AutoRicerca

Taking quantum physics and consciousness seriously: what does it mean and what are the consequences?

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Abstract

We present some of the foundational ideas of so-called *hidden-measurement interpretation* of quantum mechanics, whose proposed solution to the measurement problem does not require any *deus ex machina* intervention from an abstract ego, but asks in exchange to accept that our physical reality would be mostly *non-spatial*, and therefore much larger than what we could expect from our ordinary experience of it. We also emphasize that, similarly to quantum mechanics, the data today available from the study of psychic and spiritual phenomena about the consciousness, if taken seriously, require us to accept, as well, the existence of a non-spatial "elsewhere" where the consciousness is able to manifest. In other terms, both quantum physics and consciousness point to the existence of larger realities extending beyond the limits of our spatial theatre. This doesn't mean, however, that they would necessarily be the same realities, as is often assumed due to prejudices rooted in materialism. We also explain how the new research domain called *quantum cognition* has provided a new thought-provoking model for the non-spatial nature of the microscopic entities, in what has been called the *conceptuality interpretation* of quantum mechanics, and how the astonishing hypothesis underlying this interpretation can possibly shed some light also on the nature of those non-ordinary phenomena that we humans are able to experience when in more expanded states of consciousness.

1 Introduction

Nowadays, a bookseller receiving a new book on quantum physics may be in doubt whether to put it on the shelf dedicated to physics, or on that devoted to spirituality. This "dilemma of the bookseller" perfectly illustrates the confusion often existing among laymen, but also among some experts, regarding the fundamental differences of certain fields of inquiry, such as modern physics and spirituality, and more specifically quantum mechanics and the study of consciousness.

Part of this confusion can certainly be considered as the fair price to be paid in the process of creation of a more global and unitary vision of our reality, both inner and outer. On the other hand, it is important not to forget that a non-illusionary process of unification of different disciplines can only be realized if based not so much on the recognition of their similarities, but above all of their differences, as only then it becomes possible to build solid bridges between them, by promoting a vision that is truly interdisciplinary and, whenever possible, 'transdisciplinary'.

The vaguely defined concept of "quantum consciousness," today quite trendy, perfectly exemplifies this difficulty. In fact, although the majority of scientists are convinced that no one understands quantum mechanics and consciousness, this does not seem to prevent their use in combination with the hope that the superposition of two mysteries will produce an explanation. We do not mean by this that quantum physics will be unable to promote a better understanding of the phenomenon of consciousness, and vice versa. However, we are convinced that this "cross-fertilization" will become possible only to the extent that both fields will be taken with due seriousness.

To take quantum physics and consciousness seriously means to fully address the challenges with which they confront us and accept without biases the world-views that follow. Only then it becomes licit to ask whether some of the similarities that are shared by both quantum physics and the manifestation of the consciousness are only apparent, or the expression of a deeper isomorphism. It is the main purpose of the present article to highlight the importance of this methodological approach, and its consequences, in our attempt to construct a more mature vision of reality.

2 Mixing quantum and consciousness

Quantum physics and the *study of consciousness* are undoubtedly two fundamental fields of inquiry. They are fundamental when considered individually, as they study different aspects of our reality, but also when considered in combination. Many researchers still feel that it is not possible to understand quantum physics, or rather the reality that this theory reveals to us, without involving the consciousness and, conversely, that it is not possible to understand the phenomenon of the consciousness without involving, in some way, quantum physics.

To give a typical example, some scientists believe that the central problem of quantum physics, the so-called *measurement problem*, can only be solved by assuming the existence of an extra-physical agent – precisely, the consciousness – that can transform the abstract probabilities into concrete actualities, in what is usually called the *collapse* (or *reduction*) *of the wave function*. This thesis was defended in the past by some famous physicists, such as *John von Neumann* (1932), *Fritz London* and *Edmond Bauer* (1939), *Eugene Wigner* (1961) and more recently, for example, *Henry Stapp* (2011), just to mention some of the best-known names.

Sometimes called the *von Neumann-Wigner interpretation*, this view is often confused (especially by non-experts) with the *Copenhagen interpretation*, and surprisingly it still collects some credit among some physicists and philosophers of science. It also remains the preferred interpretation of many parapsychologists who study the interaction between mind and matter-energy, for example in the so-called phenomenon of *psychokinesis*; see for instance Radin (2012) and Sassoli de Bianchi (2013e).

Conversely, and to make another symbolic example, there are scientists who believe that the central problem in the study of consciousness, the so-called *hard problem*, to use the terminology of philosopher *David Chalmers* (1995), can only be solved by assuming that our brain functions as a pure quantum entity, that is, as a system governed by coherent, non-local and non-computational processes, where the mysterious collapse of the wave function would again play a crucial role in allowing the phenomenon of the consciousness to manifest in the here-and-now of our existence.

There are different models of the hypothesis that the consciousness, understood here also as conscious mental activity, is the product of non-classical processes (in the sense of classical physics). One of the most well-known models is that of the physicist *Roger Penrose* and anesthesiologist *Stuart Hameroff*, called *Orch-OR* (*orchestrated objective reduction*), where one assumes a connection between certain quantum biomolecular processes, taking place in specific structures of the brain (the microtubules) and the alleged structure of space-time below the Planck scale, which would be responsible (according to Penrose's interpretation) for the collapse of the brain wave function (Hameroff & Penrose, 1996).

It is important to note that, contrary to the examples mentioned above, the majority of physicists do not consider that the problems of quantum physics can be solved with a simple *ex machina* intervention on the part of the consciousness. Similarly, most cognitive scientists do not consider that the problems of the consciousness can be solved with a simple *ex machina* intervention of quantum physics, through the hypothesis of the quantum brain. This does not mean, of course, that the understanding of the phenomenon of consciousness cannot shed some light on the nature of physical entities as well, or that the understanding of quantum physics cannot help us understand the working of the human mind (and not only), especially with regard to the structure of the thought and decision-making processes. It means only that scientists are today generally not willing to increase, without due reasons, the number of entities required to explain a phenomenon, in accordance with the famous principle of *Occam's razor* (no more than necessary).

We are in agreement with this line of thought, in the sense that we believe that quantum physics does not require any *ad hoc* intervention of the consciousness to be explained, and that the hypothesis of the quantum brain, as stated above, is not necessary to elucidate the phenomenon of the consciousness. On the other hand, we think it is highly desirable, if not necessary, to take quantum physics and consciousness very seriously, which most scientists today seem to not be willing to do yet.

3 Taking quantum physics seriously

We will start by explaining what we mean by the statement: "taking quantum physics seriously." For this, it is important to remember that in quantum mechanics, as opposed to classical mechanics, the state of an entity can evolve according to two very different modalities. The first modality is a purely *deterministic* one, described by the famous *Schrödinger equation*, which characterizes the processes of change of isolated systems; see Figure 1.

The second modality, absent (or rather, not considered) in classical physics, is a purely *indeterministic* one, described by the so-called *projection postulate*, which characterizes those changes that are produced by the *observational processes*, i.e., by the *measurement processes* (we will use these two terms interchangeably in this article) of the different *physical quantities* associated to a physical entity (also called *observables*); see Figure 2.

Although a measurement process is inherently indeterministic, it is nevertheless possible to calculate with great precision the probabilities of the different possible outcomes, using a particular mathematical formula, known as the *Born rule*. In other words, although it is not possible to predetermine into what the wave function will collapse, the theory nevertheless allows us to determine the probabilities associated with the different possible collapses.

It is worth pointing out that the wave function Ψ has little or nothing to do with a wave propagating through space: it is a mathematical object, belonging to a specific mathematical space, the so-called *Hilbert space*, whose role is to describe the *state* of the physical entity in question, i.e., the *set of its properties*. More appropriately, it should therefore be referred to as the *state vector* (being the Hilbert space a *vector space*), but in this article we will continue to use the more well-known term of "wave function."

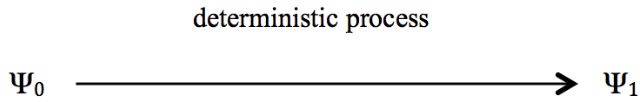

Figure 1 A process is called *deterministic* if it is the expression of a context that changes the initial state Ψ_0 of a system into a single possible final state Ψ_1, which in principle is predictable in advance.

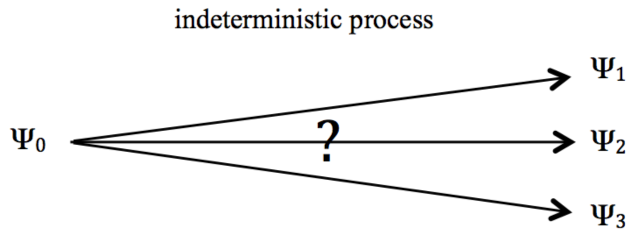

Figure 2 A process is called *indeterministic* if it is the expression of a context that changes the initial state Ψ_0 of a system into one of several possible states, for example Ψ_1, Ψ_2 and Ψ_3, in a way that is not predictable in advance, not even in principle.

Of course, much more needs to be said to complete the "quantum pie" recipe, which is formed by a number of other key ingredients, but right now let us focus on the purely indeterministic process described by the wave function's collapse. To take quantum physics seriously means, among other things, to take seriously this specific *reduction* process. Namely, to consider the wave function's collapse a perfectly *real physical process* which takes place every time a quantum entity is observed, in the practical sense of the term, that is, whenever a given physical observable, such as the *position observable*, is concretely measured by means of an appropriate measuring instrument.

To consider that a quantum measurement process is a real physical process, means to consider that the state change it produces is an *objective* physical change by which new properties are truly *created*, and others are necessarily *destroyed*. This means that a quantum observational process is not just a *discovery process*, but also in part, a *creation process*. Not only is this because it is able to bring into existence those same properties it is meant to observe, but also because this happens in a way that cannot be predicted in advance by the observer-experimenter, not even in principle, that is to say, in a purely indeterministic way.

The fact that quantum observational processes are indeterministic does not mean, however, that they would be arbitrary. In fact, if you repeat the same measurement process many times, using identical entities always prepared in the same initial state, the obtained statistics of outcomes will necessarily obey the aforementioned Born rule, namely, the *quantum probabilities* that this rule allows one to calculate as a function of the initial state. For this reason, a measurement process, while creating new properties, also allows one to acquire information about the state of the system prior to the measurement, and in this sense, it should also be considered a discovery process.

To take quantum physics seriously is to recognize that a measurement process requires the intervention of the mind (or consciousness) of the observer *only* in two specific moments. The first intervention, of an *active* kind, corresponds to the *choice* of executing a specific observational experiment. Indeed, an observation always involves, upstream, an act of choice: the choice to observe a given property, or physical quantity, rather than another, creating for this a specific experimental context.

The second intervention, of a *passive* kind, is simply to take note of the outcome of the measurement process, once it has been completed, for example, reading the value indicated by a pointer on a dedicated dial, or identifying a luminous spot on a screen detector, or the radius of a trail in a *Wilson chamber*, etc.

The nature of these two interventions is usually well understood and they do not require special explanations. Indeed, it is quite natural to assume that the state of a physical entity, either microscopic or macroscopic, cannot in any way be affected by the investigator's choice to perform a measurement rather than another, or by the fact that once the observation is completed, s/he can take knowledge, or not, of its outcome.

To take quantum physics seriously means to recognize that the collapse of the wave function is a process that takes place *after* the experimenter has chosen which measurement to execute and is completed *before* the experimenter takes (or does not take) note of its result. In other words, it means to recognize that the collapse of the wave function is a process that has its origin in the interaction between the instrument of observation and the observed entity.

Therefore, resisting the temptation to field extra systemic entities such as the consciousness of the experimenter, to take quantum physics seriously means: *to make the cognitive effort of identifying a physical mechanism that can explain how the quantum probabilities can emerge from the interaction between the measuring instrument and the measured entity*. In other words, it comes to building a *model of interaction* sufficiently general and universal from which the famous Born rule can be derived.

4 Objective collapse theories

There are few approaches that, under the assumption that:

(1) the wave function describes the real state of a physical entity, and not our knowledge of its state;
(2) the collapse of the wave function is an objective process of the change of state, and not just a subjective process of the acquisition of knowledge on the part of the experimenter;
(3) the consciousness of the experimenter does not play any causal role in the collapse;

have been able to provide models that can explain what could possibly happen, "behind the scenes," during a quantum measurement process. As far as we know, there are actually only three specific interpretations of quantum physics that include the three conditions mentioned above. Curiously, all three of these interpretations have been "synchronously" reported for the first time in 1985, and all three were subsequently published for the first time in a physics journal in 1986. More specifically, we are referring here to:

(a) the so-called *objective collapse theories*, whose first version (called *GRW theory*) was proposed by the three Italian physicists *Giancarlo Ghirardi*, *Alberto Rimini* and *Tullio Weber* (1985, 1986), of which a gravitational variant was also proposed by *Diósi* (1989) and *Penrose* (1996);
(b) the *transactional interpretation*, proposed by the American physicist *John G. Cramer* (1985, 1986), which in recent times was further elaborated by *Ruth E. Kastner* (2013);
(c) the *hidden-measurement interpretation*, proposed by the Belgian

physicist *Diederik Aerts* (1985, 1986), which has had over the years different degrees of development; see Aerts & Sassoli de Bianchi (2014) for some recent progresses.

Of course, we cannot, in the limited space of this article, explain how these three approaches aim to solve the quantum measurement problem, in what they are similar and in what they are substantially different. We personally believe that the most promising one is the hidden-measurement interpretation, to the development of which the present author has also recently contributed (Sassoli de Bianchi, 2011, 2012a, 2013a–d, 2014, 2015; Aerts & Sassoli de Bianchi, 2014, 2015a–c). In addition to its simplicity and universality, we think that the ideas behind this interpretation constitute a real paradigm shift, able to fertilize many fields of knowledge, and not only that of physics (Aerts & Sassoli de Bianchi, 2015a,b).

In the next section, we will introduce in simple terms the underlying paradigm of the hidden-measurement interpretation, emphasizing what its consequences are for our conception of the physical world. To do this, and avoid unnecessary technicalities, we will make use of a very simple example.

5 The hidden-measurement interpretation

Imagine holding an object in your hands, such as a vase, and that your intention is to measure its *solidity*. To do this, you have to conceive an observational test that will define in operational terms the property of solidity. There are, of course, different possible definitions, but let us assume that after you have consulted with some colleagues, you have arrived at the following consensual definition of solidity: "a vase possesses the property of solidity if, when it is dropped from a height of exactly half a meter, onto a Persian rug, it will not break."

Now that you have defined with precision the property of solidity (of course, you can be much more precise in the description of the experimental protocol, but for our discussion it will be more than enough), you may wonder, contemplating the vase that in this moment is in your hands: *Is it a solid vase, or a non-solid (fragile) one*? According to the *reality criterion* formulated by *Albert Einstein*, *Boris Podolsky* and *Nathan Rosen* (1935) [see also the discussion in (Sassoli de Bianchi, 2011)], to answer this question it is sufficient to be able to *predict with certainty*, in advance, the outcome of the observational test.

For some vases, depending on the material with which they are made, such a prediction is surely possible, in the sense that it is definitely possible to predict in advance, with certainty, what will be the outcome of the test, and therefore establish whether the vase in your hands has the solidity property, or the inverse fragility property. In other words, with some vases the following alternative will be perfectly valid: (a) the vase has the solidity property, or (b) the vase does not have it. To say that the vase has or does not have this property, means that the outcome of the test, whatever it will be, is entirely *predetermined*, and it is precisely because it is predetermined that you can assign the property of solidity, or of fragility, to the vase, even before proceeding with its experimental observation.

However, to believe that any experimental situation would be of this type, i.e., that the outcome of a test would always be predetermined, is nothing but a prejudice, called the *classical prejudice*, which has been largely falsified by quantum physics. But the groundlessness of this prejudice can be evidenced not only in the observation of microscopic entities, but also of macroscopic ones, such as our vase. Indeed, there is no doubt that vases exist, built with specific materials, for which it is impossible to determine in advance the outcome of the solidity test.

To understand the reasons for this impossibility, it is important to recognize that the outcome of the test will depend on, among other things, how the vase is oriented with respect to the ground when it is dropped from the predetermined height of half a meter. So far, nothing strange: the different possible orientations of the vase describe its different possible states; for some of these states (orientations), the vase turns out to be solid, that is, it will not break if dropped, while for others it will prove to be non-solid, that is, it will break if dropped.

Thus, we can say that if the experimenter can perfectly know the state of the vase before dropping it to the floor, that is, its specific orientation, its shape and the material with which it was made, in principle s/he should be able to predict with certainty the outcome of the test, even before running it. In other words, in this case we would still be in the domain of validity of the classical prejudice: given a specific vase, in a specific state, it will be either solid or non-solid (fragile), and there are no other possibilities.

In the technical jargon of quantum physics, the states for which the measurement produces an outcome that is certain in advance, are called *eigenstates*. For the measurement of solidity, since there are only two possible outcomes (the vase breaks, or does not break), there are consequently only two kinds of eigenstates: those that characterize the solidity of the vase and those that characterize its fragility. If we represent these two kinds of states in a *state space*, we would obtain two different regions: one containing the solidity eigenstates, and one containing the fragility eigenstates.

On the other hand, whenever we consider two distinct regions, automatically we also have to consider their border region, which by definition possesses both of the characteristics (or none of the characteristics) of the two regions it separates. When a vase is in a state that belongs to the border region between the region of solidity and the region of fragility, the classic prejudice does not apply anymore, since it is no longer possible to determine in advance the outcome of the observational test. In quantum physics, these particular states are called *superposition states* and describe a dimension of *potentiality*.

We can use the simple example of the vase to try to understand (and partly demystify) the nature of a state of superposition. Imagine that the vase lies in your hands in a solidity eigenstate, that is, oriented in such a way that if you let it fall to the ground, for sure it would not break. From that state, you can change the orientation of the vase (i.e., its state), until you obtain a fragility eigenstate. But in doing so, you will have to cross the border region that separates the solidity states from the fragility states (see Figures 3 and 4).

Imagine then giving the vase an orientation such that its state is precisely in the intermediary region between solidity and fragility. What will happen when you drop it? To answer this, you need to understand that such a state describes a *condition of instability*, with respect to the observational test in question. In fact, the smallest fluctuation produced by your hands, when you drop it, will cause the vase to land either on a breaking point, or on a non-breaking point, and since you are not able to control these infinitesimal fluctuations of your hands (and the experimental protocol requires you to use your hands, and not some other instrument) the outcome will not be predictable for you anymore.

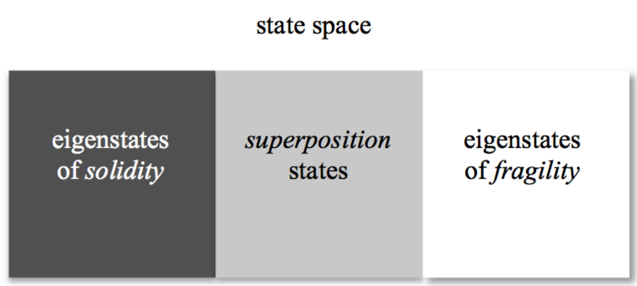

Figure 3 A symbolic representation of the *state space* of the vase-entity. The white region contains the fragility eigenstates, the dark gray region the solidity eigenstates. The in between region, in light gray color, contains the superposition states, for which the outcome of the observational test can no longer be predicted in advance.

It is important to understand the nature of these fluctuations. Each time the experimenter drops a vase the process itself is deterministic, being the result of a specific interaction that occurred between her/his hands and the vase, which is perfectly deterministic. But when the experimenter repeats the experiment with an identical vase, always in the same state, even if s/he tries to proceed in an identical manner, inevitably s/he will drop the vase in an imperceptibly different way. In other words, unconsciously s/he will select (i.e., actualize) a slightly different interaction between her/his hands and the vase.

This difference will have no effect on the outcome of the test if the initial state of the vase lies in the solidity region, or in the fragility region, but the situation is quite different when the initial state of the vase is located in the border region between them. In fact, for these "border states" the smallest variation in the interaction produced by the hands of the experimenter will either cause the vase to break or not to break.

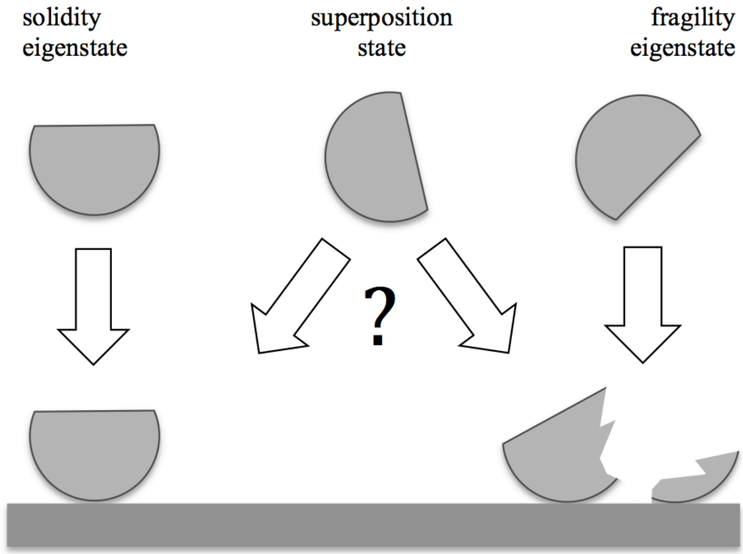

Figure 4 A symbolic representation of the three different kinds of state of the vase, relative to the solidity observational test. A solidity eigenstate corresponds to an orientation of the vase such that, by falling, for sure it will not break; a non-solidity (fragility) eigenstate corresponds to an orientation of the vase that with certainty will cause it to break. A superposition state, between solidity and fragility, corresponds to a critical orientation, such that the smallest fluctuation, when the vase is dropped to the floor, can cause it to either break or not to break.

The attentive reader will have already grasped the profound analogy between the situation described here and what happens during a quantum measurement, for example with elementary microscopic entities. In fact, the observational experiment with the vase reveals an extremely important and universal aspect of a measurement processes: since each measurement process is the result of an interaction between the measured entity and the measuring instrument, and being that this interaction is necessarily subject to fluctuations, each new measurement of a physical quantity will necessarily be a *different measurement*, although externally it may appear identical to the previous ones.

Of course, we repeat it once again for sake of clarity, when the entity is prepared in an eigenstate of the measured observable, i.e., in a state that is *stable* with respect to the mentioned fluctuations, these fluctuations will have no effect on the final outcome of the observation. But when the system is in a state of superposition, that is, of instability with respect to said fluctuations, as infinitesimal as they may be, they will have the capacity to produce outcomes that each time can be different and completely unpredictable.

It should be noted though that a superposition state does not describe a vase that would possess the properties of solidity and fragility, absurdly, at the same time. It is simply a state in which both properties of solidity and fragility are *available to be actualized during an observational experiment*. This means that these two properties are not possessed by the vase in the *actual* sense of the term, but only in a *potential* sense, as they can be created (actualized) by the very process of their observation.

What we are illustrating here, by means of this simple and anecdotal example, is what *Claude Bernard* (the father of scientific physiology) used to call the *absolute principle of the experimental method* (Bernard, 1949), affirming that if an experiment, when repeated many times, gives different results, then the associated experimental conditions must have been different each time.[1]

When confronted with the quantum measurement problem, because of their classical training, physicists were initially brought to assume that what could vary in the experimental conditions was the initial state of the physical entity, and that by taking its variability into account it would be possible to explain the emergence of quantum probabilities. This assumption is quite natural if one thinks that a measurement process should just be a process of discovery of properties pre-existing the act of measurement, and not, possibly also, a process of creation of those same properties that are measured.

The hypothesis that it was the initial state of the system that was not controllable and could therefore fluctuate when a quantum measurement was performed, gave birth to the so-called *hidden-variable theories*, of which *Albert Einstein* was one of the most famous proponents. These theories, however, went out to meet considerable difficulties, expressed by the so-called *no-go theorems* (impossibility proofs, an example of which are the famous *Bell's inequalities*). These theorems have shown unequivocally that the attribution of

[1] This is a reversed, alternative way, to state the *principle of determinism*, affirming that if everything is given in an experiment, then there are no known reasons to think that the result of the experimental process, if properly conducted, wouldn't be predetermined, whatever the outcome will be.

additional variables to the state of the system (called hidden-variables because they are not known and controlled by the experimenter) inevitably leads to the construction of a (so-called *Kolmogorovian*) classical probability model. It is important to note, however, that the *Hilbertian* probabilistic model of quantum physics is very different, from a structural point of view, from a classical probability model (in the same way as, for example, the geometry of the relativistic space-time is structurally very different from the Euclidean geometry).

On the other hand, if the hidden-variables are attributed not to the state of the system, i.e., to its wave function, but rather to the interaction between the measured entity and the measuring system, then the no-go theorems no longer apply, and this explains why the hidden-measurement interpretation is able to not only conceptually explain the nature of a quantum measurement process, but also to mathematically derive, in a non-circular way, the Born rule, which characterizes the probabilistic model of quantum mechanics (Aerts & Sassoli de Bianchi, 2014).

Of course, much more should be added about the effectiveness of the hidden-measurement interpretation, not only in solving the central measurement problem but also in shedding light on many of the mysteries of quantum physics. But doing so would require the space of an entire book, as well as the discussion of many technical details. What we want to stress here is that if we agree to take quantum physics seriously, that is, if we accept the challenge with which this theory confronts us, without seeking an easy way out, we can access new and more advanced explanations about the behavior of the physical entities in relation to the processes we use in order to observe/measure them. These more advanced explanations, in turn, allow us to open much wider windows to the genuinely multidimensional nature of our physical reality.

6 Non-spatiality

In the previous sections we have tried to explain what it means to take quantum physics seriously in relation to its central measurement problem. We have also tried to illustrate, by means of a very simple example, some of the foundational concepts of the hidden-measurement interpretation, whose distinctive characteristic is precisely that of taking full consideration of the collapse of the wave function, explaining it as a perfectly objective physical process resulting from the presence of fluctuations in the interaction between the entity subjected to the measurement and the measuring system.

Among the remarkable consequences of this approach, there is the fact that a quantum measurement process should be generally understood as a process that not only contains aspects of *discovery*, but also aspects of *creation*.[2] However, these processes of creation have nothing to do with the action of a vaguely defined non-physical consciousness through an equally vaguely defined psychophysical mechanism, but are the consequence of the interaction between the macroscopic system corresponding to the measurement apparatus and the (usually microscopic) entity submitted to its action.

By taking seriously the measurement process, the hidden-measurement interpretation takes also very seriously the wave function describing the state of the system. When the wave function of a quantum entity, such as an electron, is in a state of superposition, for example of superposition between two states localized in two separate and distant regions of space, such a state cannot be understood as the description of a condition in which the electron would be simultaneously in two different places (without being present in the intermediate region); nor can it be understood as a state describing a subjective condition of lack of knowledge regarding the actual location of the electron.

As the example of the vase illustrates, an electron in a superposition state of this kind is not present in either of these two places, as it does not possess a specific position in the three-dimensional space; it is just *available to be localized in one of these two regions in the course of an experiment of observation-creation of a position*. In other words, superposition states, here considered in relation to the *position observable*, are to be understood as *non-spatial* states, of pure *potentiality*,

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[2] Measurements maximizing the discovery aspect are the so-called *classical* ones. Those maximizing the creation aspect are called, in a metaphorical sense, *solipsistic*. Quantum measurements realize a sort of optimal equilibrium between these two aspects, which makes them particularly *robust* in statistical terms (Aerts & Sassoli de Bianchi, 2015a,b).

not characterizable by a predetermined localization in the three-dimensional physical space, in the same way the superposition states of the vase are not characterizable by a predetermined condition of solidity or fragility. To quote the words of Diederik Aerts, we are then forced to give evidence to the fact that (Aerts, 1999):

"Reality is not contained within space. Space is a momentaneous crystallization of a theatre for reality where the motions and interactions of the macroscopic material and energetic entities take place. But other entities – like quantum entities for example – "take place" outside space, or – and this would be another way of saying the same thing – within a space that is not the three-dimensional Euclidean space."

Hence, quantum mechanics, if taken seriously, tells us that our physical reality is more extensive, dimensionally speaking, than what we are led to believe based on our ordinary experience, obtained through our physical body and its macroscopic interactions with other macroscopic physical entities. This three-dimensional theater of ours emerges from some underlying "theaters" of much higher dimensionality in which the microscopic entities, when they do not form macroscopic aggregates or interact with other macroscopic entities, reside for most of their existence (see Figure 5).

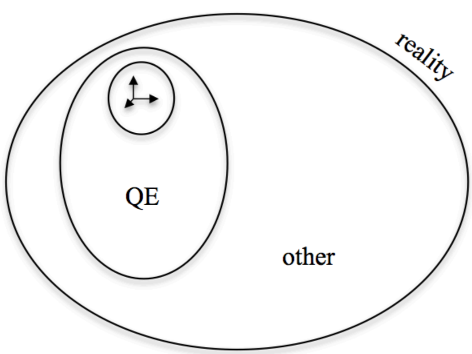

Figure 5 A symbolic representation of our reality (in the form of a Venn diagram), with the three-dimensional physical space (symbolized by the three Cartesian axes) emerging from an ampler non-classical reality, of higher (perhaps infinite) dimensionality, called the *quantum extraphysical* (QE) reality.

To think of the quantum superposition states as just *non-spatial* states remains however a rather approximate description. Indeed, it is possible to define superposition states in relation to any physical observable and not only in relation to the position observable. For example, we can superpose states of different momentum, energy, angular momentum, spin, etc., and all these superpositions continue to describe possible physical conditions that a physical entity is able to be in. Therefore, the term "non-spatial," when referring to a quantum microscopic entity, is to be understood not only in relation to the space of positions, but also in relation to "spaces" of speed, momentum, energy, angular moment, spin, etc.

The existence of (non-spatial) quantum superposition states reveals an unexpected nature of the microscopic quantum entities, in no way comparable to that of the objects of our ordinary intraphysical experience. How can we understand this nature? We will discuss this in the last sections of this article, as for the moment we must deal with the second field of investigation that, from our viewpoint, also needs to be taken more seriously by the international community of researchers: the study of consciousness.

7 Taking consciousness seriously

We now want to explain what we mean by taking seriously the study of consciousness. Of course, as is the case for quantum physics, the study of consciousness is an extremely vast and complex field of investigation, involving a number of questions not only related to the phenomenon of consciousness as such, but also to the functioning of the human mind in general, and its specific relation to the cerebral organ.

Following *Huxley* (1959), we can say that humankind corresponds to that particular stage of evolution when evolution becomes conscious of itself; and of course, when that happens, it starts questioning itself about its nature and condition. In the ambit of the modern study of consciousness, it is usual to consider that the so-called *hard problem* is about explaining the how and why of our subjective experiences, i.e., the ability of humans (and possibly, in different degrees, of other living beings) to be aware of our perceptions and of our very existence.

This is undoubtedly a fundamental issue. Why some *entities* are also *subjects*, that is, entities capable of consciously living their own experiences? Some could argue that the human consciousness is overrated, as our behaviors and thoughts are much more robotic, reactive and predictable than we are usually willing to accept, as emphasized by the Armenian philosopher and mystic *Georges Ivanovič Gurdjieff* (Ouspensky, 1949). On the other hand, regardless of the condition of "consciential sleep" in which we humans, undoubtedly, very often find ourselves, it is true that on some occasions of our life we can affirm, with reasonable certainty, that we are consciously aware of what we are experiencing and feeling at that particular moment, so much so that our awareness can become the trigger of an interrogation, for example about why we do what we do, if it is right to do it, or about why we are not able to do what we would like to do; eventually considering even deeper interrogations about the general sense of our existence and the nature of our inner being; interrogations that some people have the intelligence to then turn into a real theoretico-practical journey of self-research.

Now, the problem of consciousness, understood here as the possibility of explaining the origin of our introspective and conscious perceptive phenomena, as well as of our decision making and thought processes, can be treated either as an ordinary problem, in the sense of a problem which is in principle solvable within the paradigm of our classical spatiotemporal vision of reality, or as a problem of a purely metaphysical nature, totally unsolvable, the difficulty of which would be equal to that of the problem of the existence and characterization of what is commonly indicated by the word "God."

In the first case, we can quote the emblematic example of an author like *Douglas Hofstadter* (2007), according to whom the problem of the definition and understanding of what a consciousness is, that is, what a self-conscious subject is, would reduce, in the final analysis, to the possibility of identifying and characterizing specific *self-referential structures* in our brain. In other words, it would be the existence of specific *loops* in our brain that would confer us the ability of being self-conscious and self-aware.

The purely materialistic vision of Hofstadter, supported by philosophers such as *Daniel Dennett* (2005), can be contrasted by the view of many spiritual traditions of this planet, such as for example that of the *Vedic* doctrines of the *Upanishads*, stating that behind the manifestation of the individual consciousness there would be nothing but the very divine principle (*Brahman*). Therefore, understanding the nature and origin of consciousness would be equivalent to understanding the nature and origin of God, regardless of how we want to understand such an ineffable concept. It follows that the hard problem of consciousness would not be so much a hard problem, but an impossible problem, in the sense that it would be a problem we humans can only solve when (and if), in the ambit of our consciential evolution, we would be able to fully realize our deepest and most hidden nature and the ultimate meaning of our existence.

Without diminishing the importance of the study of consciousness from a purely brain-centric perspective, that is, from the viewpoint of its neural correlates (the so-called *easy problem of consciousness*) and of the possible self-referential structure of some of its circuitry, and without diminishing the importance of a purely philosophico-metaphysical reflection about the nature of being and consciousness, and its relation to that whole (in part manifest and in part unmanifest) associated with the concept of God, it is important to emphasize the possibility and usefulness of adopting an intermediary approach to the problem, a sort of "middle way" between physics and metaphysics: an approach which, from our perspective, is precisely about taking seriously the study of consciousness.

The starting point of this approach is the acknowledgment of the existence of many phenomena related to the manifestation of the consciousness the explanation of which is still highly problematic for those who adopt the limited perspective of *physicalism*, but also for those who, to such a perspective, only oppose a philosophical reflection on the nature of the separation between the sensible and the supersensible, where the latter is understood as a reality that, by definition, cannot be known in our present intraphysical condition.

We are referring here to the so-called *psychic* (or *parapsychic*) *phenomena*, studied in particular by the *parapsychologists*, and sometimes also referred to as paranormal phenomena, or anomalous phenomena. Among these, we may mention the category of so-called *extra-sensory perceptions* (ESP), which includes, for example, *telepathy*, *clairvoyance*, *precognition* and *retrocognition*; the category of *psychokinetic phenomena* (PK), which includes the *actions at a distance* on physical objects and "subtle" *healings*; and finally the cross category of *extracorporeal phenomena*, which includes the *near-death experiences* (NDE), the lucid *out-of-body-experiences* (OBE) and the *cosmoconsciousness* (non-dual) experiences.

These phenomena can be considered to be *extra*ordinary in the sense that it does not seem possible to explain them by remaining within the confines of a purely classical and three-dimensional view of our reality, in the same way as it is not possible to explain the quantum phenomena supposing that everything we observe would only take place in our specific spatial theater.

In other terms, we think that in addition to the easy and hard problems of consciousness (as defined by Chalmers), a *serious problem of consciousness* should also be considered, which is precisely about the identification of *physical and extraphysical models and mechanisms able to explain the parapsychic phenomena related to the manifestation of the consciousness*, the explanation of which remains highly problematic for those who adopt the limited perspective of physicalism.

The problem is "serious" for two reasons: because it is a difficult problem, whose solution will probably require a scientific revolution, and because it demands taking seriously the full spectrum of phenomena related to the manifestation of the consciousness.

8 Telepathy and non-spatiality

Let us consider as an example the phenomenon of *telepathy*. As the reader is probably aware, the evidences about extrasensory perception (ESP) phenomena (as well as psychokinesis) are still considered to be insufficient by the majority of the scientific community. In the sense that it is believed, erroneously from the viewpoint of this writer, that the data so far collected is principally the result of an incorrect evaluation, and therefore not significant enough in stressing the objectivity of the ESPs.

Unfortunately, this is an opinion mostly shared by scholars who generally operate outside this field of investigation, usually possessing very little knowledge about the value of the data that has been collected so far, in more than a century of parapsychological research. In other words, the dominant opinion of the scientific community does not seem to be always the result of a well-documented and reasoned knowledge, but more of a historical prejudice.

There is also a considerable dissonance between what many scientists declare officially, when questioned on this controversial topic, and what they sometimes say in private, about their real beliefs (as the author has been able to ascertain on some occasions). This is because in the academics parapsychism remains a taboo, with the result that the parapsychological research is still today marginalized and the opinion of the true experts called a priori into question.

Being that it is not the purpose of this article to go into the merits of these issues, we refer the interested reader to the many reference texts on the subject, in which enough information can be found about the extent of the laboratory research that has been carried out to date; for example: (Irwin & Watt, 2007; Krippner & Friedman, 2010; Parker & Brusewitz, 2003; Radin, 1997; Vieira, 2002). Particularly useful is the list of references recently selected by *Dean Radin*, which can be downloaded from the website of this researcher, who rightly writes:[3]

"*Commonly repeated critiques about psi, such as 'these phenomena are impossible,' or 'there's no valid scientific evidence,' or 'the results are all due to fraud,' have been soundly rejected for many decades. Such critiques persist due to ignorance of the relevant literature and to entrenched, incorrect beliefs. Legitimate debates today no longer focus on existential questions but on development of adequate theoretical explanations, advancements in methodology, the 'source' of psi, and issues about effect size heterogeneity and robustness of replication.*"

Let us consider the phenomenon of telepathy, which has been corroborated by numerous laboratory experiments and countless anecdotal evidences (personal experiences). It points out the possibility for an individual A, separated and isolated from another individual B, to *mentally connect* with B, in order to transfer some information about a given entity (such as a photo that A may have chosen in a non-predetermined way from a set of photos), so that B can subsequently identify, in a statistically significant way, the received information (for example by recognizing the transmitted picture among the set of photos in question).

This means that, despite the spatial separation and the physical

[3] www.deanradin.com/evidence/evidence.htm.

isolation, that do not allow A and B to communicate via ordinary channels of communication, a "subtle" form of communication takes place between A and B, i.e., a transfer of information through a *non-ordinary communication channel*. Therefore, if we take seriously the experimental data of telepathy, and do not want to renounce explaining them in an intelligible way, we are forced to appeal, similarly to quantum physics, to the notion of *non-spatiality*.

Of course, we might be tempted to speculate that telepathic communication may occur along an ordinary communication channel, of a spatial nature, as is the case with other known forms of communication, and that this channel would simply be associated with fields of force and/or matter-energy which are still unknown to us. Logically speaking, this is obviously a possibility that we cannot completely exclude; however, it faces many difficulties. In fact, if we assume, as is the case in the current dominant scientific paradigm, that a human being is nothing more than a very complex physical object, necessarily it will obey the same laws as every other three-dimensional macroscopic physical entity. Therefore, these hypothetical fields of force and/or matter-energy, carrying the telepathic communication, should have long since been observed in the general study of physical systems.

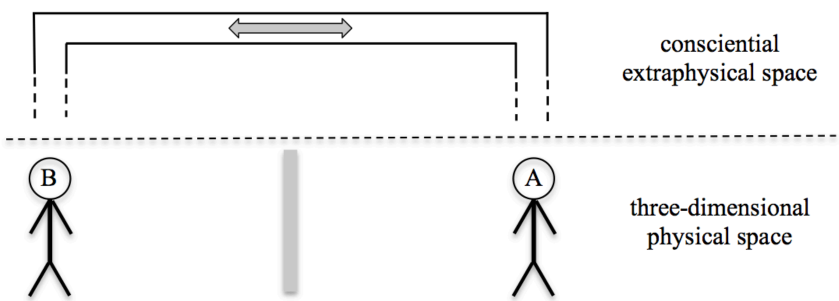

Figure 6 A symbolic representation of the non-spatial (extraphysical) telepathic communication channel, which allows two subjects, A and B, spatially separated and physically isolated, to exchange information.

Naturally, one could argue that these fields would interact in an extremely weak way with the ordinary matter, as is the case for example of the *neutrinos*, associated with the so-called *weak nuclear force*, and that this would explain why they have not yet been detected experimentally. But if so, how can we reconcile the weakness of their interaction with the possibility of a statistically significant telepathic communication?

For example, to capture one neutrino out of two, coming from a source such as the sun, we should have a physical body made of lead 10,000 billion kilometers thick. Therefore, a communication based on the neutrinic field would be infinitely too inefficient to be able to account for the possibility of telepathy, and the same argument applies, *mutatis mutandis*, to those other possible physical fields still unknown to us, having an extremely weak interactivity with ordinary matter, in standard conditions.

It therefore seems rather unlikely that telepathic communication could take place through ordinary channels of communication within our spatial theater. So, if we take seriously the phenomenon of telepathy, the only convincing explanation is that it occurs through a "mental layer" of our reality, of a non-spatial nature, and that this mental layer would be in relation to the mental activity of us humans (and of all other living creatures having mental abilities).

We would like to emphasize that we are not saying here, as one can often read, that human beings would be equipped with an *extended mind*, in the sense of a mind that would act similarly to a *field*, as a field remains a spatial entity, although of an extended nature. An electromagnetic field, for example, is an entity that can spread in space and whose perturbations do propagate in space;[4] therefore, they cannot be used to establish a communication between two spatially separated entities, for example when isolated in special Faraday cages.

9 OBE and non-spatiality

Following the above brief excursus on the phenomenon of telepathy, we want now to consider another typical phenomenon of the

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[4] This is the case only when considering an electromagnetic field of the classical kind, and not the individual quanta of this field, the so-called *photons*. These are in fact non-spatial entities that cannot be associated with a specific spatial trajectory. On the other hand, while propagating outside of space, they remain in a close relationship with it, as it is always possible to absorb them by means of specific spatial detection instruments.

manifestation of the consciousness: that of the *extracorporeal states*. As is the case with telepathy, if taken seriously, the available data about *near-death experiences* (NDE), and more generally about *out-of-body experiences* (OBE), lead us once again to hypothesize the existence of a non-spatial "layer" of our reality.

As is the case with ESP phenomena, also regarding the objectivity of OBE and NDE (NDE are just a specific category of OBE caused by traumatic events) the majority of the scientific community remains deeply skeptical, as well as deeply unprepared. Let us be clear, the phenomenon as such, and its spread within the human population, is certainly not denied; it is acknowledged that about 5% of the population has had the opportunity to experience at least once an OBE (Blackmore, 1982; Irwin, 1985). However, it is often reduced to a mere *autoscopic hallucination* produced by the brain, when exposed to certain stimuli, internal or external (Aspell & Blanke, 2009).

Typically, in psychological and neurological ambits, an OBE is characterized in terms of the following three phenomenological elements (Irwin, 1985; Blanke *et al.*, 2004): the impression

(a) that the self is localized outside one's own body;
(b) of seeing the world from an extracorporeal and elevated perspective;
(c) of seeing one's own body from this perspective.

Now, for those researchers promoting a participatory investigation conducted also, and above all, by means of a first person experimentation (self-research), as is the case for instance within *International Academy of Consciousness*, and in similar organizations, it is clear that the above three impressions represent only a caricature of what a lucid projector with sufficient expertise of the projective phenomenon is able to experience (Muldoon & Carrington, 1929; Monroe, 1977; Buhlman, 1996; Bruce, 1999; Vieira, 1997, 2002; Ross, 2010; Aardema, 2012; Minero, 2012).

An OBE, lived in a lucid and self-conscious way, involves energetic phenomena, which sometimes can be very intense, like *vibrational states* and *intracranial sounds*, typically during the take off and the reentry into the body; it also often involves a superior mental activity, if compared to that of our normal intraphysical waking state; the observation and participation in events which are not only physical but also extraphysical, that is, taking place on other "planes" of existence, relatively stable and independent from the intrapsychic activity of the projector; events which occur in a logical and coherent way, also involving meetings and exchanges of relevant information with extraphysical (disembodied) consciousnesses, of different evolutionary levels, often also including departed family members (Vieira, 1997, 2002; Fenwick, 2012).

During a lucid OBE we can also experience the crossing of interdimensional passages separating different planes of manifestation and have access to panoramic visions of our intraphysical lives, to meaningful retrocognitions of past intraphysical lives, or of the periods of preparation between them (*intermissive periods*). To this we can add the fact that people who are blind from birth are sometimes able to see when they are in an extracorporeal state, and that numerous cases of confirmed *veridical perceptions* exist (Holden *et al.*, 2009), namely, of perceptions that the consciousness can have when outside of the body that the physical body cannot have access to, which subsequently find confirmation, including experiences of shared projections. Finally, to complete this partial list of features, it is important to observe that in the case of particularly meaningful OBE (especially the NDE), they are able to promote very deep and positive transformations in the lives of the subjects, like the acquisition of a more advanced ethical sense and increased psychic abilities (which are often experienced in an amplified way when in the extracorporeal condition).

What we want to emphasize here is that the most significant aspects of an OBE are not usually taken into account in the academic study of the phenomenon, especially the fact that these experiences are very different from the ordinary dream activity (Vieira, 2002) and often involve the exploration of existential dimensions by using extraphysical vehicles of manifestation (see Figure 7) that are difficult to explain only as vivid hallucinations. One just has to read the diary of the OBEs of a veteran projector like Waldo Vieira (1997) to understand that the oneiric-hallucinatory "explanation" completely lacks *explanatory power*.

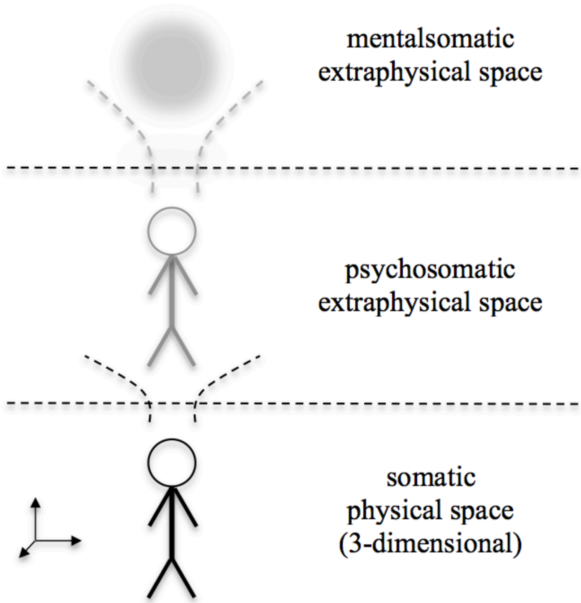

Figure 7 A symbolic representation of the (somatic) 3-dimensional physical space, symbolized by the 3 Cartesian axes, and of the consciential extraphysical (CE) "spaces" (psychosomatic and mentalsomatic) that a projected consciousness is able to experience in the course of so-called psychosomatic and mentalsomatic projections, respectively, by using corresponding extraphysical vehicles of manifestation. In the drawing, the dashed funnels represent the effect of "consciential narrowing" which is typically experienced when the consciousness moves from "subtler" to "denser" dimensions.

Certainly, its advantage is that it doesn't require the introduction of new entities, in obedience to the famous *Ockham's razor principle*. On the other hand, if it is true that Ockham's razor reminds us, rightly, not to introduce more entities than necessary, it is also true that it should always be carefully counterbalanced by the so-called *Chatton's anti-razor principle*, which warns us of the opposite danger, that of becoming too economical and introduce less entities than necessary (Smaling, 2005). What really matters is not the number of entities that we introduce in our theories, but if our theories possess sufficient explanatory power to explain the different observed phenomena, be them internal or external.

As an example, take the case of physicist *Wolfgang Pauli*, who in 1930, with courage, was brought to postulate the existence of a new ghost-like microscopic entity, later on called *neutrino* by the Italian physicist *Enrico Fermi*. For this, he had to "disobey" the dictates of Ockham's principle, and if he did so it was to *explain* in an understandable way the phenomenon of *beta decay*. Similarly, when considering the phenomenon of OBE, if we decide to take it seriously, i.e., to take into account the entire spectrum of its distinctive features, it is undoubtedly necessary to hypothesize the existence of extraphysical existential dimensions and of objective vehicles of manifestation used by the consciousness to travel through them. To quote *Waldo Vieira* (2002):

"*It is the most adequate hypothesis for explaining a greater series of consciential phenomena (phenomenology) which are currently considered to be parapsychic.*"

Of course, there are a number of reasons, having little to do with the logic of scientific inquiry, which explain why this assumption is not at the moment taken seriously by the scientific community at large. Some of these have to do with historical prejudices, and the need for a science, still adolescent and insecure (*adole-science*), to distance itself from those fundamental interrogatives that gave birth to the various religious movements; interrogatives that are judged a priori as unscientific, like for example: Who and what am I? Where do I come from and where am I going? Is there something beyond the physical death? What is my potential for evolution and how can I actualize it? (Sassoli de Bianchi, 2012b).

To this we must add the difficulty, on the part of the modern scientific enterprise, to integrate in its corpus of knowledge the results of a participatory research conducted in the first and second person, recognizing the role that subjective experiences have, while also acknowledging that, inevitably, their reliability will vary depending on the training received by the individuals who live them.

But this is not the topic of this article. What we want to stress here, based on the evidences acquired from the research on telepathy and the extracorporeal states (but not only) is that these phenomena can be understood only to the extent that we courageously open ourselves to the possibility that a being-consciousness can also exist in *non-spatial* states, associated with extraphysical vehicles of manifestations and "places" which are perfectly objective, although located outside of the three-dimensional theater of our ordinary intraphysical experience.

10 Different typologies of non-spatiality

In the previous sections we have proposed the following thesis: if the study of microscopic entities and consciousness are taken seriously enough, we reach the conclusion that our ordinary physical reality is the tip of a huge extraphysical iceberg. However, at the present state of our knowledge, we cannot know if the non-spatiality of quantum microscopic entities, of projected (or departed) consciousnesses and of telepathic communication channels, correspond to the same extraphysical layer of our reality. This for the time being remains an open question.

To simplify the discussion, we will use the term *quantum extraphysical* (QE) to denote the non-ordinary space in which quantum entities are present for most of their time (when not forming macroscopic aggregates), and the term *consciential extraphysical* (CE) to refer to the non-ordinary space which is inhabited by the projected and departed consciousnesses, and which is possibly also at the origin of telepathic transmissions and other psychic phenomena.

The first logical possibility is that the QE and the CE "spaces" have nothing in common except the three-dimensional Euclidean theater, which has to be considered as a sort of meeting place for these two distinct layers of reality (see Figure 8).

Another possibility corresponds to the hypothesis, diametrically opposite, that the QE and CE "spaces" correspond to exactly the same reality layer. In other words, physicists, through their investigation of the micro-world, would have just put their hands on that "spiritual reality" that has been described by the mystics throughout all of time, as suggested for example by *Fritjof Capra* (1975) in his famous *Tao of Physics* (see Figure 9).

Between these two extremes, it is of course possible, and desirable, to consider the possibility of an intermediary perspective, according to which there would certainly be elements of reality that are shared by the QE and CE "spaces," but there would also exist purely quantum and purely consciential non-spatial layers that would have no common elements (see Figure 10).

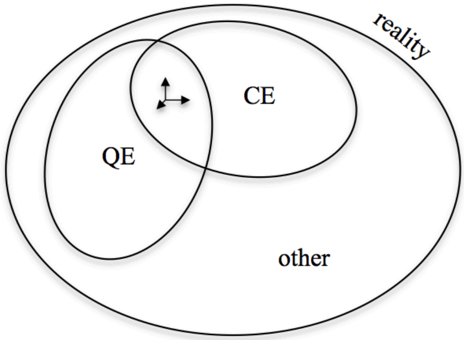

Figure 8 A symbolic representation of reality (in the form of a *Venn diagram*), with the three-dimensional physical space (symbolized by the three Cartesian axes) emerging from both the quantum extraphysical (QE) "space" and the consciential extraphysical (CE) "space," in the hypothesis that the multi-dimensional nature of these two layers would be distinct and therefore their intersection would be empty (in the sense of only corresponding to the ordinary three-dimensional space).

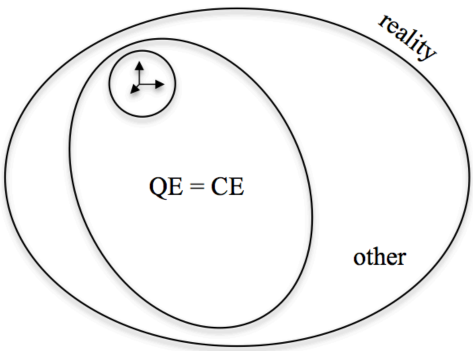

Figure 9 A symbolic representation of reality (in the form of a *Venn diagram*), with the three-dimensional physical space (symbolized by the three Cartesian axes) emerging from both the quantum and consciential extraphysical "spaces," in the hypothesis that they would coincide.

11 Entanglement does not explain telepathy

We will now present a few simple arguments to support the view that the QE layer can hardly be considered to be coincident with the CE one, as it is often assumed by many authors in the field of parapsychology, who see deep similarities between the psychic phenomena and the quantum phenomena, such as the *non-local* aspects which are present both in the extrasensory perception (ESP) phenomena, like telepathy, and in the coincidence EPR-like experiments (the abbreviation denotes the famous triumvirate Einstein-Podolsky-Rosen), performed on pairs of entities in *entangled* states (Aspect, 1999); or the fact that parapsychology and quantum experiments both use a *statistical approach*, and that the collapse of the wave function seems to imply the possibility of an active role played by the mind of the experimenter in actualizing the different possible outcomes of an experiment.

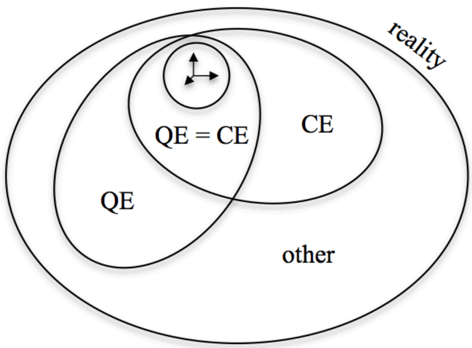

Figure 10 A symbolic representation of reality (in the form of a *Venn diagram*), with the three-dimensional physical space (symbolized by the three Cartesian axes) emerging from both the quantum extraphysical (QE) and the consciential extraphysical (CE) "spaces," in the hypothesis that they do not coincide and that their intersection does not only reduce to the three-dimensional physical space.

On the question of the *observer effect* (Sassoli de Bianchi, 2013c,f) we have already discussed it at length in the first part of this article. Until proven to the contrary, the observer effect of quantum mechanics only corresponds to an *effect of the instrument of the observer*. Therefore, this first element of correspondence between quantum measurements and ESP is only apparent.

As for the observation that both approaches abundantly use statistics, this similarity is also only apparent. Apart from the fact that any experimental investigation necessarily employs statistical methods, when it comes to analyzing the data obtained and the associated margins of error, it should be pointed out that the reasons for which quantum systems are described primarily in terms of probabilities is very different from the reasons why psi phenomena are evidenced by means of a statistical analysis.

Quantum probabilities are genuine *elements of reality*, in the Einstein sense of the term, as the values of the quantum probabilities, in the different experimental contexts, *can be predicted with certainty*. But not only that: the quantum statistics are characterized by an optimal *robustness* with respect to possible small variations of the state of the system (De Raedt et al., 2014; Aerts & Sassoli de Bianchi, 2015b). Also, quantum probabilities, associated with the different physical observables of a system, contain an objective and accurate information about the state of the system, which can be recovered using specific techniques of *quantum tomography*.

The situation is very different with regard to the data obtained in parapsychological experiments, characterized instead by a very weak replicability of the relative frequencies associated with the different possible outcomes. Moreover, the logic of the statistical analysis conducted in parapsychological experiments is very different from that of quantum experiments. In fact, considering the weakness of the psi effect in experiments conducted in a controlled environment, the purpose of the statistical analysis is to compare the data obtained in situations in which a supposedly non-ordinary ability would be at work, with theoretical data relating to situations in which this ability would be absent. To determine whether the difference between these two situations is significant, and therefore test the validity of the psi hypothesis, a probability is usually calculated (the so-called *p-value*), through various methods of statistical inference (Utts, 1991). This means that the statistical analysis of parapsychological experiments is of the *inferential* kind, and not of the *descriptive* kind, as it is the case for quantum statistical data.

Let us now consider the entanglement aspect. Here undoubtedly the similarity lies in the fact that, as already noted, both psi phenomena and those associated with the observations of microscopic quantum entities, if taken seriously, lead us to consider the existence of a *non-spatial* layer of reality. On the other hand, it is rare to read in the parapsychological literature the clear statement that quantum entanglement cannot be used as such, in no way, to transfer information from one subject to another (Sassoli de Bianchi, 2013g).

As an example, consider the well-known process of *quantum teleportation* (Bennet *et al.*, 1993). Without going into details, we can observe that this process corresponds precisely to the possibility of transferring information from one place to another (with the aim of duplicating a specific microscopic entity), using a non-ordinary, non-spatial channel, obtained by sharing a pair of entangled quantum entities. What is important to consider, in relation to our discussion, is that if it is true that such process of "teleportation" uses the phenomenon of quantum entanglement, it is equally true that the actual transport of information does not take place through the non-spatial channel, but through an additional and perfectly ordinary communication channel.

For this reason, the process is also known by the name of *entanglement-assisted teleportation*, which means that the entangled entities cannot be used to simulate, in no way, a telepathic-like communicational process. Entanglement can be used, in certain circumstances, to increase our communicational resources, when we are in the presence of an ordinary communication channel, but cannot be used as such to transfer information in the absence of the latter.

12 A simple example of entangled entities

As this is not an article aimed at an audience of only physicists, we think it is useful to explain, through a simple yet significant example, why an entangled entity cannot be used to transfer information from one place to another place. We will consider for this a model using a perfectly ordinary macroscopic entity: a *string*. The example takes its inspiration from a previous model designed by *Diederik Aerts*, known as the *connected vessels of water model* (Aerts, 1984; Aerts et al., 2000).

Since the eighties of the last century, Aerts has in fact shown that ordinary macroscopic systems are also able to violate the famous *Bell's inequalities*. These, as is known, are violated by entangled systems, that is, by systems that are not separated in experimental terms, despite being possibly separated in spatial terms. In the case of two microscopic entities, such as two electrons, or two photons, the non-separation is due to the presence of a non-spatial connection, whereas in the case of macroscopic systems the connection is of a spatial nature (i.e., is present in space). The crucial point in the violation of Bell's inequalities is not, however, if the connection is spatial or non-spatial, but if it is able to create correlations (Sassoli de Bianchi, 2013b).

Consider two colleagues, A and B, who hold the two ends of a stretched string, of length L. Suppose that the string is very long, so that between A and B there is a considerable distance, which does not allow them to communicate. The string, with its two ends, is the equivalent of a composite entity in an entangled state, shared by A and B. Suppose that A and B, in the same moment (in a coincident way), decide to pull with strength on their respective end of the string, causing it to break into two separated fragments. Accordingly, A and B will find themselves with a single string fragment in their hands. Suppose that L_A is the length of the fragment of A, and L_B is the length of the fragment of B. Since $L = L_A + L_B$, both A and B will be able to know the length of the fragment in the hand of their colleague, without having exchanged with the latter any kind of information (see Figure 11).

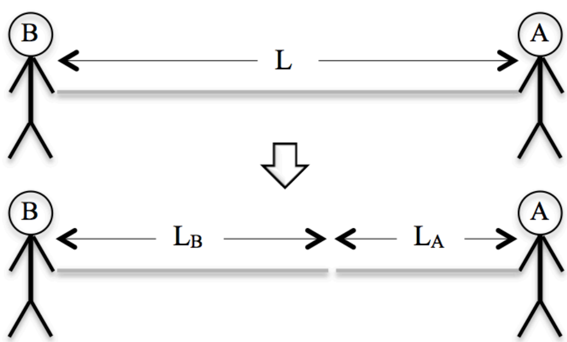

Figure 11 By pulling on the two ends of a string, a pair $(\boldsymbol{L_A}, \boldsymbol{L_B})$ of correlated values is created: $\boldsymbol{L_A} + \boldsymbol{L_B} = \boldsymbol{L}$. The experimenter A, by measuring the length $\boldsymbol{L_A}$ of its fragment, is thus in a position to know the length $\boldsymbol{L_B}$ in the hand of experimenter B, and vice versa, with no transfer of information.

We can observe that: (1) the two *potential string fragments* (forming the entangled entity) acquire a specific length only following the breaking-measurement process (in the same way as the spins of an entangled pair of electrons acquire a specific orientation only following a Stern-Gerlach measurement process). In other words, it is the measurement process which creates the properties; (2) the lengths acquired by the two fragments are perfectly correlated (as perfectly correlated are the orientations of the electronic spins); (3) the process does not correspond to a discovery of already existing correlations, but of creation of correlations that were only potential prior to the experiment (called *correlations of the second kind* by Aerts); (4) it is the process of creation of correlations that is responsible for the violation of Bell's inequalities (Sassoli de Bianchi, 2013b,d, 2015a); (5) since the breaking point of the string cannot be controlled by A and B, they cannot use the obtained pair of values $(\boldsymbol{L_A}, \boldsymbol{L_B})$, which are correlated but arbitrary, to transfer information from A to B, or from B to A.

Point (5) is the crucial one. Indeed, the situation of quantum entanglement is structurally similar to that of the string. The string is a *spatial* entity, which connects couples of potential fragments through space, whereas a pair of entangled electrons (or photons) is a *non-spatial* entity, which connects pairs of potential orientations *not* through space. But in both cases, the fundamental process is that of a genuinely indeterministic *creation of correlations*, and this process *cannot be used to communicate*.[5]

13 Differences and similarities between QE and CE

Let us consider now the consciential extraphysical (CE) reality that we consciousnesses can have access to during an extracorporeal

[5] More precisely, this is so because the quantum probabilities obey the so-called *no-signalling conditions*, also called *marginal laws*. On the other hand, some experiments have also indicated that these marginal laws could possibly be violated (as it is in fact the case for the model using the string, if additional experiments are considered). Hence, a communication which directly exploits the entanglement phenomenon may after all be possible, although not at superluminal effective speed. For a discussion of these subtle questions regarding the quantum formalism and the interpretation of quantum entanglement, see Aerts et al (2019) and the references cited therein.

projection, assuming that such non-spatial reality, and the vehicles we use to manifest in it, are perfectly objective. As for the phenomenon of telepathy, the question is then the following: *Do we have elements to support the view that the quantum extraphysical (QE) and the consciential extraphysical (CE) would form the same layer of our reality?*

It is certainly a difficult question, since we do not know yet the "physics" that governs the CE layer. However, we can observe that there are aspects of it that are both in favor and against the thesis that it would be an expression of a quantum reality. For example, an extraphysical consciousness, manifesting through the "subtle" vehicle called *psychosoma* (Vieira, 2002), will experience the equivalent of a 3-dimensional spatial scenery, in which it will be able to move along well-defined trajectories. On the other hand, it is equally true that the psychosoma can also teleport itself from one place to another, without apparently passing through the intermediate regions, like an entity able to de-spatialize at will.

In the CE layer, we can also observe the presence of objects with specific and stable individual characteristics, which can interact according to classical modalities (such as falling, or bouncing), without entering into conditions of entanglement, as well as the presence of "objects" which, instead, are able to easily vary their appearance, size, fuse with one another, establish invisible connections, etc., contrary to what the intraphysical macroscopic objects are usually able to do.

There is also a portion of the CE layer that is undoubtedly much more "abstract," where the consciousness seems to be able to manifest through an even subtler vehicle than the psychosoma, not characterizable anymore as a body having spatial-like characteristics, called the *mentalsoma*. To try to convey the idea of the possible nature of this mentalsomatic consciential reality, we leave the word to *Waldo Vieira*, who in his diary describes an experience of mentalsomatic projection (Vieira, 1997):

"*[...] I saw only lights and vivid colors of indefinite shapes. The site appeared to be completely uninhabited. There were no dwellings in sight. My experience was that of simply existing as a consciousness. I did not feel the form of the psychosoma. It was invisible even to me.*

Lighter than usual outside the dense body, I had an attitude of confidence and moral superiority, which made unequivocally sublime energies arise within me, *in an indefinable, tranquil contentment. There were no human forms or faces, only centers of energy radiation constituting familiar consciousnesses, some of which were noteworthy [...].*

They had no names, nor were they identifiable by their forms, but I knew them and was united with them through common experiences. I was suddenly sure of being a participant in a formless gathering, composed of bodiless points of mental focus, of masses of energy that was taking place in a nirvanic atmosphere that was of an unimaginable level of mental elevation, unapproachable with Earthly descriptions, and indefinable in known terms."

So, if we take seriously what the lucid projectors report, we can observe in the CE "space" the presence of entities (including the consciousnesses' vehicles of manifestation) whose behavior is seemingly classical, but also of entities whose behavior is decidedly quantum-like. This suggests that the CE layer would not be equivalent to the QE layer discovered by physics, but would correspond to a reality hosting inside of it a consciential classical-like level, of a spatial-like nature (different from the ordinary intraphysical space), and a quantum-like consciential level, of a non-spatial nature (different from the quantum non-spatial layer studied by physics); see Figure 12.

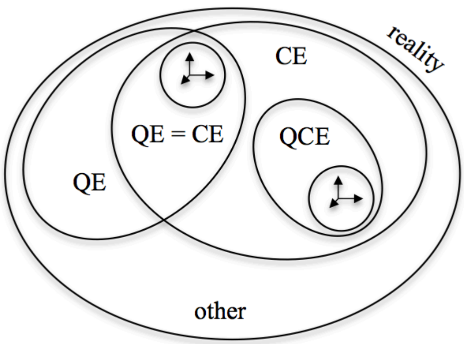

Figure 12 A symbolic representation of reality (in the form of a *Venn diagram*), containing the three-dimensional physical space (symbolized by the three Cartesian axes) and the quantum extraphysical (QE) and consciential extraphysical (CE) "spaces," in the hypothesis that they do not coincide, that their intersection does not reduce to the three-dimensional physical space, and that the CE layer also contains a quantum-like level (QCE), distinct from the QE, as well as a classical-like level (symbolized by the three Cartesian axes).

14 Quantum cognition

From what has been discussed in the previous sections, a picture of a very multifaceted multidimensional reality emerges, in which the QE and CE layers appear to be possibly distinct and not easily comparable. In this sense, we believe that the modern researcher/self-researcher has an interest in resisting the temptation to prematurely produce all too easy simplifications, as the one of considering, based on vague and unconvincing analogies, that the microscopic layer described by quantum physics would be in direct correspondence with the non-ordinary reality associated with the psi phenomena, and more generally to the more complex parapsychic experiences such as the OBEs.

To use a metaphor, we can imagine being in a house, where we were born; a house that we have never left. Getting close to a window, we open it, and through that window we see a strange and wonderful landscape. Suppose that it is the window of quantum physics. Then, we open another window, which is oriented in a different direction, and also in this case we see a landscape, also strange and wonderful. Suppose that it is the window of parapsychic experiences. Since both of these landscapes appear to us strange and wonderful, we will be tempted to believe that the two windows open on the same landscape, on the same reality. The temptation will be further strengthened by the fact that both windows belong to the same three-dimensional house. But this is obviously not sufficient. For example, if the house is located on the seashore, one window might look inland, the other one to the open ocean. And if we lived for a very long time imprisoned in that house, both of these landscapes will appear to us strange and wonderful; but their reality will remain very different: one is inhabited by fishes, the other one by quadrupeds.

Of course, we can always imagine a more fundamental level, where the inland and the sea will appear to us as part of a larger undivided reality, but here we leave the metaphor. Indeed, it is always possible to conceive a more fundamental level, but at the present state of our knowledge we have no reason to think that our parapsychic experiences, and our quantum experiments, would have been able to even scratch such level.

Having highlighted in the previous sections some of the differences between the fields of investigation of *quantum physics* and *consciousness*, when both are taken seriously, we want now to indicate what they possibly have in common. But to do so, we first need to mention a recent small revolution that has taken place in the study of human cognition and the correspondent decision processes: that of so-called *quantum cognition* (Busemeyer & Bruza, 2012), not to be confused with the theory of the "quantum brain," which we mentioned in the beginning of this article.

Similarly to how physicists, in the course of their historical investigations, were confronted with experimental data which were incompatible with classical probabilities, psychologists (here primarily understood as cognitive scientists) were also confronted with empirical data (collected in the ambit of tests conducted on statistically significant samples of subjects) that appeared to be completely irrational if analyzed according to classical logic, in the sense of being the expression of evident "logical errors," such as the *conjunction fallacy* (a condition in which subjects estimate that the probability that two events occur in conjunction is greater than the probability that only one of the events occurs) or the *disjunction fallacy* (a condition in which an alternative is considered less likely than an absence of alternative).

From these and other anomalies, evidenced in numerous experimental studies, it could be inferred that human thought processes do not always follow classical logic. Historically, these deviations were mostly considered to be the expression of purely associative and irrational processes, with no detectable structure; at least until it was thought of to apply some specific quantum mathematical models in the attempt to account for these deviations. In this way, a specific and identifiable structure in the alleged human irrationality could be observed, as an expression of a *quantum-conceptual* layer in our thought processes, of a *synthetic* nature, which has to be added to the *logico-classical* layer, of an *analytical* nature, usually (and erroneously) taken for granted (Aerts & D'Hooghe, 2009).

This quantum conceptual thought process is highly *contextual* and *indeterministic*, although not arbitrary, similarly to the measurement processes on microscopic quantum entities. In fact, like the latter, the outcomes of the quantum-conceptual thought processes do occur, in those situations that are able to promote them, in a completely systematic, inter-subjective and stable way; in other words, they are not the result of accidental effects, but of effects whose statistics are very robust and replicable at will.

The application of quantum models to human cognition allowed the explanation of the deviations with respect to the classical probabilistic predictions in terms of the typical characteristics of quantum systems, such as *contextuality*, *emergence due to superposition*, *interferences*, *correlations due to entanglement*, not to mention the "many-body effects" specific of *quantum field theory*. It is obviously not possible to review all the details of these interesting modelizations, and the data that they allowed to elucidate, also because different approaches exist, depending on the authors, which model different aspects of the cognition and decision processes.

One of these approaches, perhaps the most fundamental one if we consider the ampleness and generality of the perspective it is able to offer, is that originally proposed by *Diederik Aerts*, *Jan Broekaert* and *Liane Gabora* (2000), and further developed in (Aerts & Gabora, 2005a,b, Aerts, 2009a). The idea of these authors is to model *human concepts* as entities that *can be in different states*, depending on the contexts, and not as mere containers of data (instantiations), i.e., as collections of predetermined exemplars.

15 Interferences between fruit and vegetable

As an example, consider the human concept *Fruit*.[6] When it is not in combination with other concepts, we can consider that the conceptual entity *Fruit* is in its *ground state*. But as soon as it is placed in a context, such as in the phrase *How juicy is this fruit*, its state will no

[6] We use a capital first letter and the italic style to denote concepts, which should be distinguished from the words that are used to indicate them.

longer be the ground state, but an *excited state*,[7] which will produce different effects compared to the ground state. Indeed, if for example we ask a person to choose a typical example for the concept in question, e.g., between the two possibilities *Apple* and *Orange*, there is no doubt that *Orange* will be chosen more frequently than *Apple* when the concept in question is in the *How juicy is this fruit* state, with respect to when it is in the more neutral *Fruit* ground state. It is important to note that also the exemplars *Apple* and *Orange* correspond to specific states of the conceptual entity *Fruit*, and more precisely to the states obtained by the following two contextualizations: *The fruit is an apple* and *The fruit is an orange*.

When a concept is contextualized, we can distinguish two fundamental types of processes: the *deterministic* ones, through which the concept is prepared in a predetermined state, and the *interrogative* ones, fundamentally *indeterministic*, through which the concept, prepared in a given state, is *measured* by means of an evaluation by a human subject (or by a group of human subjects), who is asked to choose a specific exemplar for the concept in question, from a given set of possible exemplars of the same. When concepts are measured in this way, the results obtained will generally obey non-classical (quantum-like) probabilities.

We will limit ourselves to one example, analyzed in (Aerts, 2010a,b), to explain what we mean by this last statement. Consider the concept *Fruit or vegetable*. It can be considered as either the conceptual entity *Fruit* in a specific state, or as a new conceptual entity, obtained by the combination of the two conceptual entities *Fruit* and *Vegetable*, by means of the logical connector *Or* (which in turn, of course, is also a conceptual entity). Imagine then submitting a set of specific exemplars to a group of subjects, asking them to do the following:

(A) choose from the set a typical exemplar of *Fruit*;
(B) choose from the set a typical exemplar of *Vegetable*;
(C) choose from the set a typical exemplar of *Fruit or vegetable*.

Suppose that the set in question contains the following 24 exemplars:

Almond, *Acorn*, *Peanut*, *Olive*, *Coconut*, *Raisin*, *Elderberry*, *Apple*, *Mustard*,

[7] Here the term "excited" is to be understood in the same way as it is used in quantum mechanics, to indicate a state that is different than the ground state.

Wheat, *Ginger root*, *Chili pepper*, *Garlic*, *Mushroom*, *Watercress*, *Lentils*, *Green pepper*, *Yam*, *Tomato*, *Pumpkin*, *Broccoli*, *Rice*, *Parsley*, *Black pepper*.

The different subjects will then choose these exemplars with different relative frequencies, in relation to the above three questions, and of course these frequencies can be interpreted as probabilities: the probabilities that a human subject, subjected to one of the above three situations, will choose those specific exemplars.

Let us consider the values obtained in a study by *Hampton* (1988). The probability that choice (A) gives the outcome *Mushroom* is:

$$P(\mathit{Fruit} = \mathit{Mushroom}) = 0.0140,$$

while the probability that choice (B) gives *Mushroom* is:

$$P(\mathit{Vegetable} = \mathit{Mushroom}) = 0.0545.$$

This means that the subjects consider mushrooms to be more representative of a vegetable than of a fruit, though in general they do not consider them to be very representative of either category, if for example we compare these values to the much higher probabilities:

$$P(\mathit{Fruit} = \mathit{Apple}) = 0.1184,$$

with which *Apple* is chosen as a typical exemplar of *Fruit*, or

$$P(\mathit{Vegetable} = \mathit{Broccoli}) = 0.1284,$$

with which *Broccoli* is chosen as a typical exemplar of *Vegetable*. Consider now the probability that *Mushroom* is chosen as a typical exemplar of the concept *Fruit or vegetable*. If we reason in classical terms, we would expect such probability, obtained by submitting the subjects to the choice (C), to simply correspond to the *arithmetic mean* of the values obtained in the two choices (A) and (B), namely:

$$\bar{P}(\mathit{Fruit\ or\ vegetable} = \mathit{Mushroom}) = \frac{1}{2}[P(\mathit{Fruit} = \mathit{Mushroom}) + P(\mathit{Vegetable} = \mathit{Mushroom})] = \frac{1}{2}(0.0140 + 0.0545) = 0.0342.$$

This would correspond to a process where the subjects first choose which of the two questions they want to answer, either question (A) or question (B), and after they have made such choice, they simply answer the selected question. Instead, the obtained experimental value was:

$$P(\textit{Fruit or vegetable} = \textit{Mushroom}) = 0.0604,$$

which is almost twice the value predicted by the above classical reasoning and corresponding arithmetic mean.

In the case of the exemplar *Mushroom* we therefore have an effect of *overextension* of the probability, with respect to the classical prediction. But effects of *underextension* are also observed. Consider for example the case of the exemplar *Elderberry*, whose experimental data are:

$$P(\textit{Fruit} = \textit{Elderberry}) = 0.1138,$$
$$P(\textit{Vegetable} = \textit{Elderberry}) = 0.0170,$$
$$P(\textit{Fruit or vegetable} = \textit{Elderberry}) = 0.0480.$$

The classical arithmetic mean produces in this case the value:

$$\bar{P}(\textit{Fruit or Vegetable} = \textit{Elderberry}) = \frac{1}{2}[P(\textit{Fruit} = \textit{Elderberry}) + P(\textit{Vegetable} = \textit{Elderberry})] = \frac{1}{2}(0.1138 + 0.0170) = 0.0654.$$

which is much greater than the obtained experimental value.

Following the reasoning in Aerts (2010a,b), to explain these deviations we can consider that a human subject, when assessing the typicality of an exemplar in relation to the concept *Fruit or vegetable*, will proceed according to a double modality: *logico-classical* and *quantum-conceptual*. The first modality consists of evaluating the typicality of the exemplar in relation to its components *Fruit* and *Vegetable*, taken separately, that is, decomposing the concept into its parts. This will produce essentially a value compatible with the formula of the arithmetic mean.

The second modality consists of considering *Fruit or vegetable* as a new *emergent* concept, that cannot be reduced, in regard to its meaning, to the meaning of its components taken individually. Therefore, in this second modality, the subject will try to evaluate if *Mushroom* is an exemplar which can easily be attributed, individually, to *Fruit* or to *Vegetable*, and if this is not the case, as for the exemplar *Mushroom*, it will be assigned to the new emergent concept *Fruit or vegetable*. In other words, it will receive a very significant score according to this second modality of evaluation, resulting in an effect of overextension with respect to the classical evaluation (which only considers the first modality).

The underextension effect observed in the probability of choosing *Elderberry* as a typical exemplar of *Fruit or vegetable* can be explained in the same way. In this case, however, and contrary to *Mushroom*, it is not an exemplar that is difficult to classify as *Fruit* or as *Vegetable*. Indeed, *Elderberry* is considered to be a typical exemplar of *Fruit*. Therefore, it will receive a negative score as regards to its assignment to the emergent *Fruit or vegetable* concept, thus producing a downward correction of the classical analytico-reductive evaluation (Aerts, 2010a,b).

When these effects of overextension and underextension of classical probabilities are analyzed using the (Hilbertian) formalism of quantum mechanics, they can be qualitatively and quantitatively explained as the result of *constructive* and *destructive interference effects*, respectively, exactly as it happens in a typical quantum experiment, when in the presence of interfering alternatives.

Take the example of the famous *Young's double-slit experiment* (that we assume the reader is familiar with). The situation (A) is equivalent to that where only "slit A" is open; the situation (B) is equivalent to that where only "slit B" is open; and the situation (C) is equivalent to that where both slits are open; on the other hand, the different exemplars that the subjects can choose are equivalent to the different possible locations on the final screen (in the present case, 24 locations) where the quantum entity can be finally detected (absorbed).

When the process is of the classical kind, that is, when the entities passing through the double-slit screen are corpuscles, the distribution of the impacts on the final screen obeys the laws of classical probabilities, in the sense that the probability that a particle reaches a certain position on the final screen, when both slits are open, is given by the *arithmetic mean* of the probabilities that it reaches such position when only one of the two slits is alternatively open.

On the other hand, if the process is quantum, the phenomenon of interference is able to produce variations in comparison to the predictions of a classical probability calculus; variations that will result in effects of overextension (constructive interference) and underextension (destructive interference), producing the typical *interference fringe pattern* on the final detection screen. And, surprisingly, similar fringes can also be obtained when measuring the concept *Fruit or vegetables*, as shown in Aerts (2010a,b).

16 The conceptuality interpretation of quantum physics

What we have described in the previous section is just an example of a significant experiment in cognitive science, able to highlight typical quantum-like effects, i.e., experimental data whose structure is very similar to that obtained in experiments with microscopic physical entities, in different experimental contexts. The reasons why quantum mathematics is so effective in the modeling of cognitive experiments are numerous and were analyzed for example in Aerts et al. (2013), Aerts & Sassoli de Bianchi (2015a,b); see also Busemeyer & Bruza (2012), and the references cited therein.

Now, considering the significant progress achieved in recent years in quantum cognition, we may be led to ask, together with Aerts, the following fascinating question (Aerts, 2010a):

If quantum mechanics as a formalism models human concepts so well, perhaps this indicates that quantum particles themselves are conceptual entities?

This question became the starting point in the development of a new interpretation of quantum mechanics, called the *conceptuality interpretation* (Aerts, 2009b, 2010a,b, 2013), which is perhaps today one of the most general and innovative explanatory frameworks to understand the "strange" behavior of the entities described by this theory. The assumption at its basis is the following (Aerts, 2010a):

Hypothesis NQE (nature of a quantum entity): The nature of a quantum entity is 'conceptual,' i.e., it interacts with a measuring apparatus (or with an entity made of ordinary matter) in an analogous way as a concept interacts with a human mind (or with an arbitrary memory structure sensitive to concepts).

In other words, according to *Hypothesis NQE*, the elementary microscopic entities, although not describable as particles, waves or fields, do nevertheless behave as things that are very familiar to all of us, as we continually experience them in a very intimate and direct way: *concepts*.

Of course, we cannot present here all the subtleties and complexities of the explanatory framework offered by this interpretation, and its effectiveness in explaining quantum phenomena such as entanglement and non-locality, which are traditionally considered to be "not understood" or "not understandable." We therefore leave to the reader the intellectual pleasure of discovering these explanations directly from the foundational work of Aerts (2009b, 2010a,b, 2013).[8] Below, we will just describe, in a rather telegraphic way, some of the important consequences of the *Hypothesis NEQ*.

As we have seen in the example of the human concept *Fruit or vegetables*, non-classical interference phenomena result from the fact that conceptual entities can combine to give rise to new emerging concepts, whose meaning cannot be reduced to the meaning of the individual concepts that form them. In the case of the double-slit experiment, we can explain the emergence of the interference fringes produced by the photons by considering that an impact on the final screen corresponds to the selection of a typical exemplar for the photonic conceptual entity in the state *The photon passes through slit A or through slit B*. In fact, the largest number of impacts (the brightest fringe) is located right in the middle between the two slits, that is, in the position that best expresses a condition in which it is impossible to determine through which slit the photon entity would have passed, if it were a spatial corpuscle.

As for the phenomenon of interference, also quantum entanglement results from the fact that when two (or more) conceptual entities are combined, their combination is the expression of a *connection through meaning*, containing potential correlations (i.e., correlations of the second kind). To give an example (Aerts, 2010b), the two human concepts *Animal* and *Food* can be connected through meaning in the conceptual combination *The animal eats the food*. This combination is the equivalent of an entangled state. Indeed, when a subject is asked to identify a typical exemplar of the concept *The animal eats the food*, choosing *in a coincident way* a pair of exemplars of *Animal* and *Food*, for example among the list of the animals *Cat*, *Cow*, *Horse* and *Squirrel*, and among the list of foods *Grass*, *Meat*, *Fish* and *Nuts*, it is evident that some pairs of exemplars will be selected

[8] See also the review article on the conceptuality interpretation published in this volume, by Diederik Aerts, Massimiliano Sassoli de Bianchi, Sandro Sozzo and Tomas Veloz.

more frequently than others, and one can show that these correlated pairs can be used to violate *Bell's inequality*.

According to the conceptuality interpretation, the violation of Bell's inequalities in experiments with microscopic entities in entangled states can be explained in the same way: being the nature of the microscopic entities conceptual, they can *connect through meaning*, a type of connection that in quantum physics is designated by the term "*coherence*." For example, in the well-known situation of a pair of spins in a singlet state, the entangled state can be considered to correspond to the conceptual combination *The value of the sum of the two spins is zero*, whose actualizable exemplars correspond to the different possible pairs of spin values having a zero sum.

Heisenberg's uncertainty principle can also be explained very effectively by the conceptuality interpretation. Indeed, a concept can be in states possessing *different degrees of abstraction* (or different degrees of concreteness). For example, in the ambit of human concepts, we can observe that *Food* is undoubtedly more abstract than *Fruit* (namely, the concept *This food is a fruit*), which in turn is more abstract than *Apple* (namely, the concept *This food is a fruit called apple*), which is more abstract than *The apple I have in my hand now* (namely, the concept *This food that I have in my hand now is a fruit called apple*). Abd this latter state of the human concept *Food* brings it into correspondence with the world of objects of our three-dimensional space.

We can therefore say that the most concrete (less abstract) state of a human concept is the one corresponding to the notion of an *object*, and that therefore objects are an extreme case of concepts, in a state of maximum concreteness. The uncertainty principle of Heisenberg would then be nothing but the expression of the fact that *a concept cannot be simultaneously maximally abstract and maximally concrete*.

In the case of a quantum entity, such as an electron, a state maximally concrete corresponds to an electron perfectly localized in the three dimensional space, at a given instant, while a state maximally abstract corresponds to a fully delocalized electron, that is, an electron in a state corresponding to a condition of maximal localization in momentum space. The non-spatiality of microscopic entities would then be an expression of the fact that most of their states are abstract states, whereas our three-dimensional space would only be a representation of the maximally concrete states of these conceptual entities.

With regard to the superposition principle, as already noted, concepts can combine together and give rise to new emergent concepts. This explains why quantum entities, as conceptual entities, are able to obey to the superposition principle, which should then be generally understood as a *combination principle*. The reason why the objects of our three-dimensional space do not obey, apparently, to the superposition principle, is that not all conceptual combinations of objects are still in a correspondence with objects, while all possible combinations of concepts always correspond to concepts.

More precisely, if we consider two objects, "A" and "B," then of course the combination "A or B" will not be anymore an object, while the combination "A and B" may still be considered to be an object (the object formed by the ensemble of the two objects). For concepts, however, the symmetry between the connectors "and" and "or" remains intact, in the sense that if "A" and "B" are two concepts, this will also be the case for the combinations "A or B" and "A and B," and for any other possible combination.

With regard to *quantum measurements*, they describe processes during which a conceptual entity, usually prepared in an abstract (superposition) state, acquires a more concrete state, through the indeterministic interaction with a structure sensitive to its meaning: the measuring apparatus. The quantum measurement processes of actualization of potential properties are therefore processes of instantiation of abstract concepts by means of an interrogative context, where the measured entities interact with the measuring apparatuses according to dynamics where the dominant element is the *exchange of (quantum) meaning*.

There would be much more to say about the conceptual interpretation, which we have presented only schematically here; for example, in relation to the possibility of explaining the key notion of *indistinguishability* (which appears in a very natural way in the conceptual entities, such as in the human concept *Ten cats*, which corresponds to the combination of ten perfectly identical entities), the *Pauli exclusion principle*, the emergence of "many-body effects" typical of quantum field theory, the distinction between the macro and the micro, the problem of *quark confinement* and of the existence of different *generations* of elementary particles, of *dark matter*, etc. But for this we refer the interested reader to the aforementioned articles.

Before considering the possible interest of the conceptuality interpretation in the clarification of the nature of the consciential extraphysical dimensions, it is worth observing that though it suggests that quantum entities are *concepts* and not *objects*, the conceptual entities associated with the microscopic "particles" must not be confused with the *human concepts*. The quantum entities would be conceptual only in the sense that the notion that gives rise to the "way of being" (the "beingness") of a quantum entity and of a human concept are the same, as for example the notion of "wave" can describe both the mode of being of an electromagnetic wave and of a sound wave. But other than that, they remain very different entities.

For example, when we talk about violating Bell's inequalities in the ambit of experiments with human conceptual entities (Aerts et al., 2000), the measuring apparatuses consist of single human subjects measuring specific combinations of conceptual (entangled) entities, by relating them to specific pairs of possible exemplars (see the example above). Therefore, we are not dealing in this case with measuring apparatuses formed by spatially separated parts, but with instruments formed by the minds of single human subjects, whose bodies remain well localized in space, in a condition of "macroscopic wholeness."

In other words, the non-spatiality of microscopic conceptual entities and the non-spatiality of human conceptual entities are certainly not of the same kind. The first is in relation to our three-dimensional physical space, the second in relation to a mental space of conceptual entities that are simply more concrete than those that are measured (in the sense of being formed by the exemplars of the possible outcomes of a decision-making process). Therefore, as with the quantum phenomena of which we have already discussed, in this case it is also important to avoid promoting undue confusions. For example, we can read in Tressoldi et al. (2010):

If quantum-like models are valid ways of understanding certain forms of perception and cognition, and nonlocal entanglement-like connections are inherently contained within such models, then it seems reasonable to expect some aspects of those isolated systems we call "individuals" to be more connected than they appear to be. Gaining information without use of the conventional senses, or "extrasensory" perception (ESP), might be one way that those connections might manifest.

Contrary to what Tressoldi et al. write, we think it is not at all reasonable, solely on the basis of the results obtained in quantum cognition experiments, to infer the existence of a non-spatial connection between the different individual minds. There is no basis for such an assertion since, as we just explained, the non-spatiality of quantum cognition has nothing to do with the non-spatiality implied by extrasensory perception phenomena.

In addition, it should be noted that even though our mental processes are governed by quantum mathematics, it does not mean in any way that our brain would be a quantum computer, as suggested for example in the Orch-OR theory mentioned in the beginning of this article. Even "classical" systems, when governed by hidden-measurement processes, are perfectly able to promote quantum or quantum-like dynamics. To quote Busemeyer and Bruza (2012), the research in the field of quantum cognition "[...] is not concerned with modeling the brain using quantum mechanics, nor is it directly concerned with the idea of the brain as a quantum computer."

17 Thosenes as conceptual entities

Having clarified the difference between the three-dimensional space of our ordinary experiences and the conceptual "spaces" associated with the different levels of abstraction of humans concepts, and the importance of not confusing them, we can now better appreciate what the conceptuality interpretation of quantum mechanics has to offer us, as a possible key to understand the nature of the consciential extraphysical realities.

One of the remarkable aspects of the conceptuality interpretation (in addition of course to that of possibly explaining the nature of the microscopic entities, which appear to us so strange just because we would erroneously think that concepts should behave as objects) is to reveal that the *interactions of a conceptual kind* are more abundant than what we could have imagined. In fact, the only conceptual entities that are usually identified as such are the human concepts. To these we can possibly today add (if we accept the hypothesis NQE) the conceptual entities belonging to the physical microscopic layer.

We can then ask whether the additional non-spatial layer associated with the CE reality, of which we can reasonably hypothesize the existence, would also be characterizable (or partially characterizable) as formed by entities whose nature would be typically conceptual. In other words, we can ask whether in addition to human concepts (that we intraphysical humans use to exchange meaning through various forms of communication) and microscopic quantum entities (that macroscopic bodies, such as the measuring apparatuses, "use" to exchange non-human quantum meaning, in the form of coherence), also the "subtle" extraphysical entities would be primarily conceptual. In this regard, it is interesting to consider the notion of *thosene*, as usually understood in *conscientiology* (Vieira, 2002; Minero, 2012).

A thosene is a element of reality that is considered to be the expression of a triad of inseparable elements: *e*nergy (also in the sense of matter-energy), *sen*timent (also in the sense of emotion) and *tho*ught (hence the neologism "tho-sen-e"). In other words, with the notion of thosene one wants to emphasize the possibility that in every existential dimensions of our reality, physical and extraphysical, a cognitive (and therefore also conceptual) element would be present, capable of conveying meaning, through the communication of energetic, emotional and mental apsects.

For example, when a psychic individual perceives the *energetic aura* of a person, the interaction is not only of the objectual kind. The "energetic" aspect of the aura corresponds, in a sense, to its most concrete manifestation, as the aura also conveys more "subtle" elements, more abstract we could say, containing potential information of a mental and emotional nature, which the psychic would be able to interpret.

To give another example, when we manifest in the consciential extraphysical dimensions, using the "subtle" vehicle called *psychosoma*, the "thosenic" aspect of our interaction with the different entities we encounter, be them living or non-living, predominates: everything becomes a vehicle of information and meaning and the way we react to the different extraphysical entities is mostly dictated by dynamics of exchange of meaning.

Also, in these extraphysical ambits, entities can come into "contact" without there being the need to be strictly present in a same "space of manifestation," by simply creating connections based on emotional or mental affinities. For example, a projector, to go from one extraphysical place to another, s/he will not necessarily have to follow a specific trajectory, as s/he can also create a connection with the place s/he wants to visit by evoking some meaningful elements of the same, in emotional and/or mental terms. This will generally be sufficient to produce an interaction, and the corresponding "teleportation," which therefore has nothing to do with the local modalities of interaction between ordinary (intraphysical) objects.

Of course, for the time being all this remains quite vague and speculative. What we want to underline is that the conceptuality interpretation of quantum mechanics is able to offer new and fascinating keys to understand not only the strangeness of the microscopic entities, but also, possibly, the strangeness of the more "subtle" dimensions of our existence, as well as the relations that exist between the physical and extraphysical layers, be them quantum or consciential. This intellectual exercise, however, must be conducted with a lot of discernment, so as to avoid producing overly superficial analogies, oversimplifications, or easy anthropomorphisms. To quote Aerts (2009b):

"*If we put forward the hypothesis that 'quantum entities are the conceptual entities exchanging (quantum) meaning (identified as quantum coherence) between measuring apparatuses, and more generally between entities made of ordinary matter,' it might seem as if we want to develop a drastic anthropomorphic view about what goes on in the micro-world. It could give the impression that in the view we develop 'what happens in our macro-world, namely people using concepts and their combinations to communicate' already took place in the micro-realm too, namely 'measuring apparatuses, and more generally entities made of ordinary matter, communicate with each other and the words and sentences of their language of communication are the quantum entities and their combinations.' This is certainly a fascinating and eventually also possible way to develop a metaphysics compatible with the explanatory framework that we put forward. However, such a metaphysics it is not a necessary consequence of our basic hypothesis, and only further detailed research can start to see which aspects of such a drastic metaphysical view formulated above are eventually true and which are not at all. We also do not have to exclude eventual fascinating metaphysical speculations related to this new interpretation and explanatory framework from the start. An open, but critical and scientific attitude is what is most at place with respect to this aspect of our approach, and this is what we will attempt in the future.*"

This warning also applies, *mutatis mutandis*, in relation to the hypothesis that the extraphysical entities studied by conscientiology, and described as *thosenes* (and more generally as aggregates of thosenes, called *morphothosenes* and *holothosenes*), would also be mostly of a conceptual nature. The fact that we can identify emotional and mental aspects in our ways of interacting with the more "subtle" entities which are present in the CE "spaces," and also in our ordinary physical space, when we use our psychic and para psychic abilities, could lead us to develop a purely human-centric vision of reality, where human consciousnesses would play a fundamental role.

However, as it is important to distinguish human concepts and quantum conceptual entities in the conceptuality interpretation of quantum mechanics, in the same way it is necessary to distinguish, in a possible extension of the conceptual hypothesis, human (ordinary) concepts and extraphysical (thosenic) conceptual entities. Also because, when we enter the field of exploration of non-ordinary states of consciousness, and of the more "subtle" realities associated with them, the distinction between inner (intra-psychic) and outer (extra-psychic) realities becomes much more nuanced, and this should lead us to move with greater caution.

Before concluding this article, we also want to evocate an aspect of the conceptuality interpretation that may be of interest in the exploration of the extraphysical existential dimensions. We mentioned already in the previous section that the conceptuality interpretation of quantum mechanics allows addressing a number of fundamental problems of physics in an entirely new way. Among them, we mentioned that of the different *generations of elementary particles*.

As described in the so-called *standard model* of particle physics, there are three different generations (or families) of elementary entities. Entities belonging to different generations interact in the same way, but differ in their quantum numbers and, especially, in their *masses*, that is, in their *internal rest energies*. For example, there are three kinds of electrons: the one belonging to the first generation is the electron that we all know, whose mass is $0.511\ \mathrm{MeV/c^2}$; then there is the electron belonging to the second generation, called the *muon*, whose mass is more than 200 times larger: $106\ \mathrm{MeV/c^2}$; finally, the electron belonging to the third generation, called the *tau* (or *tauon*), has a mass of $1777\ \mathrm{MeV/c^2}$, which is almost twice the mass of a proton.

The conceptuality interpretation of quantum mechanics provides a possible first element of explanation of the mysterious origin of these different generations (families) of microscopic entities. Citing

Aerts (2009b):

"*Could the generations of the elementary particles, electron, muon, tauon, and their corresponding neutrinos and the different generations of quarks correspond to different energetic realizations of the conceptual structure of the quantum particles? It is true that human concepts have different mass-energetic realizations as well: a word can appear in sound-energetic form, but also in electromagnetic form when transported electronically or in writing, or in its primitive form used by our ancestors, carved into stone. All forms have different mass-energies, but, since they represent the same concepts, they have the same properties.*"

In principle, this possible (and for the time being quite speculative) explanation of the origin of the different families of elementary entities can be extended and used to also explain the nature of the "subtler" dimensions of our existence, and of the "subtler" vehicles of manifestation that we individual consciousnesses use to manifest into them, as for example the previously mentioned psychosoma and mentalsoma.

One possibility is that these realities would correspond to different energetic realizations of a more abstract conceptual entity. For example, the various interconnected vehicles of the consciousness (the so-called *holosoma*, hypothetically formed by the combination of *soma*, *psychosoma* and *mentalsoma*), could be understood as the different energetic realizations of a conceptual entity that, in human terms, we would call the *The individual evolving consciousness*. But we must not confuse such a conceptual entity with the human concept that we use to denote it.

Another possibility is that the holosoma would correspond instead to a multi-vehicular structure formed by "bodies" corresponding to conceptual entities having different degrees of abstraction, the mentalsoma being more abstract than the psychosoma, which in turn would be more abstract than the soma.

18 Conclusion

Let us briefly summarize the main points that we have touched on in this article. Our main thesis was that quantum physics and consciousness are not usually taken seriously enough. In the case of quantum physics, to take it seriously means in particular to acknowledge that a measurement processes is a real, objective process, describing a physical and not a psychophysical process.

In that respect, we have shown that, contrary to the widespread belief that there would be no convincing *physical* solutions to the measurement problem, a theory with sufficient explanatory power does actually exist, which is able to account for the non-linear dynamics of the state reduction, called the hidden-measurement interpretation of quantum mechanics (Aerts & Sassoli de Bianchi, 2014); and we have also shown that once quantum measurements are taken to be objective processes, we are compelled to expand our world vision and acknowledge that our physical reality is much larger than what is contained in our limited three-dimensional theater, which is just the tip of an immense multidimensional (possibly infinite-dimensional) iceberg.

Another point we have tried to emphasize is that when the study of consciousness is taken with due seriousness, that is, when our first person experiences are considered without minimizing the richness of their content, we are also compelled to upgrade our vision of reality and acknowledge that it is very unlikely that our stream of consciousness would just be the by-product of our brain's activity, and very likely that it *also* results from the activity of more "subtle" vehicles of manifestation.

Another aspect we have highlighted in the article is the importance of not mixing up, a priori, the different extraphysical layers, as for the time being there are no reasons to believe there would be a direct correspondence between the quantum and consciential elements of our reality. Both elements are certainly non-spatial in nature, in the sense of corresponding to extraphysical realities taking place outside of our three-dimensional Euclidean space, but as far as we know their structure is not equivalent.

Finally, we have also explained what it means to take seriously the recent progresses in quantum cognition. Our warning is about not confusing the quantum modeling of human cognition with the hypothesis of a non-local (non-spatial) quantum mind. Indeed, it is only when we avoid such confusion that we can fully appreciate what quantum cognition has to offer us, as an explanation regarding the nature of the non-spatial entities populating the extraphysical layers of our reality.

We think that this new explanation is contained in the so-called conceptuality interpretation of quantum mechanics (Aerts, 2009b, 2010a,b, 2013), which can possibly be extended to also include the description of the more "subtle" consciential realities. However, and again, this must be done with great discernment, that is, without unduly mixing the different conceptual layers.

We conclude with what we think is an important remark. It is generally believed by "post-materialistic scientists" that the materialistic paradigm should be abandoned and replaced by a more evolved one, able to account for the "psi phenomena." However, we should consider that what is really at the foundations of materialism is not, as many believe, the denial of the extraphysical consciential realities, but the requirement to found our conception of existence on a *substantial* basis (something exists, and therefore is real, if it exists in a substantial sense). This means that the unprejudiced materialist will not be a person willing to deny anything, but simply *to affirm existence on a substantial basis*.

In that respect, we think that also the so-called *consciential paradigm*,[9] if correctly understood, is a materialistic paradigm. The only difference with respect to conventional materialism is that it acknowledges a wider spectrum of substances, some of which are of a non-ordinary kind, like those forming our more "subtle" vehicles of manifestation. In other terms, the consciential paradigm is just about replacing materialism by *multimaterialism*. However, this will not be sufficient to solve the *hard problem of consciousness*, and the more general *mind-body problem*, which will only be reframed in a wider context, in what we may call the *mind-holosoma problem*.

Modern physics has also brought physicists (at least those who are willing to abandon the prejudice that our three-dimensional space, or four-dimensional space-time, would contain the whole of reality) to contemplate a much ampler non-spatial reality. This means that physicists and "conscientiologists" (individual studying consciousness from a multidimensional perspective) have to face the same challenge: that of explaining the nature and behavior of non-ordinary substances. It is therefore possible that, in the course of their

[9] The consciential paradigm considers that individual consciousnesses (like human consciousnesses) are intelligent principles manifesting through energetic multivehicles (the holosoma), in multidimensional environments and multiexistential cycles (Vieira, 2002).

investigation, they will be brought to develop similar models of reality; not because these model would address the same elements of reality, but because similar "patterns of interaction" would be at play at the different levels of reality; and it is very possible that the "conceptuality model" of quantum mechanics and the "thosenic model" of conscientiology, proposed long before also by the ancient science of Yoga (Sassoli de Bianchi, 2010), are just two different ways of expressing a same pattern of interaction.

Appendix: telepathic creation of correlations

As far as we know, telepathic experiments typically use protocols where a subject A tries to send some information to a subject B, who then tries to identify it. This is essentially a protocol of transfer of information. As we explained in the article, quantum entanglement cannot be used to directly transfer information, and this means that a telepathic communication requires more than just quantum correlations, at least as usually understood [For a more general approach, see Aerts et al. (2019)].

However, if two subjects were able to create some form of mental connection, and use it to produce correlations in a statistically significant way, this would be already sufficient to highlight a genuine psi phenomenon. Such phenomenon would not be that of a telepathic communication, as no information would be transferred, but of a *mental entanglement and mental creation of correlations.*

Our conjecture is that since a transfer of information is more demanding than a creation of correlations, an experiment that would only seek to highlight the latter could possibly obtain more favorable statistics of outcomes than what is usually obtained in the "transfer of information" protocols (like in so-called *ganzfeld experiments*). Considering the example of the string, a possibility would be for instance that of creating a *mental string*, to be mentally stretched between the two subjects, who would then be asked to break it, at some moment, in a coincident way. Following this mental breaking-measurement, they would then be asked to determine if the string fragment in their mental hand is longer or shorter than that of their colleague (that is, longer or shorter than half the length of the original mental string).

Four couples of answers are possible: (short, long), (long, short), (short, short) and (long, long). Only the first two are expression of a correlation: can they be obtained more frequently than the last two, in a statistically significant way? And what will be, typically, the *p-value* of mental experiments of this kind? We invite the parapsychologists to test the efficaciousness of this "creation of correlations" protocol.

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