Bio-Tecnho-Logos and Scientific Practice

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1. Introduction

According to the opinion of many philosophers of science, science should be made of empirical observations, such as those we find on current scientific journals, laboratory reports and reviews. What makes these works scientific is a peculiar method, completely grounded on observation and logical inference. This is the classical dominant idea of science that seems not to resist any longer. Considering science as a human action, will open us different dimension that characterize scientific work, and that are frequently neglected in the logical approach to science, such as the linguistic aspect of scientific theorization, the ethical and the esthetical dimension, the political sense, and all the sort of things that goes under "human factor". This is apparently a little shift of perspective though it opens up a whole series of dimensions else neglected that cannot be kept away from science anymore[1].

Once it has been made clear the connection of science with the domain of the action, of the individual sphere and the social context, we need to move further in order to correctly characterize science and specify that he who does science is always a human *person*, not just a sort of individual monad dropped out of context. This underscore on the personal status of those who deal with science leads us to consider that when we admire a scientific work, we are not just admiring the product of few capacities or functions of those who delivered such scientific achievements, we are rather appreciating the work of persons who express much more than logical reasoning and observational spirit in their outcomes. Capabilities are those logical reasoning and observation, but obviously, scientific work is much more than that. Science is the whole person, with all its abilities, attitudes and circumstances. This includes emotions, feelings, motivations, emotions, interests, attention span, intuition, imagination and memory, aesthetic and moral sense, social context (dialogue) and historical (traditions).

It could be said that all these personal dimensions, and therefore subjective, are precisely those, which should be at the door of the lab for scientific objectivity is not damaged. Furthermore, integration, dosage and balance of all these personal skills are achieved through common sense or, in more philosophical terms thanks to a reasonable attitude[2].

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[1] On this subject see A. Marcos, *Filosofia dell'agire scientifico, nuove dimensioni*, Academia Universa Press, Milano 2010.

[2] This reasonable attitude is the scientific correspondent of the Aristotelian virtue of *prudence* (φρόνησις). Cf. A. Marcos, *Postmodern Aristotle*, Cambridge Scholars Publishing, New Castle (UK) 2012.

2. Personal action and scientific objectivity

It could be argued that science, transformed into a personal matter, inexorably loses objectivity. If emotions are mixed in scientific research, objectivity may suffer. But on the other hand, even without emotions we would get to do science. Obviously no one would want to spend his life time, work and effort on a task that will be indifferent, just a personal achievement without any possible objective value. How can we address this apparent paradox?

We can take advantage of a metaphor borrowed from the biological domain. Consider science as the cardio circulatory system: in diastolic phase blood enters into the heart from the whole body, while the contraction or systolic phase leaves a minimal amount of blood in its cavities. Similarly, when we breathe we store in our lungs air from our environment, while the expiration leaves in them a much smaller amount of gas. Science also pulse and breathe, at least metaphorically, at certain stages we find science in need of all the capabilities of the person quoted above, while in other phases must temporarily reduce the presence of some of them and focus primarily on logical inference or observation. Again at certain stages, scientific action requires many external resources, from the social and cultural environment taken from the most diverse traditions, while at other stages these external elements are less present.

We are facing a matter of degree, not black or white. Neither the heart nor the lungs get completely empty when functioning normally and healthy. Similarly, science can never completely ignore the set of personal skills or social environment demands. And of course, the scientific action as a whole is personal action and (therefore) social. These subjective aspects are perfectly compatible with scientific objectivity, which depends from the rate, dosage, harmony and balance of the pulses as a whole, just as the proper functioning of the lungs or heart depends on its rhythms and balances, it could not be achieved only on the basis of single contractions or expansions.

3. Phases of scientific practice

Let us now consider more in detail these pulsatile movements occurring throughout scientific activity. To get started we will distinguish several stages of it. What we are presenting is a simplified diagram of the phases through which it passes scientific activity. It is just one of the possible routes that the scientist can follow, and it is not even intended to represent the actual chronological order of research. In addition, for the sake of brevity, we will put aside all feedback loops. We won’t take into account the fractal shape of scientific action: each of the phases in turn consists of sub-phases, and has a certain internal complexity. Each field has its own methodological research idiosyncrasies, with a specific history. Moreover, the scientific activity is not primarily concerned with the mechanical application of any of these methods, but all of them are created at the time of investigation. Suppose, then, with all these caveats, the scientific activity moves through these phases:

(i) Identification and problem setting;
(ii) Formulation of hypotheses and selection among them;
(iii) Identification of the auxiliary assumptions and empirical consequences evaluation;
(iv) Observation and experimentation;
(v.i) Predictive empirical verification;
(v.i.i) Explanation and prediction;
(v.i.ii) Transfer and application;
(v.i.iii) Communication and education;
(v.i.iv) Detection or construction and new problems approach;
(v.ii) Provisional empirical Falsification;
(v.ii.i) Rethinking the problem of auxiliary hypotheses or assumptions.

4. The pulse of science

4.1. Identification and problems setting

Now consider the first of the mentioned phases (i), which refers to problems. Scientific research would not even start without it. In this phase problems are identified, sometimes built, for research. It is obvious that the identification of problems depends on our sense of wonder and our curiosity as well as the social environment and the traditions in which we are embedded. Since its inception, then, the scientific activity radically depends on emotions and feelings such as curiosity or amazement. It also depends on social contexts and historical traditions. What was a riddle worthy of investigation to Herodotus (484-425 BC), the cycle of the Nile River, for many others was a simple fact of life that did not request any special explanation. What in a context or tradition can be seen as a problem, perhaps go unnoticed in others. As we saw in this volume, there is still the urge to reflect on the notion of scientific understanding and the arise of the scientific problem (Dieguez, MacLeod): is science creating its own issues? What is a problem for a scientist may not be for another. Why? Maybe it is a difference of aesthetic or social or moral sensibility, maybe a difference of interests. Perhaps some of them are more concerned about consistency, simplicity, and elegance, while others better appreciate the moral, ecological or social nuances, or the practical and functional, or economic, or any personal combination of these or other issues. Sensitivities and motivations are different, conditioned by the personality and circumstances of each person doing science, all of them legitimate, all of them rich when identifying and posing problems, all necessary for collaborative task that is science. A first important suggestion that emerges from history and philosophy of science is that Logos is something wider than mere rationality, or, vice versa, human rationality is wider than Logos as reasoning activity. In this wider meaning, in fact, Logos admits, and not excludes, aesthetical, social and moral attitudes toward life and world.

A person may be attracted or surprised by various research problems. And yet, you probably have to decide, you have to take a course or another. There is not, of course, an algorithm that allows us to make these decisions in a purely mechanical or logical way. In order to make these decisions all the aspects of the person are required. His imagination, intuition, sensitivity, practicality, experience, all of these components will tell you which of the identified problems will deserve your immediate attention, which one seems unapproachable, which may be postponed now and then resumed under better circumstances; his logical sense will tell if any of them depends on the prior resolution of another, dialogue with colleagues, sometimes even the frequentation of friends as well as the daily experiences and traditional sources of wisdom, can be very helpful to decide. All the aspects of the person and the circumstances he is in come into play, and play as a coordinated and balanced team thanks to the common sense of the person making science.

At a certain moment we move from problem identification to approach it, in understandable and relevant terms to scientific community and society in general, with which scientists share a common ground, guaranteed by our common human nature. This transit is likely to require the logical ability to argue, language and rhetorical skills to convince, the power of observation to finish outlining the problem, to confirm, to the possible extent, its relevance and viability. The way we set a problem provides guidance, orientation, connoted from the beginning by a peculiar sensitivity; the target whose service we will put our logical and observational skills, that will allow us to move from the problem identification to clear and fruitful approach. Of course the need to adopt scientific language will decrease the presence of most emotional, aesthetic or moral aspects, especially in their more idiosyncratic facets, but they won't completely disappear at any time, inter alia, for the person doing science is addressing to people equipped with emotions and interests as much as logic and observation capability.

4.2. Hypothesis formulation and selection

After the problem statement begins the search of adequate hypothesis to address it (ii). It seems obvious that the production of hypotheses critically depends on the imaginative capacities of the person. Nevertheless, some philosophers have tried to reduce the production of hypotheses to an inference of deductive or inductive nature. Some of them have even thought that this step could be executed in an inferential algorithmic or mechanical way, as we saw in some of the previous contributes, where we had the opportunity to enlighten the notion of computational simulation and modelling in scientific explanation. The modern sensibility tried to elaborate a theory for an universal scientific method. On the one hand philosophers from the rationalistic tradition thought it was possible and therefore necessary to infer deductively scientific laws directly from certain general or transcendental principles. On the other hand empiricists argued that the inference principle should be firmly grounded on the observation, so that from repeated observations it is possible to draw certain general laws. In both of these philosophical traditions utterances achieved by means of inference lose their hypothetical characterization, showing themselves since the beginning as certain laws. Nevertheless, we now know that the statements of science never completely lose their hypothetical nature, always with them goes a shadow of uncertainty and tentativeness, however tenuous, and we also know that in the production of hypotheses do not play only logical inference and observation, but the whole creative capacity of the individual.

How does this creative act occur? Growing our creativity requires much effort, it is possible of course, but we have to admit we know little about the ultimate roots of creativity. French physicist Pierre Duhem (1861-1916) commented wryly that whoever believes the scientific idea springs from nowhere, as if by magic, he is like the child who sees the chicken coming out of his shell and then thinks it is made at that time, not even imagining the complexity of a long process of gestation. Scientists usually prepare the ground through study, meditation and imaginative exercise, conversation, discussion, observation, reading ... Nevertheless, hypothesis, according to Duhem, "germinates in him, without him". And, once an idea has been conceived, again his "free and laborious activity must come into play" to "develop it and make it fruitful"[3]. We say that our ideas come to mind, not that "happen to us", what we can do about them, to promote their appearance, is to freely manage conditions under which they may arise. These conditions involve the whole person and depend on the contexts and traditions in which the person is located (inspiratory phase).

The origins of scientific hypothesis must be sought sometimes in the remote places of science, such as the artistic background of a person or his metaphysical or religious beliefs. Take here as historical case Johannes Kepler (1571-1630). His struggle of more than a decade to solve the problem of the trajectory of Mars, led to the famous hypothesis of the ellipse. Without the accurate observations of Tycho Brahe (1546-1601) this scientific advance would have not occurred, without Kepler's mathematics and logic capacity the discovery would not have been possible.
In fact, both of them knew they needed each other, especially the complementary nature of their skills. But nothing would have arisen, no great new hypothesis, without many other capabilities of Kepler and Brahe, among which are included: determination, discipline, love for scientific work,

[3] P. DUHEM (1914), *La Théorie Physique*, París: Marcel Rivière, 2ª. ed., p. 390-391.

the admiration professed by the order of heaven, and their immense curiosity. Nothing of interest would have occurred without the knowledge Kepler had in the history of mathematics, and in particular in the older studies on conic curves, without profound metaphysical convictions of their Pythagorean root, without his religious vision of the Cosmos, which for him was a reflection and symbol of the Holy Trinity, without his aesthetic sense and appreciation of simplicity and elegance. The creation of the hypothesis also depended on the personal interests of both the authors, as well as on their social environment, very peculiar, even opposite and complementary in some sense. As we can see, the hypothesis in this case is the result of the whole person and circumstances.

Consider, finally, before moving to the next phase, the situation in which a scientist – a person who makes science – or a scientific community must decide among several alternative scenarios in order to address the same problem. It is a common situation. I am not referring to the choice between two or more tested hypotheses, but the initial choice among emerging hypothesis, a discriminatory work tells us which hypotheses deserve to be followed and which not. Trying to decide which of them deserve to be empirically tested, which one or ones are most promising. Again we find that such decisions are the result of a personal agency, whereas all the capabilities of the person are orchestrated by common sense. These capabilities can hardly be formalizable such as intuition, experience[4], contextual and traditional indications, imagination again, and surely others, crucially involved.

4.3. Auxiliary assumptions and empirical consequences

Once we have considered the problem, generated and selected hypotheses, it is time to consider the phases of empirical verification. To test a hypothesis we need to extract its empirical consequences. But this is impossible if we do not add to the taken hypothesis some assumptions commonly accepted in the body of knowledge (iii). For example, the chemistry developed by Georg Ernest Stahl (1660-1734) tried to explain phenomena such as the calcination of metals, what we now call oxidation, from the hypothesis of phlogiston. According to the same theory, calcination and other phenomena, such as combustion or respiration, always occur together with the release into the atmosphere of a hypothetical substance called phlogiston. It seems to follow, as an empirical result, that the metal will lose weight during the process of calcination. But this result is necessary only if we assume that the weight of phlogiston is positive. As we can see, the empirical conclusion comes from the hypothesis plus a number of accepted assumptions that sometimes overextend themselves from a scientific discipline to theories of other fields. Not to mention the most usual cases, such as

[4] I refer here to the experience in a broad sense, in the sense thinkers as Aristotle and contemporary pragmatists give to this notion. It's the whole experience conceived as the time we have lived and learned from, as a reflective experience. It is not, of course, the empiricist notion of experience.

those related to the reliability of the instruments, the confidence to the reports from colleagues or our own senses and states of consciousness. What is empirically tested in each case is not an isolated hypothesis but a broad set of assumptions.

We have to choose our auxiliary assumptions and modulate the trust we put in them. Again we are faced with an operation that can only spring from the integrity of the person. Once done, we are in a position to infer from the hypothesis, H, and its auxiliary assumptions, A, any observable and empirical consequence, O. And now the logic is in charge to state: $(H \wedge A) \rightarrow O$. Imagine that Stahl had chosen his hypothesis of phlogiston and a Newtonian concept of mass. It follows that – ceteris paribus – calcination must be accompanied by a weight loss in the metal. Maybe Stahl did not like this empirical result, but his taste cannot interfere with the inferential mechanism.

4.4 . Observation and experimentation

We already have an empirical statement we can compare with observable data (iv). You might think that the empirical phase is completely free of personal items. But we know, at least since the time of Thomas Kuhn (1922-1996), it is not so easy, and even the simplest observation is conditioned by our expectations, to say nothing of complex experiments that are required in many of the scientific disciplines. In many of them, the action of scientists practically builds the object or phenomenon in question, as revealed Canadian philosopher Ian Hacking (1936). The perception , even the simplest, is not merely passive, but it is feasible thanks to the activity of the subject. Philosophers have given this phenomenon the name of theory-loading of facts. This suggests that empirical observations are mediated or influenced by the theoretical perspective, or in the words of Kuhn, the paradigm investigation starts from: on one side, Logos determines attitudes in perception of facts (Bios), on the other side, phenomena (Bios) suggests the way of better conceiving them (Logos).

The conditions of observation go far beyond their own theories and scientific paradigms. It is instructive, in this regard, the historical Galileo's (1564-1642)[5] case of lunar observation by. As we know, Galileo was the first to use the telescope to observe the heavens. Through it he was able to see some shadows on the moon. Immediately he interpreted these shadows as an evidence of the lunar relief. Everyone knows the famous pictorial representations of the lunar relief made by Galileo. But to see the lunar terrain is not as simple as putting the eye to the telescope, it's not jus a better use of Techne. Proof of this is that around the same time, the British Thomas Harriot (1560-1621) also observed the Moon through a telescope, but from another training and expectations, and he failed to see how relief those patterns of light and shadow that showed to him. In this case, the

[5] We are following here G. HOLTON (1993), "La imaginación en la ciencia", en L. PRETA (ed.), *Imágenes y metáforas en ciencia*, Madrid: Alianza, pp. 29-58.

formation of Galileo his pictorial techniques of chiaroscuro – his Logos in the above mentioned wider sense - conditioned and facilitated his lunar observations.

These considerations should not lead us to relativistic conclusions. At the end of the day, the Moon does have relief, and Harriot came to accept it. Luckily, we also have a few sketches of the lunar surface drawn by Harriot. One drawn before and one after seeing the Galileo's description. The two sketches differ drastically. In the first we see a linear cycle divided by a broken line, which represents the boundary of the illuminated spot. In the second clearly appear craters and valleys. Once Harriot read Galileo learned to see otherwise, he learnt to see the relief of the moon. This reminds us that even in the observation phase all personal background is involved. But imagine that Harriot, because of the attachment to his previous positions, interest or nostalgia, had refused to acknowledge what he actually was able to see after reading reports of Galileo. Clearly, when someone has assumed a certain background, what you see is what you see, and other considerations are out of place.

4.5. Verification and falsification

Once obtained the empirical results by observation and experimentation, you can match them, wholly or partly, with theoretical expectations or find them to differ. In the case the match is not perfect, we will appeal to a certain estimation capacity that will tell us if the overlap degree is significant or not. For example, the empirical results obtained by Gregor Mendel (1822-1884) in his famous experiments with peas did not conform exactly to the theoretical predictions, but they were very close, enough to give accurate forecasts by taking the slight deviations as mere disturbances.
Galileo suggested something similar in his *Discorsi*, when he admits that the empirical data on the drop of subjects to gravity do not match exactly with his theoretical predictions, but Aristotelian physics brings much greater imbalances that can no longer be attributed to disturbances. The respective uncertainties are orders of magnitude distant; they differ, Galileo says as, a grain of sand from a millstone, as a hair from a rope.

Apparently, both Mendel and Galileo were justified to ignore small inaccuracies attributable to uncontrolled disturbances. The empirical results, in spite of them, confirmed their hypothesis. But it is not easy, much less automatic, deciding when a divergence of this type is negligible and when it is not. Such estimations depend – again – on numerous capacities and circumstances ruled by the wisdom of the person doing science. But once the decision to take or not take into account the discrepancy has been made, we find empirical evidence that either reinforces or refutes the hypothesis. In the first instance we have verification (vi), in the second falsification (v.ii). Now, we must ask to what extent a an empirical success or failure can make an hypothesis respectively true or false. The logical scheme of verification would be this:

$(H \wedge A) \rightarrow O$

O

From these two premises cannot be legitimately inferred the assertion of the antecedent of the hypothesis, $(H \wedge A)$, pure logic does not allow us to assume as verified a hypothesis after its empirical confirmation. Neither the accumulation of empirical successes helps. It is of no help even to grow the probability of the hypothesis, since the probability is calculated by the ratio of favorable cases on possible ones. When possible cases are infinite, as is often the case, the accumulation of favorable cases does not grow the probability. And yet, something tells us that empirical success should have some meaning for the corresponding hypothesis. And it does, but the way it does cannot be grasped by pure logic, neither from the calculus of probability, this meaning comes precisely from the set of human faculties that a person can handle harmoniously through common sense.

The same is true regarding falsification, whose formal scheme goes as follows:

$(H \wedge A) \rightarrow O$

$\neg O$

$\neg (H \wedge A)$

$\neg H \vee \neg A$

I.e., when the observed $\neg O$, diverges significantly from the expected O, we know that something is wrong in the premise, meaning that $\neg (H \wedge A)$, but we cannot know from pure logic if what troubles are the hypothesis or any of the auxiliary assumptions, i.e. we just know that either $\neg H$ or $\neg A$. What should we do in this case? Do we reject the hypothesis or any of the underlying assumptions?

There are plenty of historical cases for all tastes. Here we will put a couple of examples so you can have a glimpse to the complexity of the case. But first let us reflect. Some philosophers have claimed, perhaps guided by their psychological preferences, interests, feelings or metaphysical belief, the truth of consequences drawn from empirical data that logic simply does not allow. Thus verificationists, as Rudolf Carnap (1891-1970), pretended empirical success to be considered as definitive, secure and permanent verification of a hypothesis. In a weaker version, probabilistic, it was claimed that the succession of empirical successes serves to generate an increased probability of the hypothesis. Meanwhile, falsificationists as Karl Popper argued that the refutation of a hypothesis is empirically rooted. But logic does not allow such conclusions, and logic tells us that even after observation, decisions are open: we can choose to keep or discard our hypothesis.

Now let's move to the promised historical cases. Consider again the case of phlogiston. Given the observation that metals are calcined with weight gain, the phlogiston theory can choose to discard the hypothesis or keeping it at the cost of reviewing any of the auxiliary assumptions. You can propose, for example, that phlogiston actually has a negative weight. It is clear that this move will put to new difficulties, but in principle it can do it. We, with the advantage that gives us the story, would say, "do not do it, give up your assumptions, phlogiston does not exist".

Well, what would we say to Copernicus? According to his hypothesis, the Earth orbits around the Sun, that is, that we as terrestrial observers toured the area, and see the stars from a position that changes throughout the year. Hence it follows an empirical prediction: we should see how the shape of the constellations will change throughout the year. Stated more technically, we should observe stellar parallax. Copernicus looks at the sky and did not see the parallax. The constellations keep their shape throughout the year. Then either the hypothesis is false, or have accepted an incorrect premise. And we, standing shoulders of giants, say to Copernicus the opposite of what you would have told to Stahl: "resist, heed your intuition, your aesthetic sense of harmony, your Sun Pythagoreanism, do not give your hypothesis up, the Earth itself orbits, check the auxiliary assumptions". That was what made Copernicus. He advocated reviewing a commonly accepted assumption on the size of the universe. He suggested that perhaps the universe is much larger than it had been assumed so far. Thus, the stars would be so far from us that the size of Earth's orbit would be negligible in relation to the distance that separates us from them. He did not live long enough to look into a good telescope. Had he got the chance to take a glance into it, indeed, he could have seen the stellar parallax his hypothesis predicted and which could have not be seen by naked eye, given the enormous distance that separates us from even the nearest star (Alpha Centauri).

What is clear is that we play with advantage, even if we don't have an algorithm or an uniform method that allows us to recommend, at a certain observation, the way to go. We would recommend to Stahl the opposite of Copernicus. We already know that the scientific personnel action is action, but there is no universal recipe to tell us at what extent we should combine all facets of the person, in which phases should be more restrictive or more inclusive. The same pictorial formation gave an advantage to Galileo respect to Hariot, bur prevented him from accepting the elliptical orbits proposed by Kepler. Galileo rejected them because of his preference for classical circle and his contempt for the ellipsoids forms of Mannerist. However, we want the investigation to be rational. But here rationality is understood as common sense, not as an algorithm. There is rationality where there are rational beings, i.e. people. As Pierre Duhem said, the message of science is directed to common sense (bon sens), the person as a whole.

4.6. Explanation, Application and more

Always from common sense we decide what assumptions need to be accepted and with what degree of confidence. Hence – via deductive inference – wee look for explanations and predictions that can be made (vii). Take this time a contemporary case. In the field of oncology there are currently two main hypotheses in contention, each with its variants. First one is the SMT (Somatic Mutation Theory), whereby genetic mutations in somatic cells are considered the primary cause of cancerous growth, the second one is TOFT (Tissue Organization Field Theory), whereby cancer proceeds, ultimately, because of incorrect tissue organization. Each hypothesis provides an alternative explanation of the diseases in question. Here, again, come into play other considerations beyond inference and observation. In the foreground is the success of each of the hypotheses in explaining phenomena linked to cancer, such as carcinogenesis, metastasis, cell heterogeneity, and other spontaneous reversion.

Moreover, Karl Popper used to say that science progresses in trouble problems. If we reject a hypothesis we have to rethink the original problem as well (v.ii.i), and if we accept a whole new kind of problem (v.i.iv) appears. That is, the explanation of a phenomenon using a hypothesis is not only one end of the route, but also the beginning of the identification and setting of new problems, perhaps deeper, or more accurate, or better formulated or more practical, in which the accepted hypotheses serve as a heuristic guide. If we adopt the SMT, we are trying to identify oncogenes, whereas if we accept the TOFT[6], we are orienting the search towards pathogenic tissue configurations.

Another common result of the acceptance of a hypothesis is the transfer and application (viii), or the attempt of application, of it in the practical and technological field. Here we move in a domain of great complexity, as there is almost never a possible automatic application of a hypothesis to solve practical problems, every application instead requires a certain art, a certain adaptability to terrain. It is not possible here to present the complexity of applied science and technology. It is enough to our purpose to remember that, indeed, each of these levels is in itself an art and a complex tradition, and not the result of a simple mechanical translation of theoretical science. Even the phase called scientific transfer, which passes knowledge gained from research to the production system, requires wisdom itself. Both the transfer and implementation require new balanced contribution of a large number of human capabilities. Consider the difficulties involved in transferring to the pharmaceutical industry scientific knowledge about cancer, so that it is possible to derive new applications. Imagine, for a moment, the amount of human and social skills required before being

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[6] Cf. M. BERTOLASO (2012), *Il cancro come questione. Modelli interpretativi e presupposti epistemologici*, Milán: Franco Angeli.

able to see an effective medication at the pharmacy, and how delicate it can be to work balancing them all.

The same is true for communication and education (v.i.iii). The science communication is done through the media, the popular works of science museums, film and literature, among other channels. It is obvious that this is not an automatable activity and it is not enough to have scientific knowledge to run successfully this system. It is a task of mediation in which the communicator has to create new metaphors, he has to perform certain critical freedom as well, and must find a new balance between different values such as rigor and amenity, for example. Also the teaching of science in schools and universities, requires that all human capacities, implied in both teaching and studying, work harmoniously, from emotional intelligence to the social one, from creativity to empathy, from expository clarity to intellectual honesty and surely many others. It follows that the teaching of science does not pursue the training of scientists, but focuses on people capable of doing science.

5. Conclusion

The aim of this chapter is to present science as an activity performed by people, with all their skills, attitudes and circumstances. Science is not a modular activity, which can be reduced to the powers of observation and logical inference of an individual. It rather is an integral personal activity. Conforming to this idea, we presented scientific rationality as a kind of harmony or equilibrium, the result of the dosage and timing where all material circumstances and capabilities are combined. We have adopted here the metaphors of heartbeat and respiration to suggest precisely these images and dose rate. According to the metaphor of the heartbeat, the person doing science takes, depending on the moment, a higher or lower dose of each of its capacities. According to the metaphor of breath, this person also includes in his scientific work more or less dose of social or historical circumstances of their environment. The dosage and the rate charged to the common sense of the person, his wisdom or prudence.

Harmony and equilibrium between different dimension of human person shed light on the mutual relationship between Bio-Tecnho-Logos in scientific practice. There can't be a primate of Bios, Tecnho nor Logos, otherwise all the scientific practice fall under a one-sided approach. On left side of the triad, phenomena (Bios) are strictly related to instruments (Techne) adopted by scientists and also to the theory (Logos) in which they are explained. On the opposite side, Logos is something you never completely understand in its complexity and multidimensionality. We can speak about Logos in scientific terms, in logical terms, in aesthetical terms, in ethical terms, in spiritual terms. There is no privileged perspective that grasps the vitality and fertility of human

Logos. Even in the restricted area of scientific research, no privileged dimension of Logos has to be evoked as the most important one. Surely, logical or inferential dimension may result decisive, but not the only one. The traditional alternative between context of the discovery and context of the justification split up Logos into different areas and personal attitudes supposed to play different roles. On the contrary, in scientific practice, discover and justification are the expression of the same rational inquiring activity on world and so are the expression of the human person as a whole. Last, as we learned from history of science, Techne is never just Techne, since it implies a Bios to be inquired and a Logos able to plan the adequate way to inquire. Therefore, Techne is fully imbued with both Logos and Bios: that's the reason why sometimes it is conceived as raw material, like technological instruments or robotic environment, and sometimes it is a refined product of pure reason, as analysis situs or integral calculus.

Unity, complexity and harmony of the person do reflect in scientific practice where the only actors are humans, not theories nor supposed natural processes. Reducing scientific research to search for truth, to human enhancement, to the elaboration of more refined theories, or to a better understanding of specific topics, forget the main basilar element of every scientific practice that is the fact that it still remains a *human* attitude. So, as a human practice, science reveals his deepest meaning, which has surely to be anthropological rather than logical nor merely methodological.