The natural ambiguity of the notion of "natural", and how to overcome it[*]

Abstract:

In this paper I will explore the ramification of the distinction between fact and values in order to show that human values enter in various ways in both science and (nano)technologies without violating Hume's fact/value distinction. Among the nanotechnologies, I will discuss the case study provided by the use of microchips implanted under our skin: though they do not obviously overcome the limits of the natural laws (intended in the descriptive sense), their *application* might in principle jeopardize our ethical principles in a way that is more powerful than previously existing "macrotechnology". This greater power depends on the fact that the properties of the macroworld depend on the "nanoworld", but not conversely.

Riassunto:
In questo saggio esplorerò le ramificazioni della distinzione tra fatti e valori allo scopo di mostrare che i valori umani entrano in vari modi sia nella scienza che nelle nanotecnologie senza violare la distinzione humeana tra fatti e valori. Tra le nanotecnologia, discuterò il caso fornito dall'uso di microchips impiantati sotto la nostra pelle: malgrado essi non violino i limiti delle leggi naturali (intesi nel senso descrittivo del termine), la loro applicazione potrebbe in linea di principio mettere in pericolo i nostri principli etici in modo più pericolo della "macrotecnologia" esistente in precedenza. Questo maggiore potere dipende dal fatto che le proprietà del macromondo dipendono da quelle del micromondo, ma non viceversa.

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> "un ombre sin tecnica, es decir, sin reaction contre el medio, no es un hombre
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> Ortega Y Gassett (1933)
> *Meditacion sobre la tecnica*

§1 Introduction

The philosophical reflection on the nature of technology in its relationship with science and ethics is an underdeveloped chapter in current analytic-oriented philosophy of science. Despite a growing interest in the role of technology for the advancement of science, especially for what concerns the constructions of models, the use of simulations and the numerical calculations provided by powerful computers, philosophers of science seem to be more attracted by so-called "fundamental science" rather than by applied science and technology. And yet we are aware from historical studies on science that the role of technology has been essential both for the first scientific revolution (Rossi 1962) and for the so called "second", a process that, according to Bellone (1973), took place during the later 19th century. The science of thermodynamics, to name but one example, is a classical case in which attempts at understanding the efficiency of the steam engine has preceded and made possible the formulation of phenomenological and then theoretical laws.

Here, however, I am not interested in the vexed problem whether pure science precedes or is preceded by applied, technologically oriented science, because I believe that the distinction between pure and applied science is at best one of degree, and is as weak and vague as that existing between pure and applied mathematics. As is well known, the branches of mathematics that are regarded as *pure* do not remain "pure" for long, and are often those that suddenly display more "applicative power": the examples of group theory for physics, of logic for computer science, or number theory for cryptography, are sufficient to illustrate this point. On the other hand, it is from branches of applied mathematics or mathematical physics that has often come the suggestion for the solutions of problems of pure mathematics, and the role of physics in the growth of mathematics hardly needs any illustration (think of Newton's invention of the calculus, or Dirac's delta function and the theory of distribution).

Since the same relationship, I hold, is valid for pure science and applied science or technology, in this paper I will not discuss the problem of the heuristic primacy of pure science over technology or conversely. I think it is time for philosophers to draw their attention elsewhere, and try to inquire, the changing image of our place in nature that the development of science and technology has fostered in the last 500 hundred years. I think that this change has not entered our common knowledge yet, and has not penetrated our emotional outlook toward nature.

In order to understand more clearly what I am referring to, it is sufficient to concentrate our attention toward one single example, namely the transformation undergone by the very concept of "law" from a purely prescriptive to *a prescriptive and descriptive* sense. Today we talk about *laws* to refer both to the laws of physics in a purely descriptive sense, and to the norms regulating our social life. However in the ancient world, and among the Greeks in particular, the word *nomos* ("law") was restricted only to the behaviour of human beings, and therefore had a pure *prescriptive* sense. This splitting of the meaning of the word "law" reflects very well that separation of facts from values which is characteristic of the creation of modern science, with its abandonment of the Aristotelian concept of a final cause, and which will be the object of analysis of the first part of my talk. Why is it that a word like law, that previously had a purely prescriptive meaning apt to capture the behaviour of persons, could eventually refer also the workings of *inanimate* matter? As I have shown elsewhere (Dorato 2005), the role of theology and technology in this transformation can hardly be exaggerated.

It is not just the word law that has a tricky meaning, the word "nature" or "natural" has obviously undergone the same fate: in philosophical discussions, the word "natural law" stands both for those ordered but unanimated types of phenomena that are subjects to physical laws (a purely descriptive meaning that refers to whatever is regular and repeatable: the laws of gravitation or the laws of optics, for instance) and to "laws" or "principles" pertaining to our moral nature, in particular within the so-called natural-law tradition, which is not restricted to theistic, or tomistic philosophies.

The natural-law tradition dates back at least to the ancient stoicism, and its main idea is that human beings are thought of enjoying some *natural rights*, independently of social contracts of sorts, or of their belonging to a political or social community. Since political institutions in this tradition exists in order to

protect these natural rights, the existence of a natural-law was essential to prevent absolutist monarchies to invade what we call today the sphere of *individual rights*. Such rights, adherents to this philosophy claim, belong to a person "by nature", "in virtue of our nature", or of what "we are essentially".

This splitting in the meaning of words like "natural law" obviously create the problem of their conceptual relationship. For instance, how can we derive norms-prescriptions (how things ought to be) from facts-descriptions (how things are) without violating the so-called Hume's law, namely the thesis that we cannot deduce a moral imperative starting with "ought" from a statement of a fact, expressed with an "is"? Another, possibly simpler way of putting Hume's law is that ethical judgments do not state facts, but express sentiments, passions, volitions, and often have the purpose of inducing our interlocutor to act or judge in a certain way. To what extent is this law valid? Do we have a *dichotomy* or simply a fact/value *distinction*? (Putnam, 2004)

In the first part of this paper, I will try to clear the ground from frequent misconceptions about the relationship between fact and value by examining some rhetorical uses of the adjective "natural" in ethical controversies: this will serve us as an introduction to what in the title I called "the natural ambiguity of the word natural". I will then use the historical case of the emergence of the notion of natural law to explain why the ambiguity of natural is "natural", that is why many human cultures tend to regard nature (considered in a descriptive sense, as the complex of physical and biological phenomena) as the origin and source of moral end ethical norms. This preliminary, philosophical and conceptual clarification will be essential in the second part of the paper, where we will try to present the ethical web of problems generated by the application of some nano-technologies. I will primarily discuss some of the most interesting moral questions generated by mini-chips implantable under our skin.

§2 The ambiguity of the word "natural": a discussion of some paradigmatic examples

1) "It is *natural* for big fishes to eat small ones", the slogan of the social Darwinists,
2) "this action, this law, this rule is *against nature*", a frequently used rhetorical appeal
3) "this is natural (non-adulterated) water, this is *natural*, "*biological*" food", slogan used by environmentalists
4) "mammals are *naturally* carnivorous, or naturally polygamous",
5) "the (Italian) Republic acknowledges the rights of the family as a *natural* society founded on marriage"[1].
6) «Our individual natures are part of universal nature. Hence the chief good is life *according to nature*, that is, according to one's own and to universal nature». [Zeno of Cittium, Diogenes Laertium].

Let me briefly comments on each of these uses of "natural" in the list. All of them, and others that can be easily found by analysing common discourse, can all be classified under the *opposite* perspectives of behaviour, action, laws, etc. that are "*according to nature*" or are "*against nature*".

1) The first metaphor was often presupposed by the ancient sophists, who introduced a fundamental distinction between what is "by nature" (*physis*) and what holds by "human convention" (*nomos*). This distinction is often neglected in our discussion even today and is therefore worth recalling it. We should notice that what holds "by nature" for the sophists concerns more or less stable regularities of the natural, biological world − like "the law of the strongest." In the Platonic dialogue *Gorgias*, for instance, Callicles contrasts such regularities with the conventions of human laws, which were created by the weak to protect himself against the strong. In a word, according to Callicles that there is a conflict between nature and laws, and human laws are criticized because they are "against nature":

«But in my opinion those who framed the laws are the weaker folk, the majority. And accordingly they frame the laws for themselves and their own advantage, and so too with their approval and censure, and to prevent the stronger who are able to overreach them from gaining the advantage over them, they frighten them by saying that to overreach others is shameful and evil, and injustice consists in seeking the advantage over others. For they are satisfied, I suppose, if being inferior they enjoy equality of status. That is the reason why seeking an advantage over the many is by convention said to be wrong and shameful, and they call it injustice. But in my view nature herself makes it plain that it is right for the better to have the advantage over the worse, the more able over the less. And both among all animals and in entire states and races of mankind

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[1]   «La Repubblica riconosce i diritti della famiglia come società naturale fondata sul matrimonio »(art. 29 of the Italian Constitution).

it is plain that this is the case--that right is recognized to be the sovereignty and advantage of the stronger over the weaker» (Plato, *Gorgias* 482e)

It is quite clear that we do not accept Callicles' argument as valid: unlike social Darwinists, *we* do not consider *the fact* that big fishes eat smaller ones, and similar "natural" facts, as a justification for the validity of an ethical or a legal principle that would recognize to stronger or more intelligent people more rights than to weaker or less able persons. Possibly the Christian precept of helping the weak and the vulnerable is not going against nature, but it certainly amounts to an reversal of what is a widespread regularity of the biological world. So human laws, to the extent that they protect the weak and limit the strong, are "*against nature*", but this is no reason to criticize them from the moral point of view. This brief remark taken from the history of philosophy is a strong piece of evidence that ethical arguments drawn from "nature", i.e., from widespread regularities, are unsound. Unlike Callicles, we prefer our ethical, possibly conventional convictions to what happens in nature, and refuse to model our institutions on the relationship between predator and prey. Of course, in the natural, and in the human world, there are cooperative or "symptathetic" tendencies",[2] but they coexist with predatory and aggressive passions. In a word, it is our *prior* commitment to certain values (cooperation, selfishness) rather than others that make us select those biological regularities that best fit them in order to try to find a justification for those values.

2) Despite this, in public discussions scientists are sometime invited not to overcome the limits of nature, or not to go against it. Likewise, politicians and legislators are reminded not to vote for laws that would go against nature, or "human nature". But what does "against nature", "going beyond nature", or overcoming the limits of nature, *mean*? Properly speaking, there are two ways of interpreting the locution "against nature" or beyond nature, corresponding to a descriptive and a prescriptive sense of "nature".

In a descriptive sense, events going "against nature", or that "overcome its limits", would be events that occurs highly infrequently, very rarely, or even "miracles". These, however, would not count as events breaking the laws of nature, if by laws we mean exception-less, universal regularities described by mathematical equations, or empirical generalizations of the kind "all butterflies have wings". An exception capable of breaking a law would simply falsify the known laws, and would obviously not go "against nature". There is a clear sense in which physical processes cannot *trespass the limits* of, or *go against*, *physical laws*, since laws, interpreted scientifically, yield the very concept of what is *physically possible*. That is, a group of natural phenomena, or some event or process *x*, is to be regarded as physically possibly if and only if *x* is compatible with the laws of nature. If a physical law *L* turned out to be falsified by an event or a group of phenomena that are considered to be "going against" *L*, we would simply say that *L* is not as universal as we previously thought, and has exceptions. That is, we would say that it is not a law, in some definitions of law. This will also help to explain the ambiguous expression "going over the limits of nature": in an innocent sense, this expression simply means that we have discovered, or better *produced or constructed* new phenomena that do not seem to be covered by old laws. But in no sense can "going over the limit" imply "going against nature" in the descriptive sense of nature.

In the other sense of "against nature", nature is interpreted *morally*, and involves the realization of our moral essence. "Nature" here does not refer to the individual characters or natures of distinct human beings, but to a standard of moral perfection common to all human beings. In other words, nature involves the question "how human beings ought to live", not the question of how they practically and factually live. In this sense, civil laws, behaviours, and technological inventions *can* go against our nature, but only if "human nature" is interpreted morally. A different, but crucial question, is, of course: whence do we derive such shared ethical norms, if we cannot deduce them from empirical regularities, i.e., by looking at our biological nature? It seems to me that there are two major options at our disposals here, one based on creationism, or religious faith, the other on the so-called virtue-centered morality.

Certainly, if we view biological evolution as a process in which there is no pre-ordered design and everything unfolds aimlessly in a dialectic of chance and necessity, there seems to be even less room for deriving norms from the empirical regularities of the natural world, or from the way we are on the descriptive level (see also Sidgwick 1907, p.80-1). The scenario looks different if we presuppose a sort of providential plan for nature and for human lives, so that a human life should be lived in a certain way because God wanted it to be so, since God created us to fulfil a certain aim.

However, there might a second way that is neutral toward creationism, in the sense that does not presuppose it, and is therefore compatible also with neo-darwinism. In other words, there might be an Aristotelian notion of "human flourishing" or self-realization that is independent of any religious hypothesis,

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[2]   Think of all the examples of cooperation in the animal world, or to David Hume's sympathy.

a virtue-centered morality that presumably bases our moral behaviour on our natural, moral impulses (sympathy, compassion, or impulses that make us "completely realized").

There are two main problems with this important tradition. The first is epistemological: provided we are also endowed with passions that lead us astray, how can we identify and distinguish the good impulses from the bad ones, previously and independently of a moral evaluation? (see Sidgwick 1907). We can always retort that only the good passions make us really *flourish*, and that we have a natural tendency toward *flourishing*, unless a bad education distorts our "nature". Of course, cultivating genuine friendships, or having a healthy parent-child relationship, or possessing literacy and education are all objective goods for human beings, or part of what we mean by "flourishing", and not merely instrumental to it. The problems is not so much about the objectivity of such values (in which I believe, and which the theory of flourishing advocates), but whether we want to ground such objectivity in the way we are as biological beings, in our common biological nature.

This difficulty, which I can only hint at in this context, is reflected in the twofold meaning of the word "flourishing" or "thriving". These words describe our being absorbed in a complex process or in an activity (having or meeting friends) or our possessing of a capacity (like having literacy) as facts that we value: complex facts that also seem values, and this seem to go against the fact-value distinction. In reality, they don't go against a certain way of putting the distinction. From the fact that the so-called well-educated or well-trained persons appreciate and enjoy in a special way certain activities, like spending time with friends, cannot be derived an ethical imperative *per se*. In cases of this kind, one can always raise the question "why should we value an enjoyment of that kind?" which appears a legitimate one,[3] especially if our nature is changeable and dependent also on cultural modifications.

3) "this is natural, non-adulterated, biological food," often used against the introduction of OGM, is also a bad rhetorical trick. Agriculture, even biological, is not natural, is as artificial as it gets, it has been invented in the sense of being a complicated, contingent technique which has changed the history of human beings. Of course apple-trees produce apples "naturally", but their cultivation often requires wearing and "artificial" interventions on our part (watering, pruning, or cross-fertilizing). This example is interesting for what will come next, since it is a clear instance of our tendency to mix the natural and the artificial: "natural" or bio-food here can *not* be synonymous with non-artificial, since even "biological" agriculture is to a large extent artificial. Rather, it is synonymous with what we are most used to, what we are accustomed, what we have experimented so far. On the other hand, feeding animals with antibiotics or hormones is likely to cause health problem, so the right emphasis should be not on the opposition natural/artificial or according to nature/against nature, but rather on beneficial/harmful for our health, or not harmful/harmful. The same practical attitude should prevail on the issue surrounding the genetically modified organisms.

4) the fourth case involves our attitude toward food. The fact that mammals typically eat meat, and that we are mammals, does not make a choice for vegetarianism *immoral*. And yet sometimes we hear discussions in which vegetarianism is condemned in the name of what is natural, of what factually most mammals do. Another instance of trying to derive norms from natural facts, that is also used in the name of discouraging or encouraging sexual promiscuity. Choosing pairs of mammals that show a faithful behaviour after copulation, or alternatively, indicating male mammals that are promiscuous as a paradigm for human males presupposes a previous commitment to ways of living that cannot be justified in the name of what happens in the biological world.

5) the fifth case, the expression "family as a *natural* society" in the Italian Constitution, has been recently the subject of hot controversies, in which I will not enter. Let it suffice to note that the reference of the adjective "natural" here is to one of the functions of our biological make-up, namely reproduction, with all its accompanying "activities", namely, sexual attraction, caring for the children and their growth, etc., which are regarded as pre-legal, pre-institutional, pre-social contract facts of which the constitution takes into account.

The institution of marriage is then regarded as a legalization or the "institutionalisation" of our biological function of reproduction, regarded in this enlarged sense. We should also note that the fact that human beings can, or have the ability to, reproduce, does not create by itself a moral duty to reproduce: priests, nuns and other admirable human beings choose and have chosen not to do so, that is, not to have a family.

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[3] Of course being able to read and write is instrumental to the enjoyment of many cultural and social activities, and is therefore also an instrumental value in this sense.

Analogously, deciding whether the only kind of "family" should be formed by people of different sex − an ethical and legal principle − cannot be justified solely on the basis of *facts* pertaining to our biological make-up and to our natural capacity for reproduction, but depends on some other values.

6) "living according to nature" is an important precept in stoic philosophy, with very important modern and even contemporary ramifications. The stoic precept is, once again, based on the idea that everything *is as it should be*, and our complaining about the presence of evil is simply due to our short-sighted incapacity of perceiving the whole chain of events constituting nature: our life is but a fragment of a cosmos permeated with a logos (reason) which ensures the rationality of all that is the case. As the quotation above shows, the utmost duty of the wise or the philosopher is to know the cosmic order of things, and control one's passion in such a way that the unavoidable is accepted as an expression of our own will. The natural, physical order, as an expression of the rationality of the whole universe, also offers a moral guidance, so that the survival force of this position can hardly be downplayed...This position is also related to the idea that there is a human nature in the factual and moral sense and that the two are entangled.

§3 Why is the natural so naturally entangled with the ethical

In these six examples, "the entanglement of facts and values" (see Putnam 2004) seems quite evident, but devoid of much argumentative force.[4] While a natural regularity, a description, a fact, something taking place in the biological world, cannot ground a juridical norm or an ethical rule, in the sense that we can derive it from the regularity, we have nevertheless a strong tendency to identify in nature a dispenser of norms. Why is this the case? Are there explanations for this natural, possibly innate tendency of human beings to find a norm in the equilibrium/stability of the natural world to which we adapted during long centuries?

There are various reasons that can be considered to try to provide an answer to this complicated question. The first reason is that identifying norms in the natural, biological world, regarding nature as a dispenser of value, might itself be a form of natural or cultural adaptation! Human beings live in a natural environment to which they adapted during long intervals of time. Consequently, keeping an equilibrium between ourselves and the environment is functional to our survival, that is, tends to increase it. Put is simply, my hypothetical explanation, for which I cannot try to provide empirical arguments here, is as follows: since keeping an equilibrium with our natural environment involves, plausibly enough, a certain invariance or stability of the niche in which we have lived for millennia, we probably evolved a universal cultural attitude to consider any radical change in the relationship between ourselves and the environment as bad, or potentially dangerous.

If any attitude that favours the stability of the environment is potentially adaptive, nothing can be more efficient to this aim than developing an approach toward the physical world around us that considers it as a dispenser of sacred norms that must be respected. The physical order, the descriptive regularity of the biological world and human morality are then inextricably entangled in order to preserve the equilibrium between ourselves and the external world, an equilibrium upon which our survival can obviously depend. I think that it is in this direction that we must search the reasons for the deep fear that new technological devices have always generated. The fear for (nano-) technologies is therefore the heritage of a long evolutionary past, and we must keep it in mind if we want to avoid simple technocratic recipes.

The second reason that explains the presence of a strong tendency to confuse the notion of natural regularity (laws of nature in the descriptive sense) with a moral law in the prescriptive sense derives from the persistent residue of an anthropomorphic projection, a pre-scientific tendency to explain the pervading existence of regularities in the physical world by an animistic attribution of "a soul" also to unanimated matter. In this way, the latter could be regarded as betraying the presence of an intellect or a more or less divine entity endowed with volitions, capable of imposing limits and norms of the same kind that human legislators impose in our societies.

That natural regularities in the descriptive sense could only be explained as the fruit of an ordering will was already evident in Babylonian thought. As Robert Eisler indicates, the characteristics of the movement of the planets, which Babylonian astronomers studied with attention and skill, were interpreted

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[4] Such an entanglement is also evident in our language, whenever we use morally thick concepts like *cruel*, *generous*, or *criminal*. According to Putnam, these concepts refer to a certain range of behaviours, so have a descriptive force, but at the same time qualify them morally, by evaluating them as bad or good.

«[. . .] by the authors of tablets who created the library of Assurbanipal [. . .] as dictated by the "laws" or decisions governing "heaven and earth," as pronounced by the creating god from the beginning.» (Eisler 1946, pp. 232 and 288).

The same author later adds that the concept of universal, scientific law derives "from this mythological concept [. . .] of decrees from heaven and from earth," and in one of his other studies, (Eisler, 1929, p. 618), highlights the importance of the social/political condition on the way nature is represented, given that the idea of the world as an entity ordered by events (what the Greeks called *Kosmos*) originated, in his opinion, in Babylonian social theory. This fact hints to a third, possible explanation of the tendency to confuse nature and norms, one that comes from an understandable inclination to project the social political world onto the natural world.

With this theoretical background, I now pass to discuss the applied ethics case given by implantable micro-chips

§4 External vs. internal machines: is it still a meaningful distinction?

In the near future, our bodies might end up using not just use external prop-ups, like glasses or walking sticks, but also lots of internal ones, constructed artificially or naturally. Is this process of "hybridation" of our bodies with the artificial something to be afraid of? How should we proceed?

I report here the words of Giuseppe O. Longo, professor of computer science in Trieste. First of all, he claims, "it is impossible for the biological part of the symbiotic hybrid to keep in step with the speed of the technological evolution, and this creates a deep discomfort. The second problem is the self perception of the person. Our body is the source of our personal identity… the unity of body and mind would be altered by fictional prosthesis that, for instance, could alter the capacity of our memory".[5]

The first point is obvious: I already pointed out the necessity for our well being of considering our relationship with the environment as stable as possible; the second fear, however, is not purely science fiction. Stefano Rodotà, an Italian jurist, refers to this hybridation as a "post-human state" (La Repubblica, 6/12 2004): «On the 12th of October 2004 the Food and Drug Administration, has authorized the use of a very small chip that can be read at a distance, called VeriChip, to be installed under the skin of the patient and containing her whole clinical story.» The chip, as the www.verichip.com site advertises, "is able to offer rapid, secure patient identification, helping at-risk patients to get the right treatment when needed most." The chip would help patients affected by memory losses, impaired speech or simply patients that have lost consciousness. Further applications of "Verychip" envisage a protection against "baby switching", which, according to web site, amount to thousand of cases per year in the U.S. only; the prevention of incidents related to old people wandering around and getting lost, or to have a maximum security of access to houses or banks or secret archives via a radio frequency identification.

Rodotà concludes his article in a very poignant manner: «in this way the subject changes her personal and social status. A subject can always be on line, and become a networked person, configured in such a way that she can emit and receive impulses that allow others to track and reconstruct physical and mental conditions, habit, movements, contacts thereby modifying the sense and content of her autonomy» (Rodotà 2004).

I agree with Rodotà that cases like these deserve an attentive consideration, and a case-by-case analysis: our main guiding star, as in other ethically sensitive cases, should be the principle of the dignity of the human being, and the idea that a human being should be treated not only as a means but always also an end in him/herself. For instance, as noted by Rodotà, the importance of protecting personal data in cases like these should be obvious, especially if the data contained in the microchip are alterable by others. However, at the same time, we should be aware of an attitude that is still widespread in our cultures, and for the reasons we have tried to sketch in the previous sections: this attitude regards the whole of technological evolution as *the* dehumanising force of mankind. The following, brief considerations, will therefore try to convince the reader that we must learn to live with the extraordinary possibilities offered by nanotechnologies, without abandoning ourselves to easy or superficial enthusiasm.

1) The technological development is following (and has in part fostered) that cultural tendency of going "inward bound" that has accompanied the last two century of physics, from the molecules to atoms, to quarks to string, if they exist…(see Pais 1988). The important message of the physics of the last two centuries is that the macroscopic properties of all the physical bodies supervene on the microscopic ones. From the statistical

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[5]   http://www.swif.uniba.it/lei/rassegna/021119h.htm

mechanics of gases onward, we have learnt that given two possible worlds with the same microscopic structure, the worlds in question must be alike also from the macroscopic point of view (i.e., as philosophers say, they must supervene). Clearly, the major impact that nanotechnologies will have is going to depend on the *asymmetric* supervenience (dependence) of the properties of the big things on the very small ones.

2) Despite their different speed, *biological evolution and technological evolution obey the same abstract mechanism.* Namely, a reproducing mechanism with some variations, and a selection process. Clearly, the reproduction of a machine or of an artefact is based on different supports and mechanism, since it depends on human brains, culture, and therefore on education and other processes that depend on learning, while the reproduction of an organism relies on chemical means (the DNA). This difference explains the difference in speed. But variations on the projects of technical artefacts explain their different impact on the market or on society, and this, in its turn, creates a selective process depending on many aspects, price, dimension, pollution, etc. The advantage of a portable computer on a desktop having the same speed and memory is so obvious that the selective process goes in the direction of miniaturization and portability. This explains a strong selective push toward miniaturization.

3) Applying the considerations of the first two sections to the question of the possible role of nanotechnologies in our societies, what can we conclude? Once we accept the idea that artificially constructed hearts, or parts thereof, of dental prosthesis, of knees or hips can be already inserted in a human being, so that a person becomes a mixture of natural and artificial machines, where should we stop? I will simply present three examples involving the application of future technologies in the biomedical sciences, with potentially advantageous effects.

First of all, think of the possibility that a microchip inserted in the brain of an epileptic patient might detect the onset of an epileptic seizure and switch it off by cooling down the involved neurons. Researchers at Washington University in St. Louis, a couple of years ago, developed a microchip that can detect an oncoming seizure and prevent it from spreading by cooling the brain cells. The study, realized at the University of St Louis and published in the medical journal *New Scientist*, claims that it is possible to stop the seizure in the brain of rats by cooling brain cells from body temperature (about 37 degrees Celsius) to around 22 degrees Celsius.[6] Apparently the cells did not suffer any damage.

Second point, the future of pharmacology can be revolutionized by the so-called individualized medicine: one could synthesize a particular gene, insert it in a certain organism for production, and then obtain a molecule with a certain shape and function to be used to attack a determinate target (Boncinelli 2006, p. 66). Finally, there is the well-known case of regenerative medicine, with the possibility that stem cells or other similar *totipotent* cells might create new biological tissue. This is certainly a very promising and important field.

4) Of course, limiting oneself to examples taken from future applications to medicine may be too easy, as we are now talking about the possibility of implanting a nanocomputer in our brains that can either modify at will our mnemonic and algorithmic capacities, or augment the natural perceptive abilities. This would cause a collapse of our identity if and only if the chip will be used in a way that jeopardizes our dignity. However, there are no compelling reasons to depict a catastrophic picture here.

I can imagine that people having memory losses, or having serious prosopagnosic disorders (face-blindedness), for example, could be helped by a chip that could correct the malfunctioning of some known parts of the brain.[7] Don't we write down in external artefacts (soft or hard *agendas*) the things we have to do in order to prevent forgetting our appointments? There is little question that there is a substantial difference between an external and an internal device, but I don't see how the implant of an internal agenda that can be constantly updated as a terrible tragedy overturning our identity. However, it must be admitted that a chip that would put us in the condition of not forgetting a single experience of our life would not only jeopardize our identity but also destroy our social adaptation and well-functioning.

But who want to have an implant of this kind? One needs only to be reminded of the tale of Jorge Borges about *Funes el memorioso*, the man who was incapable of forgetting.

«We, in a glance, perceive three wine glasses on the table; Funes saw all the shoots, clusters, and grapes of the vine. He remembered the shapes of the clouds in the south at dawn on the 30th of April of 1882, and he could compare them in his recollection with the marbled grain in the design of a leather-bound book which he had seen only once, and with the lines in the spray which an oar raised in the Rio Negro on the eve of the battle of the Quebracho»

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[6] The process of cooling shuts off the release of neurotransmitters, thereby making cells less susceptible to seizures.

[7] Those of us suffering from the Capgas syndrome are convinced that the persons that are around them that they know and care for are constantly being replaced by copies of the real persons.

It is obvious that our minds require an economic system of encapsulating information, to prevent them from being cluttered with irrelevant minutiae. There is also the practical impossibility of living without forgetting because remembering is, automatically, selecting certain aspects of our experience at the expense of others, i.e., we cannot remember if we do not at the same time, forget. The Russian psychologist Luria (1969) has told about his medical experience with a patient that could never complete any task because he was constantly reminded of thousand of things that were connected with his present experience.

The Italian philosopher Paolo Rossi correctly reminds us about the importance of forgetting in the very process of life:

«Quindi, se non c'è dimenticanza, non c'è neppure memoria, c'è soltanto questa specie di cosa spaventosa che sarebbe il ricordare tutto. Tant'è vero che, quando lo lessi mi colpì molto, citai nel mio libro un racconto dei chassidim un racconto, diciamo mitico, che dice che gli uomini debbono imparare a dimenticare e a ricordare e che se non fossero in grado di dimenticare non potrebbero neppure vivere, perché non avrebbero la forza di fare cose, penserebbero soltanto alla loro morte. Per questo — dice il racconto − quando un bambino nasce c'è un angelo che gli insegna le cose e uno che gli batte sulla bocca perchè dimentichi le cose che ha imparato. E' una cosa, un racconto che mi è sembrato splendido, mi sembra ancora splendido, perché in questa forma di analogia dice il nocciolo di quello che volevo dire.» (Paolo Rossi, in http://www.emsf.rai.it/tv_tematica/trasmissioni.asp?d=392).

We would not be able to live because we would constantly think about our future death, while during our daily life we forget that we are mortal.

One could imagine to be able to transfer the whole ocean of data that is available in the web in the head of each of us. Would that be useful? We should not forget that one can have already now as many data (externally available) through the web as one may want, but the real question is organizing it and understanding in more economical schemes, i.e., frame it in order to construe a valuable hypothesis. This is what, for instance, discovering a law of nature is: summarizing a lot of possible observations in a single formula. [. . .] «science is a form of *business*. It aims, with a minimum of effort, in a minimum amount of time, and with a minimum exertion of thought, to appropriate the maximum amount of infinity and external truth for itself» (Mach 1896 p. 14). And in this sense, transferring the whole head in an updatable chip would not serve any purpose. And I trust that people would not even try to have such a chip implanted.

One last, important aspect is the emotional one. So far I have explored the cognitive rather than the emotional part of the possible changes introduced by implantable chips in our heads, but what about a chip altering our internal emotional states, and, similar to the experience machine invented by the Harvard philosopher Robert Nozick in *Anarchy, State and Utopia* (Nozick 1974, pp. 42-45). In this book Nozick imagines a machine capable of simulating all the pleasurable experiences we might want to dream of, with the corresponding pleasure. Suppose now that a chip could be realized in such a way that we would not be able to tell that those experience are *not* real. So we could experience to have a dinner with the most beautiful man or woman, to win the final game of Roland Garros, to cross the Pacific with a sailboat, or receive a Nobel prize for peace. But all of this would not be a real experience, simply a virtual one. How many of us would decide to have chips inserted under their skin that simulate virtual and dreamt-of realities without the possibility of coming back to the real world? That is, would we choose to have the chip implanted over real life?

Nozick gives the following three reasons not to attach ourselves to the machine, which can be extended to microchips altering our emotional states.
1) We don't want the strawberry because we like the experience of eating one, we like the experience because we want to eat the strawberry. "It is only because we first want to do the actions that we want the experiences of doing them." (Nozick, 1981, p. 43)**.** Here the opposition is between the real action and what it feels doing it. But we could imagine that the chip gives us the impression of acting as well. Nozick's point here does not look decisive.
2) We want to be a certain sort of person: "Someone floating in a tank is an indeterminate blob." (ibid, p. 43). This is more central point, and relates to our need of living a life of effort and plan. But the reply could always be that by having the chip inserted one would have the impression of living such a life.
3) "There is no *actual* contact with any deeper reality, though the experience of it can be simulated." (ibid, p. 43). This seems the crucial problem. Knowing in advance that what we will experience after

having a microchip implanted has not been gained with honest toil and is not real, would deprive the pleasurable experience from any meaning.

Not only does this show that hedonism is not a correct theory of our behaviour − i.e, that pleasure does not completely motivate our actions, let alone something that ought to motivate it − but also that we should not worry too much about chips that in the foreseable future could alter our emotional states.

No reason to worry, I would conclude, about implant altering our cognitive/affective states, even though the effort to adjust to the speed of technology cannot be downplayed and is the main and foremost reason of fear, a fear that could even have been implanted in our brain by biological evolution.[8]

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[8]   For the interplay between nature and culture in scientific explanations, I refer the reader to my recent book (Dorato 2007).