primitive tools.

arises even more powerfully when we analyze technical gestures and see how our tools sprang, literally, from the nails and teeth of primates without the smallest perceptible interruption.

The technical equipment of the earliest anthropoids the Australanthropes and Archanthropes consisted of percussion tools, rough-edged choppers, stag antlers cut down to make clubs or digging sticks, and spherical projectiles for which the act of throwing was a direct development of earlier gestures. The human hand is human because of what it makes, not of what it is, namely a fairly simple osteomuscular device capable, from the monkey, of performing, in a mechanically very economical manner, movements of grasping, rotation, and transmission which thereafter undergo no change. The human value of the gesture is not in the hand for which freedom while walking is a sufficient precondition but precisely in the



107. Equipment used by Australian aborigines: (a) spear and throw-stick, (b) digging stick, (c) boomerang, (d) chopper, (e) knife, (f) piercing tool, (g) double scraper, (h) dish made of bark

ability to walk upright and is paleontological consequences for the development of the cerebral apparatus. The gradual enrichment of tactile sensibility and of the neuromotor apparatus occurred qualitatively without changing the nature of the basic equipment.

The complex actions of grasping, handling, and kneading which already existed at the primitive anthropoid stage still account for a large share of our technical gestures today. But with the emergence of the percussion tool, the chopper and the antler employed for a practical purpose, a perceptible shift took place. cutting, crushing, molding, scraping, and digging operations were transferred to tools. The hand ceased to be a tool and became a driving force.

The Intermeshing of Tools and the Motive Gesture

The hand's modes of action became gradually enriched during the operational process in the course of human evolution. The manipulative action of the primates, in which gesture and tool form a single whole, was followed in the first anthropoids by directly motive action of the hand with the hand tool separable from the motive gesture. In the next stage, reached possibly before the Neolithic, gesture became annexed by the hand-operated machine, the hand merely supplying is motor impulse by indirect mobility. In historic times motive force itself was transferred from the human arm, and the hand intervened only to stars the motor process in animal-operated machines or mechanical machines such as mills. Finally, in the last stage, the hand is used to set off a programmed process in automatic machines that not only exteriorize tools, gestures, and mobility but whose effect also spills over into memory and mechanical behavior.

This enmeshing of tools and gestures in organs extraneous to the human has all the characteristics of biological evolution because, like cerebral evolution, it develops in time through the addition of elements that improve the operational process without eliminating one another. Earlier we saw that the brain of Homo Sapiens sail preserves all stages acquired since the fish stage, and that each stage, overlaid by the next, continues to play a role even in the most sophisticated forms of human thought. Similarly the existence and operation of an automatic machine with a complex program implies that at every stage of is manufacture, regulation, and repair, all categories of technical gestures from handling metals through handling a fi le to coiling electric wire to assembling the machine's parts, whether by hand or mechanically are sail present though only faintly discernible.
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Handling

The complex operations of grasping, rotation, and transmission that characterize handling were the first to appear and have crossed the ages without undergoing any transposition. They still form our most common stock of gestures, the prerogative of the human hand which is so very archaic and relatively so unspecialized by comparison with those marvelous machines for capturing or running that are the "hand" of the lion or the horse. The privilege of long life which in paleontology is enjoyed by species that are not over-specialized also attaches to operations performed by the bare hand with which, to this day, the fi nest forms of architectural construction, pottery, basketry, and weaving are connected.

Devices for grasping, transporting, and positioning objects did not become available in assembly lines or in the form of automatic manipulators until a highly advanced stage of industrialization had been reached. In cranes and pulley blocks, known since ancient times, the hand intervenes only as a hook and the machine is a simple exteriorization of the motive force. The example of weaving too is conclusive: In the most elaborate fabrics such as those of Peru or in oriental brocades, the hand picks up the threads individually in order to make the desired design. Yet freeing of the fingers was achieved quite early, perhaps as early as the Neolithic, by reducing operations to the repeated lifting of one thread in two or three. Not until the nineteenth century did the introduction of a punched-card system raise mechanical weaving to the level of handling skill of which the bare hand had been capable from the start. In both cases the development is the same: In the first stage, the hand can perform actions that are limited in terms of force or speed but infinitely diverse; at a later stage, that of the pulley block or the weaving loom, a single action of the hand is isolated and transferred to the machine; in the third stage, the programming of movements is reconstituted through the creation of an artificial and rudimentary nervous system.

The Hand Acting through Direct Motor Function

Unlike handling, actions involving the use of the teeth or nails became exteriorized from the very first. In these actions the hand merely serves as a pincer at the extremity of a device that has a direct motor function and is suitable for percussion of various kinds (see my *L'Homme et la nature*).

The range of percussive actions of which Anthropoid apes are capable is quite wide, but their main instrument is the teeth incisors for cutting and scraping, canines for piercing and tearing, molars for crushing. The role of the hand consists

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above all in presenting the object to the teeth or in preparing it for being eaten. The nails are employed only in operations involving scratching or digging, but their action is important because of is rhythmic nature. If we consider the operation behavior of the great apes, we are left with an impression of a potential rudimentary technicity based on dental percussion, handling, and recurrent scraping movements. Everything required to constitute human technicity is already there, and it all comes together the moment tools enter upon the scene.

Lacking records as we do, we find it difficult to visualize how the incisor became a chopper how, in other words, our only organic tool capable of cutting, worn on the projecting end of the jaw, became transferred to the hand via the incisive action of a splintered pebble. We do know, however, that at an extremely early stage, by the time of the Austraianthropians, this transfer seems to have been effected. Here again, walking upright played the decisive role. In monkeys the two operating fields (biting and handling) are involved simultaneously when the quadruped is seated and separately when it is walking; the dental apparatus remains the forward point of the body and the animal's chief organ of association. With erect posture, the hand takes over as the organ of association. Operations performed when seated remain connected with simultaneous action of the face and hand (food consumption and technical operations involving the teeth), but labiodental contact is no longer dominant as in quadrupeds, nor even equivalent as in many monkeys. In the human it continues to be important only in a few contact and in a few technical operations where the mouth serves as an additional claw or pincer. The transition to tools is thus functionally justified by the transfer of the field of association to the hand.

To view the chopper as an incisor placed at the ends of our fingers or the percussion tool as a molar brandished in the fist would be childishly fanciful: Yet it is true that the scale of actions remained the same before and after the transfer that took place at the hypothetical point in time when an upright-walking primate transposed is percussive activity from the teeth to a pebble activated by the arm. The vast number of objects with which humans have surrounded themselves obscures the fundamental simplicity of the tools they need for survival. The forms of the technical equipment used by Australian aborigines are few in number: the spear and the throwing-stick for hunting, the digging stick for gathering, the pebble crusher, the knife, the flint chopper and scraper for the preparation and consumption of food, the bone awl, fibers for tying, pieces of bark to serve as receptacles. What we know of fossil humans up to and including the Palaeoanthropians is of the same order and covers a range of dental and manual actions exactly the same as that of the primates: The percussion tool attests to crushing and hammering, the deer antler used as a dig-

ging tool, and the small scraper used on wood to scraping; cutting actions, whether by direct application of a hand-held tool or by throwing a sharpened weapon, are performed with sharp-edged splinters and the chopper or biface. In the Upper Paleolithic, with Homo Sapiens, the range widens, but there is nothing to indicate except in levers and traps that indirect motor function had been achieved.

The ability of the hand to exercise indirect motor function reflects another "liberation," with the motor gesture finding new freedom in the hand-operated machine that extends or transforms it. The point in time when this important stage was reached is very difficult to define. It does seem, however, that by the late Paleolithic there were at least two implements attesting to indirect motor function, the pierced stick and the spear thrower. The former is a length of reindeer horn pierced with a hole and probably employed as a lever for hot-straightening bone rods. With this tool both the force and the direction of movement of the hand are transformed. This very simple application of indirect motor function in the form of a tool that acts upon the direction of movement is found as early as in the Aurignacian period, some 30,000 BC Evidence of the hurling stick dates back to a later period, the Magdalenian, around 13,000 BC This is a hooked stick that seems to accelerate spear-throwing (see my Milieu et techniques) by adding the mechanical value of an extra elbow and forearm to the arm of the thrower, who holds it in his hand.

From that point onward and until the dawn of historical time, applications of indirect motor function developed further. The transition to an agricultural-pastoral economy caused them to become incorporated in a variety of techniques and in many forms as springs and levers, as continuous or alternating motion in hand operated machines such as the bow or the crossbow, in snares, pulleys, millstones, cranes, and transmission cables. These machines, which are discussed in my two earlier books, reflect a logical stage in human evolution. As with hand tools the process whereby all implements came gradually to be concentrated outside the human body is again perfectly clear: Actions of the teeth shift to the hand, which handles the portable tool; then the tool shifts sail further away, and a part of the gesture is transferred from the arm to the hand-operated machine.

The Hand Separated from Motor Function

The evolution continued with muscular impetus itself becoming separated from the human body through the harnessing of the motor function of animals and of wind and water. It is a singular property of the human species that by confining itself to engendering action, it periodically eludes the organic specialization that

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would definitively tie it down. If the hand of the earliest anthropoid had become a tool by adaptation, the result would have been a group of mammals particularly well equipped to perform a restrained series of actions: It would not have been the human being. Our significant genetic trait is precisely physical (and mental) nonadaptation: a tortoise when we retire beneath a roof, a crab when we hold out a pair of pliers, a horse when we bestride a mount. We are again and again available for new forms of action, our memory transferred to books, our strength multiplied in the ox, our fist improved in the hammer.

The freeing of motor function is the decisive stage, perhaps not for the individual but for human society collectively in possession of each member's means of anion. The phenomenon is a very recent one. The adoption of animal traction and of machines activated by water or wind are reported in ancient history; moreover it was confined to a few Eurasian civilizations whose technoeconomic supremacy continued to be founded upon it until the eighteenth century. Generally regarded as historical phenomena of technical significance, the invention of the four-wheeled carriage, the plough, the windmill, the sailing ship, must also be viewed as biological ones as mutations of that external organism which, in the human, substitutes itself for the physiological body.

The animal machine requires a good deal of muscular participation. Motor function is "deflected" to drive the animal motor, but it remains considerable. Moreover the efficiency of the animal-driven machine became stabilized very early on and at a rather low level: The number of horses does not increase the speed of the vehicle nor, within certain limits, their resistance to fatigue.

The relationship between humans and their exteriorized force is altogether different in the automotive machine, including even the simplest water-driven pile driver or mill. Having set the process in motion, the hand no longer intervenes except to feed or to stop the machine. The operator can increase the machine's power or distribute it among machine tools which will perform all the operations for which human intelligence has designed them.

The conquest of water and wind was accomplished in antiquity-early in historic time-but for many centuries they remained the only sources of automotive power. Not until the nineteenth century was the decisive step taken with the harnessing of steam pressure.

The momentous nature of the change in scale of the relations between the human and the natural world was clearly perceived at once. The initial conquest of metals had been a triumph of the hand: the conquest of steam definitively confirmed the exteriorization of muscle power.
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However, human participation was still considerable, and the Age of Steam was also the age of the cruelest enslavement of the manual worker. The automotive machine of the nineteenth century possessed neither a brain nor a hand. Its nervous system was extremely rudimentary, consisting simply of speed and pressure regulators discharging a constant but blind force. The worker operating the machine provided the brain that made that force useful and the hand that stoked the fire, fed raw material to the machine, and oriented and rectified in action.

Nevertheless, if we are agreed that biological change affects both the physical organization and the behavior of the organisms concerned, the birth of automotive force was a crucial biological stage. The fact that the organs involved are extraneous to the body matters little if the change creates a new living reality. We have seen that human evolution from Homo Sapiens onward has been a story of more and more radical separation between the rate of change affecting the body sail governed by the geological time scale and that of change affecting tools, which now occurs with every generation. If the species was to survive, some accommodation was necessary, and this accommodation was bound not only to affect our technical habis but also to involve thoroughgoing changes in the laws according to which individuals group themselves together. Of course the parallel with the zoological world cannot be maintained except by way of paradox, but we cannot completely dismiss the thought that some species change takes place whenever humankind replaces both in tools and in institutions. Although peculiar to humans, the changes that affect the entire structure of our collective organism hang together in much the same way as changes that affect all the individuals in a group of animals. From the moment when the exteriorization of motive force became unlimited, social relations assumed a new character; a nonhuman observer unfamiliar with the explanations to which philosophy and history have accustomed us would separate the eighteenth-century human from the human of the tenth century as we separate the lion from the tiger or the wolf from the dog.

The Automatic Machine Nineteenth-century machinery was sail a long way from the ideal mutation whereby exterior to the human there would be another, wholly artificial human acting with unlimited rapidity, precision, and force: a long way from the moment when everything tool, gesture, strength, and thought would be transposed to a perfect twin image of the social ideal. The gradual establishment of a social organism wherein the individual increasingly plays the role of a specialized cell makes it more and more clear how inadequate the human being is the flesh-and-bone human, a living fossil, immutable on the historical scale, per-

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fectly adapted to external conditions at the time the human species was triumphing over the mammoth but already overtaken by them when required to use muscle to operate the trireme. Our constant search for more powerful and more precise implements has inevitably led to the biological paradox of the robot, a creature which, in the form of the automaton, has haunted the human mind for centuries. The ape-ancestor image evoked in chapter 1, the expression of a nostalgic retreat into the past, has is counterpart, not in the spiritual image of the angel or the physical one of a perfect human body, but in the image of the perfectly made machine, the Anthropoid's mechanical twin Tarzan, the astronaut, and the robot gravitating like a constellation around the human of flesh and blood.

Many of the mechanical monsters produced in the nineteenth century sail survive today machines without a nervous system of their own, constantly requiring the assistance of a human partner. Developments in the use of electricity, and above all the rise of electronics, taking place less than a century after the mutation that produced automotive machines, have triggered another mutation that leaves but little in the human organism sail to be exteriorized. Machines have changed radically as a result of the development of small-scale motors, photosensitive cells, transistors, and miniaturized devices of all kinds. This disparate arsenal is supplying the parts for a composite body strangely similar to the biological one. Whereas nineteenth century machines with their voluminous energy sources conducted a single force to blindly acting organs via extensive transmission systems, today's machinery with is multiple sources of energy is leading to something like a real muscular system, controlled by a real nervous system, performing complex operating programs through is connections with something like a real sensory-motor brain.

Mechanical automation, from the mechanical brontosaurus of the nineteenth century rolling mill to the automatic pilot of today, represent the penultimate possible stage of the process begun by the Australanthrope armed with a chopper. The freeing of the areas of the motor cortex of the brain, definitively accomplished with erect posture, will be complete when we succeed in exteriorizing the human motor brain. Beyond that, hardly anything more can be imagined other than the exteriorization of intellectual thought through the development of machines capable not only of exercising judgment (that stage is already here) but also of injecting affectivity into their judgment, taking sides, waxing enthusiastic, or being plunged into despair at the immensity of their task. Once Homo Sapiens had equipped such machines with the mechanical ability to reproduce themselves, there would be nothing left for the human to do but withdraw into the paleontological twilight. In point of fact, the

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chance of machines equipped with a brain taking our place on earth is slight; the threat lies within the zoological species itself, not directly in the exteriorized organs. The nightmare picture of robots pursuing human beings in a forest of mechanical tubes will come true only to the extent that other human beings will have regulated the robots' automatic system. What is to be feared if only slightly is that in a thousand years' time Homo Sapiens, having exhausted the possibilities of self-exteriorization, will come to feel encumbered by the archaic osteomuscular apparatus inherited from the Paleolithic.

Mechanical Program and Mechanical Memory

The development of automatic programs represents a peak in human history, comparable in importance with the emergence of the chopper or the rise of agriculture. Because it has occurred so recently, it can provide us with some insight into the mechanism of great technical mutations in general. The idea that a series of technical gestures might be performed mechanically evolved very slowly in historical time. Automatic machines capable of performing a single gesture, like the water-driven pile driver, were developed in Mediterranean or Chinese antiquity, but the idea of mechanical programming was technically unrealizable until the Middle Ages. The first means of programming by purely mechanical processes were found in clock making. A technical confraternity specialized in giving material expression to the concept of time provided a favorable environment for innovation. The medieval clock maker, a specialist in progression and animation, learned to use pinions and cams and to combine circular with rectilinear motion in order to devise the simple program of the first animated clocks and automata.

The evolution of animation depended on that of the source of motive power employed. From the twelfth to the fifteenth centuries, clockwork mechanisms were operated by rectilinear traction using a weight, a system that considerably restrained their possibilities. From the fifteenth century on, the use of a spiral spring provided a means of reducing the size of the automatic device and making it portable. Improvements to the mechanism led to the eighteenth-century automata, which represent the peak of what could be achieved in programming with clock making devices. The nineteenth century saw a change in the scale of the pinions and cams employed and the invention of steam-operated machines capable of simple gestures. Like the automata that preceded them, these machines represent a fascinating stage of technical evolution not without parallels in animal evolution.
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Mechanical automata are programmed to perform a sequence of simple gestures in an order prescribed within the mechanical organs themselves. The operating memory is situated at the level of the cams, a little to the back of the machine's active part; there is no nervous system and no coordination network other than the transmission mechanism. Jacques de Vaucansson's automata are to electronic devices what the earthworm is to the mammal. In other words, they are like living organisms with a segmental memory stored in each of their active elements, cams being distributed to each part to be animated like the chain ganglions that animate each of the annelid's joins.

By a completely different path, automatism entered weaving techniques at the beginning of the nineteenth century. Joseph Jacquard invented a loom for patterned fabrics using a set of punched cards which determine what threads should be picked for each run. A complex pattern can thus be executed by wholly automatic means. Barrel organs using perforated bands of paper, which operate on a similar principle, made their appearance at about the same time. The Jacquard loom and the barrel organ can be described as a pair of automatic machines which, in terms of their principle, are opposable to the pair formed by the automaton and the music box. Perforated card machines are equipped with a centralized memory separate from the execution organs, to which it transmits a real message corresponding to a program capable of a large number of modifications. Like the tune of the music box or the bird organ, the program that activates an automaton's finger comprises a set of cogwheels. It is invariable for a specific mechanical situation and can be modified only by adopting a different mechanical formula, just as the progression of the annelid consists in coordinating the simple movements of a series of joins endowed with an invariable motor function. The program of the Jacquard loom is external to the organs of execution it is "intelligent" by comparison with a mechanical device. Furthermore, by changing the set of perforated cards the machine can be made, without any mechanical modification, to perform a different set of operations. A "nervous system" proper is not yet there, but everything that the nineteenth-century technical environment could contribute toward developing a memory machine is already in place.

Not until the last twenty years* has the mimicry of living matter by artificial matter achieved a reasonably high standard. A century of familiarization with electricity and, later, with electronics was needed before this became possible. The resulting

*Translator's note: Again, it may be useful to remind the reader that this book was first published in 1964.
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machine represents a synthesis of all previous stages. Mechanical organs of execution, actuated by as many energy sources as efficient articulation may require, are set in motion by a program that, at one stage at least, is recorded on tape. The essential difference lies in the presence of what amounts to a real nervous system through which the central organs transmit commands and monitor their execution. The sequence of mechanical gestures is prescribed by a transformable memory. The physical health of the machine is checked by organs that regulate the speed, temperature, and humidity of each organ. The texture and form of the substance being processed is examined by ponderal, tactile, thermosensitive, or photosensitive organs that transmit their findings to automatic regulating centers, and the machine can orient, correct, or suspend is actions in response to messages it receives from is "sensory" organs. A biologist will find it hard to resist comparing the mechanisms of animals whose evolution is already completed with these organisms which, in the last analysis, constitute a parallel living world.

Evolution of Operations and of the Gesture

For these reasons there may be some benefit in adopting and sustaining the same attitude toward the whole of human evolution. Proceeding from the very general biological phenomenon of evolution employing earlier stages to serve as the active substratum for new, innovative ones, we have considered the evolution of the nervous system in terms of the addition of new cortical areas that led to the simultaneous emergence of technical motor function and of language and, later, to technicity controlled by mental processes and to fi gurative thought. It is already clear at the paleontological stage that erect posture and the general osteomuscular structure, once they have achieved human form in the Australanthrope, are no longer decisive. The hand, already formed in the monkey, stops changing (except for purposes of neuromotor adaptation) from the moment it begins to hold a tool. The decisive evolution of primitive anthropoids lies in the neuromotor equipment of the manual and facial cortex. From the osteomuscular point of view, nothing more takes place except adaptation accompanied by minor variations. The main thrust of evolution is massively oriented toward tools.

The actions performed by tools are relatively simple and few in number. The gestures of hammering, cutting, and piercing, which remain the stock-in-trade of hand manufacturing to this day, are quickly acquired. Evolution therefore became focused entirely on materials and forms of motion. The evolution of motion determined the freeing of motor function. Ever since the earliest agricultural societies, the

conquest of force together with the conquest of new materials has been the dominant pursuit: conversion of rectilinear into circular motion, conversion of force through transmission, transfer of driving force from human to animal and, later, to the motor. The orientation to yard new materials affected both the tool itself and the force that actuates it. Initially confined to metals, over the course of history it gradually created the problem of fuels directly or indirectly employed to drive machinery. Between the Bronze Age and the eighteenth century, advanced techniques evolved very slowly and with great difficulty, confronted with the problem of imparting more powerful motion to tools made of more resistant materials. With the solution offered by iron founding, motion and materials merged into a single cycle and everything became a matter of coal and steam. The prodigious leap forward of the nineteenth century was due to the fact that coal not only meets the requirements of iron founding and steelmaking but also provides the motive energy needed for mining and for operating machine tools. It thus fulfilled the conditions for a tremendous advance toward the freeing of force and, as a corollary to this, challenged the whole inner structure of humankind. The consequences of coal for our way of life have been as important as a rapid transformation of the dental and digestive apparatus would be for an animal lineage. Railways and the emergence of a proletarian working class, to name only two of the immediate consequences of the freeing of driving power, have had a direct effect on the entire organization of our species. The adjustment of human individuals, whose brain and physical frame are sail those of Cro-Magnon man, to the new conditions has involved an ever-increasing degree of distortion.

Today the process of adaptation is not yet complete. Evolution has entered upon a new stage, that of the exteriorization of the brain, and from a strictly technological point of view the mutation has already been achieved. From a more general point of view, the distance between ourselves the descendants of reindeer hunters and the intelligent machines we have created is greater than ever. The compression of time and distance, accelerated rates of activity, nonadaptation to carbon monoxide and industrial toxins, permeability by radiation all these facts raise the curious problem of our physical compatibility with the environment in which we must now live. The conclusion to be drawn may well be that progress is beneficial only to society, while the individual human being is already an outdated organism, useful like the cerebellum or the rhinencephalon, like the foot and the hand, but already receding into the background to become the mere infrastructure of humankind in which "evolution" will henceforth be more interested than in the individual

human being. Indeed, that would only confirm the identity of the human species with animal species, whose progress as a species is alone worthy of consideration.

Evolution of Operational Sequences

Technical liberation unquestionably reduces the technical freedom of the individual. From the Australanthrope to the age of mechanization, the operational behavior of individual has progressively become richer, but is nature has not changed. The technical life of the hunter, and later of the farmer and the artisan, involves a large number of sequences that correspond to the many actions needed for their material survival. These sequences are empirical, borrowed from a collective tradition that one generation passes down to the next. Their principal trait, for all the unity of their broad outlines and their extension over vast polyethnic territories, is their strongly marked local and individual character. Everything humans make tools, gestures, and products alike is impregnated by group aesthetics and has an ethnic personality which even the most superficial visit to an ethnographical museum will reveal. Individuals introduce their personal variations into the traditional framework and, safe in the knowledge of belonging to the group, draw some of their sense of existing as individual from the margin of freedom allowed them.

With the passage to industrial motor function, the situation changed thoroughly. The purpose of operational sequences was now to fill the gaps still very wide in the behavior of the machine. The worker was required to perform parts of sequences measured at the rhythm of the machine, series of gestures that excluded the worker as an individual. Complete "technical deculturation" took place, while at the same time the individual ceased to belong to a group of marked personality and comfortable size.

Early industrialization was followed by a process whereby the worker was gradually adapted to the machine without the latter's losing any of its preeminence. The "Taylorization" of gestures was accompanied by the standardization of tools and products, intensive adaptation to continuous circular motion (of rotary tools, lathes, spindles), and undifferentiated processing of different materials. Then mechanical automatism gradually came in, the worker's activity becoming confined to supervising the input of feedstock, executing the program, and delivering the finished product.

There cannot be any value judgments made about an evolutive process. We may think that the gigantism of dinosaurs in the Mesozoic era was "bad" because the

dinosaur vanished while the crocodile survived, but we know nothing about the future of whatever it is that will replace Homo Sapiens. What we can do, being far enough advanced in the present stage of evolution, is measure those things that have already changed beyond retrieval. From Pithecanthropus to the nineteenth-century carpenter, operational sequences remained essentially the same: Workers considered the materials they were to process, drew on traditional knowledge to select a certain series of gestures, and then manufactured and possibly rectified the products of which they were the authors. Throughout the process, their expenditures of muscular effort and of thought were in balance. However mechanical their behavior, it involved the "outcropping" of images and concepts and the presence however shadowy of language. For several hundreds of thousands of years, the human species-determined operational behavior was total, integrated in an immediately significant collective context and inseparable from the quality of humanness.

The possibility of feeding wood into a machine without paying any attention to the grain or knots and obtaining a standard piece of parquet flooring that will then be automatically packaged undoubtedly represents a very important social advance. But the only option it leaves to us is that of ceasing to be Sapiens and becoming something else, something that may perhaps be better but will certainly be different. When we consider the ways open to us if we are to have some sense of existing other than the satisfaction of being a depersonalized cell within an organism (however admirably planetized that organism may be), we should remember that it takes more than a century or two for the zoological human to change.

The Fate of the Hand

The same facts can be verified from a different perspective that brings out another aspect of the mutation the human species has undergone. In preindustrial societies the individual level of technicity was relatively high: Putting it more precisely, the lives of all individuals were filled with manual activities of many kinds and of a quality at least sufficient for survival. The group made use of individuals of below-average ability as stopgaps, while virtuosos led in every field, offering a stimulating image to the rest of society: Artisans, musicians, or rich farmers, each little group had is share of models and maintained itself through contact with them. At the stage we have now reached, the redo has changed very considerably, with vast masses of average and below-average people confronting an ever-diminishing number of models. Participation still exists, but it is exercised via the press or the audiovisual media: The following of the macrocollective model, whether astronaut, hero

of labor, or Iranian princess, has no common measure with that of the master of the wolf hunt, the village blacksmith, or the local bartender, but the savor of proximity has gone, and the model's only value is as a purveyor of illusions.

The situation is quite similar if we consider the human hand. Originally it was a claw or pincer for holding stones; the human triumph was to turn it into the ever-skillful servant of human technical intelligence. From the Upper Paleolithic to the nineteenth century, the hand enjoyed what seemed like an interminable heyday. It still plays an essential role in industry, a few skilled toolmakers producing the operative parts of machines to be operated by crowds of workers requiring no more than a five-fingered claw to feed in the material or simply an index finger to push the buttons. But ours is still a transitional stage, and there can be no doubt that the nonmechanized phases of industrial processes are being gradually eliminated.

The dwindling importance of the makeshift organ that is our hand would not matter a great deal if there were not overwhelming evidence to prove that is activity is closely related to the balance of the brain areas with which it is connected. "Being useless with one's fingers," "being ham-fisted," is not a very alarming thing at the level of the species as a whole: A good number of millennia will pass before so old an organ of our neuromotor apparatus actually regresses. But at the individual level the situation is very different. Not having to "think with one's fingers" is equivalent to lacking a part of one's normally, phylogenetically human mind. Thus the problem of regression of the hand already exists today at the individual if not the species level. I shall revert to this question in part III in order to show that manual imbalance has already partially destroyed the link that used to exist between language and the aesthetic image of reality. It is not a matter of pure coincidence, as we shall see, that nonfigurative art is flourishing at the same time as "demanualized" technicity.