VISUALIZATION AND COGNITION:
THINKING WITH EYES AND HANDS

Bruno Latour

I. PUTTING VISUALIZATION AND COGNITION INTO FOCUS

It would be nice to be able to define what is specific to our modern scientific culture. It would be still nicer to find the most economical explanation (which might not be the most economic one) of its origins and special characteristics. To arrive at a parsimonious explanation it is best not to appeal to universal traits of nature. Hypotheses about changes in the mind or human consciousness, in the structure of the brain, in social relations, in "mentalités," or in the economic infrastructure which are posited to explain the emergence of science or its present achievements are simply too grandiose, not to say hagiographic in most cases and plainly racist in more than a few others. Occam's razor should cut these explanations short. No "new man" suddenly emerged sometime in the sixteenth

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century, and there are no mutants with larger brains working inside modern laboratories who can think differently from the rest of us. The idea that a more rational mind or a more constraining scientific method emerged from darkness and chaos is too complicated a hypothesis.

It seems to me that the first step towards a convincing explanation is to adopt this a priori position. It clears the field of study of any single distinction between prescientific and scientific cultures, minds, methods or societies. As Jack Goody points out, the "grand dichotomy" with its self-righteous certainty should be replaced by many *uncertain* and *unexpected* divides (Goody, 1977). This negative first move frees us from positive answers that strain credulity.[1] All such dichotomous distinctions can be convincing only as long as they are enforced by a strong asymmetrical bias that treats the two sides of the divide or border very differently. As soon as this prejudice loses hold, cognitive abilities jump in all directions: sorcerers become Popperian falsificationists; scientists become naive believers; engineers become standard "bricoleurs"; as to the tinkerers, they may seem quite rational (Knorr, 1981; Augé, 1975). These quick reversals prove that the divide between prescientific and scientific culture is merely a border—like that between Tijuana and San Diego. It is enforced arbitrarily by police and bureaucrats, but it does not represent any natural boundary. Useful for teaching, polemics, commencement addresses, these "great divides" do not provide any explanation, but on the contrary are the things to be explained (Latour, 1983).

There are, however, good reasons why these dichotomies, though constantly disproved, are tenaciously maintained, or why the gap between the two terms, instead of narrowing, may even widen. The relativistic position reached by taking the first step I propose, and giving up grand dichotomies, looks ludicrous because of the enormous consequences of science. One cannot equate the "intellectual" described by Goody (1977, chap. 2) and Galileo in his study; the folk knowledge of medicinal herbs and the National Institute of Health; the careful procedure of corpse interrogation in Ivory Coast and the careful planning of DNA probes in a Californian laboratory; the story telling of origin myths somewhere in the South African bush and the Big Bang theory; the hesitant calculations of a four-year-old in Piaget's laboratory and the calculation of a winner of the Field Medal; the abacus and the new super-computer Cray II. The differences in the *effects* of science and technology are so enormous that it seems absurd not to look for enormous causes. Thus, even if scholars are dissatisfied with these extravagant causes, even if they admit they are arbitrarily defined, falsified by daily experience and often contradictory, they prefer to maintain them in order to avoid the absurd consequences of relativism. Particle physics must be radically different in some way from folk botany; we do not know how, but as a stop-gap solution the idea of rationality is better than nothing (Hollis and Lukes, 1982).

We have to steer a course that can lead us out of a simple relativism and, by positing a few, simple, empirically verifiable causes, can account for the enormous differences in effects that everyone knows are real. We need to keep the

scale of the effects but seek more mundane explanations than that of a great divide in human consciousness.

But here we run into another preliminary problem. How mundane is mundane? When people back away from mental causes, it usually means they find their delight in material ones. Gigantic changes in the capitalist mode of production, by means of many "reflections," "distortions," and "mediations," influence the ways of proving, arguing and believing. "Materialist" explanations often refer to deeply entrenched phenomena, of which science is a superstructure (Sohn-Rethel, 1978). The net result of this strategy is that nothing is empirically verifiable since there is a yawning gap between general economic trends and the fine details of cognitive innovations. Worst of all, in order to explain science we have to kneel before one specific science, that of economics. So, ironically, many "materialist" accounts of the emergence of science are in no way material since they ignore the precise practice and craftmanship of knowing and hide from scrutiny the omniscient economic historian.

It seems to me that the only way to escape the simplistic relativist position is to avoid both "materialist" and "mentalist" explanations at all costs and to look instead for more parsimonious accounts, which are empirical through and through, and yet able to explain the vast effects of science and technology.

It seems to me that the most powerful explanations, that is those that generate the most out of the least, are the ones that take writing and imaging craftmanship into account. They are both material and mundane, since they are so practical, so modest, so pervasive, so close to the hands and the eyes that they escape attention. Each of them deflates grandiose schemes and conceptual dichotomies and replaces them by simple modifications in the way in which groups of people argue with one another using paper, signs, prints and diagrams. Despite their different methods, fields and goals, this strategy of deflation links a range of very different studies and endows them with a style which is both ironic and refreshing.[2]

Like these scholars, I was struck, in a study of a biology laboratory, by the way in which many aspects of laboratory practice could be ordered by looking not at the scientists' brains (I was forbidden access!), at the cognitive structures (nothing special), nor at the paradigms (the same for thirty years), but at the transformation of rats and chemicals into paper (Latour and Woolgar, 1979). Focusing on the literature, and the way in which anything and everything was transformed into inscriptions was not my bias, as I first thought, but was for what the laboratory was made. Instruments, for instance, were of various types, ages, and degrees of sophistication. Some were pieces of furniture, others filled large rooms, employed many technicians and took many weeks to run. But their end result, no matter the field, was always a small window through which one could read a very few signs from a rather poor repertoire (diagrams, blots, bands, columns). All these inscriptions, as I called them, were combinable, superimposable and could, with only a minimum of cleaning up, be integrated as figures

in the text of the articles people were writing. Many of the intellectual feats I was asked to admire could be rephrased as soon as this activity of paper writing and inscription became the focus for analysis. Instead of jumping to explanations involving high theories or differences in logic, I could cling to the level of simple craftsmanship as firmly as Goody. The domestication or disciplining of the mind was still going on with instruments similar to those to which Goody refers. When these resources were lacking, the selfsame scientists stuttered, hesitated, and talked nonsense, and displayed every kind of political or cultural bias. Although their minds, their scientific methods, their paradigms, their world-views and their cultures were still present, their conversation could not keep them in their proper place. However, inscriptions or the practice of inscribing could.

The Great Divide can be broken down into many small, unexpected and practical sets of skills to produce images, and to read and write about them. But there is a major drawback with this strategy of deflation. Its results seem both obvious—close to being a cliché—and too weak to account for the vast consequences of science and technology that cannot, we agreed above, be denied. Of course, everyone might happily agree that writing, printing and visualizing are important *asides* of the scientific revolution or of the psychogenesis of scientific thought. They might be necessary but they certainly cannot be sufficient causes. Certainly not. The deflating strategy may rid us of one mystical Great Divide, but it will, it seems, lead us into a worse kind of mysticism if the researcher who deals with prints and images has to believe in the power of signs and symbols isolated from anything else.

This is a strong objection. We must admit that when talking of images and print it is easy to shift from the most powerful explanation to one that is trivial and reveals only marginal aspects of the phenomena for which we want to account. Diagrams, lists, formulae, archives, engineering drawings, files, equations, dictionaries, collections and so on, depending on the way they are put into focus, may explain almost everything or almost nothing. It is all too easy to throw a set of clichés together extending Havelock's argument about the Greek alphabet (1980), or Walter Ong's rendering of the Ramist method (1971), all the way to computer culture, passing through the Chinese obsession with ideograms, double-entry book keeping, and without forgetting the Bible. Everyone agrees that print, images, and writing are everywhere present, but how much explanatory burden can they carry? How many cognitive abilities may be, not only facilitated, but thoroughly explained by them? When wading through this literature, I have a sinking feeling that we are alternately on firm new ground and bogged down in an old marsh. I want to find a way to hold the focus firmly so that we know what to expect from our deflating strategy.

To get this focus, first we must consider in which situations we might expect changes in the writing and imaging procedures to make any difference at all in the way we argue, prove and believe. Without this preliminary step, inscriptions will, depending on the context, be granted either too much or too little weight.

Unlike Leroi-Gourhan (1964) we do not wish to consider all the history on writing and visual aids starting with primitive man and ending up with modern computers. From now on, we will be interested only in a few specific inventions in writing and imaging. To define this specificity we have to look more closely at the construction of harder facts.[3]

Who will win in an agonistic encounter between two authors, and between them and all the others they need to build up a statement S? Answer: the one able to *muster on the spot the largest number of well aligned and faithful allies*. This definition of victory is common to war, politics, law, and, I shall now show, to science and technology. My contention is that writing and imaging cannot by themselves explain the changes in our scientific societies, except insofar as *they help to make this agonistic situation more favorable*. Thus it is not all the anthropology of writing, nor all the history of visualization that interests us in this context. Rather, we should concentrate on those aspects that help in the mustering, the presentation, the increase, the effective alignment or ensuring the fidelity of new allies. We need, in other words, to look at the way in which someone convinces someone else to take up a statement, to pass it along, to make it more of a fact, and to recognize the first author's ownership and originality. This is what I call "holding the focus steady" on visualization and cognition. If we remain at the level of the visual aspects only, we fall back into a series of weak clichés or are led into all sorts of fascinating problems of scholarship far away from our problem; but, on the other hand, if we concentrate on the agonistic situation alone, the principle of any victory, any solidity in science and technology escapes us forever. We have to hold the two eyepieces together so that we turn it into a real *bi*nocular; it takes time to focus, but the spectacle, I hope, is worth the waiting.

One example will illustrate what I mean. La Pérouse travels through the Pacific for Louis XVI with the explicit mission of bringing *back* a better map. One day, landing on what he calls Sakhalin he meets with Chinese and tries to learn from them whether Sakhalin is an island or a peninsula. To his great surprise the Chinese understand geography quite well. An older man stands up and draws a map of his island on the sand with the scale and the details needed by La Pérouse. Another, who is younger, sees that the rising tide will soon erase the map and picks up one of La Pérouse's notebooks to draw the map again with a pencil . . .

What are the differences between the savage geography and the civilized one? There is no need to bring a prescientific mind into the picture, nor any distinction between the close and open predicaments (Horton, 1977), nor primary and secondary theories (Horton, 1982), nor divisions between implicit and explicit, or concrete and abstract geography. The Chinese are quite able to think in terms of a map but also to talk about navigation on an equal footing with La Pérouse. Strictly speaking, the ability to draw and to visualize does not really make a difference either, since they all draw maps more or less based on the same

principle of projection, first on sand, then on paper. So perhaps there is no difference after all and, geographies being equal, relativism is right? This, however, cannot be, because La Pérouse does something that is going to create an enormous difference between the Chinese and the European. What is, for the former, a drawing of no importance that the tide may erase, is for the latter the *single object* of his mission. What should be brought into the picture is how the picture is brought back. The Chinese does not have to keep track, since he can generate many maps at will, being born on this island and fated to die on it. La Pérouse is not going to stay for more than a night; he is not born here and will die far away. What is he doing, then? He is passing through all these places, in order to take something *back* to Versailles where many people expect his map to determine who was right and wrong about whether Sakhalin was an island, who will own this and that part of the world, and along which routes the next ships should sail. Without this peculiar trajectory, La Pérouse's exclusive interest in traces and inscriptions will be impossible to understand—this is the first aspect; but without dozens of innovations in inscription, in projection, in writing, archiving and computing, his displacement through the Pacific would be totally wasted—and this is the second aspect, as crucial as the first. We have to hold the two together. Commercial interests, capitalist spirit, imperialism, thirst for knowledge, are empty terms as long as one does not take into account Mercator's projection, marine clocks and their markers, copper engraving of maps, rutters, the keeping of "log books," and the many printed editions of Cook's voyages that La Pérouse carries with him. This is where the deflating strategy I outlined above is so powerful. But, on the other hand, no innovation in the way longitude and latitudes are calculated, clocks are built, log books are compiled, copper plates are printed, would make any difference whatsoever if they did not help to muster, align, and win over new and unexpected allies, far away, in Versailles. The practices I am interested in would be pointless if they did not bear on certain controversies and force dissenters into believing new facts and behaving in new ways. This is where an exclusive interest in visualization and writing falls short, and can even be counterproductive. To maintain only the second line of argument would offer a mystical view of the powers provided by semiotic material—as did Derrida (1967); to maintain only the first would be to offer an idealist explanation (even if clad in materialist clothes).

The aim of this paper is to pursue the two lines of argument at once. To say it in yet other words, we do not find all explanations in terms of inscription equally convincing, but only those that help us to understand how the mobilization and mustering of new resources is achieved. We do not find all explanations in terms of social groups, interests or economic trends, equally convincing but only those that offer a specific mechanism to sum up "groups," "interests," "money" and "trends": mechanisms which, we believe, depend upon the manipulation of paper, print, images and so on. La Pérouse shows us the way since without new types of inscriptions nothing usable would have come back to Versailles from his

long, costly and fateful voyage; but without this strange mission that required him to go away and to come back so that others in France might be convinced, no modification in inscription would have made a bit of difference.

The essential characteristics of inscriptions cannot be defined in terms of visualization, print, and writing. In other words, it is not *perception* which is at stake in this problem of visualization and cognition. New inscriptions, and new ways of perceiving them, are the results of something deeper. If you wish to go out of *your* way and come back heavily equipped so as to force others to go out of *their* ways, the main problem to solve is that of *mobilization.* You have to go and to come back *with* the "things" if your moves are not to be wasted. But the "things" have to be able to withstand the return trip without withering away. Further requirements: the "things" you gathered and displaced have to be presentable all at once to those you want to convince and who did not go there. In sum, you have to invent objects which have the properties of being *mobile* but also *immutable, presentable, readable* and *combinable* with one another.

II. ON IMMUTABLE MOBILES

It seems to me that most scholars who have worked on the relations between inscription procedures and cognition, have, in fact, in their various ways, been writing about the history of these immutable mobiles.

A. Optical Consistency

The first example I will review is one of the most striking since Ivins wrote about it years ago and saw it all in a few seminal pages. The rationalization that took place during the so-called "scientific revolution" is not of the mind, of the eye, of philosophy, but of the *sight.* Why is perspective such an important invention? "Because of its logical recognition of internal invariances through all the transformations produced by changes in spatial location" (Ivins, 1973:9). In a linear perspective, no matter from what distance and angle an object is seen, it is always possible to transfer it—to translate it—and to obtain the same object at a different size as seen from another position. In the course of this translation, its internal properties have not been modified. This immutability of the displaced figure allows Ivins to make a second crucial point: since the picture moves without distortion it is possible to establish, in the linear perspective framework, what he calls a "two way" relationship between object and figure. Ivins shows us how perspective allows movement through space with, so to speak, a return ticket. You can see a church in Rome, and carry it with you in London in such a way as to reconstruct it in London, or you can go back to Rome and amend the picture. With perspective exactly as with La Pérouse's map—and for the same reasons—a new set of movements are made possible: you can go out of your way

and come back with all the places you passed; these are all written in the same homogeneous language (longitude and latitude, geometry) that allows you to change scale, to make them presentable and to combine them at will.[4]

Perspective, for Ivins, is an essential determinant of science and technology because it creates "optical consistency," or, in simpler terms, a regular avenue through space. Without it "either the exterior relations of objects such as their forms for visual awareness, change with their shifts in locations, or else their interior relations do" (1973:9). The shift from the other senses to vision is a consequence of the agonistic situation. You present absent things. No one can smell or hear or touch Sakhalin island, but you can look at the map and determine at which bearing you will see the land when you send the next fleet. The speakers are talking to one another, feeling, hearing and touching each other, *but* they are now talking *with* many absent things presented all at once. This presence/absence is possible through the two-way connection established by these many contrivances—perspective, projection, map, log book, etc.—that allow translation without corruption.

There is another advantage of linear perspective to which he and Edgerton attract our attention (1976). This unexpected advantage is revealed as soon as religious or mythological themes and utopias are drawn with the same perspective as that which is used for rendering nature (Edgerton, 1980:189).

> In the West, even if the subject of the printed text were unscientific, the printed picture always presented a rational image based on the universal laws of geometry. In this sense the Scientific Revolution probably owes more to Albrecht Dürer than to Leonardo da Vinci. (p. 190)

Fiction—even the wildest or the most sacred—and things of nature—even the lowliest—have a meeting ground, *a common place*, because they all benefit from the same "optical consistency."[5] Not only can you displace cities, landscapes, or natives and go back and forth to and from them along avenues through space, but you can also reach saints, gods, heavens, palaces, or dreams with the same two-way avenues and look at them through the same "windowpane" on the same two-dimensional surface. The two ways become a four-lane freeway! Impossible palaces can be drawn realistically, but it is also possible to draw possible objects as if they were utopian ones. For instance, as Edgerton shows, when he comments on Agricola's prints, real objects can be drawn in separated pieces, or in exploded views, or added to the same sheet of paper at different scales, angles and perspectives. It does not matter since the "optical consistency" allows all the pieces to mix with one another. As Ferguson says, the "mind" has at last "an eye":

> Oddly enough, linear perspective and chiaroscuro, which supply geometric stability to pictures, also allow the viewer a momentary suspension of his dependence on the law of gravity.