Scientific Research Publishing

Open Journal of Philosophy, 2018, 8, 317-341
http://www.scirp.org/journal/ojpp
ISSN Online: 2163-9442
ISSN Print: 2163-9434

Free Will, Subjectivity and the Physics of the Nervous System

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How to cite this paper: Ceroni, M., & Prosperi, G. M. (2018). Free Will, Subjectivity and the Physics of the Nervous System. *Open Journal of Philosophy*, *8*, 317-341.
https://doi.org/10.4236/ojpp.2018.83023

Received: March 12, 2018
Accepted: May 26, 2018
Published: May 29, 2018

Abstract

We want to stress the irreducibility of subjectivity to a pure physical process and, related to this the existence of an actual free will. A discussion on the existence of free will goes back at least to the Middle Ages. Today however the problem has been considered again in the framework of Neurophysiology and in connection with specific experiments. The problem is related to reductionism, i.e. the claim that subjectivity could be considered an epiphenomenon of the cerebral processes, the argument being that all our sensorial perceptions, the control of movement, our states of wakefulness or of unconsciousness can be related to the activation or to the block of specific areas of our cerebral cortex. In the frame of this conception free will is denied essentially on the basis of physical determinism. In contrast to such attitude, we argue that experiences like consciousness of ourselves, of a personal identity or even simply of qualia completely escape from concepts of physical nature. As a consequence of the specific epistemological choice, they cannot even be expressed in the language of Physics. The point of view of Physics and introspection appear both essential but complementary and irreducible one to the other; any attempt to do so brings to unresolvable aporias. Specifically on free will, we note that our nervous system is a complex mesoscopic system, for an understanding of its occurrences, reference to Quantum Theory is essential. As consequence, its reaction to any external input is not uniquely determined but is open to a plurality of responses for which only a distribution of probability is given. Physics does not provide any cause for one response rather than another, while we experience our response to be intentional. Quantum Mechanics seems to offer the logical space to reconcile Physics with introspection. Some basic notions on the structure and working of neurons and of the central nervous systems are also recalled, Liebet's experiments on retarded awareness and the role of free will in the knowledge process are discussed.

Keywords

Free Will, Cerebral Processes, Reductionism, Subjective Perceptions, Mind, Introspection, Quantum Mechanics

1. Introduction

I am sitting at my desk and *decide* to write to a friend, I feel myself *free* to move an object from here to there and then from there to another place. I dwell on the memory of some nice experience I have lived in the past, I call to my mind the image of some place I have visited during last holidays and which I was particularly impressed by. Since I was a baby, as I grew up, I developed an ever clearer awareness of a world which is something different from me, which I can act on, but I cannot dispose of at my will, an awareness of myself experiencing it and of a limited freedom I have, even if under various conditionings.

Free Will is the term used to express the ability of man to make free decision and a discussion on Free Will goes back at least to Middle Ages, but until recent times it was in the framework of Philosophy, Psychology and Theology. It is clear that the problem is strictly connected to the possibility of Ethics and to the recognition of our responsibility for our actions. The recognition of such freedom is implicit in the existence itself of a set of rules which we are required to conform to in any human society, in the existence of a more or less structured penal law and in the exceptions that are acknowledged in case of serious mental upsets.

Today, however, the problem of freedom of will has been questioned again on the basis of our present knowledge of Neurophysiology and the results of specific experiments. There are scientists who maintain that freedom of will is an illusion. Obviously this is in the context of reductionist conceptions, in the belief that our subjectivity itself could be led back only to an understanding of the structure of our brain and of the physical processes that occur in it. So, with reference to the problem of free will, it must consider the preliminary problem whether it is really possible to reduce our awareness, consciousness of ourselves, our personal identity, simply to a physical problem.

The problem of reductionism or that of the irreducibility of our inner experience is naturally strictly connected with general philosophical conceptions, today however it deserves a reconsideration in the light of our present scientific knowledge. From this point of view reductionism rests on two different orders of arguments:

a) The possibility to relate our sensorial perceptions, the control of our movements, our activity of thought, our state of wakefulness or of unconsciousness, to the existence and the activation of specific areas of our brain cortex. This can be obtained by considering the effects of specific injuries to our brain or by a direct measurement of its electric activity or blood fluxes by means of our

present instrumentation.

b) A certain analogy with artificial intelligence models. Under various aspects, in fact, our brain can be assimilated to a computer, with its operative system, with working and storage memories. Actually, computers are organized according to a serial plan, while our brain has a net structure, but this may be seen as a complication rather than an essential difference and there are attempts of a mathematical theory of *neural nets*. People maintain that our *mind* could be led back to a purely physical event if we only got to understand the structure and organization of the system (the *hardware*) and the *software* by which it works in a more complete manner.

For instance Francis Crick[1] expresses himself in this way (Crick & Koch, 1998, 2005):

"*You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associate molecules. As Lewis Carroll's Alice might have phrased it: 'You're nothing that a pack of neurons* (*nerve cells*)'".

In a similar way, after an introduction on formal languages and logical operations, simply intended as a set of rules that enables us to obtain new strings from former given strings, and tried to discuss in such terms the workings of the brain, Douglas R. Hofstadter (well-known scholar of artificial intelligence) writes (Hofstadter, 1980):

"*Looking back on what we have discussed, you might think to yourself, 'These speculation about brain and mind are all well and good, but what about the feelings involved in consciousness? These symbols may trigger each other all they want, but unless someone perceives the whole thing there's no consciousness.*"

This makes sense to our intuition on some level, but it does not make sense logically. For we would then be compelled to look for an explanation of the mechanism which does the perceiving of all the active symbols, if it is not covered by what we have described so far. Of course a "soulist" would not have to look any further; he would merely assert that the perceiver of all this neural action is the soul, which cannot be described in physical terms and that is that. However we shall try to give a "non-soulist" explanation of where consciousness arises.

Our alternative to the soulist explanation (and a disconcerting one it is, too) is to stop at the symbol level and say, "This is it; this is what consciousness is. Consciousness is that property of a system that arises whenever there exist symbols in the system which obey triggering patterns somewhat like the one described in the past several sections."

In the context of a reductionist interpretation, in the assumption that everything can be explained in purely physical terms, the existence of an actual freedom of action is essentially denied by appealing to the physical determinism. It is said: given certain initial conditions, corresponding to given sensorial stimuli and to a given internal state of the brain, the response would be uniquely deter-

[1]Francis Crick, Nobel laureate for Biology and Medicine 1962 together with J. D. Watson for the discovery of the DNA structure, moved successively to Neurophysiology.

minate without any space for a different behavior. Actually, we know that this is true only for Classic Physics, while the most fundamental Physics, Quantum Physics, necessary to study the elementary processes, is not deterministic, in the sense that, even given a complete knowledge of the state of the system, only statistical predictions can be done on its successive behavior. However, often one says that a living organism should behave in a classical way, being made of a very large number of atoms or molecules.

A second matter that is often mentioned is the result of retarded awareness experiments, starting from the Benjamin Libet experiments and their successive developments. It is claimed that such experiments would show that all our actions start in an unconscious way.

In the following pages we shall be back to both questions.

But there is a last topic about free will that we want to raise and which is almost completely ignored today; it is its role in the process of knowledge. All our culture, even philosophical culture, considers free will as the free energy through which human beings act in order to accomplish a purpose, a decision, a judgement, a discovery that human reason has acknowledged. As we will see through an experiential analysis free will intervenes and determines and influences in a very relevant way the process of knowledge; it is essential for a true understanding.

The plan of the paper is the following. In Sections 2 and 3 we recall some basic notions on neurons, their properties, the nature and transmission of the nervous signals, the structure of the central nervous system. In Section 4 we confront the physical aspects of the cerebral processes and the nature of the subjective perceptions related to them. In Section 5 we discuss Liebt's experiments on retarded awareness; in Section 6 the role of Quantum Theory in the understanding of the cerebral processes and in what sense we can talk of a complementarity of the point of view of Physics and of Introspection; in Section 7 the implications of feeling and free will in knowledge. Finally in Section 8 we summarize our point of view.

2. Physics and Physiology of the Nervous Cells

Obviously living organisms are made of the same particles, atoms and molecules that build the inanimate world. So there is no doubt that all the processes that occur in them have to be described in terms of the same Physics. In particular this must be true for the processes that occur in our nervous system and in our brain, so it is natural that our entire psychic activity, our perceptions, our acts of will have always a physical counterpart.

As is well-known, our nervous system is made of active cells, *neurons*, and other cells, the *glial cells*, whose function of support and nutrition for the preceding ones, however, is not completely understood. Neurons are made of a *central body* of different shapes that contains the nucleus and pushes out in irregular filaments, *dendrites*, aimed at increasing the cell surface. A single regular and larger filament, *axon*, leaves the central body. This can be very long (it can

even reach one meter in length in some case) and it branches out in its end part by making contacts with various other cells. Often an axon is surrounded by white matter, *myelin*, an insulator layer made by other cells (*oligodendrocites*), which wraps around the axon in many spirals. This layer breaks at intervals, leaving short uncovered gaps, *nodes of Ranvier*, essential for the propagation of *action potentials*. The axon branches end with bulges in the shape of buttons on the surface of the dendrites or on the central body of another neuron, on the membrane of an endocrine cell or in the form of an *endplate* over a muscle fiber. These buttons or end plates are generally not in direct contact with the membrane of the *target cell*, but they are separated by gaps filled with liquid of about 20 thousand micron, *synapses*.

A neuron is essentially aimed at transmitting and receiving signals. Inside the single neuron such transmission is of electric nature. Between one cell and another, through synapses, it is of chemical type. A signal from a sensorial receptor or coming from another neuron, is received through one of the synapses present on the dendrites, propagates along the axon and hits successive cells through the later terminal synapses.

From the electric point of view (Hille, 2001), in rest conditions the cell interior is polarized negatively relatively to the external liquid. Such polarization results from the combined action of an *active transport* and a passive migration of ions through the cell membrane. Cellular membrane is built by a double layer of molecules of *phospholipids*, with the polar heads (phosphoric groups) towards the two surfaces. Such membrane is impervious to ions and to the big polar molecules. Their transport through the membrane is controlled by complex protein molecules (made by the aggregation of three, four or more, simpler unities). These are inserted in the thickness of the membrane and cross it completely. Some of them are structured as selective channels, which enable the transfer of only specific ions. They can be permanently open or equipped with a gate mechanism. Others act as actual carrier devices, which work at the expense of energy released by the decay of an ATP (*adenine-triphosphate*) in an ADP molecule (*adenine-diphosphate*).[2] In a neuron such structures are spread on the entire surface of the dendrites, on the central body and along the axon on the nodes of Ranvier.

The settling of *membrane potential* (the difference of potential between the inside and the outside of a cell) is the consequence of the concomitant action of *potassium channels* which allow a free flux of K^+ ions from the inside to the outside of the cell and of the *sodium-potassium carriers*. The latter are molecules that have receptor sites for Na^+ and K^+ ions. In its normal conformation this kind of molecule is open toward the inside and leave exposed the receptors for

[2]ATP is a typical molecule used by the biological systems to stock energy ready to be used. It is made by an organic radical, *adenosine*, constituted in turn by a nitrous basis, *adenine*, a sugar, *ribose*, and three phosphoric groups bound together in a chain with elimination of water molecules. It is an *endothermic* compound kept by appropriate potential barriers. By dividing for hydrolysis in one molecule of phosphoric acid and one of ADP, the ATP molecule releases an energy of 0.32 eV (electronvolts).

the Na^+ ions that tend to bind on such sites, while the K^+ receptors remain covered. Statistically this molecule can take a phosphoric group and the corresponding energy from an ATP molecule present in the cytoplasm. When this happens it goes to an excited state and tends to change conformation, opening toward the outside, releasing the Na^+ ions and exposing the K^+ receptors binding the latter type of ions. At this point it again changes conformation, opens again toward inside and releases the phosphoric group and the K^+ ions, assuming again the original conformation. The net result of all this process is that every three Na^+ ions brought outside, two K^+ ions are brought inside. This is how an outside excess of Na^+ and an inside excess of K^+ are generated, but with an unbalance of positive electric charges toward the outside. Due to the difference of concentration the K^+ ions tend to reflow toward outside trough their proper channels, which on the contrary do not allow the Na^+ ions to reflow toward the inside. The K^+ flux carries on until an equilibrium is reached, according to Boltzmann law, with the electric field created by the excess of positive charges in the outside of the membrane. This situation is reached for an inside potential of about −70 to −90 mV (millivolts) in nearly all animal cells.

In the membranes of neurons, muscular fibers and other types of cells, *electro sensitive sodium channels* are present together with the potassium channels. Such electro-sensitive channels are normally closed. However if by any means one produces an electric depolarization, larger than a sharp threshold (about 15 mV), on the surface on a dendrite or on the body of a neuron, those next to it tend to open, allowing a flux of Na^+ toward inside and producing in the nearby a pick of depolarization. Then, in a few milliseconds they close again and pass to an inactive state, allowing the sodium-potassium carriers to reestablish the rest situation. The process is helped by electro-sensitive potassium channel which also opens with a certain delay and keeps open until the depolarization ends. The brief pulse of depolarization produced in this way (*action potential*) transmits to the nearby membrane and propagates along the axon with a very large velocity, which can reach even 100 m/s and arrives eventually to the synaptic buttons.

In the postsynaptic surfaces of the cells reached by the branches of the axon, *chemical sensitive channels* are present. The arrival of an action potential to the synaptic buttons produce in these a release of appropriate substances present inside the buttons (*neuro-transmitters*) in the inter-synaptic space. These substances are enclosed in vesicles which open toward the outside of the cell under the intermediate action of electro-sensitive calcium channels. Neuro-transmitter molecules can be captured on appropriate ligand receptors present in the exterior structure of the chemical sensitive channels, the latter then tend to open, allowing a reflux of positive ions and producing a depolarization in the adjacent membrane. In this way in a neuron chain signal transmits electrically along a neuron and chemically to a successive neuron, to a muscular fiber or to a cell of an endocrine gland. Among the most used neuro-transmitters substances there is *glutamic acid* in the *central nervous system*, *acetylcholine* in the *peripheral*

nervous *system* and in the transmission to a muscular fiber and *adrenaline* particularly in the *autonomous nervous system*. The transmission time of a signal through a synapsis is about 1 ms.

Beside the neurons whose axons make *excitatory synapses*, there are other neurons that make *inhibitory synapses* and use other substances as neuro-transmitters (typically *GABA*, *gamma-aminobutyric acid*). No neuron can make both types of synapsis, but can receive both. In the inhibitory synapses the chemical-sensitive channels set in the postsynaptic membrane allow only the passage of negative ions (like chlorine ions, CI^-) and their opening has the effect of *hyperpolarizing* this membrane blocking or possibly reducing the effect of signals coming through excitatory synapses. On the surface of a single neuron a very large number of synapses (from 1000 to 10,000) is present coming from other neurons. Some of them may be excitatory, others inhibitory. Therefore a cell receives conflicting signals. So it is not a simple transmitter, but it may have an actual integration function.

Furthermore there are other types of neurons, *pacemaker neurons*, that, continuously, or in bursts when activated, emit rhythmic signals with frequencies from few Hertz (one pulse per second) to about 40 Hertz. This mechanism is essentially the result of the combined action of calcium electro-sensitive channels (similar to the sodium one but with a much longer response time, of the order of fraction of second) which open as a consequence of a depolarization and other types of channels permeable to some positive ions (I_v channels permeable to Na^+ and K^+ ions and K_{ir} channels permeable to K^+ alone) that open under the effect of an hyperpolarization. Pacemaker cardiac neurons are of this type, but even others occurring particularly in the thalamus and in the hippocampus, which seem to play an important role in the conscious states and in establishing memory.

Contrary to the idea of physical determinism, we must stress that the events we have described, specifically the opening of channels, typically involve conformation changes of single molecules and are therefore governed by the Quantum Mechanics laws and are not of a deterministic kind. In particular the depolarization of the membrane in which an electro-sensitive channel is inserted, or the capture of a molecule of neuro-transmitter by a chemically-sensitive channel, only elicits an increasing probability that the channel will open. The same can be said, due also to its sharp threshold, of the starting of an action potential, which strictly follows a yes or no rule. That is why above several times we have used the term "it tends".

3. Structure of Our Nervous System

Let us consider the structure of the nervous system on the whole. This is constituted by the *receptors* of the sense organs, the *peripheral nervous system*, the *central nervous system* and the *autonomous nervous system*. The sensory receptors convert various types of external or internal stimuli to nervous impulses. The peripheral nervous system carries the signals elicited by the receptors to the

central nervous system and the responses elaborated by the latter to the *effector* organs, muscles (in particular voluntary skeletal muscles) and glands. The central nervous system is the place of the response elaboration and memory conservation. It is constituted by an axial cylindrical part enclosed in the vertebral column, the *spinal cord*, and by the brain or *encephalon*, which in turn consists of the *encephalic trunk* with the *cerebellum* annexed and the *cerebrum* (or *telencephalon*).

The cerebrum is divided in two hemispheres connected by a bundle of fibers that makes the *corpus callosum*. Every hemisphere consists in a *cerebral cortex*, grayish in color, which in humans is about 3 mm thick, divided in various layers or *strata* and in an internal white part. The bodies of the majority of the neurons which make up the organ are located in the cortex. They are organized in columnar structures perpendicular to the surface, which are functioning unities. The internal part of the cerebrum mainly consists in the axons (with their myelin protection) that leave from or arrive in the cortex cells and connect the columnar structures in various ways. Furthermore, at the bottom of the cerebrum there are some important structures among which the *thalamus*, the *hypothalamus*, the *hippocampus*, which have important functions in linking the sensorial receptors and in controlling the connections among the various areas of the cortex.

The autonomous nervous system has regulation and control functions of the internal organs, but it never reaches the level of consciousness and therefore is of minor interest for our problem.

The peripheral nervous neurons can be distinguished in *afferent* neurons, which transmit signals to the central nervous system from the sensorial receptors, and *efferent* neurons, connecting the nervous central system to effector organs. Their axons are gathered in bundles that constitute the nerves. The afferent neurons project their signals through some intermediate structures, among which the thalamus in the majority of the cases, into primary specific areas of the cortex. There are a *primary somatic-sensorial area*, a *primary visual area*, a *primary auditory area*, etc. Different parts of these areas are connected to the various types of tactile receptors located in various parts of our body, light receptors located in the retina and sensitive to the various color, auditory receptors in resonance with the different musical notes. The muscles are controlled by efferent nerves that leave from the *primary motor areas*, located on everyone hemisphere immediately ahead the so called central sulcus or Roland sulcus, and different regions are connected with the muscles in the different parts of the body. The signals coming from these areas are just what produce and regulate the muscle contractions.

On the whole, the various sensory and motor areas occupy 5% of the cortex, the remainder constitutes the so called *associative areas* and is devolved to a synthesis function, an elaboration of the responses and the conservation of memory. The sensory and the motor areas are connected to the latter in a complex way; partly through bottom structures, typically the hypothalamus, which,

among other things carries out a filter function. There are various type of memory, a short time memory or *working memory*, which is located in the hippocampus, and a long time memory; a *declarative memory*, which can be recalled at the level of consciousness, a *procedural memory*, which, after a training period, intervenes largely in an unconscious way in the regulation of movements, in the recognition of an image or of a sound. The long time memory consists in neuron circuits which are built by reinforcing certain synapses and excluding other ones, it would seem under the action of the hippocampus in the case of the declarative memory, of other structures in the case of the procedural memory. The location of the latter seems to be in the corresponding specific areas themselves. The recalling of a memory, when it is necessary, corresponds to the activation of one or more such circuities; a working memory is rebuilt guiding the action in development.

A large part of actions and reactions of our nervous system develop in an automatic and unconscious way. It would seem that the level of consciousness is reached with the simultaneous activation of all the areas of our cortex involved in each specific sensation or action, guided by the *gamma waves*, 40 Hertz frequency signals emitted by pacemaker cells of the thalamus. A complex mechanism of inhibition and counter-inhibition should be at the basis of shifting our attention, with the activation of certain areas and deactivation of others.

Due to the complexity of our central nervous system it is not generally possible to follow how a certain excitation pattern develops in detail, how the information coming from the sensorial receptors is elaborated and how finally the signals to the effector muscles are produced. By the present means so far, however, enormous progresses have been made in understanding the role and the function of the various cerebral structures and in identifying the various circuits.

4. Physics of the Cerebral Processes and Subjective Perceptions

Even if very many problems still remain unsolved, as we have already said, it should be clear from the preceding brief notes, all our behaviors and conscious or unconscious activities appear related to physical processes which occur in our nervous system. However the description of such processes is given in terms of ions distributions and fluxes, electric signal propagation, changes in molecule conformations. There is nothing that could make reference to the appearing of awareness, to our subjective perceptions and much less so to our personal identity. There is nothing in the physical description that can explain our way of perceiving light, forms, colors, heat and cold, musical notes etc.; in a word the so called *qualia*.

As regards, for instance, think of our perception of colors. Our eye can be viewed as a system of lenses that projects the image of an object upon our retina. There are various types of receptors on the retina, *rods*, which are at the basis of our black and white vision, and three types of *cones*, related to our perception of colors containing three different pigments that absorb light in three different re-

gions of the visible spectrum, around the red, the yellow and the blue wave lengths. These receptors are in contact with neurons that project their signals into different cells of the primary visual cortex, located in the occipital region. At the level of this cortex the image of the object is broken up in different aspects of vision. We know for certain that at least four features are sent to other specific cortex areas: colors, forms, movements of objects, field dept. Then specific maps are re-elaborated and projected in various ways into other cortex areas and particularly into frontal cortex areas. We do not yet know for certain haw the final synthesis is attained. It is assumed that there is no last synthesis area, but that this is the result of the connections of the various cortical areas. It should be the simultaneous activation of all these areas, under the action of specific thalamus nuclei, which brings about our conscious perception and offers us a unitary scene, with all its forms and colors and rich in details our vision shows every time.

However, we know that there are people with visual defects, *daltonians*, who do not distinguish some colors from others, *color blinds*, who do not perceive colors at all (they can see only black and white vision). These people miss one or more species of cones. Obviously nothing can remedy to the lack of a direct experience of them and no description of the physical processes related to vision of the kind we have attempt can be able to communicate our perception of the color or colors lacking. Our subjective perceptions, the very consciousness of ourselves appear incommensurable with the description of the physical processes that occur and, consequently, cannot simply be reduced to them. The association itself of our conscious experiences with the activation of certain cerebral structures rather that with others can be achieved only questioning the person.

So the already mentioned Benjamin Libet writes (Libet, 2004):

"*In fact, conscious mental phenomena are not reducible or explicable by knowledge of nerve cell activities. You could look into the brain and see nerve cell interconnections and neural messages popping about in immense profusion. But you would not observe any conscious mental subjective phenomena. Only a report by the individual who is experiencing such phenomena could tell you about them*."

Physics corresponds to a particular visual angle from which we look at reality. Due to a fundamental choice of method, Physics keeps subjectivity out of its consideration. Subjectivity is necessarily presupposed, but it is put between brackets, so to say, and we cannot expect to find it again in its framework, if not at the price of circularities and serious contradictions.

Galileo himself had postulated a restriction to considering what were later called *primary qualities* alone, that is the *measurable* and *quantifiable* aspects of objects. These were considered actual properties of the objects compared to *secondary qualities*, related to *subjectivity perceptions* and therefore rather to a relationship of the object with the subject. In Physics all quantities have to be defined in an *operative* way, all conventions must be explicitly stated and a *mathematical language* must be adopted. *Efficient causes* alone are considered ex-

planation elements, while any reference to *final causes* is excluded as considered typical of intentionality and intelligence. A *hypothetical deductive* method is assumed, models and theories must be *empirically verifiable* and are justified according to their *explicative* and *predictive* power.

These are the constitutive choices that make Physics a *public* science, whose theoretical conclusions can be verified by anyone with the necessary mathematical competence and which control experiments should be *always repeatable* on principle. It is a science whose statements are somehow incontrovertible, at least in specific frameworks. These are the reasons for its great success, but also those that define its limits.

Naturally, as we said, Physics presupposes subjectivity. To state its method, introduce its concepts, stipulate its linguistic conventions, establish its control protocols, it *necessarily has to make reference* to a previous language and this can be only the *natural language*. It has therefore to refer to a set of concepts whose roots are in our *primary experiences*, which cannot even be communicated, but that everybody has to *experience personally*. Fundamental concepts, like *to be*, *to feel*, *to understand*, the concept of *truth*, the concept of *implication*, but even more specific experiences, like perception of event in progress, object in space, light, sound, heat, are of this type and are all at the basis of important *preconceptions*. Every attempt to forget this circumstance brings to *aporias* and circularities. In this connection, the discussion may be interesting about the role of language in the development of cognitions given in Perlovsky (2012), in the perspective of Free Will and Cognitive Science and references therein.

In the development of Physics, preconceptions and subjective experience are necessarily taken as a basis for successive operative definitions, but then, as we said, they are put between brackets. As a result a physical theory necessarily knows only the *third person*, there is no place in it for a *first person*. From the point of view of Physics we are simply *impersonal automats*. I experience my body as *my body*, you your body as *your body*, but there is no place in physics for concepts as *my*, *your*, *his*, *her*. Our *personal identity* itself has nothing to do with concepts of a physical nature. As we said, experiences like those of *qualia*, of *consciousness of ourselves*, *our personal identity*, cannot even be expressed in the language of Physics. Every one of us feels himself as something absolutely unique, unrepeatable, individual. Through our life and the changes that can affect our body, we have the perception of remaining always ourselves; even if all our memories were erased, we would feel to be always *us* to feel a pain, a pleasure, any sensation. Each one of us was born at a particular time of History, in a particular place and from particular parents, but why *that particular person is me*? There is no answer in Physics. All this has no sense for Physics and in Physics even the concept of the individuality of a system, of a structure, is extremely weakened.

At the most fundamental level, present Physics does not put the concept of *particle* but the concept of *field*, of *quantum field*. A field is thought as an entity distributed in the entire space. Reality is conceived as a system of fields and the

state of minimum energy of this system stands for absence of matter (*vacuum state*). Occurrence of matter, of a particle or of a structure is depicted as a specific excited state of such fields. Such excitations are localized within the limits allowed by the Heisenberg incertitude principle and differ for the particular state of excitation of the various fields involved. One can recognize some individuality to two different structures as long as they differ for their localization and type of excitation, and they maintain it until they remain separated and change in a continuous manner, but they lose it completely as soon as they overlap. A system of two electrons is something different from twice an electron, and this circumstance has very important consequences even on the properties of the macroscopic matter as we know it.

In the face of these circumstances, a *reductionist* can go as far as denying that terms as consciousness, awareness, consciousness of one have a meaning. Referring to Hofstater's passage we cited, there is an obvious attempt to replace the term consciousness, which is indefinable and refers to a fundamental experience of ours, with an operative definition, the only viable one in Physics. However this definition cannot gather the essential meaning of awareness and could perfectly be applicable to so many automatic systems that nobody would dream of considering conscious. The concept itself of self has been questioned, by referring in some way to David Hume's conceptions. Between '800 and '900, for instance, Ernst Mach so wrote in his book "*The analysis of sensations and the relation between the physical and psychical reality*"[3]:

"*So the world for us does not consist in mysterious essences which, by interacting with another essence, just as mysterious, myself, generate the "sensations" which alone are accessible to us.* […] *First of all, relatively more lasting* (*functionally*) *coordinate complexes of colors, sounds, pressures, etc. stand out in space and time; just for this reason such complexes assume specific names and are denoted as bodies, but they are not at all, absolutely persistent* […]. *Furthermore, there is a complex of memories, dispositions, relatively persistent and related to a specific body, denoted as me.*"

So terms like *I* or *me* would be terms that simply denote a complex of "memories, dispositions, feelings,…". Terms of this type however have no meaning without the subject of those experiences. The *aporias* of Mach's conceptions are evident. The point is that the *secondary qualities cannot be ignored*, even if for a methodologic choice, they are left out of the context of Physics and of the majority of the other experimental sciences. Obviously, Psichology and Neurology must refer necessarily to secondary qualities, as they try to relate cerebral processes to conscious perceptions. However, the fact itself that this could be achieved only by questioning the person, shows the irreducibility of the latter to

[3]E. Mach can be considered one of the precursors of the neo-positivist trend. He is well known above all for an historic critic study on Newtonian Mechanics and for the formulation of an *equivalence principle* between gravitational forces and inertial forces by which Einstein was inspired for his General Relativity Theory. In the context of his conception of Science, however, Mach did never want acknowledge Relativity Theory either the reality of atoms.

the first. Obviously, the point of view of *introspection* must be considered *complementary* to the point of view of the external sense on which Physics is based. This was very much the position of e.g. Niels Bohr, the father of modern Atomic Physics and in a way of Quantum Mechanics. Our inner world, the world of our thoughts, of our sensations, of our feelings, cannot be reduced to the inanimate world, whatever its connection with our physical being. And yet it is as real as the *physical* one and it is the most important for us, as already Ludwig Wittgenstein acknowledged in a comment on his famous *Tractatus logico-philosophicus* sent to the editor.

As regards to the problem of free will, it should be clear that, if our subjectivity cannot be reduced to understanding the processes that occur in our nervous system, the matter vanishes of physical determinism against our possibility of a free choice, and the possibility of an action of our mind on our physical being has to be accepted. This has to be true independently of any attempt to understand how Physics and subjectivity could be put together at a more fundamental level. In any way, however, to the latter, one has to remember that living systems have to be viewed as *mesoscopic* rather than macroscopic systems on the level of their inner constitution, and reference to Quantum Theory is essential to treat the processes which occur in them.

5. Libet's Experiments on Retarded Awareness

Libet's results are essentially of two different types: delay in the conscious perception of a sensorial stimulus and delay in becoming conscious even of a seemingly voluntary action.

In the first type of experiments, it was verified that an electric impulse applied to any point of the skin was perceived with a 0.5 sec delay if with intensity above a certain minimal threshold. A similar single stimulus did not produce any sensation, if directly applied to the corresponding surface of the somatic-sensorial area, even if of a much higher intensity than the threshold value. On the contrary an impulse chain with a frequency of 20 Hertz, was perceived as coming from the corresponding skin area, only if its length was of at least 0.5 sec, otherwise it was not perceived at all. Such results seem to indicate that about 0.5 sec is necessary for the cerebral processes corresponding to the activation of consciousness to develop. It is clear particularly and it is in a sense according to our daily experience, that a similar delay must occur when a sudden stimulus produces a reaction conditioned by our procedural memory, as for instance in the case of a sudden obstacle occurring when we are driving. The activation of the reaction command in the cortex *occurs before* we become conscious of the problem. However, after becoming conscious and before executing the command, that is before the actual contraction of the appropriate muscles, there is a brief time interval (about 0.15 sec), during which we can exercise a *veto* and stop or direct the action in a different way.

In the second set of experiments the person was required to make a move-

ment with a finger or bending his/hers wrist at chance and to read at what time this occurred on an appropriate chronometer[4]. Correspondingly the beginning of the cortex activation was registered by a contact set in the appropriate position on the head surface. Once again a delay of 0.5 sec was found between the cortex activation and the time indicated by the person, but again he could intervene with a veto before the movement was actually performed. This would seem to show that the initial command was independent of displaying consciousness even in this case and therefore it were the cause rather than the consequence of the act of volition.

Clearly the first type of experiment has no relation with *free will*, the second could appear to contradict it. Against such a conclusion Libet appeals to the possibility of a veto. The initial stimulus would start quite independently of our will; however by the power of veto we could later direct it. Actually the second type of results seem very different from the first. In the first case we have an automatic response determined by training and according to a preset program, contained in the procedural memory, as it happens even in other reactions that do not even reach the level of consciousness. One could think of muscular contractions which are necessary to walk, to ride a bicycle, drive a car. In the second case the choice of the time of the movement is left to the person and should be different for each event. To deny a role to the person will even to the origin of the process would amount to do not give any reason for the choice of a moment rather than another. The most obvious interpretation would seem to be that 0.5 sec. is actually the time necessary to activate the various processes necessary to shift the attention of the subject from the choice of lifting his finger to reading the chronometer, in line this with the Crick idea of a *search light* that moves on the cortex. Such time is reasonably just as the time necessary to activate a conscious sensation. Another possibility could be that the delay is the time between the viewing the light spot on the screen and the awareness of the vision, which again we know to be 0.5 sec. A third line of explanation could be that consciousness and free will are active in "being ready" for the motoric decision. When decision is taken, automatic, unconscious, fast stimulus starts and the person become aware of the movement with the usual 0.5 sec delay.

6. Quantum Theory and Cerebral Processes

Let us come back to the importance of Quantum Theory for describing cerebral processes.

As we said, the activation of an action potential in a single neuron involves processes on the molecular level and cannot generally be of a deterministic type. This circumstance would be disastrous in transmitting signals from motor areas to muscles or from sensorial receptors to the corresponding cortices. In such cases, however, Nature remedies by a multiplication of the contacts. The *neural*

[4]This consisted in a luminous spot moving on a circle on the screen of a cathodic tube at the velocity of 1 rotation every 2.56 seconds.

plates, by which the moto-neuron axons establish contacts with the muscular fibers, are equivalent to a hundred synapses and make practically certain the response of the fibers. Neurons of the IV stratum of the cortex, to which the signals arrive from the sensorial receptors carried by the afferent neurons, establish contacts with the neurons of the adjacent layers by means of cartridge structures, which consist in clusters of synapses placed on the apical dendrite of the target cell. On the contrary quantum indetermination is likely to play an important role in the response of the associative cortex.

As already pointed out by Henry Poincaré (referring originally to the so called three body system) a characteristic of the complex systems is to be extremely sensitive to initial conditions. This means that a very small modification can bring about completely different developments. In this situation one can expect that quantum indetermination in the response of the single neurons could emerge at the level of their collective behavior. In other words if, taking a similar attitude to that of Laplace, we imagined to know the state of the brain in all details at a certain time (as is implicated by the signals which arrive to primary cortices from the various internal and external receptors, by its memory assets and by the general condition of the body) and if we could solve the extremely complicated corresponding Schrödinger equation, we should not expect a unique response, but the possibility of a plurality of responses each with a specific probability significantly smaller than 1.

On the basis of this observation some scientists, like the theoretical physicist Henry Stapp, have tried to relate our mind's physical action to the quantum mechanical axiom of the *wave function reduction*.

One of the most anti-intuitive aspects of Quantum Theory is the principle of superposition of states. If the system is in a superposition of states (represented by certain wave functions), each corresponding to one of the different admitted values of a certain observable quantity, it is not possible to attribute without contradiction a definite value to the quantity independently of an actual observation. This is due to the occurrence of the interference terms, which in turn are a consequence of the fact that the probabilities depend on the square of the wave function, while the wave functions compose linearly. The experimenter has the possibility to choose among different types of observation corresponding to different ways of decomposing the wave function and therefore generally incompatible. Of this type there is what we can call the observation of the position or of the momentum of a particle. The operator can choose the question to ask nature and the time to ask the question. Once that a specific observation has been made and one of the possible results has been obtained, however, the wave function has to be redefined and matched to the function corresponding to the value found (*wave function reduction*)[5] Therefore it is clear that the wave function cannot have a physical meaning in itself but it has to be considered a mathematical tool to calculate the probability that an experiment can give a certain result. As

[5]This comes essentially from a physical continuity requirement, the requirement that an immediate repetition of the observation give the same result.

disconcerting as this aspect of the theory could appear, the theory is at the basis of the all modern Physics and has enabled us to understand the properties of the most elementary components and the collective properties of matter in the most various and exceptional conditions. Its predictions turned out to be always correct in the most various situations and with great precision.

The term observation used above, in fact, does not immediately refer to the human observer, it denotes the result recorded by a measurement apparatus. That is, it describes the effect that the interaction of the object with the apparatus has produced in the latter. However, since even the apparatus is a physical object, constituted by the same atoms and molecules which build the object observed, it too has to be described according to Quantum Theory at the fundamental level. In principle, therefore, even any statement on the apparatus must refer to a second apparatus observing it. In this way a chain is created that necessarily has to extend to the nervous system of the human observer.

Given such premises, one can understand why the sense and the implications of the theory could be the object of discussions even today and why various attempts at a reformulation have been made. However according to what is today's most consistent interpretation, due to the great mathematician John von Neumann (to make original ideas of Niels Bohr[6] more consistent) and strongly supported by Eugene Wigner[7], it is just becoming aware of a subject (von Neumann, 1932; Bohr, 1928; Wigner, 1971, 1987; Wheeler & Zurek 1983) that allows us to break the chain and produces the reduction of the wave. According to this type of interpretation a reference to a conscious being, thought as extra physical, appears essential.

In this perspective the consciousness would simply seem to take note of the result and so to play only a passive role. However there is an important theorem, which follows from the basic postulates of the theory, according to which a repetition at very closed successive times of the observation of a quantity would freeze the quantity at its initial value. According to Stapp a sensorial stimulus would induce a superposition state in the brain, corresponding to various possible responses of the organ. By focusing on the development of the process, more or less in the long run and at an appropriate time, the mind could stop it carrying out a *veto* function, if it is not desired, or let it free of occurring, by addressing in this way the course of events (Stapp, 1993, 1999).

A more reasonable alternative would seem, however, to attribute to the mind a more explicitly active role in the quantum lack of determinism. The important

[6]Niels Bohr, Nobel Laureate for Physics 1922, is famous for his atomic model and for the introduction of the idea of energetic level. He was the recognized referent for the interpretation of Quantum Mechanics. According to him Q. M. must be understood as a theory that makes forecasts of actual experiments performed on an object, providing specific probabilities for the various possible outcomes. To attribute to a quantity of the object a value independently of an observation has no meaning, as we said. The experimental framework however and the result of the experiment have to be described in classical terms, that is in terms of quantities having a well determined value. The classical language is understood as the language of our experience.

[7]Eugene Wigner is one of the most important theoretical physicist of the last century, Nobel Prizes, he is particularly famous for having set the basis for the study of symmetry in Quantum Theory.

point is that there does not exist a physical cause for the occurrence of one or other among different possible responses. From the point of view of Physics the result is purely casual in every single occurrence and only in a very large number of repetitions of the process, under the same starting conditions, an actual distribution of responses could be attained, which tends to the probability distribution. The proposal of the neurophysiologist John Eccles (Nobel Laureate 1953) is that our mind can act on the associative cortex at the level of the synapses, by modifying the quantum probabilities (Eccles, 1986), addressing the responses in a sense rather that in another and making intentional what would be casual according to Physics.

Eccles's proposal was made in the context of his *dualistic interactionist* interpretation, which is a modern rebooting of Cartesian dualism in a sense. The mind is thought as an entity independent of the body, with which it communicates through the *associative cortex* (Eccles & Popper, 1977).

In the context of Neurology the Cartesian dualism, based on a sharp distinction between "res cogitans" (what thinks) and "res extensa" (what is extended) has been particularly criticized by Antonio Damasio, well known scholar for his studies on the cortical area at the basis of emotions (Damasio 1994). He starts from observing that the possibility itself of a thought appears related to the reaching of a sufficiently complex cerebral development at a very recent stage of biological evolution and, even in the development of the human being, it appears progressively during the growth.

Actually Damasio's criticism applies only to a radical interpretation of Descartes conception and in this sense should not apply to Eccles, according to whom any action of the mind, including thought, would be carried out through the brain[8] In fact even Eccles's proposal, in the specific and very schematic terms in which was originally formulated, naively based on the Heisenberg[9] time-energy uncertainty rule, is rather informal and has been criticized from other points of view. However, at a general level it appears very suggestive under various aspects, and in no way constrained to the schematically dualistic conception in which it has been expressed. It keeps its entire value even in a more unitary conception of the human being, somewhat more in according to Aristotle than to Plato[10]. We should look at what we can call the external sense, on which Physics is based, and the internal sense of introspection as to two different but *complementary* points of view, both essential, each non reducible to the other one, but concerning the same reality. This was in particular the position of Niels Bohr in analogy with the complementarity of the aspects of particle and wave in Quantum Mechanics. In a context of this type the quantum probabilities could

[8]In a sense the proposal of Eccles amounts to conceive the mind as an operator that press the keys of a computer (the brain). The operator cannot do anything without the computer, but the computer is dead without the operator.

[9]Nobel laureate for Physics 1932, he is one of main founders of Quantum Mechanics.

[10]A dualist conception like that of Descartes is not opposed only by materialists, as obvious, but significantly even by the majority of the theologians, somewhat more in the line of St. Thomas of Aquino and so of Aristotle.

be interpreted as expressing the intensity of conditionings. As we said, Physics does not provide a cause for the occurrence of one among the various possible conscious reactions to a set of stimuli, which appear casual from its point of view. From the point of view of introspection, however, the choice appears the result of an intention. Obviously, in this perspective, we must admit that in presence of a conscious being we have a departure from the quantum probability laws. Actually this would be just the sign of its presence and that this should be the case seems completely obvious.

In the above sense Quantum Theory should provide the *logical frame* in which the two points of view of Physics and introspection could better compose.

At this point one could pose another problem. From the point of view of introspection we have experience only of *our own self*, of us as a conscious being. The physical similarity and the possibility of communicating and exchanging experiences with other men, mainly through natural language, convinces us of the existence of other selves. But what we can say about the other superior animals, which have too a complex brain, even if less developed than ours, and that have simpler reactions but even analogous to ours under certain aspects. Descartes managed the difficulty, by denying that the animals had any form of consciousness and stating that they were simply kind of machines. However, if it is true that animals cannot speak and appear lacking in reflected consciousness, they have manifestations too by which they do not appear to be completely determined by instinct and they might seem to be provided by some feeling, as some kind of affection for dogs. The danger of anthropomorphisms is very high in this field, however, if we admit that animals are provided with a true psyche (Aristotle talked of sensitivity without intelligence), we should conclude that not only man but *life* itself cannot be reduced to a purely physical phenomenon, even if this may appear to be against common assumptions. However, this should not imply a kind of vague pan-phsychism, which in our opinion cannot solve anything and particularly cannot solve the problem of personal identity.

7. Free Will, Feelings and Knowledge

Finally, as we told, free will is essentially involved in the process of knowledge. Emotions, affectivity, the values in which we believe are at the basis of the motivation of our research. They could be view as conditioning factors that interfere in our right reasoning, but they cannot be removed. They should be put in their proper place and in this our freedom plays an essential role.

Modernity, from its origins in Italian Humanism and then to its Rationalistic development, exalts the reason for man as a means of grasping reality in its completeness (exhaustiveness of rational knowledge) and according to all its details (analyticity of knowledge).

Such a conception sought the conditions that could provide complete and analytical knowledge, true and objective. From the beginning, this absolutization of the value of reason, based on an abstract idea of reason and not based on hu-

man experience in its concreteness, has felt the feeling, the emotion and therefore the affirmation of value and interest (in the original sense of the word, that is, participation in the being of things) as an interference in the cognitive process, in deploying the use of the reason instrument. The discovery of the scientific method seemed to confirm beyond all doubts the truth of this conception: the reason in order to function correctly must be free from feeling, judgment of value, and interest. Indeed, if this interference is not prevented as much as possible, the knowledge that is generated is false, erroneous, and not objective. This setting obviously is a true one because man is always tempted to manipulate the reality as he pleases. However, this has ended up creating the myth of pure knowledge, without interference of emotion, completely separate from any interest and hence morally superior. Nowadays, it is common practice in scientific publications to enclose and sign documents attesting, at least declaratively, formally, the lack of interest, the "conflict of interests": disclaimer document. Scientific knowledge is still regarded as a process of pure knowledge without interference of emotions, while it is well-known that in the scientific and technical world, in the field of scientific applications, there are huge economic interests and there are significant interferences of power, not only in dictatorial states, but also in our democratic countries.

Therefore, if we start from human experience in its concreteness, as we can see it in the man who acts within the particular situation, we will easily find that reason is inseparable from the unity of the ego. Reason is not conceivable if we want to remain adherent to experience as a faculty separable from the human person with all its physical, psychic and existential characteristics in general. Physical pain, illness, a feeling of anger or disappointment for the misunderstanding of others inexorably affects the way of seeing and judging of the person, the way to use the reason instrument. In fact human knowledge is always determined by the totality of the conditions that characterize the person at a given moment.

This underlining seems to argue for the need to separate reason from all interfering factors, so a way of seeing this is rooted in our culture. Instead, it must be taken into account in its finding of fact, regardless of whether it is a favorable or adverse condition for man's ability to know.

This simple finding that reason is inseparable from the person in all the aspects that make it, introduces us to a fundamental observation about the relationship between reason and sentiment or more globally between reason and affectivity. Any event that penetrates within the person's experience is thus captured by its sensory channels and arrives up to the level of consciousness produces inexorably and mechanically also a reaction, a perturbation of the mood, arouses emotion and feeling. We stress the observation just made: whatever happens in the cognitive horizon of the person produces an inevitable, irresistible reaction, emotional modification, precisely to the extent of that person's human livelihood. We would like to note that the word affection comes from a pas-

sive Latin *afficior* verb, which indicates the repercussion that events bring about in man's conscience: *afficior* means I'm hit by and then I react, I'm moved, struck. Here, the structure of the human person is such that anything that enters the horizon of perception and human knowledge is not recorded coldly and mechanically, as a photographic plate reproduces the scene to which it has been exposed, but causes an affective reaction that little or so much moves the whole person, affects knowledge. The object of knowledge as it is capable to affect, to attract the human reason is a value. Value is the reality known just as it affects the person, reality as "well worth" to be known and experienced. If the person has a narrow mind, the scope of value will be narrower than those who have a great soul and a deeper human sensitivity. The feeling, however, is the inevitable affective reaction resulting in the knowledge of something that crosses or penetrates the horizon of our experience and attracts it. Therefore, the reason in order to know the object has to deal with feeling, with mood, is anyhow affected by these.

At this point a fundamental observation emerges: the more one thing, an object vitally affects the person, the more it will generate an intense affective reaction and will disturb and condition the person and its reason. However, we note that, despite the scientific knowledge being considered as free from the influence of feelings and emotional reactions, which in any case should alter the data obtained from the experiment, especially when we consider the moment of discovery and innovation, researcher wonder and passion are fundamental. Only those who are emotionally involved, with all their own, with all their passion for research, make scientific discoveries, which can then be appreciated in their value and in their objective clarity. "*The ability to be amazed, to wonder at nature as something of a mysterious kind is identified by Einstein as the fundamental characteristic of the scientist*" (Bersanelli & Gargantini, 2003). However, it remains evident that objects determine an affective reaction that is as bigger as they have to do with the interest, happiness, fulfillment, and realization of the person.

But then it would mean that as much as one thing interests me, moves me, I wish it, the less I can know it. The rationalistic and positivistic mentality typical of our world undoubtedly subscribes to this affirmation. According to this conception nature would place man in this paradoxical situation: the more it provokes and raises the interest, the more it precludes the possibility of knowledge and therefore of possession and of realization. For this mentality, the problem of human origin, its destiny, the meaning of the world, the purpose of our life, love for others, the contradiction of pain and death cannot be addressed by rational, scientific knowledge and so they are purely subjective questions, that is, unknowable, that is, fundamentally nonexistent. Before joining such an unreasonable hypothesis, it is worth exploring other possibilities. If, as we have seen, in our existential investigation that starts with the concrete man acting within the world, we come to find that little or so everything that enters our perceptive and

cognitive horizon provokes emotional perturbation in us, is not reasonable, in the name of a preconceived idea (pure and objective knowledge) to eliminate a factor of such importance.

7.1. The Feeling in his Place

As we have already anticipated, feeling, human emotion that makes us astonished at things is not an interfering factor that needs to be eliminated. They are a tool that intensifies attention, extends the cognitive energy of reason, strengthens reason in its attempt to penetrate reality in its entirety. Certainly this function and the implementation of this mode is not automatic, mechanical: as a telescope made to approach distant objects and allow a distinct vision of them unless it is focused it prevents distinct vision, so feelings, affectivity are a tool that must be used reasonably, somehow focused and finely focused, if we want to prevent a reduction, distortion of knowledge. The problem then is not to eliminate sentiment from the cognitive trajectory, but it is to put it in its proper place.

That in order to judge man must be absolutely neutral, namely, absolutely indifferent to the object, abstractly may seem right, but in practice never happens. The concrete man is always the bearer of interests and aspirations and these always interfere with any judgment man faces, whatever object they seek to know. It is a mystification to imagine that the judgment with which reason seeks to attain the truth of the object is more appropriate, dignified, and valid when the state of mind is in perfect ataraxia, in complete indifference.

7.2. Reason and Freedom

So the real problem is to understand what it means to "put the feelings in their proper place".

First of all, it should be emphasized that this is not a scientific issue, nor is it a cognitive one in the strict sense; it is a problem of attitude, in the way of being, the problem of an original position in front of the whole of reality. So let's say the fundamental word to understand the nature of the problem: freedom, is a problem of freedom.

When Pasteur proposed his discovery, that revolutionized and determined the whole Western medicine and allowed the framing and understanding of the pathogenetic mechanisms of the most common diseases of the human race, that is, the discovery of microbes and that life can never be self-generated, but it comes only from the existing life, the last to believe it, that is, to recognize how things were in fact, were the professors of the Sorbonne. Why? Were they less intelligent than ordinary students and people? Of course not! What made it so difficult for them to recognize the value of those unconfutable experiences even for the profane? It would have been a loyalty to them, a passion for the truth, that is to say, the reality they could not invent from day to day. They should have adhered to what Pasteur proposed, even though he upset and defeated all they had been teaching and proposing for years; in the end, they were not faithful to the scien-

tific method which they even rightly asserted in theory, they were not really true scientists in that prejudice prevailed in them.

We are therefore led by experiential analysis to admit that the heart of the human knowledge problem is not in a particular intelligence capacity. The more a value is vital and elementary in its importance to the concrete person, the more nature gives everyone the intelligence enough to know and judge. The center of the problem is really the right position of the subject in front of reality in its entirety.

What is the right position of the human subject in reality? You should want to know what the object of knowledge really is, have an interest in the object for what it really is. It seems trivial, but in fact we too easily are interested in retaining and backing the opinions we already have on the subject. In the field of knowledge, the fundamental factor is to love the truth of the object more than to remain attached to the opinions we already have about it. We need to love the truth more than ourselves. The heart of the human cognitive problem is therefore the ultimate loyalty of the subject to reality.

Freedom, therefore, does not only intervene in the coherence of the implementation of what reason has recognized and judged, it is not a purely moral energy of the implementation of a project conceived without any interference; it intervenes decisively in the cognitive process, determines that ultimate fundamental attitude with which the human subject faces the circumstance in which he lives. This last attitude can be traced back to a single alternative: to be open to the whole of reality, with the eyes gnawed as a child, honestly, recognizing things for what they are, or standing in front of reality defending ourselves, calling the reality of the court's own opinion, imposing upon reality our own mental pattern, ultimately determined by the cultural and social pressure of the situation in which we live.

Finally, let us point out that only one of the two positions is appropriate to reality: every person involved in some scientific research knows that in the face of a set of data offered by a given experiment one can never eliminate those that appear contradictory with most measurements or that seem to contradict the scientific hypothesis on which the experiment was conceived and built. You must have the patience to resume all the details of the experiment, look for random or systematic errors, repeat the experiment several times. So sometimes the discovery that comes up is more important than the scientific hypothesis from which it started. In any other case, the results that are reported are likely to turn us away from the truth and help to increase the general confusion, to distance ourselves from the resolution of the problem.

8. Conclusion

Summarizing, we started from the common experience of a sphere of freedom, even if limited, in our action and from a perception of the singularity of our person; circumstance these that are denied by some trends of Neuro-Scientists,

according to whom the existence itself of a free will would be a pure illusion and our subjectivity an epiphenomenon of cerebral processes which could be fully explained in physical terms. We agree that all of our actions, our thoughts, our sensations, our states of consciousness and unconsciousness, can be correlated to the structure of our central nervous system, to the processes that occur in it and the algorithm by which it proceeds. These are certainly necessary conditions for consciousness but cannot be sufficient. We have observed that a description according the physical laws of the cerebral processes turns out to be incommensurable with our subjective perceptions. No description of the cerebral processes related to the vision will ever be of any use to communicate to a color blind the idea of the colors that he cannot perceive. In particular, no analysis of the cerebral processes in themselves can enable us to foresee when consciousness appears and to put them in relation with our subjective experiences; to do this, as Libet observed, questioning the individual is essential.

We have observed that, for a constitutive methodologic choice Physics has not even the language to state problems such as the problem of consciousness and particularly of consciousness of our personal identity. The language of Physics in itself, to be established, requires the natural language, which is based on our primary, personal experiences, which are in themselves incommunicable, are a necessary premise to the physical concepts and therefore cannot be explained in its context. The materialistic claim of reducing our subjectivity to purely physical fact brings to insuperable aporias, which cannot be overcome and actually is equivalent to completely ignoring an extremely important part of our experience. The points of view both of external and internal sense are necessarily complementary and rationally one cannot disregard the one rather than the other one.

As concerns more specifically the problem of free will and the claim of its denial since incompatible with physical determinism, we observed first that modern Physics is not deterministic and that, in any way, the moment we recognize that subjectivity cannot be reduced to Physics, we must even accept that it conforms to laws that transcend Physics. Then, we have also observed that the essentially quantum nature of the laws regulating the behavior of the single neurons very likely has to emerge at the macroscopic level, due to the complexity itself of our brain, which makes it extremely sensitive to fluctuations in the initial conditions. It seems plausible that, if we were able to calculate the reaction of our brain to external stimuli, given a certain internal state, we would find many possible responses with different specific probabilities. We have seen that just this fact could help better understand the relation between a description of our cerebral processes according to Physics and our subjective perceptions; that what appears casual from the point of view of Physics turns out to be intentional from the point of view of introspection. We have also tried to show, that the results of experiments like those performed by Libet, not only are not in contrast with the existence of a free will, as somebody would imply, but, on the contrary, it would be incomprehensible without it.

Free will is such an essential trait of the human subject that is implicated and determinant in the process of knowledge. Also it is essential for the scientific knowledge as we all know in the field of scientific papers and their loyalty to data.

In conclusion the perception that we have of a freedom to act is deeply inborn in our entire life. As we said, it is implied in the assumption of any behavior codex, in judgments that at any time we express, in any reference to justice. Who wants to deny this freedom, is inescapably forced to live a break between a purely theoretical abstract statement and an attitude in practical life which cannot be avoided. He is essentially forced toward something like a double truth doctrine.

Acknowledgements

It is a great pleasure to thank our colleagues Prof. P.F. Bortignon and Prof. M. Pauri for comments and very stimulating discussions.

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