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Quantum Theory and the Nature of Consciousness

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Abstract Our interest focusses on the idea, that consciousness is a powerful acting entity. Up to now there does not exist a scientific concept for this idea. This is not due to problems within the field of psychology or brain research, but rather in resisting theories of modern physics. That is, why we have to search for a solution in the field of physics. A solution can be found in a new understanding of the basics of physical theory. That could be given by abstract and absolute quantum bits of information (AQI bits). To avoid the popular misunderstanding of "information" as "meaningful" it was necessary to find a new word for the free-of-meaning AQI bits: the AQI bits establish a quantum pre-structure termed "Protyposis" (Greek: "pre-formation"), out of which real objects can be formed, starting from energetical and material elementary particles. The Protyposis AQI bits provide a pre-structure for all entities in natural sciences. They are the basic entities, whereof the physical nature of the brain, on the one hand, and the mental nature of consciousness, on the other hand, were formed during the cosmological and the following biological evolution. A deeper understanding of quantum structures may help to overcome the resistance against quantum theory in the field of brain research and consciousness. The key for an understanding is the concept of Protyposis, which means an abstract quantum information free of any definite meaning. With the AQI bits of the Protyposis, both, massless and massive quantum particles can be constructed. Even quantum information with special meanings, in example grammatically formulated thoughts, eventually could be explained. As long as the fundamental basis of quantum theory is misunderstood as being formed by a

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manifold of some small objects like atoms, quarks, or strings, the problem of understanding consciousness has no solution. If instead we understand quantum theory as based on truly simple quantum structures, there would be no longer fundamental problems for an understanding of consciousness.

Keywords Consciousness · Psyche · Philosophy of science · Quantum information · Evolution · Protyposis

1 Introduction

The brain is the very organ, whose functioning gives rise to what we experience as our conscious personality. At present, the publication of books on brain research is booming. However, those books dwell at length on matters like "neuronal correlates of consciousness", but fail to present an actual explanation of the nature of consciousness itself.

On the other hand, there are lots of publications addressing the various aspects of perception and consciousness. They understand that consciousness is a basic and undeniable reality in human life. It is generally accepted, that the consciousness of a living person needs a normally working brain.

The important research results, in particular experimental findings, in the two mentioned topics, will not be the concern of this article. But there is an explanatory gap between the material structure of the brain and the mental reality of the consciousness that cannot be bridged by traditional concepts. The explanatory gap will be the topic of this paper. Quantum theory, more precisely, the theory of abstract free-of-meaning bits of quantum information (AQI bits) has made it possible to close the explanatory gap.

As was pointed out, there is a large amount of experimental and theoretical work addressing important aspects of the connection between neuro-physiological and psychological data. However, it is usually maintained that none of them has to do with quantum theory.

The invention of all the modern techniques for experimental studies of the living brain require quantum theory, such as NMR scanners or the comprehensive computer-based data processing. That, of course, is only a secondary aspect. Much more important is that all biochemical processes are based on the emission and absorption of real and virtual photons. Moreover for systems usually termed "macroscopic", like nerve cells, the accuracy of quantum theory may become relevant in unstable situations, which are a characteristic of living beings. Whenever high accuracy is required, quantum phenomena can no longer be ignored. Often, however, it will be sufficient to deal with the reduced accuracy provided by averaging a great many similar quantum processes. This may create the misunderstanding that the accuracy of quantum theory is not necessary.

The most important aspect however, is the role attributed to information in this context.

The brain is a place, where permanent feedback processes take place. Processed meaningful information retroacts on the information possessing tools. An action of information is possible only in instable situations. In theories of non-linear dynamic phenomena, here permanently situations arise commonly denoted as bifurcation points. At least in such situations, the accuracy of quantum theory can no longer be ignored. In those situations, meaningful information can act as a steering agent. Such situations are constantly and ubiquitously encountered in the body. This implies that the material or

energetical carriers of the information are of less importance than the meaningful contents. Here the respective meaning is coded in a receiver-specific way, being, for example, different for the various types of cells in the body. The decryption of those codes is a wide and important field of research, directly relevant to human health issues.

The meaning of hard information is strictly to be distinguished from the material or energetic carriers involved in the processing of information. Many previous concepts resort to magic formulas, such as "emergence" or "functional link", which, however, obscure the fact that an actual understanding of the essence of "consciousness" is thereby not afforded. This applies also to the comprehensive and valuable studies on the correlations between activities in brain regions and the conscious experience of visual, auditory, and mental impressions.[1] Of course, one can simply require that "consciousness" is a well-known phenomenon, but obviously the acknowledgment of its existence does not make obsolete the need for a scientific foundation.

> ART (Adaptive Resonance Theory) clarifies key brain processes from which conscious experiences emerge. It predicts a functional link between processes of Consciousness, Learning, Expectation, Attention, Resonance, and Synchrony (the CLEARS processes). See foonote 1.
>
> It is just a step from here to propose that those experiences which can attract our attention and guide our future lives after being learned are also among the ones that are conscious. Support for the predicted link between resonance and consciousness comes from many modeling studies wherein the parametric properties of brain resonances map onto parametric properties of conscious behavioral experiences in the simulated experiments. Indeed, without such a linking hypothesis between brain mechanisms and behavioral functions, no theory of consciousness can be fully tested.[2]

It is important to investigate and understand all the correlations between brain physiology and contents of the consciousness. However, that is not the purpose of the present article. Rather, what shall be explained scientifically is the "linking hypothesis between brain mechanisms and behavioral functions".

> I have predicted that such a consciously visible percept is supported by a surface-shroud resonance between visual cortical areas and the parietal cortex that is predicted to play a role in learning invariant object categories (Sect. 17). This prediction illustrates how ART clarifies mechanistic relationships between the CLEARS processes of consciousness, learning, expectation, attention, resonance, and synchrony.[3]

The reference to correlation is not sufficient though; the challenge is to explain consciousness from a natural-scientific point of view. This has been achieved in a comprehensive recent monograph,[4] abandoning the path predefined by mainstream science. But the endeavor could not succeed without a theory of abstract and free-of-meaning bits of quantum information (AQI bits).

In a very interesting paper, Coward und Sun[5] address the design of possible theories of consciousness. Sketching a hierarchical structure, they note:

[1] Grossberg (2013), p. 2.

[2] Grossberg (2013), p. 6.

[3] Grossberg (2013), p. 15.

[4] Görnitz and Görnitz (2016).

[5] Coward and Sun (2007), p. 947.

> Detailed descriptions are usually more accurate but information-dense and therefore often beyond human comprehensibility (unless limited to tiny segments of a macro-level phenomenon). High-level descriptions are usually much less information-dense but more approximate.

As Coward and Sun let their hierarchy begin at the level of elementary particles, in the stages above atoms, molecules, cells, etc., there is no scientific approach to what constitutes consciousness, namely meaningful information, or to the so-called "hard problem":

> How does this relate to the so-called "hard problem": "Why is it that when our cognitive systems engage in visual and auditory information processing, we have visual or auditory experience: the quality of deep blue, the sensation of middle C? How can we explain why there is something it is like to entertain a mental image, or to experience an emotion?" (Chalmers 1995a). This is not exactly a scientific question within the current scope of science, although a scientific understanding will probably reduce the sense of mystery around the questions by giving a better perspective on the issue.[6]

Hence, the authors end with the insight:

> An argument has been made here that a scientific theory of consciousness analogous with theories in the physical sciences is likely to be possible, but the form of that science may be different from some existing (and often widespread) expectations because of the misunderstanding of what a theory in the physical sciences actually delivers. The rough general form of an eventual theory of consciousness has been outlined (to a very limited extent, of course), and issues with a few of the many approaches to understanding consciousness briefly identified.[7]

In this context, it is important to distinguish "intelligence" and "consciousness". As "deep learning" shows ever more clearly, multi-layered technical neuronal networks can be devised to acquire pattern recognition capabilities, building on huge data sets supplied by their—equipped with consciousness—constructors. As those technical constructs show, the distinction is essential of intelligent behavior that those systems have, and consciousness that they have not.

In the better books of brain researchers, it is openly admitted that so far mainstream science has not resolved the issue "what is consciousness?".

To the question "What is consciousness?" the brain researcher Christof Koch responds, "Your inner experience", adding "That experience is generated somewhere in the catacombs of the cerebrum. How this comes about, is a deep mystery."[8]

Rather cryptically, Wolf Singer speaks of a "phase transition". According to Gerhard Roth, consciousness is "a physical state sui generis obeying various particular laws of nature",[9] however, without further specifying what those laws might be. Hans J. Markowitsch, a leading German brain researcher, renowned in particular for his distinguished studies on memory, comments on the situation here as follows: "A fundamental

[6] Coward and Sun (2007), p. 953.

[7] Coward and Sun (2007), p. 953.

[8] http://www.zeit.de/2013/44/christof-koch-bewusstsein-hirnforschung.

[9] Roth G. Geist und Bewusstsein als physikalische Zustände. In: Dresler M. (Hrsg) Kognitive Leistungen. Intelligenz und mentale Fähigkeiten im Spiegel der Neurowissenschaften. Heidelberg: Spektrum Springer; 2011: 172.

paradigm change wouldn't be too bad!" However, he pointed out in a very interesting interview conducted by the science journalist Matthias Eckoldt, that this cannot be afforded due to the present structure of the sciences: "Scientists are under pressure to produce continuous output. That only works if one sticks to the familiar old stuff and addresses topics on the safe side."

One should expect that a new generation of young researchers would come up with new ideas. But that until now did not happen. However, Christoph von der Malsburg, leading neuro-informatics scientist in Germany, does not expect, given the present scientific environment, that the young academics will be in the position to trigger a decisive paradigm change in brain research[10]: "The young researchers stick even stronger to fashionable topics and refrain from pursuing dissenting ideas. Otherwise they couldn't publish their papers. When the referees keep saying we don't understand that and reject your articles, their young scientific career will be over after three years."

In view of this situation, one can hardly escape the following conclusion:

- The necessary paradigm change will not come about within the brain research community, irrespective of how many millions of funding money will flow in. The impulse has to come from outside, from the foundations of natural sciences.

Concerning the relation between brain research and humanities let us note that reservations against a natural scientific explanation of consciousness have been raised in particular from the side of humanities.

We tend to assume, that the rejection of physicalism and reductionism reflects the fear that the diversity and reality of life processes could ultimately be traced back to something like a "movement of tiny little balls". In 1872 the famous physician Emil Du Bois-Reymond had already formulated that this assumption is impossible. (Conference of Natural Research Scientists and Physicians, speech "On the Limits of the Knowledge of Nature"):

- "It is definitely and forever incomprehensible that it should not be unimportant for a number of carbon-, hydrogen-, nitrogen-, oxygen- etc. atoms how they lie and move, how they lay and moved, how they will lie and move. There is absolutely no way to understand how consciousness could emerge from their connection."

As already noted, with regard to the appearance of a definitely different quality, namely, that of consciousness, the term emergence is often used these days. However, "emergence" is not an explanation at all, and we have to understand how to explain the new quality scientifically.

All the sciences dealing with nature and, in particular, human beings, are concerned with objects full of color, diversity, and beauty. At school we learned that physics is the science of inanimate nature. By this the opposition and prejudice against the scientific explanation of consciousness have been preprogrammed. Also in this respect, quantum theory has initiated a radical change. This presently is realized by the researchers in various scientific fields. Only quantum theory can establish, why in molecules something completely different from the original atoms can emerge with entirely new characteristics. In the chemical bonding of atoms to a molecule the electrons of the atomic valence shells are 'socialized' to forming a new whole, and all that can only be explained by quantum theory. Ultimately, quantum theory also allows us to understand the great leap from inanimate matter to the area of living beings in the course of evolution.

[10] Eckoldt, S. 20 f.

In the following we shall discuss why and how quantum theory allows ourselves to go from the physiology of the brain to a scientific understanding of the conscious and unconscious components of its information processing, which, for humans, may be designated by the term psyche.

2 A Brief Explanation of the Essential Structures of Quantum Theory

2.1 Quantum Theory is Realistic

- Quantum theory—when correctly interpreted—is, in its general basic features, not at all "puzz-ling".

If we try to understand essential specific features of quantum behavior without mathematics, the type of images we know from our experience and dreams is more applicable than conceptions associated with the characteristics of macroscopic objects.

Considering our living body, it seems clear to us that it constitutes a whole, although we can distinguish distinct organs. After all, even pains in a toe can cause emotional effects. In our imagination, at the same time various possibilities can be present; when we are acting we are able to realize one possibility at a time only. Multiple coexisting possibilities can create something absolutely new as in art or dreams. In our feelings we can be ambivalent. That means that not only one possible situation is vital for us, but various others may be as well. All of these aspects can hardly be reconciled with a mechanistic point of view, but they readily conform to the ideas that follow from the structures of quantum physics.

To satirize the connection between consciousness and quantum theory it has been very often stated that since both consciousness and quantum theory are not understood there should be a connection between these puzzling subjects.

In the serious literature the statements are much more nuanced. An opposition to connecting consciousness and quantum theory may be based on unconscious prejudices, as the following statement, reminding to a "Freudian slip", indicates:

> Viewing the mind as a nonphysical phenomenon, discontinuous with the biology that creates and sustains it, is responsible for placing the mind outside the laws of physics, a discrimination to which other brain phenomena are not usually subject. The most striking manifestation of this oddity is the attempt to connect the conscious mind to heretofore undescribed properties of matter and, for example, explain consciousness in terms of quantic phenomena. The rationale for this idea appears to be as follows: the conscious mind seems mysterious; because quantum physics remains mysterious, perhaps the two mysteries are connected."[11]

What is interesting in this quotation is the probably unconsciously formulated antithesis: 'mind' is placed outside the laws of physics—and this becomes most apparent in the attempt to explain the 'mind' by using quantum physics.

Perhaps this may be not indeed A. Damasio's ultimate opinion. In the next paragraph he writes:

> Given our incomplete knowledge of both biology and physics, one should be cautious before dismissing alternative accounts. After all, in spite of neurobiology's remarkable success, our understanding of the human brain is quite incomplete.

[11] Damasio (2011), p. 14.

In this chapter Damasio refers to some other authors, especially to D. J. Chalmers. Chalmers wrote about quantum mechanics and consciousness:

> The problem of quantum mechanics is almost as hard as the problem of consciousness. Quantum mechanics gives us a remarkably successful calculus for predicting the results of empirical observations, but it is extraordinarily difficult to make sense of the picture of the world that it delivers. […] There is nothing even approaching a consensus on the answer to this question. Just as with consciousness, it often seems that no solution to the problem of quantum mechanics can be satisfactory.
>
> Many people have thought that these two most puzzling of problems might be intimately linked. Where there are two mysteries, it can be tempting to suppose that they have a common source.[12]

At the end of his book Chalmers has written:

> I have also raised the possibility of a kind of panpsychism. Like mind/body dualism, this is initially counterintuitive, but the counterintuitiveness disappears with time. I am unsure whether the view is true or false, but it is at least intellectually appealing, and on reflection it is not too crazy to be acceptable.[13]

Two decades later it become obvious that apart from the misleading denotation "panpsychism" Chalmers speculation appears as farsighted. With the AQIs of the Protyposis a common ground for an explanation of both quantum theory and consciousness is given.

There is much to be gained when we abandon popular and centuries-old views and direct our thoughts towards a new ground. Our view of nature will be expanded in this way. As the physicists know, the essential features of any process in nature cannot be explained accurately without quantum theory. There is no experiment that would contradict quantum theory, and more than one-third of the Gross National Product in industrial nations already relies on applications of quantum theory.

2.2 Basic Principles of Quantum Theory

The basic principles of quantum theory describe features that are completely familiar to living beings, particularly to those with consciousness.

- Quantum theory can be characterized as the physics of relations and possibilities.

It is a way of designing a distinct mathematical structure for two fundamental experiences of everyday life.[14]

- Relationships, in contrast to mere juxtapositions, establish wholes being more than mere sums of their parts. As a consequence, quantum theory also provides the scientific basis for explaining how something new can emerge.

While classical physics describes composite systems by combining the parts in an additive way, quantum theory uses a multiplicative approach. This generates new possibilities for the whole that cannot be anticipated by the properties of the parts alone. Already simple

[12] Chalmers (1995b), p. 311.

[13] Chalmers (1995b), p. 332.

[14] Cf. Görnitz, Th. (1999).

structures show the evidence that in the evolutionary process something new is produced continuously. In example the hydrogen and oxygen gases have completely different properties than water to which they can be combined.

- Not only facts, but also possibilities yield real effects.

It may sound unfamiliar that possibilities should be able to produce effects. However, introspection makes it obvious that not only the memory of past facts, but also the expectations associated with future possibilities influence our actions in the present. People often think about unrealized possibilities and are affected by them in the present. They may even ask for psychological help to recall repressed possibilities and resolve compulsions. Obviously, the effect of possibilities cannot be denied.

But effects, induced by possibilities can only be predicted with some probability, which means that there is an element of chance in nature.

Quantum theory offers a more exact and better description of nature. However this does not mean, that we can do without classical physics.

- According to its mathematical structure, quantum theory, strictly speaking, does not recognize facts nor separate objects. Nonetheless, both, facts and separable objects, are indispensable ingredients of our comprehension of nature.

2.3 The Dynamic Layering Structure

In our daily life we cannot avoid to understand and recognize past facts as something real, whereas in universal quantum theory this would only represent an approximation to reality. Nor can we avoid disassemble the real world around us into separate objects, although it follows from the mathematical structure of quantum theory that this, too, seems to be only a very reasonable approximation to reality.

If we try to explain the phenomena of our living world by physics we have to go back to the dynamic layering structure of descriptions in classical physics and quantum theory.

In the description of classical physics the real world is fragmented into separate objects with forces acting between them. In Quantum theory the shortcomings that arise in that procedure are avoided by focusing on the relationship connection within the real world as fundamental. For us as human beings it is obvious that, while we are autonomous persons separated from one another, it is inconceivable to deny the social relationships and our integration in a cultural surrounding which we share with everyone else.

Niels Bohr introduced the concept of complementarity as a way of transferring the reality of quanta into the language and the mindset of classical physics.

Within the framework of quantum theory a quantum state, which is a full characterization of the system at a given time—can be completely and exactly described. However, when one assumes that one may still maintain the ways of description applying to the facts of classical physics, then there is a problem. The quantum-theoretical possibilities encompass outcomes that, taken as coexisting facts, necessarily imply contradictions.

After all, this is the meaning of possibilities for mutually exclusive events: as realized facts they exclude each other, while being perfectly compatible as present eventualities. There is the possibility that a train is punctual or not, but only one of the two possibilities can become factual.

It is certainly not necessary to go so far as Dieter Zeh[15] did in stating:

[15] Zeh (2012), p. 51.

> Complementarity has therefore rightly been designated a 'non-term', and it could perhaps, in agreement with a recent fashion, even be called 'the non-term of science in the 20th century'.

Nevertheless, there is some truth in this criticism. What actually is the issue?

- Possibilities mutually exclusive as facts may be precisely defined within the framework of quantum theory but cannot be well-defined facts at the same time. Classical physics is less accurate; it allows for the illusion that clear description should be possible in any case.

As basic example, consider position and velocity. Since Zenon's paradoxes, since Greek antiquity, it has been known that those concepts are mutually exclusive. A position relates to a point; a velocity is well-defined only for a distance. With the ingenious invention of the differential calculus, Newton and Leibniz discovered a trick for circumventing this problem. The idea of a point as limit of increasingly smaller distances led to the illusion that position and velocity can exist simultaneously. The precision of quantum theory no longer permits this trickery. Either there is a well-determined position or a well-determined velocity—but never both at the same time. *This is the core idea of Heisenberg's uncertainty relation.*

In the context of quantum theory any factual outcome is the result of an event or an action—and the finding that the order of actions can rarely be interchanged without altering the outcome is a familiar experience in everyday life.

Quantum theory provides the foundation of any physical descriptions. However, when we speak about physical situations we usually do this in a way, which is adapted to facts. Here the concept of complementarity is crucial, as it allows us to use classical notions in addressing quantum behavior. *However, complementarity is rather a makeshift than a genuine basis for explanation.*

Unfortunately, up to this day there is the belief that classical physics is the ideal to be strived for. Often quantum theory is seen as an inadequate theory. For example, Richard Feynman, in his textbook on quantum mechanics, which is well worth reading, states:

> Yes, physics has given up. We do not know how to predict what would happen under given conditions and we believe today that it is impossible—that the only thing that can be predicted is the probability of various events. *One must realize that this is a restriction of our former ideal, of understanding nature. It may be a step backward, but nobody has seen a possibility of avoiding it.*[16]

In his bestseller "*A Brief History Of Time*", Stephen Hawking[17] takes the same line:

> One certainly cannot predict future events exactly if one cannot even measure the present state of the universe precisely! « … » Quantum mechanics therefore introduces an unavoidable element of unpredictability or randomness into science.

Obviously, such statements are hardly suitable to help the reader recognize that quantum theory is the most exact and best description of the real world by natural science. Moreover, we note a basic congruence of quantum physics with our experience as human beings: the future is open and not everything is determined.

[16] Feynman et al. (1966), pp. 1–14.

[17] Hawking (1988), p. 77.

- According to quantum theory, what is determined is the time evolution of possibilities but not the resulting facts.

3 Protyposis as the Basic Substance and as the Substratum for a Scientific Explanation of Consciousness

3.1 What is Really Simple: from Becoming to Being

For an explanation of the transition from becoming to being it is unfortunately necessary to take a look at the mathematical foundation of quantum theory. Science searches for structures in the real world and the processes taking place among them. An attempt is made to explain these structures and their alterations with the help of mathematical structures. If sufficiently successful, that mathematical structure is then considered a useful description of the respective part of reality.

A not easily comprehensible metaphor in quantum theory is the "state space". In modern mathematics, many problems are translated into a geometric language. While being a helpful illustration for the initiated, this is often confusing for those lacking the background knowledge. The term "space" in this context means a representation by vectors, or arrows. The drawing sheet in school geometry is two-dimensional, as at most two vectors can be orthogonal to each other (are perpendicular). An oblique vector can point slightly to the right and slightly upward, it has a share in each of the two directions. However, the upward vector does not point to the right at all. Upward and 'to the right' are mutually exclusive—stated geometrically: the directions are perpendicular. Translating logical statements into geometric notions, one may say that mutually exclusive states are "orthogonal to each other". The space we live in features three orthogonal directions: length, width, and height, and here at most three vectors can be orthogonal to each other. In a two-dimensional state-space, for a given state (vector) there is exactly one other state (of a definite length) orthogonal to the former (which in quantum theory means: the latter state cannot be found if the former state is actual). Perhaps one might have reservations because a two-dimensional state seems to be rather "flat". However, as mentioned above, quantum theory also takes into account the effect of possibilities. Future possibilities are not yet real. In the mathematical framework of quantum theory, it is essential that, in addition to real numbers, also imaginary numbers come into play, forming together with the former the set of complex numbers.[18] As a consequence, the two-dimensional state space of the quantum bit, based on the use of complex numbers, has a structure, which is as mathematically comprehensive as the four-dimensional manifold of space and time we live in.

The relational character of quantum theory is reflected by the fact that, according to its theoretical structure, complicated and complex systems can be composed in a

[18] Whereas the square of all real numbers is positive, the square of an imaginary quantity is negative. Complex numbers can be represented by drawing the axis of the imaginary numbers perpendicular to the axis of the real numbers. This makes it clear that a complex dimension can be represented by 2 real dimensions. More elaborated arguments for use of complex numbers in quantum theory are given in Görnitz and Görnitz (2002), Kap 5.2.2 and Görnitz and Görnitz (2016), pp. 471–473. In the space with two complex dimensions the Protyposis uses the symmetry group U(1) × SU(2). This group has four real parameters, which will be interpreted as representations for the coordinates of space and time. In quantum information theory the vectors of the state space of a qubit are reduced to norm 1 and further on for a single qubit a phase is declared as not essential. Therefore in this context only the real 2-dimensional Bloch sphere is seen as crucial.

multiplicative way out of simpler ones. This means that the dimension of the state space of the composite system is the product of the dimensions of the fragment state spaces. This is the central difference to classical physics, in which a composition is accomplished in an additive way. Here, surprising relationships to complexity theory arise as well. As D. C. Mikulecky writes:

> Analytical models which are expressed mathematically as direct products of state spaces are no longer equivalent to synthetic models which are built up from disjoint pieces as direct sums.[19]

Noting the multiplicative structure of the quantum theoretical building up of complex structures, we can ascertain that:

- The simplest conceivable quantum entity must have a two-dimensional state space.

It is however difficult to ascribe an illustrative term to such a basic entity. To call it a "system", would imply unfavorable associations with systems we know in technology and society as complex objects. In particular, it is not an "object", because in the simplest case an object is a quantum particle, having already an infinite dimensional state space.

- Such a "quantum pre-structure" with a two-dimensional complex valued (based on real and imaginary numbers) state space is the simplest and, at the same time, most abstract construction that can be introduced within the framework of quantum theory and formulated mathematically.

To attribute any concrete meaning to this entity would require a context, and thus much additional structure not available in a two-dimensional state space. However, with sufficiently many of these quantum entities, via the multiplicative composition, it is possible to form photons, that is, the quanta of the electromagnetic field, as well as electrons, protons, and neutrons, thus all the particles and fields of physics.

Out of the Big Bang, the sheer possibility of a mathematically construed beginning of the cosmic evolution, there unfold, based on such an elementary entity, all the phenomena we describe as factual occurrences, such as, for example, the forming of a star.

- In a philosophical interpretation one can consider the beginning of the cosmos as an intermediate phase between "nothing" and factual "existence". It can be described as a pure "becoming" and clearly indicates the process character of the cosmic evolution.

In physics we are familiar with examples of these simplest quantum structures, such as the spin of electrons or the quantum bit. However, the spin of the electron is always bound to a massive particle—and a particle has, as mentioned, an infinite dimensional state space. A quantum bit has only a 2-dimensional state space. As an"atom of quantum information", in the usual terminology it is always related to a sender, a receiver, and, above all, also with the notion of meaning. Meaning, however, always has a subjective component and thus cannot be subject of an objectively oriented science like physics. That in fact meaning only emerges via a complex interpretational process has also been noted by E. Werner.[20]

[19] Mikulecky (1999).

[20] Werner (2010).

3.2 Quanta and Atoms: An Opposite Ignored

Why has the idea of atoms, ultimate indivisible building blocks, been introduced in the description of nature? In view of the abundance, diversity, and complexity of reality one could barely hope to comprehend and explain it.

- Fragmenting things into ever smaller parts, the parts were supposed to become ever simpler as well.

Ultimately—as was expected and hoped for—the tiniest components would turn out to be fundamentally simple—and, thus, amenable to comprehension and explanation. Once those 'elementary building blocks' had been understood, it should be possible to explain the more complex phenomena as being composed of the former—as was expected and hoped for. For two and a half millenia, this has been the core paradigm in the natural sciences. This creed is not only propagandized in countless popular scientific texts, but it also dominates, to a certain extent even subconsciously, the way of thinking of many scientists until today. So in the official website of CERN for example it is stated:

> The model describes how everything that they observe in the universe is made from a few basic blocks called fundamental particles, governed by four forces.[21]
> The theories and discoveries of thousands of physicists since the 1930s have resulted in a remarkable insight into the fundamental structure of matter: everything in the universe is found to be made from a few basic building blocks called fundamental particles, governed by four fundamental forces. […]
> All matter around us is made of elementary particles, the building blocks of matter. These particles occur in two basic types called quarks and leptons. Each group consists of six particles, which are related in pairs, or "generations". The lightest and most stable particles make up the first generation, whereas the heavier and less stable particles belong to the second and third generations. […]
> The quantum theory used to describe the micro world, and the general theory of relativity used to describe the macro world, are difficult to fit into a single framework.[22]

That the "basic blocks" can decay apparently does not harm their "fundamentality". A similar way of thinking is being cultivated elsewhere, as the following statement on the website of DESY (Deutsches Elektronen-Synchrotron at Hamburg) shows:

> What does the world consist of at the smallest level? What are the most fundamental particles of matter? Natural scientists have been looking into these basic questions since antiquity. In the course of their search, they have encountered ever smaller building blocks—first atoms, then atomic nuclei consisting of protons and neutrons, and finally tiny particles called quarks. Today, particle physicists are investigating the fundamental mysteries of the universe: what holds the cosmos together, and how do particles acquire their mass in the first place?"[23]

[21] http://home.cern/about/physics vom 20.4.2016.

[22] http://home.cern/about/physics/standard-model vom 20.4.2016.

[23] http://www.desy.de/research/particle_physics/index_eng.html vom 20.4.2016.

It is important to note that, down to the atoms of chemistry, this concept has been extremely successful. By the end of the nineteenth century, the triumphs of chemistry and, moreover, of the kinetic theory of gases had crushed the counter-arguments of continuum physics.

- However, the question is whether a continuation of the 'atomistic' concept to spatially ever smaller realms can be justified by quantum mechanics?

Let us recall Planck's formula from the advent of quantum theory: $E = h\,\nu = h\,c/\lambda$. The energy E of a quantum is inversely proportional to $\boldsymbol{\lambda}$, its characteristic length. In the case of massless quanta, λ is the wavelength. For a quantum with mass one may use Einstein's equation, $E = m\,c^2$, and assign to it the corresponding Compton wavelength: $\lambda = h/m\,c$. In both cases we find: the larger the energy or mass, the smaller is the characteristic length. In short:

In the atomistic concept the basic idea is:

the smaller, the simpler.

In quantum theory, since Planck, the finding is:

the more, the smaller.

Combining both statements, that is,

'the more, the smaller' and 'the smaller, the simpler'.

would imply the statement:

the more, the simpler!

which, however, is patently implausible.

The fact that $\boldsymbol{\lambda}$ refers to a length suggests that, from the viewpoint of quantum theory, the very simplest will not be small, when 'small' refers to the spatial extension.

- Quantum theory shows that the very simplest will be the utmost extended as well.

Recalling that since Pauli postulated the neutrino the usual procedure in physics is to invent new hypothetical particles as the solution to any problem encountered. Here a typical and actual example:

> Four research groups have proposed the existence of various new particles to explain an anomalous signal picked up by the two largest particle detectors at the Large Hadron Collider at CERN, Europe's particle-physics lab in Geneva, Switzerland.[24]

As was recognized already half a year later, that signal was a mere statistical deviation and it disappeared when a larger data set became available (Figs. 1, 2).

Therefore the following becomes apparent:

- Weighing in the significance of the basic formula of quantum theory, an entirely new way of thinking is required, a radical change in the framework of physics.

Science is always an approximation to reality:

- In natural sciences "explaining" means to reduce complex structures to simple ones, and to recognize the mathematical methods and approximation procedures required for that task.

[24] Nature 532, 284–285 (21 April 2016) doi:10.1038/532284d.

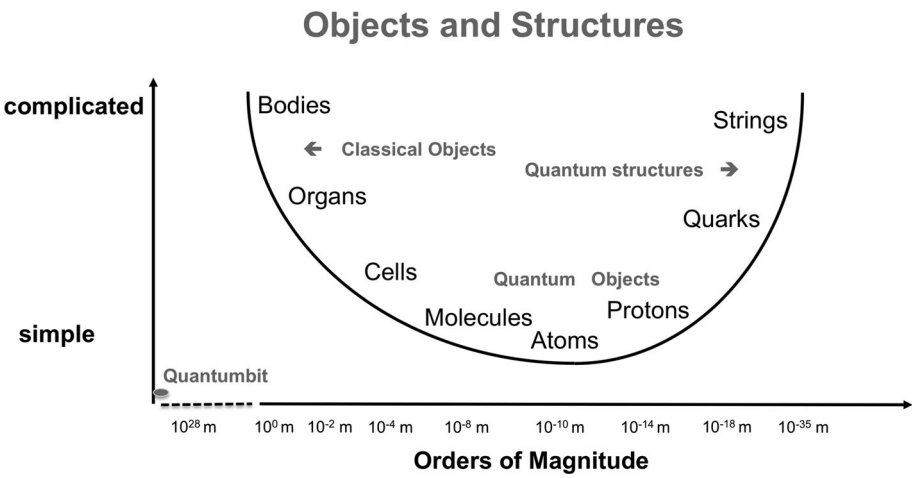

Fig. 1 Simplicity and magnitude of structures

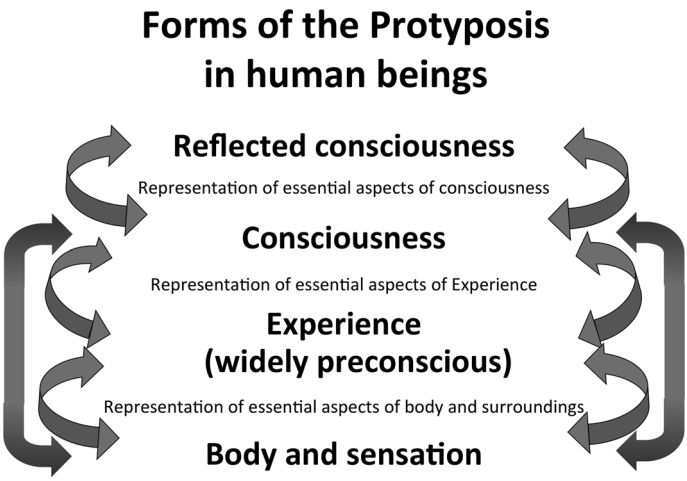

Fig. 2 Forms of Protyposis in human beings

Presently, the fundamental problems in physics are treated using methods of quantum field theory. Quantum fields have configuration spaces of non-denumerable infinite dimensions. They are the most complex structures quantum theory deals with. According to Einstein's great discovery of the quanta of light, a quantum field can be understood as representing an indefinite number of quantum particles. Accordingly, quantum particles are significantly simpler structures than quantum fields. Using quantum-field structures allows one to describe the creation and annihilation of quantum particles.

A particle is defined as an object that can be moved in space and time. The group of motions in space–time is the Poincaré group. The infinitely many states of a quantum particle can be assigned to an irreducible representation of the Poincaré group. However, even such a corresponding countably infinite state space does not stand for actual simplicity.

Truly simple are quantum structures associated with the smallest conceivable state space, that is, a two-dimensional Hilbert space. That such entities can be structures of their own right has hardly been realized in physics so far. They are familiar as spin one-half or as qubits. The latter two structures are always seen in conjunction with another quantum acting as a 'carrier'. In the case of the spin, the carrier is a particle, and likewise a photon or a particle with mass in the case of the qubit. In both cases the carrier is a quantum object with an infinite-dimensional state space.

Really simple are qubits without any carrier. These entities, by the very mathematical procedure used to construct quantum fields from quantum particles, allow for the generation of quantum particles from qubits.

- Qubits, being quantum structures associated with a state space of dimension two, are the really simplest structures that can be conceived for logical reasons.

They must not be seen as particles—though it will be difficult for many scientists, embedded in the conventional way of thinking, to break free of that picture. As a consequence of Planck's formula, they have to be associated with the largest conceivable "wavelength", that is, the radius of curvature of the closed cosmos.

Via the multiplicative combination, as suggested by the quantum structure, of ever more qubits ever more localized states can be constructed. The quantum structure necessarily leads to the conclusion: *"plenty of spatially extended can become spatially small"*. Obviously, the latter contradicts the unconscious perceptions hitherto prevailing in physics.

3.3 The Interpretation of Protyposis

In order to avoid rash and erroneous associations, it was required to introduce a new conception for the simplest conceivable quantum structure, which—as explained—possesses only a 2-dimensional state space: ***Protyposis***.[25]

- If we want to illustrate Protyposis and relate it to a familiar idea, then the quantum bit of information is the best choice, supposing here a notion of information, which is entirely abstract and free of meaning.

The Protyposis concept allows us to recognize that the basis of existence is more aptly described as a mental structure, even if any material thing is generated from it. Analogous to the way a quantum field can be constructed from an indefinite number of quantum particles, a quantum particle can be generated from an indefinite number of Protyposis qubits (AQIs).

Ultimately, quantum information obviously reminds us of our thoughts, or something mental, rather than of our bodies, or something material.

In our daily experience, there are many phenomena lacking any tangibility so that we cannot picture them. How, for instance, should one be able to imagine, without invoking physical theories, that, at this very moment, information pertaining to, say, 20 TV programs and 5000 mobile phone conversations is streaming through our bodies completely unnoticed by us?

[25] This term was suggested to us by the Classical philologist Roland Schüßler of Frankfurt University: The Greek term Protyposis stands therefore for something that can be formed into matter, energy and also into meaningful information.

- Protyposis can be perceived as completely abstract, free-of-meaning quantum information, which primarily is not localized at all (i.e. being of cosmic extensions), and which must be conceived without recourse to a sender and a receiver.

Let us note that the principle of non-locality, being a central feature in quantum theory and particularly in Protyposis, can help explain many non-localized phenomena of consciousness.

Again, it should emphasized that in no way the AQIs of Protyposis can be thought of as particles or "objects", as such systems come along with infinite state spaces. Only in the limit of infinitely many qubits particles can be formed out of them.

The interpretation of Protyposis as quantum information suggests that a scientific understanding of consciousness may become possible.

This Greek term means "pre-forming, exemplification". Accordingly, Protyposis designates something that can be transformed into matter, energy, and, ultimately, meaningful information.

Quantum theory makes it obvious that distinctions, to which we are accustomed in our daily life or in classical physics, become increasingly obsolete, increasingly less fundamental if examined at sufficiently high precision. In physics, we know, since Einstein's famous formula, that matter and motion (kinetic energy) can be converted into one another. While the formula $E = mc^2$ was discovered within the framework of the theory of relativity, we are dealing here, more generally, with quantum theory, as indicated by the instance that anti-matter is always involved in those processes.

Other consequences of quantum theory are a relativization of localization and extendedness, and a relativization of force and matter. While the latter findings belong to the accepted knowledge of science for a long time, only recently the insight is beginning to gain ground that *Protyposis*, conceived as quantum information, *is equivalent to matter and energy.*

Equivalence can stand for 'equal value'. Opposed to equality, it means that items of different appearance can be converted into one another. Of course, for the respective conversion a theoretical foundation in mathematical form has to be established. Matter is not motion or, physically speaking, kinetic energy, but, involving anti-matter, the two can be converted into each another.

3.4 Manifestations of Protyposis

The first to suggest a foundation of physics based on quantized binary alternatives was C. F. v. Weizsäcker, already in the fifties of the last century.[26] He introduced the term 'Ur' taken from the German prefix in words such as 'uralt' (very old) or 'Ursprung' (origin) to denote what usually is called a 'qubit' at present.

The idea of such an elementary quantum structure forming the foundation of the physical description of reality was also taken up by other authors.

In his 'space–time-code', D. Finkelstein devised a discretized space–time—a kind of a four-dimensional chessboard. He was in friendly contact with Weizsäcker for a long time, and later with me as well. Finkelstein often participated in the "Tutzing conferences", initiated by Weizsäcker.

[26] Weizsäcker, C F v: Komplementarität und Logik, *Die Naturwissenschaften* **42** (19) (1955), S. 521–529 and **42** (20) (1955), S. 545–555. Die Quantentheorie der einfachen Alternative (Komplementarität und Logik II), *Zeitschrift für Naturforschung* **13a** (1958), S. 245–253., Scheibe, E, Süßmann, G:, Weizsäcker, C F v: Komplementarität und Logik III: Mehrfache Quantelung, *Zeitschrift für Naturforschung* **13a** (9) (Scheibe et al. 1958), S. 705–721.

In 1980, Weizsäcker had invited A. Wheeler to the conference in Tutzing (near Starnberg and Munich, Germany), which was devoted mainly to the theory of Urs and their ramifications.[27] Ten years later, Wheeler coined the slogan 'It from Bit'. This was commented by Claus Kiefer[28] as follows:

> Weizsäcker's Ur corresponds to the familiar bit; the term was chosen to indicate the fundamental character of those alternatives. Pursuing a similar approach with his idea 'It from Bit', J. A. Wheeler sets out to reduce the entire physics to 'Uralternativen', however, without in any way referring to the work of CFvW (Wheeler 1990).

However, Weizsäcker's already very abstract starting point was not yet sufficiently abstract, as he always maintained a close relation of the Urs to knowledge and meaning. By contrast, as explained above, it is necessary to begin with an entirely abstract notion of information, which is dissociated from the notions of knowledge and meaning. This has been accomplished with the Protyposis concept.

The underlying mathematical structures have been clarified elsewhere; they show how the qubits of Protyposis can form relativistic quantum particles.[29] Moreover, supposing a growing Protyposis, reflected by an increasing number of quantum bits, the structure of the cosmic space, with the expansion of the cosmos, and also the effect of gravity can be established.[30] The Protyposis concept has also allowed for a rationalization of why the three other fundamental interactions, that is, the electro-magnetic, weak, and strong interactions, prove to be local gauge interactions of the three gauge groups U(1), SU(2), and SU(3), respectively.[31] The clarification of such mathematical connections is the prerequisite for advancing from pure philosophical considerations to actual natural science.

Thus, analogous to the distinct manifestations we encounter in H_2O, namely ice, water, and steam, we find different *manifestations of Protyposis:*

- *Matter*, being inert, resisting change.
- *Energy*, being necessary to set matter in motion and change it.
- *Information,* in the narrow and normal sense, being instrumental in releasing available energies.

4 What Influences the Forming of Individual Consciousness?

The focus here is on several general aspects of the development and function of consciousness as a highly dynamic process. This involves many factors that affect consciousness.

[27] See Castell, L, Drieschner, M, Weizsäcker, C F v (Eds.): Quantum Theory and the Structures of Time and Space 4. Papers presented at a conference held in Tutzing July 1980, Hanser, München (1981).

[28] Kiefer, C: Weizsäckers Zeitbegriff aus heutiger Sicht, in: *Acta Historica Leopoldina*, Nr. 63, (2014) S. 179: » Das Weizsäckersche Ur entspricht dabei dem üblichen Bit; die Wortwahl soll aber auf den fundamentalen Charakter dieser Alternativen verweisen. Einen ähnlichen Ansatz verfolgt John Archibald Wheeler mit seiner Idee des It from Bit, mit der er die gesamte Physik auf Uralternativen zurückführen will, ohne dabei freilich auf CFvW in irgendeiner Weise Bezug zu nehmen (Wheeler 1990).«

[29] Görnitz et al. (1992), Görnitz and Schomäcker (2012).

[30] Görnitz (2011a, b) (1).

[31] Görnitz and Schomäcker (2016).

Living beings can be characterized as thermodynamically instable systems that stabilize and control themselves by internal information processing. Here "control" means the effect of information on the behavior of the system. In this way information becomes meaningful for it.

The possibility of control by information of material systems was introduced in natural sciences by Norbert Wiener, coining the notion "cybernetics". Wiener control referred both to living beings and machines. Technical cybernetic systems, by and large, should be stable, whereas living beings, by contrast, are unstable at all levels of organization, from cells to organs up to the entire organism.

According to G. Günther, cybernetics can be seen as a transition from the bivalent Aristotelian logic to a multi-valent logic, which allows one to construct analogues to consciousness. Assessing cybernetics as a science of direct importance for the essence of humans, he considers the theory of relativity and quantum theory as "relatively neutral scientific concepts affecting the moral essence of humans, at best, at the outermost periphery."[32] Here the fundamental difference between classical physics, as in the theory of relativity, and quantum structures is ignored. Given Wiener's dictum "Information is information, not matter or energy",[33] at that time it could not yet be seen that the role of subjectivity, as rightly emphasized by Günther, is introduced in natural sciences by quantum theory. A further elaboration on these issues shall be given in a forthcoming paper.

Turning now to biological topics, we note that our biological inheritance with the experiences accumulated over billions of years and stored in the genes enables the development of our human brain. The social relationships during our first years of life make it possible for us to survive and assimilate the knowledge and internalized intellectual wealth of the respective culture.

The repeated processing of the same or similar information produces anatomically recognizable transformations in the brain. The mental information, with its physical development and storage of information, such as in the development of synaptic structures, effects a development of memory induced by learning.

Around the age of 18 months, the development of the human brain is sufficiently advanced to sustain a consciousness, which is capable of recognizing its own reflected self in a mirror. Being embedded in cultural surroundings is the prerequisite for the faculty of formulating our thoughts linguistically.

- Our consciousness thus develops in a process of examining our natural, cultural and social surroundings.

The experiences and interactions occurring during this process are retained in the memory, and, via the memory, influence the respective state of the consciousness. In addition, there is influence by meaningful information transmitted from the body and its sensory organs, especially perceptions and feelings, as well as our expectations of future possibilities.

Information processing in the brain is "very costly" from an energetic point of view, in fact, the human brain represents only 2% of its body mass but consumes approximately 20% of its energy. The largest part of the consciousness is not reflected, i.e., not considered and assessed back and forth. Rather, its processing ensues according to what has been learned, and in part, like automated patterns of the respective individual processing of information. This can be compared to the familiar proceedings in politics and economy.

[32] Günther, p. 20.

[33] Günther, p. 22, quoted Wiener, p. 155.

The general aims, of course, are prescribed by the management, but many secondary decisions do not at all reach the upper level of management; moreover, important decisions are usually initiated at the top, but then prepared without recourse to the upper level, to be finally decreed "above", that is, on the upper level.

The consciousness thus relies on a large amount of unconscious acts that are only presented to the consciousness to be decided upon after having been prepared unconsciously and pre-consciously.

When no essential objections from the "higher echelons", for example, ethical or moral reasons and objectives stand in the way, the preparation for a decision made by the unconscious will, as a rule, be "waved through" by the consciousness. Otherwise, in the process of reflection, the unconsciously prepared action will be interrupted or completely stopped. Here another problem of reflection plays a role: Reflection requires time. Under stress and time pressure, reflection, with its back and forth considering and contemplating of possibilities, becomes impossible. Lacking sufficient time, decisions are and must be made spontaneously, as a "knee-jerk" response. Such unreflected, and to some extent pre-conscious, decisions will succeed the better, the less the unconscious is burdened with unresolved conflicts of the respective person.

In relationship to the psyche, the reflexive consciousness is only the tip of the iceberg. The largest portion of meaningful information is processed without bothering the consciousness.

This is not a new insight. Carl Gustav Carus had already written comprehensively about the unconscious. Sigmund Freud, and later C. G. Jung made it the foundation of their psychology.[34]

5 The Autonomous Reality of Consciousness

As we will argue in the following, a close examination of consciousness has to resort to the dynamic layering structure of quantum theory and classical physics.

- It is a clear scientific insight today that no area of reality can actually be understood in depth without quantum theory.

And this finding is not affected by the instance that there are scientists still in doubt. The problem, however, is that working with this theory usually presupposes an intensive and arduous training, involving extensive mathematical efforts, and, on the experimental side, extreme precision.

A definition for matter would be:

- Matter is a special form of Protyposis, namely quantum information localized in space and time.

Therefore we can state:

- Protyposis appears in the cosmic development in the form of quanta of energy and matter, from which macroscopic objects can later be formed, and, ultimately, even meaningful information in living beings.

The equivalence of Protyposis with matter and energy suggests that it is not less real in the form of our thoughts than in the form of atoms as constituents of our brains.

[34] Cf. Görnitz and Görnitz (2002, 2006, 2013).

As a consequence of Protyposis, it becomes possible to comprehend the relationship between the brain and consciousness. Considering only the brain a reality, consciousness can at most be something like a feature of the brain, which cannot generate independent effects. As Protyposis shows, there is no need to view only the so-called material aspect as being exclusively real.

- In view of Protyposis, one no longer needs to speak of the brain if one rather means consciousness or, in general, the psyche.

To draw a simple analogy: in reviewing a book one would not restrict oneself exclusively to the quality of the binding, the paper, and the colors used, even if they considerably influence the aesthetic appearance of the book. On the other hand, without the paper (or a computer screen) the print could not at all be seen, while it is of course the content of the text that really is important.

In addition to the equivalences mentioned above, quantum theory features also an equivalence of object and property.[35]

- In this sense, consciousness can be understood, on the one hand, as a property of the brain, together with its emitted and absorbed photons, and, on the other hand, as an independent real entity formed quantum information.
- Consciousness, on the other hand, can be understood as an independent form of Protyposis, as quantum bits that change their carriers, e.g. transmitter molecules and photons—carriers which themselves are ultimately built of Protyposis.
- The effective power and reality of the meaningful information of consciousness are also recognizable in that they can produce independent effects, which are not dependent of special carriers, e.g. photons or molecules.

Acknowledging its objective and independent existence is the key to the scientific understanding of consciousness.

A scientific definition of consciousness may be formulated as follows:

- Consciousness is a special form of Protyposis, namely, quantum information that experiences and recognizes itself.[36]

If Protyposis allows for a scientific description of consciousness, then it is also clear that the role of the observer as "residing outside of physics" is no longer needed. In an extension of the Copenhagen interpretation of quantum theory it was shown how the origination of facts is possible without involving an observer.[37]

Here we should again recall that a special folding of a single molecule probably is accorded only as much "meaning" as some characters in a long text. On the other hand, some characters—consider for example the letters $E = mc^2$—may convey as much meaning as a complete article.

One can write on a computer, with a pencil or a pen on loose sheets of paper, in a notebook, or as print in a book. The carriers of conscious information in the brain can

[35] Cf. Görnitz and Görnitz (2008).

[36] Görnitz and Görnitz (2006), p. 285, 322, Self-reflection means that a part is able (in principle) to map one-to-one the whole. This necessitates a set that is possibly infinite. Whereas all classical information memories are finite, even a simple quantum object, such as a hydrogen atom, has an infinite state space. Quantum systems are essential for another reason: Only via quantum physics the distinction between hard- and software can be overcome. This point is essential crucial in any biological information processing. See Görnitz and Görnitz (2016), ch. 5.4.9.

[37] Görnitz (2011b).

appear with a similar diversity. They can, as mentioned, be virtual or real photons, but also ions or molecules; for instance, we may think of transmitter molecules, the exchange of which at the synapses determines an important part of the information processing. When we speak of such objects, we have particles in mind. However, owing to Protyposis we can now understand that particles are not the fundamental physical entities. The particles may undergo changes, being the result of an addition or a removal of qubits. Those qubits, depending on the context, can acquire a meaning in the living being—just as letters of the alphabet in a text also only acquire meaning within this context. Since the AQIs of the Protyposis can and must be seen as an independent reality, this reality character applies as well to the qubits of our consciousness. From the quantal possibilities of our thinking and feeling, consciousness extends to our factually formulated thoughts.

What is also important is that consciousness is not localized in a particular place of the brain, but its carrier is the whole brain and the whole body.

Here it should be helpful to briefly reconsider, in the framework of quantum theory, the issues of localization and extended wholes without parts. Brain researchers have posed the rhetorical question, where there was the "site of the I" in the brain—as no such site had been found after all. From a quantum-theoretical point of view, it would be most peculiar if there was such a site, given by a small region in the brain. Rather, one should expect that a substrate of the "I" is extended, stretching, at least, over the entire brain.

The question whether a whole can be understood as being without parts, depends on the mass or rather the energy of the system. The Planck mass, about 10^{-5} g, characterizes the most massive quantum object lacking actual parts. In more massive systems, an absence of parts can only be virtual. However, it is always possible that subsystems, in particular, ones pertaining only to quantum information, may act as a whole without parts, even when residing on a massive substrate.

For example, the quantum information of the consciousness represents a quantum system, the size of which is far below the 10^{61} quantum bits of the Planck mass. This makes understandable that we rightly perceive our consciousness as a wholeness, extending over the cells, the brain, our entire body, and, in certain situations, possibly even beyond.

When we define consciousness as quantum information that experiences and recognizes itself, then the present state of the consciousness provides also the framework necessary to incorporate information coming in from the surroundings as meaningful.

6 The Evolution of Intellectuality and the Forming of Meaning

The long course of cosmic development was required before information could become meaningful in the biological evolution.

For single cell organisms, meaning can be attributed to incoming information when it triggers a reaction. If the cell reacts such its stability and further existence is promoted, the information has the "right" meaning for the cell, and the "wrong" meaning in the opposite case. If the cell reacts in the "wrong" way, it will drop out of the evolutionary process more quickly. In more highly developed forms of life, secondary meanings can replace those associated with mere survival. As mentioned above, that can pertain to reproduction, and, at a tertiary level, to all cultural influences of civilization.

That the information matters and not the carrier is a familiar daily experience for us. A warning signal can have the same effect for us irrespective of whether it is acoustic or

optical. In the first case the air is the carrier, in the second the light. Of course, this is not entirely correct; after all, there are blind or deaf people, for whom the two carriers convey different meanings.

That this meaning is not something "objective" is particularly evident in medicine. Apoptosis, or the "suicide" of defective cells, is vitally necessary for the organism, not of course for the affected cell. When growth is important for a tumor, because of its separation from the meaning context of the whole organism, it is extremely dangerous.

Information processing requires the ability to preserve the information over a longer period of time so that a form of memory needs to be established. Living beings are steady states linked to chemical processes, which enable and promote a differentiated processing. That is to say, they are based entirely on catalytic processes. A catalyst can be understood as a molecule or a material surface that exerts a strong attraction to the initial molecules and deforms them in such a way that they can more easily undergo a chemical reaction. The products of the reaction may differ completely from the educts, having entirely different features, so that they can again separate from the catalyst. Catalytic processes usually are mild chemical reactions—as opposed to violent ones like perhaps a real fire, even though one speaks of the "burning of nutrients in the body"—so that they can run in parallel and simultaneously with other processes, without damaging the entire system. Living beings rely on enzymes, which are complex molecules with very special catalytic characteristics. Molecules that can function as memory, as well as enzymes, are the ribonucleic acid (RNA). At the beginning of life they were probably the essential components of cells. In the further development of lifeforms the memory and enzyme functions became separated. The deoxyribonucleic acid (DNA) is more stable, and thus more suitable than RNA as a memory substrate for longer storage of information. Proteins are more efficient catalysts than RNA.

In more highly developed animals, at least in birds and mammals, the evolution of the brain has reached a state where consciousness becomes possible. In consciousness essential aspects of experience can be represented.

- Normally almost all control processes proceed unconsciously. Consciousness makes it possible, in a theoretical model, to simulate some of the intended processes and inspect their results, without having to carry them out in the reality.

This enables one to run through various options in the consciousness, so that results, which possibly are unfavorable under real circumstances, can be avoided.

In very highly developed animals consciousness becomes capable of reflection. They become capable of recognizing themselves in the mirror. So far this capability has been demonstrated, among others, in apes, macaques, elephants, dolphins, and ravens. Humans acquire this faculty, as mentioned, at the age of about 18 months. In reflection, a part of the consciousness can contemplate the whole of the consciousness.

- During reflection, quantal possibilities consolidate into facts: Facts are amenable to classical logic, thus a consciousness capable of reflection is also capable of logical thought.

Probably, such transitions from (quantal) possibilities to linguistically formulated facts are familiar to everyone. We have a certain idea—and when we formulate that idea in spoken language, perhaps even in writing, we may have the impression that something is being lost, something which, in an indefinite way, had been resonating in us before.

7 The Relationship Between the Brain and Consciousness

Dismantling an organism into cells, and in turn into molecules, atoms and ions, can be useful and extremely effective for understanding many processes. However, according to numerous accounts and the perception of many scientists, the reactions in living beings—such as the formation, transport, and reorganization of molecules—are depicted as a mere resorting of "small particles". What is not adequately recognized is the quantum nature of all those processes.

Any reaction in a biological system is an electro-magnetic phenomenon. In fact, any biochemical reaction involves an exchange of photons, more specifically, of real and virtual photons. The motion of ions, electrically charged molecules or atoms, is often described as a response to the action of electromagnetic forces. In a precise—i.e. quantum physical—description, this is the action of virtual photons. Real photons are emitted when the motion of charges is not uniform, e.g., being accelerated from rest or slowed down. In view of the small energies acting in the living brain, it is often assumed that one can ignore quantum aspects and only needs to take electromagnetic waves into account. For a mere pragmatic description this may sometimes be appropriate, though certainly not for a real and deeper understanding of those processes.

This finding is of particular importance when it comes to the relationship between brain and consciousness.

- In the field of biology all interactions among atoms, ions, etc., are facilitated by real and virtual photons.

Since massive objects, atoms, etc., are ultimately built of Protyposis, they can also gain or loose Protyposis in the form of energy, as well as in the form of meaningful information.

- The equivalence between matter and energy has been well known for over a hundred years; that there is an equivalence between quantum information and matter is a recent result of quantum theory.

Molecules, atoms, ions, and photons in the body always appear in a double role. They are carriers of meaningful quantum information, being a form of Protyposis, and, on the other hand, are formed of Protyposis. It is also for this reason that the boundary between carriership and meaningful information is fluent and depends on the situation and the context. Meaningful information can change its carrier, which is very important for an understanding of consciousness.

Living beings are unstable systems. Other than something stable, they can be influenced not only by matter and energy, but also by information. Living beings acquire stability by means of processing of information, which thereby becomes meaningful for the living being. Here it should be recalled that meaning is always linked to processes of encoding and decoding. The incoming image of a predator or a nutrient can only become meaningful in the context of already existing information, by decoding and association with something already known. Through quantal parallel processing this can be accomplished at great speed. Even more obvious is the necessity of decoding in the case of spoken and written language. Here meaning is to be derived from sound vibrations or scribblings on paper, which is only possible if a meaningful context is already given.

The more highly developed animals are equipped with a specialized organ for processing information, a nervous system with a brain as the center. According to present accounts, the information flows along specialized nerve fibers to the subordinate

processing centers in the brain. This refers primarily to classical, or factual, aspects of information processing.

As the significance of photons shows, exemplified for instance by the way one determines brain death, the information can also be transmitted in a different way—non-locally and irrespective of the nerve fibers.

The previous research results on information processing in the brain are important. It has been shown that in the brain distinct ways of storing and encoding are used—as was to be expected from quantum theory—namely in a more localized as well as a more delocalized mode. The latter has been related to the principle of holography by Karl Pripram.[38]

While for a long time the idea of a "grandmother cell" has been popular, in which a particular cell is responsible for recognizing the grandmother, research today has progressed much further. Ch. Koch and his co-authors, for instance, speak of concepts in which memory is distributed over a large region—as population coding—as well as being localized and "sparsely" represented in the brain.[39] In view of the quanta as features of Protyposis, it is very easy to understand these two forms of storage. Other authors, such as S. Greenfield,[40] emphasize more strongly the holistic character of information processing in the consciousness, without referring to quantum physical foundations though. The holistic character can be connected very well with the idea of networks.[41]

The models of technical neuronal networks are an important aid for the modeling of information processing—that is, however, only for their classical, i.e. factual aspects. For all what is fast and non-local, quantum features are essential.

For a deeper understanding of information processing in the nervous system and the consciousness we will again refer to several quantum aspects.

Firstly, quantum systems can interpenetrate spatially and yet remain completely separate, provided there is absolutely no interaction between them. Secondly, a quantum system can be spatially extended without being divided or disintegrating into something like "natural parts".

- Quantum theory recognizes extended and integral wholes.

Furthermore, quantum theory demonstrates that not only facts but also possibilities cause effects. Anticipated possibilities are constantly elicited and integrated in the quantal information processing of our consciousness.

Knowledge about everything that exists is conveyed through our consciousness.

- Our brain is only a carrier and a processing organ.

When we are unconscious, e.g., in deep anesthesia, neither our body nor the surroundings 'exist' for us.

Our consciousness presents itself directly to us; however, to explain our brain we have to use analogies and technical tools. (It is notable that all probes of the intact living brain, such as PET (Positron Emission Tomography) or fNMR (functional Nuclear Magnetic Resonance), are based on quantum physical methods.)

Just as we need the dynamic layering structure of classical and quantum physics for an optimal description of the world, this applies as well to the task of describing consciousness and its essential carrier, the brain. As long as only cells or molecules are seen

[38] Pripram (1975).

[39] Koch (2005), Koch et al. (2013).

[40] Cf. Koch and Greenfield (2007).

[41] cf. Werner (2011).

relevant in natural sciences, it cannot be understood how the mental realm can become a likewise effective agent. By contrast, this becomes possible by relying on the Protyposis concept.

8 The Dynamic Layering Structure and Consciousness

The transition from possibilities described by quantum theory to facts described by the less exact classical physics is called in physics the "measurement process". Ultimately, the result of a measurement should be a resilient fact and not a mere possibility. The firing of a nerve cell, for example, can be seen as a fact that concludes a quantum process, and, concomitantly, as the opportunity for the preparation of a new quantum process.

- The preparation of a quantum system means isolating it from its environment to such an extent that a relationship between system and environment is practically no longer perceptible.

Under such conditions, the quantum features can become effective; otherwise, the system would become part of a larger compound comprising both the system and the environment, so that the system can no longer be perceived as having an independent existence.

The measuring process interrupts the linear time-development of the quantum process. Here a non-linear aspect comes into play. This is consistent insofar as a result of a measurement, that is, a fact, has been generated—and something of that kind belongs to the realm of classical physics.

- Consistent with the concept of the dynamic layering structure, we encounter in psychological phenomena an interplay of quantum and classical information.

Classical information, as is well known from the visual process, can be copied any number of times. For information, in contrast to energy and matter, there is no local conservation law.[42] Out of the classical result a new quantum process sets in, which, of course, is based on that result, now providing the initial condition. Upon another measurement, a new fact is produced, which, to some extent, will reflect the originally available possibilities.

Thus, in daily procedures we will always be confronted with an alternation of possibilities and factual results; from facts new possibilities emerge, while other, previously available possibilities no longer can be realized. Still, memories of some of the past possibilities may be retained.

Memories, however, are usually not carved in stone but rather subject to changes, sometimes considerable ones, when they are recalled and stored again, and also as a consequence of unconscious processes. Amongst others, this plays a role in testimonies, as here too frequent questioning can affect the recollection and render it less accurate.

When human consciousness has been sufficiently developed, it becomes feasible that a part of it can interrogate another part. For example, one can ask oneself which decision options had been available. Such a self-reflection can be seen as a measuring process performed by the consciousness onto itself.

The answers can be stored as facts, i.e. classical information. Such classical information can be copied at will and, thus, retrieved and processed anew.

Quantum information processing is reversible. It does not produce waste heat. This explains why compared to a computer the energy consumption of the brain is so low.

[42] Locally energy and matter are strictly conserved; globally, i.e. in cosmology, this is not valid.

- The generation of a possible result leads to a fact, e.g., a word, a decision, an insight in linguistic form, storage in long-term memory, etc.

However, any of these processes involves energy production, since the information on the originally available quantum possibilities needs to be eliminated from the system, here the human being. As a rule, this involves the emission of photons.

The processing of meaningful information in consciousness does not operate only via carrier transport within nerve fibers—like blood in the veins; rather, the photons can generate non-local effects, not necessarily limited to the axons. The various carriers—the photons, molecules, synapses, etc.—establish a common unitary system for the processing of quantum information. It maintains its unitarity constantly regenerating and preserving itself, even if the carrier parts at the surface of the manifestations may be changing.

- Because of the non-locality of the photons, the most important carriers of the stream of consciousness, the consciousness can be thought of as being extended: stretching over the nerve cells, the regions between them, and possibly to some extent even outside the brain.

This is in line with the instance that the legal criterion to determine the irretrievable loss of a person is that no photons can be detected any longer in the EEG (ElectroEncephaloGraph).

8.1 The Path of What is Seen from the Eye to Consciousness

When light falls on the retina, single photons trigger a process in individual nerve cells, in the cones and rods. When the cells are activated, the neighboring cells are simultaneously inhibited, which produces a contrast-based intensification. Because always a single nerve cell is stimulated, the incoming light is virtually broken down into pixels—similar to a computer screen. Each cell corresponds to a pixel. In this process, which in physical terms must be described as a measurement process, the absorbed photon triggers a veritable cascade of reactions. Here the energy of the photon is used directly, besides ATP (AdenosineTriPhosphate), which serves as energy supplier in living beings and which—triggered by the photon—becomes operative. In this process, the incoming photon activates approximately 6 million molecules,[43] which then are moved by electromagnetic forces, i.e. virtual photons, from the eye cell to the nerve fibers and further into the brain. Such a macroscopically effective reaction is described as the firing of a nerve cell. In the usual descriptions of this process the exactitude of quantum theory is disregarded. There the sophisticated differentiation of the entire process is reduced to a mere "flip of the switch".

The incoming photon is, as mentioned, a special form of Protyposis, here primarily abstract free-of-meaning quantum information. A tiny part of the approximately 10^{30} qubits forming the photon, roughly a few hundred, become meaningful in the process, beginning in the visual organ of the eye and acquiring actual meaning in the brain. The by far largest part of the photons Protyposis serves practically as the carrier of the information, which in this process is recoded into meaningful information. In the visual process, the absorbed photon only procures the initial conditions for the potential meaning for the recipient.

What is the meaningful information we here are concerned with?

The location of the retina cell, from which the molecules start flowing into the fibers, encodes the direction of the incoming photon. Its color is encoded in the type of the retina cell, being sensitive to red, green, or blue. The three colors offer a rough distinction of the

[43] Müller and Kaupp (1998).

photon frequencies, that is, energies. Red light has long wavelengths, about 800 nm, and is of lower energy than blue light, at about 400 nm. The information (in the usual sense of this expression) inherent to a single photon, its direction and color, conveys, by itself, certainly no meaning at all. Only upon processing, upon correlating the information carried by many photons, somewhat more meaningful structures can be generated; for example, when many photons arrive in the shape of a line, this may create the perception of an edge, in another case that of a colored surface, etc. Such structures in the eye will be further processed in the brain, in the visual cortex.

The simple functions of optical perception are treated within the brain in a way similar to that in the motoric and sensory homunculus. Neighboring regions in the retina are mapped to neighboring regions in the visual cortex. Based on this finding, for example, a computer can indicate, upon analyzing the electromagnetic activity of the visual cortex, that a proband just sees something, which, say, has the form of a letter. Yet, it is still not clear, whether the proband also understands that form as "this particular letter".

These primary activities and the seeds of meaning they produce are now compared in the next higher processing step, in which the information is transferred from the memory into the consciousness. In the process, factually stored memories are transformed into quantum states, which on their part usually will have photons as carriers. The comparison of the initially perceived structures with activated memory contents will proceed to a large degree unconsciously. Here, the quantum character of this step becomes particularly obvious. The procedure must be understood as being performed in a practically infinite parallel processing mode. However, it has to be taken into account that the ensuing results are always only probable ones. Errors can occur.

To be capable of having a conscious perception we must already "be conscious". Our consciousness is a "stream" of meaningful information, which is transmitted from the brain as a whole and from its subdivisions to the photons and back again. Information from the environment and the body is constantly entering this highly dynamic structure, and constantly being discarded again. Internally and externally perceived images are compared with already stored forms, in which similarities are sought. While, as a rule, this proceeds very successfully, mistakes are always possible, though. Occasionally, when we encounter something completely new, it may be difficult to relate it to something already known.

With regard to these processing steps, it is important to keep in mind that meaning only originates within a context. Whether a line is part of an "i" or an "l" or only a dash becomes clear within a textual situation. This is similar to the information content of the respective photons. Here, too, an eventual meaning emerges only via the correlation with lots of other information.

All these direct entries into the consciousness are dealt with in the brain, so that, of course, there is a dependence on our physical condition. The information processing is considerably influenced by our emotional state.

Given in a linguistically reflected form, information clearly has a classical (non-quantum) character. Processing will be slower here and always sequential (non-parallel); but in this form it is amenable to the laws of logic.

9 Body, Psyche, and Self

Even if the division of the human being into psyche and body is not fundamental and, ultimately, not possible, it is nevertheless useful.

Which portion of the Protyposis should be categorized as material objects and massless photons, and which, on the other hand, as meaningful information, is not irrevocably determined, but rather depends crucially on the respective situation.

What, in the case of a hormone molecule, should be classified as meaningful information causing an effect, and what, on the other hand, serves as mere carriers? This may depend for example, even on the location of the effect.

Despite certain variability, it is a fact that in a living person a particular amount of quantum information organizes a controlling entity. In psychology, the "I" is defined as the "organizer of the psyche".[44]

There is an authority in the psyche that coordinates the internal and meaningful (for the individual) external information, and supervises, in close connection with the consciousness, the control mechanisms. The reflexive psychic structure is described as the Self:

> The I takes itself as the object of perception and in this way becomes itself (self-image). The self evaluates itself and feels evaluated by others (self-esteem). The self experiences itself as constant and coherent (identity). The self integrates all psychological functions and dispositions into a whole, it controls itself and organizes the relationship to others.[45]

The protyposis model makes it possible to comprehend that one can experience oneself and also perceive oneself like someone else. In this way, there results a unity of the first and third person.

- Since quantum systems are, as a rule, spatially extended, it cannot be expected that something like a special "location of the I in the brain" will be found.

The 'I' will have the entire brain as a carrier and can even be understood as spread over the body. Invoking quantum theory, we will understand that there can be something such as a system of quantum information, which is both a unitary whole and spatially extended. It is notable that medical aids, like prostheses, heart and brain pacemakers, can also be incorporated in the extension of the 'I'.

Likewise, it is useful to assume that, in addition to the unconscious, the pre-conscious, and the waking consciousness, there is also a core-self. Of course, a highly dynamic interplay will constantly take place among those 'participants'.

Our "core-self" can be considered as an "individual quantum process"—almost in the sense N. Bohr used the term—which only ends with death and which, as long as we stay mentally healthy, is not affected by a 'measurement' process that would alter it in a fundamental way.

- The "core-self" ensures our core identity, and its impairment or loss would mean a serious illness.

When we wake up, the waking consciousness links up with the core-self and remains active. This part of the psyche, the waking consciousness, is constantly subject to influences from the environment, the body, and the memory. All of these processes influence the "attention spot" of the consciousness.

[44] OPD-1, p. 67.

[45] OPD-1, p. 67.

10 Psychosomatics as an Expression of the Unity of Body and Consciousness

In recent times, psychosomatics, for a long time a disparaged side aspect, has become a regular facet of orthodox medicine. Here, the former theoretical concepts, however, were not without problems. Thus, according to Hoffmann and Hochapfel:

> The central problem of psychosomatic medicine is the body-soul problem. It is a question of how they can mutually influence and alter psychological and physical processes. It concerns the puzzling leap (Freud) from the psychological to the physical and vice versa. For these questions there is no satisfactory answer today.[46]

For a long time, that assessment has remained essentially unchanged.

- If only molecules are real and the psyche is not a reality, then an influence of the psyche on the body remains mysterious.

A top-down effect, as in psychosomatics, from the psychological to the physical body, is now explainable by means of the Protyposis concept, and, thereby, also the various psychosomatic manifestations.

- "Meaningful information" is the common base for the effects of areas of influence on human beings. Information is the uniting idea for rationalizing positive and negative psychosomatic influences.

We must realize that living things, from cell components through cells and organs to whole living beings, are unstable steady states. Every moment there are countless situations in which weak influences can result in great changes. In other words: quantum information can continually affect other quantum information and thus produce changes in the course of processes. Photons affect catalytic processes in cells; the strength of information interchange alters synaptic conditions, etc.

As described, the carriers of meaningful information and the information itself are, at the very foundation of the natural scientific description, the same basic substance. For that reason, depending on the situation, a particular part of the carrier can develop a specific effect as meaningful information. For example, this can be the energy or polarization direction of a photon intervening in a catalytic process. Or it can be the creation of a further synaptic connection, which then assigns a stronger meaning to a particular data stream. It must, of course, be reiterated that meaning can only unfold for the living thing when a large amount of such single events cooperate. The meaning of a photon, a molecule, or a synaptic transition also depends on where the effect occurs. This is exactly as in a text where meaning only arises from many letters generating a combined effect, while the meaning of a letter emerges in the context of a word.

Psychological problems are an expression of various inner conflicts or an incompatibility of inner authorities and external conditions. They can have a negative influence on the psychological processes and lead to real, physically visible disease symptoms. It is especially the psychosomatic symptoms that often make recognizable the symbolic core of a psychological conflict, exhibiting here also strong cultural influences. This can express itself even in a psychosomatic paralyzation.

Many similar examples of such psychological conflicts can be found in the literature.

[46] Hoffmann and Hochapfel (1987) p. 168.

Symbols represent a strong condensation of meaning, which is enabled primarily by their embedding in the cultural context. The enormous amount of meaningful information conveyed here indicates their great effectiveness, contrasting starkly the almost meaningless information of the symbol itself, that is, taken out of its cultural context.

In the physical course of events in living things, meaningful quantum information, as a form of protyposis, plays the decisive role in controlling all vital processes.

- Supposing the reality of consciousness, there is, naturally, a Bottom-Up-Effect—from the absorbed nutrient and the microbiome as well as the body in general—to the contents of the consciousness. Likewise, there is an effect in the reverse direction, namely a Top-Down-Effect, from the unconscious and even the consciousness, to the control of the life processes in the body.

In conclusion, the broad field of psychosomatics is open to a description based on natural science.

10.1 Explaining the Placebo: A Special Form of Psychosomatics

How could it be that a pill lacking any molecule of an active substance can have the same effect as a medicament?

- The placebo is a way in which meaningful information can have an effect.

Given the reality of psychological contents and their interaction with the physical forms of Protyposis, the *placebo-* and also the *nocebo-phenomena* become conceivable and understandable.

As long as only material phenomena were considered real and psychological phenomena seen as so-called epi-phenomena—which has been the principal theoretical paradigm, for a long time even in many fields of medicine—the latter effects, let alone the psychological effect on the physical body, could not be understood. On the other hand, such effects must be seen as absolutely natural from the viewpoint of the Protyposis.

- All Top-Down-Effects from the psyche on the body find a explanation in terms of the Protyposis concept, which thus applies to any psychosomatic effect.

It should, however, be recalled that we are dealing here with quantum information, which involves experience, to be seen as an extended quantum state of meaningful quantum information, and the body, a form of structured quantum information. This means that, while such top-down processes are possible, one cannot expect definite cause-effect relationships here. Being quantum phenomena, there are at most probabilities, and, moreover, these probabilities will depend on the individual patient.

11 From the Ability of Reflection to Free Will

To understand the ability of the consciousness to reflect, quantum theory is indispensible. Self-reflection means that a part of the consciousness, in principle, can think about the whole of the consciousness. One may wonder how a part, being smaller than the whole, can capture the whole in an essentially one-to-one fashion. On the one hand, there is no need to exclude anything from the reflection; on the other hand, it is not necessary either to deem different aspects of the content of the reflection as being identical. In fact, a part can capture the whole without any necessary loss. A mathematical analogue to self-reflection

requires infinite sets. Only in an infinite set there are as many integers as even integers (i.e., there is a one-to-one mapping between integers and even integers); only in infinite sets a part can be of the same magnitude as the whole. Since already a single hydrogen atom possesses an infinite-dimensional state space, a corresponding infinity requirement poses no problem within the framework of quantum theory.

- The human consciousness is an activated entity of meaningful quantum information, the living brain being its carrier.

After childhood consciousness is so comprehensive that a part can observe another part of the consciousness, which means—in terms of physics—"measure" it.

What is important here is that a quantum state is always temporally extended; we call it *extended presence.* This is reflected in the finding that our thoughts persist a certain period of time, so that we can reflect upon them. Thus, it is not surprising that a "3-seconds-now" was discovered in brain research, though the connection with quantum theory was not drawn there.[47] This 3-second-presence reflects a quantum state, which, as *present possibilities,* comprises memories of past facts and expectations of future events, together with ethic values and behavior patterns that have been learned. In meditation a prolonged "now" can be experienced.

11.1 Self-Reflection: The Prerequisite for Free Decisions

We human beings are capable of thinking about what we are just thinking. A reflection, of course, terminates the extended presence, and we arrive at a fact, the result of a measurement. This, in turn, can form the starting point of a new quantum state.

Being capable of self-reflection is the prerequisite for being able to make free decisions. A free decision should not be confused with arbitrariness. Freedom, on the other hand, would be at odds with deterministic processes, already for logical reasons.

- The two conditions that, on principle, would preclude a free decision—i.e. arbitrariness and determinism—are not supported by the arguments of natural science.

In many scientific presentations the human being is portrayed as a determinate machine. Such a portrayal, offending the dignity of human beings and ignoring modern scientific insights, must be rejected.

The unconscious part of the psyche prepares a decision. Now the pragmatic, cultural and ethic standpoints that we have internalized are activated and consciously confronted with the prepared decision. As a result, the corresponding quantum state is reformed, representing a set of possible answers to questions we have recalled from our memory.[48]

This means that because of the reflective examination the result cannot be entirely arbitrary. Rather than just any quantum state, only those can become an answer that are sensible in the given context. Out of the infinite manifold of possible quantum states, a very rigorous selection leads to sensible answers. The actual result of the examination, i.e., the resulting final state, is not determined by the laws of quantum theory. To sum up the natural science point of view: for an examination, which is not affected by temporal or other restrictions, the result is neither strictly determined nor completely arbitrary.[49]

[47] Pöppel (2004), p. 298.

[48] Mathematically speaking, the quantum state turns into a sum over the amount of eigenstates on the question, therefore of sensible answers to the question.

[49] cf. Görnitz and Görnitz (2008), p. 273 ff.

Hence, natural science demonstrates the possibility of free decisions, beyond both determinism and arbitrariness. It is also clear that external or temporal restraints are in conflict with making free decisions. Ultimately, natural science demonstrates that free decisions are possible, but not necessary. Being obliged to make a free decision—instead of being able to do so—would be a contradiction in terms.

12 Artificial Intelligence: Yes; Artificial Consciousness: No

In the process of the evolution of the protyposis some biological entities with consciousness—like humans—eventually become able to construct artificial entities—such as computers—which are capable of performing complex types of intelligent information processing. The present advances in constructing systems of artificial intelligence are amazing indeed.

The ability to simulate seemingly rational behavior is astonishing. Technical artifacts can react as if there was some implemented understanding. To this end the information processing may even be "embodied". This can be arranged by placing the computer into a robot and supplying sensory tools. Cars operating without human drivers already exist.

The scientific thought on artificial consciousness sometimes appears to entertain a dualistic view; e.g. Cardon writes:

> On the reality of the life we have, on one hand, a neural network made of very numerous cells. We have, on the other hand, our mind and the impression we can have about this component of ourselves as generating sophisticated representations about things of the world.[50]

However, in the natural sciences there is no room for a dualistic worldview. Intelligent beings evolved from non-intelligent creatures. Living beings evolved from non-living matter. Science dos not only have to declare that something has "emerged", on the contrary, natural sciences have to explain the emergent transitions.

In all artificial information processing systems up to now, there is a strict distinction between hard- and software. Biological systems, by contrast, feature the unification of hard- and software into a "uni-ware". This is an imperative precondition for the possibility that consciousness can evolve. The scientific rationalization here is afforded by the concept of protyposis, constituting the common background for both, matter and mind.

Sometimes, constructivist aspects are emphasized:

> It is really necessary for the construction of an artificial consciousness, to have a specific theory of the mind, and a really constructivist one.[51]

The reference to constructivism suggests that "mind" or "consciousness" do not exist in a scientific sense, that is, as a real entity causing actual effects, such as the brain. Again, the protyposis concept allows for an alternative non-dualistic point of view.

[50] Cardon (2006), p. 245.

[51] Cardon (2006), p. 266.

13 The Cultural Evolution and its Consequences

With humans and their ability of speech, and finally written language, the information processing reaches a new stage in the cosmic evolution. Now, information processing and dissemination becomes feasible far beyond the temporal and spatial limits of their biological existence. Here, it is important to emphasize the distinction of consciousness and human culture. One often reads accounts implying that the consciousness is a "third entity" "between human beings". Obviously, the forming of the human consciousness is crucially dependent on being embedded in the respective cultural environment. And, of course, there is an interplay between the psyche of human beings and the evolution of their culture. Human beings form their culture, especially language and symbolic thinking, and the cultural context retroacts on human language and thinking. In this sense, culture and consciousness are closely interrelated. Nevertheless, the essential carrier of a person's individual consciousness is the own brain.

Quantum theory, however, allows us to envisage psychological phenomena in which the carrier is constituted simultanously by several people, thus manifesting a kind of non-local correlations. C. G. Jung's model of the "collective unconscious" could possibly be related to such phenomena. It is, however, problematic, when such non-local correlations are to be understood as cause-effect relations, in the sense of classical physics.

As many examples show, there is a large controlling cultural influence, extending even to our physical condition. For example, fainting hysterically was an accepted cultural behavior some hundred years ago, whereas in the present cultural setting this is no longer the case (notwithstanding pop concerts or people of other cultures); today conflicts manifest themselves in different physical forms.

Let us thus note that the cultural environment can affect the psyche and body, acting, like in the case of a placebo, in the form of meaningful information.

14 Summary: Closing the Explanatory Gap between Mind and Matter

- Today modern quantum theory indicates how the age-old conceptual antagonism between what is mental and what is material can be overcome.

The one reality must be founded, also theoretically, on one unitary substance. That is the abstract cosmic quantum information, a conception, which in everyday language would be closer to the notion of mind rather than matter.

Quantum theory makes it possible to replace the spatially small entity, an "atom" (of whatever form), with an actually simple elementary structure. The simplest conceivable quantum structure is completely characterized by its 2-dimensional state space. Most aptly, it can be envisaged as an AQI bit, an abstract, free-of-meaning qubit, referred to as *Protyposis*.

From Protyposis, the well-known manifestations of physical reality can be derived, the material quanta, as well as the quanta of energy, and the forms that we encounter as meaningful psychological quantum information, and finally as consciousness.

- In the natural scientific context, consciousness can be understood as a form of Protyposis, a form that can experience and recognize itself.

All the processes and manifestations of nature can only be understood in the light of cosmic evolution. An initially formless quantum structure, the Protyposis, to be interpreted

as abstract and free-of-meaning quantum information, reshapes itself, in its evolution, into the form of elementary particles.

- This allows for a new understanding of matter as a special form of quantum information.

Elementary particles and black holes bring into being galaxies with stars and planets, and on some of the planets life can develop.

Living beings are unstable equilibria of flow that control and stabilize themselves by means of quantum information. In life, for the first time, Protyposis can become meaningful information. A "correct interpretation", an appropriate assignment of meaning to the information, increases the life expectancy of the living being; a "false" one lowers it. The control entailed is a real effect of quantum information on macroscopic material objects. Ultimately, it is possible because both the material body of the living being and the quantum information involved in its self-control are only different manifestations of Protyposis.

Living beings in need of rapid information processing develop specialized organs to that task, brains. In very highly developed living beings, such as birds and mammals, the information processing becomes so comprehensive that the ability of consciousness and even self-perception arises.

Quantum theory provides us with the framework required for the modeling of consciousness. It allows us to understand that the Protyposis, experiencing itself as consciousness in its form of meaningful information, is to be interpreted, depending on to the situation, as a feature of the brain or an independently acting quantum system. The possibility to understand the brain and the consciousness as different manifestations of the Protyposis closes the "explanatory gap" between consciousness and brain, and, more generally, between matter and mind.[52]

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[52] Some philosophers have the tendency to classify the protyposis concept as "panpsychism". The AQI bits are neither matter, nor energy and not even mind. However, they are the foundation, the basis for all these entities. The term "psychism", having a great proximity to "mind", should not be applied to the protyposis outside of a living being—even if a qubit looks much more like our thoughts then our body.

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