

Brain and Consciousness

Proceedings of the First Annual ECPD International Workshop on

Scientific Bases of Consciousness

24-26 September 1997

Belgrade, Yugoslavia

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First edition 1997

Publisher

European Centre for Peace and Development (ECPD) of the United Nations University for Peace

Belgrade, Terazije 41

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For ECPD: Negoslav Ostojić, Executive Director

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CIP - Каталогизacija y пyблиkацији
Народна библиотека Србије, Београд

165.62(082)

ANNUAL ECPD International Workshop on
Scientific Bases of Consciousness (1st; 1997; Belgrade)

Brain and Consciousness: Proceedings of the
First Annual ECPD International Workshop
on Scientific Bases of Consciousness,
24-26 September 1997 Belgrade, Yugoslavia /
edited by Ljubisav Rakić ... [et al.]. - Belgrade:
European Centre for Peace and Development (ECPD)
of the United Nations University for Peace,
1997 (Belgrade: Čigoja štampa). -II,
206 str. : graf. prikazi; 24 cm

Tiraž 300. - str. I - II: Preface / Ljubisav Rakić ... [et al.].

- Abstracts. - Bibliografija uz svaki rad.

ISBN 86-7236-010-9

1. Gl. Stv. Nasl.

159.922(082) 616.8-009.83-073.97(082)

612.821(082) 577.38(082)

a) Свест - Зборници b) Феноменологија - Зборници
c) Електроенцефалографија - Зборници d) Неурофизиологија
- Зборници e) Биофизика - Зборници

ID = 57080844

PREFACE

Consciousness is one of the oldest scientific problems, recognized already in ancient times, both in the civilizations of East and West. However, in contrast to scientific problems related to the structure of matter and physical interactions, the problem of consciousness has remained *scientifically* unresolved to date. The last decade of 20th century has been proclaimed by United Nations as the decade of brain research, which certainly gave a new impulse to investigation of the phenomenon of consciousness, as the most complex brain function. It is currently estimated that the problem of consciousness belongs to ten most significant scientific problems, although it might soon become one of the most significant ones owing to its potential implications:

- (a) in *medicine* it might give rise to enlightening of many secrets of the brain functioning, as well as of the role of the acupuncture system in holistic health and reprogramming of internal conflicts;
- (b) in *psychology* one might understand mechanisms and roles of altered states of consciousness in a growth of personality, control of creativity, as well as transpersonal phenomena usually accompanying these states;
- (c) in *biology* it might appear that limits of interactions between individuals are more provisional than widely believed, which would be of significance not only for adaptive mechanisms on the level of whole biological species, but even for deeper understanding of the very significance of morals in human population;
- (d) in *physics* an understanding of the phenomenon of consciousness might give rise to deeper understanding of fundamental problems of the observer's role in quantummechanical act of measurement, which would demonstrate that consciousness, space, time, and matter are more deeply interwoven than commonly believed;
- (e) in *engineering* an understanding and controlling of transpersonal interactions should significantly change the field of *communications*, with many traditional spatio-temporal barriers radically surpassed, and in *computer* sciences an understanding of the nature of consciousness might give rise to computers with artificial consciousness, functioning on deeper relativistic and quantum principles;
- (f) finally, a deeper understanding of the very nature of consciousness and transpersonal phenomena might radically shift our scientific understanding of some ultimate *philosophical* and *religious* questions, like spiritual and practical significance of imperative moral behavior of every individual - with prospects for a new humanism, without meaningless and painful interpersonal, interethnic, and interreligious conflicts.

As a result of these contemporary scientific trends, *European Centre for Peace and Development (ECPD) of the United Nations University for Peace* in Belgrade initiated in 1996 an international scientific project *Brain and Consciousness*, which will include research, scientific meetings, publishing and organization of postgraduate studies at the specialist, master and doctor levels - with a specific aim to educate for peace and international cooperation. Along this line, the first successes were Belgrade's ECPD Symposium *Consciousness: Scientific and Technological Challenge of the 21st Century*, 29-30 May 1995, and Belgrade's ECPD Seminar *Consciousness: Scientific Challenge of the 21st Century*, 27-28 September 1996, and we certainly expect for the *First Annual ECPD International Symposium and Workshop on Scientific Bases of Consciousness: Brain and Consciousness*, 22-26 September 1997, to be a continuation of the above successes.

So, our workshop, with eighteen invited outstanding tutorials published in this proceedings, will be a very good opportunity for those who want to gain in-depth knowledge about current status and future directions of selected critical areas in the extremely wide and intriguing field of consciousness.

Editors and Publisher greatly acknowledge academic and/or financial sponsorship of Biomedical Department of Serbian Academy of Sciences and Arts, and Yugoslav, Serbian, Montenegrin, and Greek Ministries for Science and Technology, as well as of ICN Galenika.

We are especially indebted to the Symposium & Workshop Secretaries, Dušan Bobarević, Emil Jovanov, and Mateja Opačić for their hard organizational work, Mr. Petar Vujićin for his intense lectoral work, and Mrs. Tatjana Opačić for her high professionalism in technical preparation of the book.

Belgrade,
September 1997

Editors

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PRINCIPLE OF PHILOSOPHICAL RELATIVITY

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Abstract. The internalist and externalist points of view are distinguished by different attitudes about the relationship between what is given in experience, including the feeling of control, and the description of experience in terms of constructs assumed to refer to properties that have an objective existence outside the self. The principle of philosophical relativity asserts that scientific theories should be open to different interpretations on such antinomic issues. Today's major physical theories, quantum mechanics and general relativity, are examined from the point of view of philosophical relativity. A model that incorporates the main but conflicting features of these theories (quantum superposition and gravitational nonlinearity) is briefly outlined, and its significance for understanding the biological life process considered. The analysis supports the idea that the universe as a whole, and biological life in particular, are always chasing an unattainable self-consistency.

Key words: *quantum mechanics, general relativity, fluctuon model, biological information processing, consciousness*

1 INTERNALIST VERSUS EXTERNALIST STANCE

Daily we have the experience of exerting control on the world around us. Daily we also experience limitations on this control. One might take an extreme view and deny either of these facts, or with more caution, admit them as impressions, but assert that they are really very strong illusions rather than facts.

The control point of view we can call an internalist perspective. The no-control point of view we can call the externalist perspective. Many intermediate perspectives are possible, corresponding to the fact that there are aspects of the world over which we can, in practice, exert more or less control. Thus I feel I can control the next series of letters in this sentence, and could have referred to these as a word if I chose. I feel I can change the angle of the monitor I am looking at, and could choose to make it more or less comfortable. I don't feel my thoughts have any influence on the orbit of the moon.

Many scientists by nature, including the present writer, are highly attracted to the external point of view. After all, the form, color and architecture of nature is what natural scientists want to appreciate, describe, and in so far as possible compress into shorter descriptions that we call explanations. One could, as noted above, take this point of view to the extreme and argue that our sense of self and control is an illusion. But the existence of an experiencer is difficult to deny, since it is the precondition of all external experience. The sciences of the mind, such as psychology, have an unavoidable orientation to this direction. Just as students of the natural sciences may find an externalist attitude to be most useful, the student of the mind might find an internalist perspective, with its basis in the phenomenology given in experience, to be most fruitful. One could conceivably pursue along this line, and going to the extreme

argue that really the whole world is mind, and that it is the external rather than the internal that is illusory. But the existence of that which cannot be controlled, and the existence of other minds external to us, is at least awkward to deny.

Philosophy has been chasing itself around these two extremes, and covering various intermediate positions, as far back as the records go. The pure externalist attitude has the advantage that it provides a more complete explanation of phenomena that we experience, other than the phenomenon of having experiences, and accordingly has the advantage of affording more control of the world, despite its basic denial of control. The pure internalist attitude has the advantage that it is logically more consistent, since it does not exclude itself, but it has the disadvantage that in practice it provides a much less complete account of experience (since it does not even explain why we can't control the orbit of the moon as easily as we control the motions of our fingers).

One does not have to go to either of these extremes of course. A vast spectrum of intermediate views are possible. To their exponents they all appear sensible. Undoubtedly they all are. The problem is that they share the essential defects of both the pure externalist and pure internalist points of view, with the addition of some arbitrary assumptions designed to hide these defects.

2 PRINCIPLE OF PHILOSOPHICAL RELATIVITY

My goal in the present paper is not to solve the above problem. I regard it as antinomic, in the sense that equally credible arguments can be given to contradictory positions. Issues with this character include freedom versus necessity, the ultimate nature of reality, and whether the universe has a beginning.

What I will do is propose instead that scientific theories should be so constructed that they do not provide definitive answers to inherently arguable issues such as the above, but rather allow for multiple conflicting interpretations. I will call this the principle of philosophical relativity, since it asserts that there are no preferred philosophical coordinate systems. If there is no good reason for choosing between two philosophical stances it is a matter of indifference which one is chosen, except as a personal preference. This does not mean that every philosophical theory is equally good, no matter how well or badly architected, any more than it means that every choice of coordinate system is equally convenient, and that coordinate systems could not be constructed that are of no conceivable use. What it means is that scientific theories should strive as an ideal, possibly an unattainable ideal, to be open to different interpretive perspectives.

Philosophical relativity should not be confused with logical positivism [1]. It does not assert that antinomic questions are meaningless, or mistakes of language, or that answers to them are meaningless. To say that the will is free should not, in short, be analogized to a statement such as "time tastes like a soba noodle". Nor does the principle assert that the only meaningful statements, apart its own statement, are those that are empirically verifiable or mathematically provable. The criterion implied by it is absolutely different. If scientific theories do not satisfy philosophical relativity then, according to the principle, they should be modified so as to do so. Furthermore, if doing so requires adding a construct to the theory that has no empirical counterpart and is not deducible from an empirically testable assumption of the theory, this is not only permissible but even mandatory. The principle of philosophical relativity is thus a tool of scientific theory construction. Furthermore, it is not a tool that can adhere to entirely positivistic criteria (in so far as these can actually be specified), since it

requires theories to include constructs that ensure the facts of experience can be interpreted in antinomic ways.

Thus, we may imagine a purely deterministic theory that is in principle complete and consistent. Consistent means that it entails no internal contradictions. Complete means that it could in principle account for all experience (we ignore here the in principle impossibility of ever verifying this). Present such a theory to the man who is inclined to determinism and that man will applaud. For him the theory covers all experience and demonstrates that any feeling of freedom that he possesses is illusory. Present the same theory to the man who believes that he has freedom to choose the next word that he utters, and that man will simply say the theory is not consistent with the facts of his experience. A fortiori, no theory that gives a definitive answer to this issue - resolves the antinomy of freedom versus necessity - can be regarded as demonstrably valid in a public way. The public will always disagree among itself. The pure externalist program may have achieved a victory with the development of our putatively universal deterministic theory, but it is a Pyrrhic victory, for at the very moment of its public presentation the theory will lose the universal objective character that is the ideal of the externalist program.

3 PHYSICS TODAY

Let us first look at science today, using the philosophical relativity principle as a tool of analysis. It is of course incorrect to speak of science today as if it were a single party platform. There are lots of different theories, models, methods, and approaches, so it would be quite unfair to assert that physics or biology says this or that. It is just individual scientists who say this or that, and accordingly there is plenty of disagreement about what science as a whole says.

Nevertheless, there are two theories - quantum mechanics and general relativity - whose essential ideas have established themselves as having particular foundational value. So let us consider whether these two theories satisfy philosophical relativity.

But first step back for a moment and consider Newtonian mechanics, where the situation is much simpler, since the model is completely deterministic. At best it is possible to create the appearance of indeterminism by considering cases in which the dynamics are highly sensitive to initial conditions. In these cases the future is not computable, but still there is a definitive ontological answer to the question of freedom versus necessity. Furthermore, the description of world in the Newtonian model is completely in terms of real numbers, interpreted as referring to space and time. If the model is regarded as a universal theory it therefore gives a definite answer to the question, "What is the ultimate character of reality?" Reality, it asserts, can be completely described in terms of real quantities. Qualities, such as the quality of red, are only secondary, hence fundamentally illusory. Space and time are also qualities, usually referred to as primary qualities, since secondary qualities such as red are presumably reducible to them. But there is no place for such primary qualities in the theory either, at least as they are given in experience. There is no place for experience, and therefore for an experiencer that has experience. There is no place then for consciousness, and for the experiencing process that we ordinarily associate with life.

The Newtonian model fails philosophical relativity on all these grounds. It is not only problematic philosophically, it is problematic for biology and psychology as well. It makes it very tough for the biologists to give a unified account of physical and biological phenomena. One can gloss this problem by saying it is all a matter of complexity. But in reality it is a

conceptual dissonance that implies a division of the phenomena of nature. In practice much of modern science follows along this line without admitting it. The brain is explained in terms of neurons, regarded as atoms of the nervous system, and neurons are explained in terms of large and small molecules taken as indecomposable entities, and then the chemist comes along and explains something about molecules in terms of electrons and nuclei, and then finally the physicist tries to explain the properties and transmutations of the various elementary particles in terms of concepts that are never called on by the chemist. If one admitted that this is a necessity, at least when it comes to the life process, then one would be making a rather definite statements about monism versus dualism, and about the relation of part and whole, that would in themselves violate philosophical relativity.

Quantum mechanics is a step towards satisfying philosophical relativity, but not a full step. The theory is deterministic so far as the equations of motion are concerned, but introduces randomness in the measurement process. Of course randomness does not by itself mean control or free will. It just means that so far as known the description of some phenomena is not susceptible to compression [2]. But this would also be true of a spontaneous phenomenon, and such a phenomenon would at least not exclude free choice. This is all that is required by the philosophical relativity principle.

Let us look a little more carefully at quantum mechanics, and why it only goes a half step, without here attempting to consider all the multifarious interpretations that have been proposed [cf. 3]. The main feature is the superposition principle. The wave function governing the time evolution of a system is a linear superposition of its possible states. The crucial point is that the possible states interfere with each other. Thus the superposition cannot be a statistical ensemble (unless hidden variables and hence entirely nonclassical actions at a distance are contemplated). An electron in my hand could actually be anywhere, including outside of what appears to be my hand. The possible locations of this single electron in effect interact with each other in a manner reminiscent of the interactions between different actual molecules in a disturbed body of water.

Whenever we think about an electron we locate it somewhere. This is the classical picture, the kind of picture we can have in our conscious experience. Picturing quantum superpositions is an oxymoron (apart from mathematical pictures [cf. 4]). The process of measurement finally means bringing something into our conscious experience in an acceptable way. Thus the superposition must be collapsed into a classical picture, one that can be described by real numbers that ultimately refer to dimensions of space and time. The jump from the set of possible states to an actual state depends on a probabilistic way on weights assigned to each of the possible states. This is the process that in today's quantum mechanics is problematically related to the time evolution equations. The latter are reversible and entropy conserving, whereas the measurement process is irreversible and entropy increasing.

The dichotomy between time evolution of the wave function and its collapse in measurement reflects an ambiguous treatment of acceleration. The superposition principle requires the time evolution equations to be linear, otherwise the superpositions would break down. (Here linear means that the changes in the wave function can be described by unitary transformations, i.e., transformations involving rotations in Hilbert space, with no stretching or bending.) So it appears that the quantum mechanical model of acceleration, or change in state of motion, must be linear. Change in state, as measured by the change in the probability distribution of a system, proceeds through the interference of possible states of different energy [cf. 5]. The linear time evolution equations capture this. But actually we can never see that a change in state has occurred until a measurement is made. This is a nonlinear process, since measurement is a nonunitary transformation. When we do look we see that the system has

jumped between two of its possible (stationary) states, as when an electron jumps from one energy state to another and either emits or absorbs a photon. In short, the quantum jumps that occur when the measurement process collapses the wave function from possibility space to actuality correspond to the quantum jumps that occur when a system undergoes time evolution. But the former are described by a probabilistic process, whereas the latter are not.

This is the source of the paradoxes of quantum measurement, and of the great controversies over the interpretation of quantum mechanics. No choice is allowed by the equations of motion. But when we make a measurement we make a choice, first as to what measurement is to be made, therefore what aspect of the system is to be made classical, and second as to when to make the measurement. Furthermore, this choice strongly affects the future development of the system, since if we make one aspect (say position of an electron) precise than a conjugate aspect (momentum) must become imprecise. The quantum mechanical model of acceleration allows no choice when it comes to the possible quantum jumps whose occurrence is retrospectively buried in the time evolution equations (the so-called sum over histories), but requires choice whenever a quantum jump is made explicit. The theory thus satisfies philosophical relativity so far as the possibility of choice is concerned, but not in a consistent way.

We can note another feature of the above discussion that on the surface at least appears contradictory. We said that measurement involves the creation of a classical picture in terms of real numbers that ultimately have space-time referents (other quantities, such as mass and charge, are ultimately operationally defined in terms of combinations of space-time measurements). But we also said earlier that space and time are qualities in our experience (sometimes referred to as qualia). We therefore have referred to space and time as something describable in terms of quantities and in the next breath as qualities which should not be obligatorily reducible to quantities, for if the theory imposed such an obligation then it would violate the principle of philosophical relativity. It would do so because it would then entail implications about the ultimate nature of reality, including the implication that the qualityness of our experience is illusory. The pure externalist will applaud this entailment; but the man who takes the qualityness of his experience as a fact of experience would be perfectly entitled to say that any theory which required him to deny this fact did not fit the facts.

The Newtonian model cannot escape this collision with philosophical relativity, since everything is classical. This is not so for quantum mechanics. The unpicturable stratum of superpositions is not describable by real numbers. Complex quantities are required. If a human observer is a quantum mechanical system, then that observer should be described by a superposition. There is a place for qualities. The superposition must collapse in order for that observer to ever take a definite action. Choice enters. So the theory has qualities (including the qualities of space and time, and many other qualities) as eligible referents, and has decision making (or control with choice) as an eligible referent. The term "eligible" here means that these features are not excluded. It does not mean they are entailed. It is possible to propose that collapse never occurs and that nothing ever becomes definite; or that everything is really definite because hidden variables underlie the superposition. Alternative philosophical interpretations, with antinomic philosophical positions, are possible. This is just what is required of a theory that satisfies philosophical relativity.

But still quantum mechanics is only a half step in this direction, because the observer is not in fact included in the theory. If the observer were included, the measurement process would be embedded in the time evolution process. The theory should at least allow the measurement process to be so embedded, for if it excluded this it would definitely entail dualism. But any such entailment would violate the principle of philosophical relativity.

Now let us see how this situation is affected by the other leading idea in today's physics, the general theory of relativity. The central idea is the principle of equivalence. It is impossible to locally distinguish acceleration (or change in state of motion) from a gravitational field. The general theory of relativity is thus a theory of the gravitational field. Furthermore, it culminates in a self-consistent field theory of the gravitational field: mass controls the structure of space-time and the structure of space-time controls the motions of mass [cf. 6]. Thus the theory is inherently nonlinear. Since the equations describing gravitation are nonlinear, and since gravitation is locally equivalent to acceleration, this means that the general relativistic model of acceleration is nonlinear.

But this in turn means that the linear superposition principle cannot hold. Superpositions should collapse when gravity is taken into account.

By itself general relativity is an entirely deterministic theory. Accordingly it does not satisfy philosophical relativity. Furthermore, the theory is formulated at an entirely classical level. Operationally speaking it is quite impossible to transform to a coordinate system that eliminates changes in the state of a quantum system, since any such a change in state is an unpredictable jump. Nevertheless, the general point holds: if the macroscopic description of gravity is necessarily nonlinear the micro description should be as well. Superpositions should collapse spontaneously. A theory along this line would satisfy the principle of philosophical relativity, since the time evolution would embed the measurement process within itself. It would not compel anyone to admit the existence of internal observers, or of irreducible choice, or of qualia, but it would not deny anyone the possibility of admitting these features. They would all be eligible as referents of the theory.

4 THE FLUCTUON MODEL

At this point I would like to turn to a specific model, called the fluctuon model, which I believe is a step towards a theory that meets the above requirements. Here it must suffice to indicate some of the motivating ideas of the model. Technical treatments can be found elsewhere [7-13]. Nontechnical discussions more extensive than the present one can be found in [14,15].

At the outset it has to be said that the development of such a theory, one that merges the basic ideas of quantum mechanics with those of relativity, has turned out to be extremely difficult. The problem is that it is difficult to satisfy all the fundamental principles which are generally believed to apply (e.g., symmetries associated with the various conservation laws, the uncertainty principles, microscopic reversibility, second law of thermodynamics). The distinguishing idea of the fluctuon model is that the universe itself cannot satisfy all these fundamental principles simultaneously. We can think of it as a system that keeps changing until it reaches a self-consistent form of organization, at which point change would stop. But final self-consistency (or equilibrium) is never possible. The irremovable inconsistency (or disequilibrium) is the motive power of the time evolution of the universe, both in the narrow sense of the changes in states of motion of particles due to their interactions with one another and in the larger sense of cosmic evolution.

This viewpoint has close conceptual relations to the idea of perpetual disequilibration that has been forwarded by Matsuno [16] and Gunji [17]. Inconsistency and hence generative power, according to Matsuno, is inherent in the inseparability of a system's dynamic development from the boundary conditions that are assumed to confine this development

The physical picture that serves as the starting point of the fluctuon model is a Dirac-like vacuum sea. The so-called vacuum is a sea of unmanifest vacuum fermions. In the Dirac model these are negative energy electrons, but in the eventual development of the fluctuon model the vacuum particles only acquire energy and charge by virtue of being in a superposition of manifest and unmanifest states.

For concreteness consider the electrostatic force between two electrons. The interaction in conventional field theories is due to the exchange of virtual photons. The rough picture is that the electron emits a photon and recoils. Momentum is conserved, but energy is not. The photon is virtual since it can only exist in such a forbidden energy state for a time allowed by the time-energy uncertainty principle. If the photon is absorbed by a second electron its momentum is transferred to that electron.

The exchange process in the fluctuon model is in some respects a generalization of this. The photon is viewed as a virtual electron-positron (or electron-hole) pair, spontaneously manifesting in the vacuum sea due to an energy fluctuon compatible with the time-energy uncertainty principle. The fluctuation energy must at least be equal to the mass-energy of the electron-positron pair. Thus the pair must rapidly decay. If the fluctuation energy is about equal to the mass-energy of the pair it will decay in a reasonably restricted amount of time. Such pair creation is only possible in the neighborhood of a manifest mass, otherwise it would be impossible to conserve momentum in all coordinate systems. We will call the manifest mass (in this case a manifest electron) an absorber. When the pair is transiently excited it recoils from the absorber with a definite quantity of momentum; momentum overall is conserved, as in the conventional picture of a virtual particle exchange. When the pair decays, as it is required to do by the time-energy uncertainty principle, it is no longer next to the absorber. At this point it satisfies conservation of energy, but can no longer satisfy conservation of momentum, since there is no neighboring manifest mass that can assure that momentum is conserved in all inertial coordinate systems. We have thus arrived at our first inconsistency. The only way of resolving it is for the pair to regenerate, and to continue to decay and regenerate until it collides with a second absorber.

We can think of the virtual photon as a sequence of transient electron-positron pairs that skips through the vacuum somewhat in the fashion of a stone skipping over water, except that there is no friction, due to the quantum nature of the system. In the conventional picture we would only have one skip, and since there would then be no requirement for the length of the skip to match the density of unmanifest vacuum particles (or potentialities for pair production) the skip could have any energy. Furthermore, self-interactions that are excluded in the multi-skip picture would occur. The problems of infinite renormalization that plague conventional field theories derive from these features. The multi-skip picture eliminates these problems altogether.

The model actually comprises three vacuum seas. The gluons that mediate the strong force can be interpreted as chains of transient quark-antiquark pairs. This is the least dense sea (in the fluctuon model the strength of an interaction decreases as the density of the sea increases). The weak force can be interpreted as a variation of the electromagnetic force that occurs due to variations in the density of the electromagnetically active subsea. Mesons mediating attractive interactions can be interpreted as single step exchanges involving quark-antiquark pairs of zero spin that are confined to the neighborhood of the absorbers. The gravitational force is mediated by the supersea of all vacuum fermions. The vast majority of vacuum fermions that contribute to it (called massons in the fluctuon model) do not contribute to the other forces. Thus gravitons are mainly chains of transient masson-antimasson pairs.

The gravitational force is actually an indirect force in the fluctuon model. Manifest absorbers polarize the vacuum sea around them, due to the fact that vacuum particles act as temporary absorbers (being partly in manifest states). The electron subsea is overall homogenous, with only local density depressions surrounding manifest charges, due to the requirement for overall charge neutrality. But mass comes only in a positive charge. Thus the vacuum depressions surrounding masses can become large, and concomitantly the distant elevations in vacuum density can become large. The attractive gravitational interaction is due to masses being pushed together by gravitons emanating from transient vacuum absorbers (called trapped fluctuons) in these distant regions of space. All the masses in the universe accordingly contribute to gravity. The fluctuon model of gravity thus incorporates Mach's principle.

The space curvature of general relativity is identified with the density structure (or curvature) of the full vacuum sea. The electron and quark subseas do not follow this curvature, by virtue of the overall neutrality requirement, and due to their much smaller densities they make a negligible contribution to it. This is why it is possible to make a geometrical model of gravity, and yet have other fields that would seem to require that different geometries cohabit the same universe.

Now let us return to the fluctuon itself. We saw that this is a chain of transient particle-antiparticle pairs that propagates due to the impossibility of simultaneously satisfying all the requisite conservation and uncertainty principles except when it interacts with an absorbing particle. Let us check out the broader consequences of this local inconsistency.

The first point is that the existence of the chain is consistent with the uncertainty principle as long as no observer is allowed to ride on top of it. The chain must therefore propagate with the same velocity (light velocity) in all inertial coordinate systems. It is possible to show that a perpetual motion device could be constructed if this were not the case. The principle of special relativity follows and from this, along with the basic fluctuonic interaction between two electrons (and a few technical assumptions) it is possible to deduce Maxwell's equations [7]. A generalization of the argument leads to the principle of equivalence, and hence to the principle of general relativity. The variations of vacuum density produced by mass and charge mean that fluctuons could not propagate without impermissibly violating conservation of energy unless accompanied by distortions of vacuum density. Electromagnetic and gravitational waves can thus be interpreted in terms of distortions of the vacuum sea.

When absorbing particles change their state of motion in response to the exchange of fluctuons (mainly photons, gluons, gravitons) the density structure of the vacuum sea must change as well. This is most important for the gravitational interaction, since the density structure of the electron and quark subseas is held nearly constant by the overall neutrality requirement. The gravitational forces between absorbers change as a result of this altered density structure. In short, the manifest masses control density curvature, and density curvature controls the motions of manifest masses. This is precisely the same self-consistent field nonlinearity that is the hallmark of general relativity, except that space curvature is replaced by the isomorphic concept of density curvature.

But a new feature enters at this point. The density structure must be consistent with the fluctuation energy required for pair production, therefore with the rest mass of the particle-antiparticle pairs constituting the chain. If the fluctuation energy is too high the fluctuons will not extend over enough of a spatial range to excite a neighboring vacuum particle. If it is too low they will jump over neighboring pairs, yielding an effectively lower vacuum density and hence a stronger interaction (which will itself lead to alterations in vacuum density). As absorbers move and surrounding density structure changes the self-consistent relationship

between the distribution of manifest absorbers and the distribution of vacuum particles is disturbed. Self-corrective interactions come into play that move the relationship back towards self-consistency. To the extent that self-consistency is disturbed the forces between absorbers are altered and consequently the motions of the absorbers are altered in a highly random way. The element of randomness concomitant to wave function collapse enters, corresponding to the fact that the nonlinear character of the field equations of gravitation should lead to the collapse of superpositions.

Actually two processes occur. The first is a random alteration (or mutation) in the motions of absorbers in response to the break down of the self-consistent relationship between manifest and unmanifest distributions. This is an entropy increasing process. The second is the self-corrective process that pushes these distributions back to self-consistency. This is an entropy reducing process. In the very high mass, high velocity region both these processes become more pronounced. Superpositional collapse merges into gravitational collapse. But gravitational collapse creates gigantic self-corrective interactions that reverse it. The major crisis of today's physics, the end of the principle of energy conservation in ultimate gravitational collapse, is precluded in the fluctuon model.

5 THE MOST POWERFUL PHYSICS LABORATORY IN THE UNIVERSE: YOU

Now we can see why inconsistency is important. If there were no inconsistency in the underlying physics of the universe there would be no self-correction. If there were no self-correction there would be no control. A physics that is perfectly self-consistent, if it could be constructed, would violate the principle of philosophical relativity, since it would exclude control.

Nonlinearity allows for stability, which is tantamount to control. Quantum mechanics, being essentially linear apart from measurement, does not build the possibility of control into its basic structure. It must be added by augmenting the theory with assumptions that justify statistical mechanics. General relativity, being nonlinear, allows for stability. The microscopic interpretation provided by the fluctuon model enlarges this nonlinearity. Furthermore, it yields a bona fide error correction system, with a noise generator and basins of attraction. The noise generator is superpositional collapse. The basins of attraction are inherent in the self-consistent field aspect of gravity. The universe envisioned by the fluctuon model is in effect a giant servomechanism. Furthermore, the control capabilities inherent in it extend far beyond those of any classical control system, due to vast parallelism inherent in the superposition principle.

It might be thought, given the apparent precision of today's theories, that control features such as those predicted by the fluctuon model would be far too slight to measure except under the most extreme high mass, high velocity conditions or in some future super-super high energy collider. This is not the case, for two reasons. The first is that the effects are unseen not because they are small, but rather because of their ubiquity in macroscopic matter. The second is that the organism is a much more sensitive measuring instrument than any existing technological measuring apparatus.

First consider the ubiquity issue. Ordinary matter is highly homogeneous as compared to bioorganic materials, which are constituted of a vast variety of molecules in highly choreographed arrangements. The consistency restoring effects of the fluctuon model restrict the possible movements of particles, both in ordinary and biological matter. But the effects are completely randomized in ordinary matter, since there are an enormous number of

choreographies (technically called complexions) that are entirely equivalent from the macroscopic point of view. The only consequence that would be discernible would be the stability of macroscopic form, a feature that does not have an entirely clear basis in standard quantum mechanics [18]. This is the feature that is too ubiquitous to be discernible.

The second reason, the extraordinary capacity of biological organisms as detectors, is in a way a restatement of the structural heterogeneity and high dynamic choreography of biological matter. The concept of *vertical* flow of information (or more generally influence) captures the key feature [14, 19]. Biological organisms are the most powerful instruments for discerning the underlying physics of the universe because of their unrivaled capacity to transduce the macroscopic inputs impinging on them to meso- and microphysical forms, to process them at each of these levels, and then to amplify these micro processes up to the macro level of action. The term "amplification-transduction cascade" highlights this important aspect of vertical information flow.

Thus a single molecular switching operation at the level of DNA may have dramatically visible macroscopic consequences, such as the differentiation of a biological cell into a skin cell or a liver cell, or the development of an organism into one of two very different forms. Macroscopic environmental signals impinging on the organism are converted to, say, hormonal or nerve signals. The latter are converted to chemical signals within cells, which in turn trigger shape changes in a macromolecule, say a protein, and concomitant molecular actions. The shape changes depend on interactions among the various particles that constitute the protein, including the atomic nuclei (whose positions define the shape) and electrons. The mass of the electrons is small enough for the wave properties of matter to come to the fore. It is this tight coupling between components heavy enough to have an approximate classical description in terms of shape and components light enough to require a quantum description in terms of waves that allows biological organisms to be so much more powerful as detectors than measurement apparatus based on conventional materials. The parallelism inherent in the electronic wave function of the electronic system can thus contribute to the capacity the protein to selectively respond to molecular and physiochemical features in its immediate environment, to make the appropriate shape change, and to take the appropriate action. This is the quantum speedup effect [20]. The consequence, in the case considered, might be to activate a gene, and therefore to release the upward running chain of processes that culminates in the morphological form of the organism. But many other examples could be considered, including molecular level control of the manner in which nerve cells respond to the pattern of impinging inputs [21-24].

Now we can consider how gravity enters the process. The small mass of the electrons makes them susceptible to the restorative processes that maintain the self-consistency between the manifest distribution of matter and its "shadow" in the vacuum. When external inputs impinge on the organism these are transduced to molecular and electronic level events. The atomic nuclei and electrons change their state of motion (or, more accurately, undergo transitions to states of different energy). The arrangement of manifest mass and its vacuum shadow becomes inconsistent. Superpositions collapse. The response of the electrons to the consequent restorative forces influences the motions of the atomic nuclei, leading to the molecular actions (in particular catalytic actions) that culminate in the macroscopic actions of the organism. The tight coupling of atomic nuclei and electrons is extended in this way to a coupling with the vacuum sea. It is an arrangement of matter that feeds on the self-regulatory dynamics inherent in the universe. Furthermore, it is an arrangement that can arise only in mutual co-evolution with the structure of the vacuum sea. One could not simply place molecules in an arrangement corresponding to an organism and expect them to be held together by self-corrective interactions with the vacuum; they would be pulled apart by these

interactions unless the vacuum sea was also arranged in a complementary manner. According to the fluctuon model the vacuum shadow is an unseen memory that underlies the fantastic form and coherence of biological organisms.

6 PHILOSOPHICAL RELATIVITY SELF-APPLIED

Have we arrived at model that does enough, and not too much? Doing enough means that it covers the phenomena in a way that allows for antinomic interpretations. Doing too much would mean that it solves the antinomy.

Let us go back to the initial antinomy between the internalist and externalist viewpoints. For the internalist the main fact must be that he has a viewpoint. What is given to him in experience, the qualities that constitute his consciousness, is paramount. We cannot see these in the fluctuon model, since all we can see there are formal symbols or linguistic descriptions. But qualities are eligible referents of these descriptions. since superpositions are not themselves quantities. The internalist would reasonably assert his sense of choice is real, and that he is free to exert control on the world to at least some extent. The fluctuon model allows for this, since it is a control theory. Furthermore, the collapse of superpositions, since it introduces a random element, means that genuine spontaneity is an eligible referent of the model. The internalist might hold that his experience is private, or at least private for all practical purposes. The transduction-amplification cascades that define the circular flow of influence between the macroscopic level of organism behavior and the excitations of the vacuum sea are so delicate and so history dependent that for all practical purposes it would never be possible to directly experience someone else's pain.

But as noted above, the theory does not compel these interpretations (however attractive they might be to the present author). The pure externalist could still argue that consciousness is just the sum total of the spatio-temporal activities of organisms, and that limitations on the possibility of observing these activities do not have any ontological implications. Or he might argue that even though the theory has random elements there exists a map in principle—a giant table—that we just don't happen to know. It might be that this map has no possible constructive existence, that even writing it down would require more matter than exists in the whole universe. But our determinist-externalist could still adhere to ontological determinism. Or, he might take the tack that someday it should be possible to develop a theory that in all respects is equivalent except that it in principle eliminates superpositions and randomness, presumably at the expense of strange action-at-a-distance interactions. He might even hope that the new theory would make more powerful predictions and that it would therefore demonstrate the nonexistence of freedom and the derivative character of qualia. But this would be going to far, for the theory would then disagree with what the internalist has the right to take as fact. According to the principle of philosophical relativity this new, putatively more predictive theory, would actually be making incorrect predictions. It should be replaced by a theory with constructs that preclude these incorrect entailments; if it is not in principle replaceable in this way it could not lay universal claim to being the better theory.

What would happen if an argument arose as to whether an issue was antinomic? It would be obtuse to argue that the issue of consciousness, for example, has not been the subject of highly competent but conflicting philosophizing. It would be obtuse to argue that the arguments for a flat earth are just as credible as the arguments for a globular earth. But cases could arise in between these extremes that are themselves inherently arguable. To eliminate all such cases one would require a criterion that itself was immune from criticism. This is highly unlikely. As

indicated at the outset, philosophical relativity is an attitude and an ideal. It is probably not possible to sharply separate questions that should be definitively answered by a scientific theory from those which should be left open to its interpretation. In fact, in the spirit of the philosophical relativity principle, this itself should be an open question, since clearly the credibility of arguments is a matter of judgment. Recalling the term "inseparability" used by Matsuno [16], we must perhaps in the end think in terms of the ultimate inseparability of scientific description and philosophic interpretation. The inconsistency inherent in this inseparability is quite consistent with our whole model. The impossibility of consistency and of standstill inconsistency is the generator of cosmic evolution in the fluctuon model, and of the evolution of those self-enclosed transduction-amplification circles that we call biological organisms. So also is it the generator of scientific and philosophical advancement.

Acknowledgment. This material is based upon work supported by the National Science Foundation under Grant No. ECS-9409780.

REFERENCES

- [1] A. J. Ayer, ed., *Logical Positivism* (The Free Press, New York, 1959).
- [2] G.J. Chaiten, Gödel's theorem and information, *Int. J. Theoret. Physics* 22 (1982), pp. 941-954.
- [3] J.S. Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge University Press, Cambridge, UK, 1987).
- [4] P.A.M. Dirac, *The Principles of Quantum Mechanics*, 4th ed. (Oxford University Press, Oxford, UK, 1958).
- [5] D. Bohm, *Quantum Theory* (Prentice-Hall, Englewood Cliffs, NJ, 1951).
- [6] C.W. Misner, K.S. Thorne, and J.A. Wheeler, *Gravitation* (W.H. Freeman and Co, New York, 1973).
- [7] M. Conrad, Force, measurement and life, in J. Casti and A. Karlqvist, eds., *Toward a Theory of Models for Living Systems* (Birkhauser, Boston, 1989), pp. 121-200.
- [8] M. Conrad, Transient excitations of the Dirac vacuum as a mechanism of virtual particle exchange, *Phys. Lett. A* 152 (1991), pp. 245-250.
- [9] M. Conrad, The fluctuon model of force, life, and computation: a constructive analysis, *Appl. Math. and Computation* 56 (1993), pp. 203-259.
- [10] M. Conrad, Fluctuons-I. Operational analysis, *Chaos, Solitons & Fractals* 3 (1993b), pp. 411-424.
- [11] M. Conrad, Fluctuons-II. Electromagnetism. *Chaos, Solitons & Fractals* 3 (1993c), pp. 563-573.
- [12] M. Conrad, Anti-entropy and the origin of initial conditions, *Chaos, Solitons & Fractals* 7 (1996), pp. 725-745.
- [13] M. Conrad, Fluctuons-III. Gravity. *Chaos, Solitons & Fractals* (1996), pp. 1261-1303.
- [14] M. Conrad, Cross-scale information processing in evolution, development and intelligence, *Biosystems* 38 (1996), pp. 97-109.
- [15] M. Conrad, Percolation and collapse of quantum parallelism: A model of qualia and choice, in S.R. Hameroff, A.W. Kaszniak, and A. C. Scott, eds., *Toward a Science of Consciousness* (The MIT Press, Cambridge, MA, 1996), pp. 469-492.
- [16] K. Matsuno, *Protobiology: Physical Basis of Biology* (CRC Press, Boca Raton, FL, 1989).

- [17] Y.-P. Gunji, Global logic resulting from disequilibrium process, *BioSystems* 35 (1995), pp. 33-62.
- [18] R. Penrose, *The Emperor's New Mind* (Penguin, New York, 1989).
- [19] M. Conrad, Molecular computing. In M.C. Yovits, ed., *Advances in Computers*, (Academic Press, Boston, 1990), pp. 235-324.
- [20] M. Conrad, Quantum molecular computing: The self-assembly model, *Int. J. Quant. Chem.: Quantum Biology Symp.* 19 (1992), pp. 125-143.
- [21] G. Matsumoto and H. Sakai, Microtubules inside the plasma membrane of squid giant axons and their possible physiological function, *J. Membrane Biol.* 50 (1979), pp. 1-14.
- [22] E.A. Liberman, S.V. Minina, N.E. Shklovsky-Kordy, and M. Conrad, Changes of mechanical parameters as a possible means for information processing by the neuron (in Russian) *Biofizika* 27 (1982), pp. 863-870 [Translated to English in *Biophysics* 27 (1982), pp. 906-915].
- [23] E.A. Liberman, S.V. Minina, O.L. Mjakotina, N.E. Shklovsky-Kordy, and M. Conrad, Neuron generator potentials evoked by intracellular injection of cyclic nucleotides and mechanical distension, *Brain Res.* 338 (1985), pp. 33-44.
- [24] M. Conrad, Emergent computation through self-assembly, *Nanobiology* 2 (1993), pp. 5-30.

NEURAL BASIS OF CONSCIOUSNESS

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Abstract. Consciousness is interpreted in light of "knowledge" as the accompaniment of all faculties and the final results of operations mediated by neural net of enormous complexity. Beyond doubt, there are four psychological phenomena necessary for composition of consciousness as "knowledge" of cognitive and conative conditions and self per se, as selfconsciousness. They are: wakefulness, attention, short term memory and long term memory. They create conditions for components to be structured as totality. Behind these psychological functions lie engram formations by synchronized association of many components. Neural substratum mediating synchronous activity and associations could be found in structure and intrinsic function of cortical units richly interconnected cortically and as well with subcortical structures. The stress is laid on connections between neocortical associative zones, especially prefrontal lobes, and neothalamic nuclei, especially nucleus dorsomedialis. Cognitive hippocampal function, its functional relationship with memory but structurally belonging to limbic system - the highest integrative level of conative functions - putatively offers partial explanations for several things: connection of distress, experience, and survival; consciousness of emotions; integration of rational and irrational parts of man; formation of "knowledge" attitude (consciousness and selfconsciousness); and, at last, integrative nature of truth (logic and trust). In section Psychology of Consciousness and Gross Waves are given some electrophysiologic correlates of mental operations, e.g. cognitive N 130 P 400 and three surface negative potentials accompanying conscious and willful states.

Key words: *wakefulness, consciousness, selfconsciousness, hippocampus, hierarchy, cortical unit, thalamo-cortical circuitry, prefrontal lobe, limbic sistem, cognitive P 400, knowledge, truth*

All aspects of mental life represent difficult riddle for exploration, and it holds true to the utmost for *consciousness* - "the upper level of mental life marked by awareness" (by definition from The New Grolier Webster International Dictionary of the English Language) giving us reason to think of a tautology. It seems trustworthy to think of consciousness as the final result of complex work of all mental operations mediated by neural net of enormous complexity. Cousin wrote: "We not only feel, but we *know* that we feel; we not only act, but we *know* that we act; we not only think, but we *know* that we think...The peculiar quality, the fundamental attribute of thought is to have a consciousness of itself. Consciousness is the accompaniment of all our faculties; and is, so to speak, their echo" [1].

1 THREE "CONSCIOUSNESS"

It is possible to discern three meanings of consciousness: (1) wakefulness (2) consciousness in the narrow sense of the meaning as a specific attitude of "knowledge" towards subject's mental contents and activities, and (3) selfconsciousness as specific attitude of "knowledge" of subject himself.

Wakefulness is prerequisite for normal conscious mental activity, and with attention makes energy function group [2]. It belongs to a well developed concept in neuroscience, thanks to

experiments of Bremer [3], and Morruzi and Magoun [4], revealing ascendent activating reticular system (AARS) coming from brainstem [2,5] which we are not going to discuss further.

But if we want to enlighten another aspect of *consciousness* (synonyms - awareness and another in clinical psychiatry - orientation: spatial, temporal and allopsychic), or the experience of knowledge about oneself i.e. *selfconsciousness* (synonyms - selfawareness and another in clinical psychiatry - orientation: autopsychic), then we face almost irreproachable obstacles. The closer we come to the concept of selfconsciousness, the greater our frustration grows. And this is true for mental phenomena supporting the state of "knowledge" and even more for neural network, the very site of mental processes giving rise to consciousness. The main obstacle is non existing convenient model for controlled studies of the problem.

Consciousness explorer must inevitably encounter a four-level strategic problem: (1) the problem of structure - neuroanatomy and neurohistology with molecular specificities of CNS; (2) the problem of function - neurophysiology of CNS, which has many elaborate faces; (3) psychic capabilities and means participating in mental operations, and (4) correlations of specific mental functions with neural zones ("centers" for each specific operation - localization and lateralization problems) and correlation with some electrophysiologic phenomena registerable even at present level of scientific development (e.g. cognitive N 140 - P 400).

And all these items should be put in the context of time - through simultaneous multichannel activation creating opportunities for mental associations to be established concerning actual conscious experience about past and new inputs, with additional knowledge of self including the feeling of distance [6,7].

When we ruminate on awareness in terms of neuronal organization, which is our ultimate assignment, it is necessary to be aware of cortical neurons arranged in cortical modules as telencephalic cortical structural and functional units.

2 CORTICAL UNIT AND CONSCIOUSNESS

In 1957 Mountcastle published observations on structural unit in somatic sensory primary cortex [8]. Later it has been confirmed for the whole cortex, and also to be cortical functional unit [9]. About 4 million vertical units constitute the total mass of brain cortex. Each cortical vertical unit (synonyms: vertical column, module) is composed of a couple of thousand cortical neurons. Most cortical neurons in unit are oriented vertically to the surface of the cerebral cortex (cf. Fig. 1). The most conspicuous are pyramidal cells by size small, middle and large (in fifth ganglial layer). Stellate cells in fourth cortical layer are also vertically oriented. Vertical orientation holds true for all efferent and afferent fibers penetrating unit of whatever origin, so all electric fields are *parallel*, as their structures are.

The main principle of parallelism in vertical unit enables formation of *dipole electric fields* generated either spontaneously or evoked, as well as summation (add/subtract) of small field values (*potentials, potential differences*) by averager technique [10].

And exactly some of these small potentials, made visible by averager technique, have become correlates of awareness, attention and even free will opening incipient enlightening on relationship between brain and functional correlates of consciousness.

When an axon enters a vertical unit, its complete arborization does not leave the unit. The axon branches throughout the unit making synaptic contacts with numerous neurons being part of the unit. Convergent input pours into unit, and after processing it sends divergent output shaped in time/space patterns mediating by mechanisms like time and space summation. At the same time the vertical unit sends inhibitory influences toward other units in its vicinity. Units are overlapped

which means that all neighbour units process the same inputs. A few thousand cells bound in vertical unit can create enormous number of patterns codes because they can combine and vary: intensity, lasting, sequence of discharges beside the possibility simultaneously to engage many or few neurons and to be brought about *in the same phase of activity*. The same variety of probabilities exist for module engagement, so each vertical unit is a link between input and output. But not the simple one. It is supposed for module to possess intrinsic power, internal nervous activity connecting old informations and new ones, and these might be the part of neural basis of *consciousness* according to descriptive Cousin's definition [1].

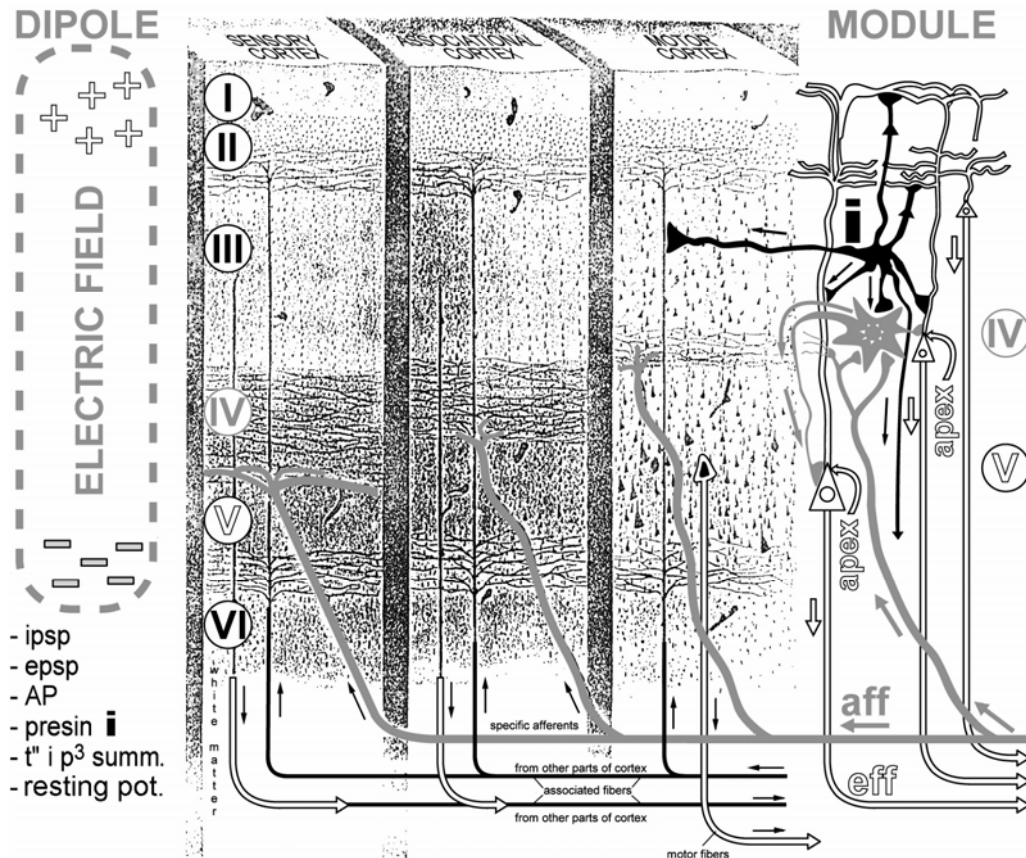


Figure 1. Organization of cortical vertical unit and electric field. Central part of the figure shows three cortical units disclosing three different types of neocortical organization: sensory, associational and motor. On the right side of these three cortical units a very simplified and very schematic inner organization of a cortical unit is displayed. In white arrows are represented pyramidal cells from whose apexes apical dendrites project to superficial first and second cortical layers. Brightly shaded paths are sensory-afferent inputs terminating on its stellate neurons, also vertically oriented as pyramidal cells are. In black is depicted inhibitory neuron acting inhibitory within its own cortical unit, but also spreading its inhibitory influence into other units in the vicinity. On the left side electric field is designed with a short list of electrophysiologic events having impact on it, modifying intensity and reversal polarity of dipole. It should be noticed that parallel organization of the component cellular parts in cortical vertical unit is essential for formation of electric field.

3 CNS HIERARCHICAL NEURONAL ORGANIZATION AND CONSCIOUSNESS AS “KNOWLEDGE”

It seems that the crucial phenomenon which defines consciousness and specific part of it - self consciousness is the state of - "knowledge". Unless it is unconscious, any activity concerning oneself (cognitive, conative, or orientation) goes hand in hand with "knowledge" that the activity is going on, or is done. What is brain substrate, neuronal setting of the phenomenon, is not an easy question for science.

However, Crick [11,12] proposed previously to answer "easier" problem: how through perception different features of one object become integrated as one object. It is supposed that behind synchronously perceived different features of an object lies activation of neuronal settings in different and often distant parts of brain. This timing of neuronal settings activity brings them into union, so that separate characteristics vanish in holistic impression of oneness. *Synchrony* is made possible by abundant feedback connections among all levels where computation is interchanged, and brain can be imagined as vast net of reverberatory excitatory/inhibitory processes.

Hierarchical organization of nervous system is rather old hypothesis, and it is part of evolution theory. Looking globally, brain regions are hierarchically organized. Older, lower and more primitive levels are under control, functionally comprised by and integrated in younger and more developed. The newer aspect in Crick's concept is that even in one region there exist *local levels of hierarchical organization*. Lower level passes its result of computation on further and more sophisticated elaboration to higher one, and so in several steps. At least, it seems to be true for visual perception processing in occipital lobes.

It has already been shown [13-15] that area striata cortical neurons columnary organized are specialized to perceive either vertical or horizontal lines. For every neuron there is the particular position of line when it fires maximal frequency action potentials. But, its firing is influenced by the condition in *neighbour receptive fields*. The contextual relationship seems to hold true on all levels of brain organization. It brings us to a "projection field" concept, which means all population of neurons where an axon branches creating synaptic connections.

Many inputs converge on one set of cortical vertical unit, and wide dispersion of its activity reaches many neighbour and distant parts of brain - horizontally and transversally (cortically) and vertically (subcortically).

Oscillatory circuits exist between cortex and subcortical structures such as: *three parts of thalamus, striatum, and claustrum* [16]. It seems to be of special importance the existence of three well developed systems in thalamus according to anatomy, electrophysiology, and particularly by type of thalamocortical and vice versa - corticothalamic connections. The oldest part is *archithalamus* (nonspecific nuclei); younger - *paleothalamus* (specific nuclei), and youngest *neothalamus* (associative nuclei) [7, 17-19]. Archithalamus is a part of cortical activating system and it has prominent role in attention generation and consecutively in formation of alpha rhythm [7]. Paleothalamus is the principal sensibility relay. Paleothalamic neurons forward impulses into primary sensory cortical zones, and their electrical escort are evoked responses. The connections between specific thalamus and primary sensory zones are very precise - point to point making homunculus. Neothalamic mass is bigger than total paleo and archithalamic mass taken together. Evolutionary, it goes hand in hand with powerful neocortical development. And thus neothalamic nuclei communicate with neocortical associative ("mute") areas by feedback ties. Every nucleus has its own, definite cortical zone. So, there is sound reason to suppose that row stimulus impulse is processed in hierarchically organized neural levels (globally and locally), lower level proceeding the result of its work to higher one where the process is continued until final information is shaped.

4 MEMORY AND CONSCIOUSNESS

Memory is essential in two ways. First, there is no experience without formed engrams. And second, by definition [1] consciousness is described by attitude of "knowledge".

At the present moment, *hippocampus* and entorhinal cortex are supposed to be crucial structures mediating "knowledge" by harmonious binding rich results of computations in different brain regions organized hierarchically [7]. In spite of rather primitive structure, hippocampus is very intriguing and odd in some functional aspects. Green & Arduini [20,21] have shown some peculiar hippocampal characteristics. When everywhere brain showed desynchronization, over hippocampus theta activity was registered. Later, hippocampal tonic and phasic activities have been discovered and these have been proposed to have connection with memory [22]. Tonic activity is followed by theta rhythm, and phasic correlates with hippocampal desynchronization. Phasic desynchronization lasts parallelly with sensory stimulation, and it dies the very moment sensory stimulation is stopped. So it might be that hippocampus plays central role in consolidation of fresh engrams (tonic theta rhythm) and period of its phasic activity to be important for binding perceived different features in total object (from analysis to synthesis). Both hippocampal activities might be neural basis of short term memory, being necessary for consciousness, or the state of specific "knowledge" in man. And it is quite reasonable to suppose that short term and long term memory (experience) must have to do with "knowledge" being essential part of consciousness (cf. Fig. 2).

On neuronal level, *short term memory* might complementary be mediated by functional changes in brain such as excitatory processes in phenomena resembling post tetanic potentiation [23,24], sustained firing of neurons, oscillatory circuits (like neuronal organization in respiratory center, and AARS), and intrinsic properties [25-28]. It is possible that thalamo-cortico-thalamic circuitry also may have to do with short term memory and so directly to do with consciousness represented in phenomenon of "knowledge". So, we might imagine that basic and global activation (facilitation) of cortical units comes from brain stem Ascending Activating Reticular Substance (AARS) input. Additional energy to selected vertical cortical units, engaged in memory process, comes through archithalamic system of attention. Thus, attention brings two qualities: first - selection and second - strong experience of consciousness. The last two mechanisms might be taken as supportive ones for more sophisticated cortico-thalamo-cortical circuitry activity. And here we can introduce the hypothesis that fifth layer gigantic pyramidal "bursty" neurons are intimately connected with consciousness. They send axons toward thalamic neurons, receiving reentrant impulses into cortical layers 4 and 6. *The cortical brain areas rich in neurons and synaptic feedback connections could sustain long-term excitation mediating consciousness experience.*

Medial septal nucleus is pace maker [20] in producing hippocampal 7,7 Hz activity when all other parts of brain are desynchronized [21,20]. And, as we said, it has to do with memorizing, consolidation and reviving engrams. Furthermore, we know that for memory function hippocampus plays crucial role, but only in interplay with septal nuclei. And additionally, septal nuclei are connected with hypothalamus - the source of behavior patterns (fight/flight, avoid/approach).

Memory mechanism is deeply interwoven in limbic system (hippocampus, parahippocampal region with entorhinal cortex and fornix). Biologically it is rational arrangement. The more important experience for survival, the more emotional event it is. So process of remembering should be proportional to elicited emotion. It seems to rely upon connections among: Gyr. cinguli - parahippocampal gyr. - hippocampus - mammillary bodies - nucl. anterior thalami - and back to gyr. cinguli thus making brain circle for memorizing life experience.

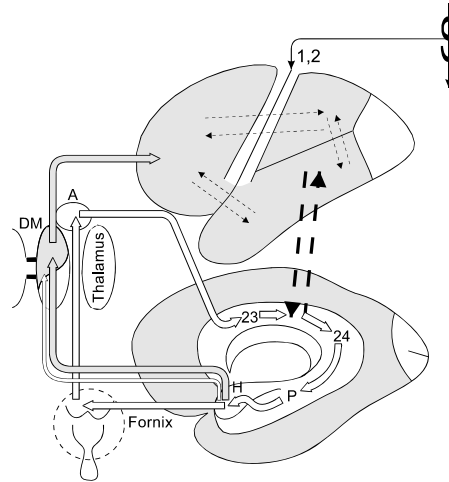


Figure 2 *Memory, hippocampus and selfconsciousness.* Shaded associational neocortex and neothalamic nucleus dorsomedialis suggest organic substratum for selfconsciousness on cognitive aspect of emotions, as well as interplay between these structures and main memory site - hippocampus. Rich interconnections between prefrontal, and greatest parts of parietal and temporal lobes on one hand, with limbic cortex on the other, prepare the brain basis for selfconsciousness regarding emotions. And outstanding position of hippocampus in this circuitry gives rise to hypotheses why we not only feel, but we are conscious - we know that we feel. Abbreviations: H - hippocampus; P - gyrus parahippocampalis; 23,24 - gyr. cinguli; DM - dorsomedial thalamic nucleus; A - nucleus anterior thalami; 1,2 - Brodman zones of somatic sensibility.

5 PSYCHOLOGY OF CONSCIOUSNESS AND GROSS WAVES

Consciousness and free will are basic human mental features, and with symbolization make three properties by which human being is essentially different from the rest known living world.

Free will encompass three phases: motive struggle, making decision, and carrying out decision. Within willful act there is the state of deliberate and *conscious intention* and it speaks by itself of the existence of the specific quality which we designate consciousness and selfconsciousness. Neurophysiologic explorations of entirely subjective phenomena, accessible previously only by introspection, discovered their correlates - objective electrical potentials.

5.1 EEG - Consciousness and Alpha Suppression

Good example to start with is manipulation with alpha rhythm in EEG. *Suppression of alpha activity* by opened eyes, confirming that we deal really with alpha spindles and not e.g. with "mu" rhythm, does not mean only consequence of optical stimulation [22]. If subject is seated for a while in front of monotonous, unstructured surface, in *lighted* room with *opened* eyes - alpha rhythm reappears. It justifies the surmise that attention activation (without any other source of activation: e.g. movement, stress, sensory or emotional) is the basic reason for disappearance of alpha activity, and not visual stimulation of neocortex per se. So, we might suppose alpha blockade to be correlate of conscious and willful attention.

5.2 Cognitive Somato-Sensory EP (SSEP)

When a sensory channel is stimulated, on the surface of cerebral cortex can be registered threephasic primary response, specific response or potentials, evoked potentials [7,23-28]. In primary sensory cortical zone contralaterally, primary potential is clearly readable, and ipsilaterally it is present as a weak trace. But, in human psychology regarding consciousness exceptionally important are later deflections such as *N 140-150 (N3)* and *P 300-400 (P4)*. These are very low voltage potentials and for their detection averager technique is indispensable [10]. *N 140 - P 400* wave pair seems to be electrophysiologic correlate of free will, willful intention, or volitional attention [29-31].

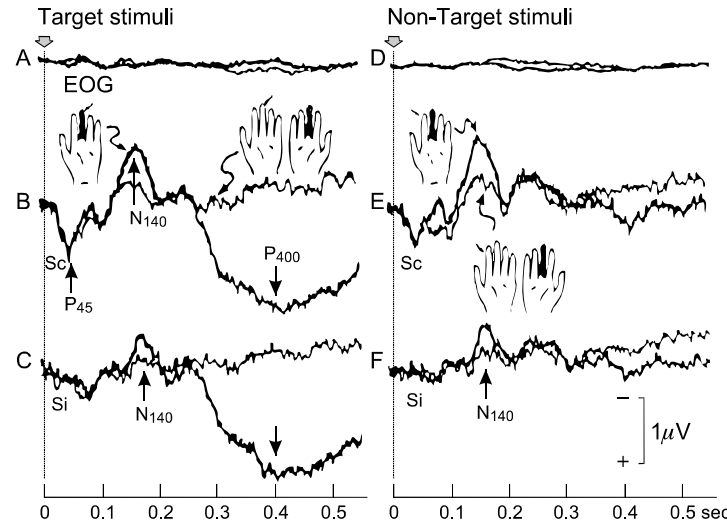


Figure 3 *Correlates of willful attention: P400 and N140.* There are Figs. 9 (B) (C) (E), and (F). Figs. 9 (C) and (F) represent ipsilateral registrations. We can see only two traces with clearly formed P400, both contralaterally (B) and ipsilaterally (C). These traces are correlated with paid attention to the stimulated finger. Whenever, in all other combinations, attention was directed in wrong direction - to nonstimulated finger - in registered evoked potential the complex wave P400 missed entirely. (For more detailed comments see the text)

In Fig. 3. upper B and E traces are registered contralaterally, and lower C and F ipsilaterally. Subject was told to pay attention to his third finger and this finger was actually stimulated. *N 140* and *P 400* were well depicted bilaterally; *P 400* symmetrically, but *N 140* asymmetrically - lower amplitudes ipsilaterally. It should be noticed that primary (specific) EP is asymmetrical - amplitudes are much higher contralaterally. But *P 400* is symmetrical bicortically. Also EP early components are localized *only* in primary sensory cortical zones, but late components spread over bifrontal and biparietal lobes, the highest amplitudes over parietal lobes. To elicit specific part of EP very narrow strip of neocortex is necessary, because transformation of one stimulus modality into nerve impulse and cortical event is much less complicated process then creation of *consciousness*. Because of this reason generation of *N 140* and especially *P 400* need wide neocortical areas. For somatosensory *conscious* perception even three lobes are involved. This is in concordance with consciousness bringing definitely new quality to perception process.

5.3 Three Negative Surface Potentials

Conscious-volitional intention has got its electrophysiologic correlates in form of three negative surface potentials.

We already talked of free will and consciousness from psychological standpoint, but the role of attention as their part was not sufficiently stressed. Willful act is made possible by focus of awareness, or attention. Attention is both turning point and connection between wakefulness as non specific general state of CNS readiness, and consciousness as integrated result of all mental events-processes, with emphasis on "knowledge" concerning contents incorporated in consciousness.

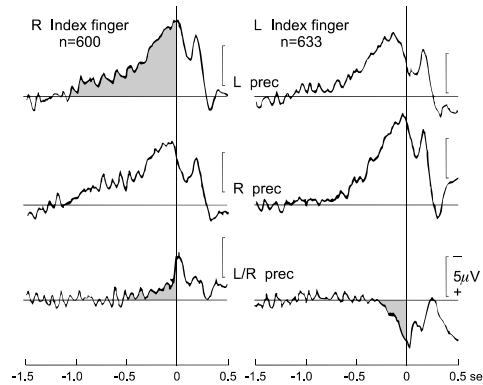


Figure 4 *Readiness potential*. Experimental procedure is summarized in the text. Four upper curves are registered monopolarly, and two bottom traces bipolarly. The subject absolutely freely makes decision when to move his finger. About two seconds before movement a negative potential commences to build up amplitude with its maximum at the very moment when muscle contraction starts. Negative potentials are higher contralaterally which means: for right index finger it is over left precentral zone, and for left index finger it is over right precentral zone. Bipolar traces registered voltage difference between ipsi and contralateral precentral zones demonstrating contralateral potentials always to be higher.

By now three electrical phenomena [7] - three different types of negative waves are registered from scalp having to do with volitional attention and very subjective mental state i.e. *intention*. These are: contingent negative variation [32-34], negative potential of goal directed movement [35] and readiness negative potential. *Readiness potential* (cf. Fig. 4) is electrophysiologic correlate of willful intention to perform movement. Subject chooses freely when to move his finger. All the time brain activity is registered and stored in computer. When voluntary movement elicits muscle potentials through EMG, these muscle potentials trigger the computer to analyze stored electrical potentials *backwardly*, potentials being registered before movement did happen. And this analyze revealed gradually building negative potential with onset about two seconds *before voluntary movement* shall take place [36,37].

These negative potentials are registered almost symmetrically with highest amplitudes over parietal lobes and considerably lower over prefrontal regions, and asymmetrically higher contralaterally.

Readiness potential originates in the course of very subjective mental situation - when a subject *prepares intentionally* to make voluntary movement. *It is correlate of intention to perform motor act* which actually did not happen, but shall happen in near future.

5.4 Prefrontal Lobe

Here, we should recall results from radioactive isotope scanning. Detection of radioactive isotope distribution shows increased blood circulation in specific motor zone, supplementary motor zones, postcentral gyrus, and prefrontal lobe when a subject forms intention to move his hand, *only imagining* the movement. Prefrontal activation is noticed in contingent negative variation studies too, and these facts suggest the significance of *prefrontal lobes* for producing volitional attention, for conscious and willful intention. So it is understandable why prefrontal leukotomy [38,39] abolished formation of aggressive *intentions* in dangerous psychotic patients. What rests is shamrage [39,40] - without target. Drive does not enter phase of vector formation, ie. motivation phase.

There is some evidence that near Brodmann area 24, slightly more frontally, a sort of "center" for integration of free will is situated. Anyhow, this is the place where free will may be easily damaged [41,42]. Area 24 belongs to limbic brain, emotional brain and this is our next topic - emotions and selfconsciousness.

6 CONSCIOUSNESS OF EMOTIONS

Biologically, emotions are mediated by (1) limbic system (2) hypothalamus, and (3) two brain stem opponent systems: cholinergic (periventricular) aversive system and monoaminergic pleasure (affiliative) system with medial forebrain bundle (MFB).

Limbic system (emotional brain) consists of cortical and subcortical structures, and connections [43]. There are *two cortical* rings situated on medial sides of hemispheres.

Outer ring is younger sixlayer mesopallium (gyr cinguli, 23 and 24 Brodman areas); and inner ring is older three layer archipallium (gyr dentatus, induseum griseum, *hippocampus*). *Subcortical nuclei* comprise: septal nuclei and amygdala nuclei. Strongest *connection* in limbic system is fornix. Three monoamines - two catecholamines (Noradrenalin-NA; dopamin-DA) and serotonin-5HT are the main neurotransmitters in limbic system and in hypothalamus.

Papez [22,44] was among the first to sketch integrative conception of mechanisms generating emotions. He shifted the place of highest control and integration from hypothalamus [45, 46] to gyrus cinguli, a part of mesopallium. With Mac Leans [47] improvements (diminished significance of gyr. cinguli, and introduced septal and amygdala nuclei complexes) it did not lose its value. Papez proposed the circle which could primarily explain expression of emotion (through preformed patterns in hypothalamus; hypothalamus in connection with hypophysis). After increased knowledge about the role of hippocampus in memory process [48-50] which is through fornix connected with mammillary bodies, part of hypothalamus (behavior patterns, endocrinology, ANS), and by tractus mamilothalamicus hypothalamus is connected with nucleus anterior thalami (belonging to archithalamus - attention), this construct became refreshed and refined. Via nucleus anterior thalami the system gets its additional connection with gyrus cinguli (main part of mesopallium, and in hierarchy organization of limbic structures - superior instance overruling hypothalamus); from gyr. cinguli circle is closed because it is connected with entorhinal cortex and hippocampus (memory function, cognitive aspect of emotion), back to hippocampus - to the starting point of circle.

In short, it is supposed for *amygdala* complex [51-53] to mediate *selfpreservation* (mostly aggressive motivation), and *septal complex* [54,55] to be *organic basis of species preservation and sexuality*.

By introducing septal and amygdala complex into limbic system Mac Lean widely opened door for two stem systems to be included in Papez construct, as bearers of two opposite groups of

emotion - pleasant/unpleasant. In brain stem there are two opposing systems: cholinergic periventricular (PVH) [56-60] - *aversive* system (fibers collected in dorsal and ventral bundles), and monoaminergic MFB (containing noradrenergic and serotonergic neurons mostly, plus dopaminergic neurons in mesolimbic bundle, and to some extent nigrostrial DA system) composing - *pleasure* system [61-67].

Before we summarize possible neuroanatomy giving rise to "knowledge" of emotions, let us first summarize elements of system mediating cognition taking part in genesis of emotions. We already talked about hippocampus and memory. Through neothalamic nuclei limbic system has rich communication with associative neocortex zones necessary for cognitive processing. Between neopalium and mesopalium rich direct connections are also verified.

We already talked about septal and amygdala inputs to nucl. dorsomedialis thalami (one of three neothalamic nuclei) which projects into prefrontal association area of telencephalon. Cortical association areas are situated in prefrontal, parietal, and temporal lobes. There are strong interconnections among neocortical vertical units (cortico-cortical associations: within the same hemisphere - ipsilaterally, and contralaterally through commissures, mainly corpus callosum) and, on the other side, between them and thalamus. Sir John Eccles proposed more complete explanation of cortical memory mechanism. Coding engrams by spatiotemporal organization of neuronal activity seems to be widely accepted as well as changes of synaptic membrane grid [68]. The process of coding depends on a sort of spatial summation of vertical inputs from inside vertical unit ("cartridge" excitation) in conjunction with inputs coming from commissural, associative and Martinotti axons forming densely packed horizontal first and second cortical mostly fiber layers. Interesting hypothesis is offered for cartridge input to be initiated by hippocampus [68], which is, as we know directly influenced by stress, distress, arousal, excitation. It is [54, 55] proposed for neuronal core of *anxiety, main distress emotion, to be located in septo-hippocampal complex*.

Keeping in mind all the time integrative and supreme control of limbic system, in general we can present brain basis for all four aspects of emotion which includes connections necessary for simultaneous multichannel integration of cognitive "knowledge" about emotional experience (cf. Fig. 5):

- (i) Subjective-specific emotional color (septal nuclei + monoaminergic MFB: amygdala nuclei + PVH bundles)
- (ii) cognition (hippocampus, via neothalamus-association areas of neocortex - prefrontal, parietal, temporal, and direct cortico-cortical communication between association neocortex, and limbic mesocortex)
- (iii) expression (through hypothalamus: behavior patterns, VNS, endocrine glands)
- (iv) excitation (AARS and archithalamus)

Nucleus dorsomedialis could have crucial role as the intersection of three inputs coming from pleasure (hedonic) system from septal nuclei, as well as from amygdala the basis of unpleasant, aversive emotions. Direct and indirect inputs from hippocampus also come to nucleus dorsomedialis, subjoining necessary cognitive component in emotion integration. Nucleus dorsomedialis and neocortical association zones were also of the first rate interest when we talked about memory mechanisms deeply intervoven into emotional brain. These structures could be crucial also for consciousness and selfconsciousness, *that specific knowledge of our own experiences*, with attention participating in conscious relationship toward ourselves with the result of being selfobserved as some neutral phenomenon outside subjective mental space.

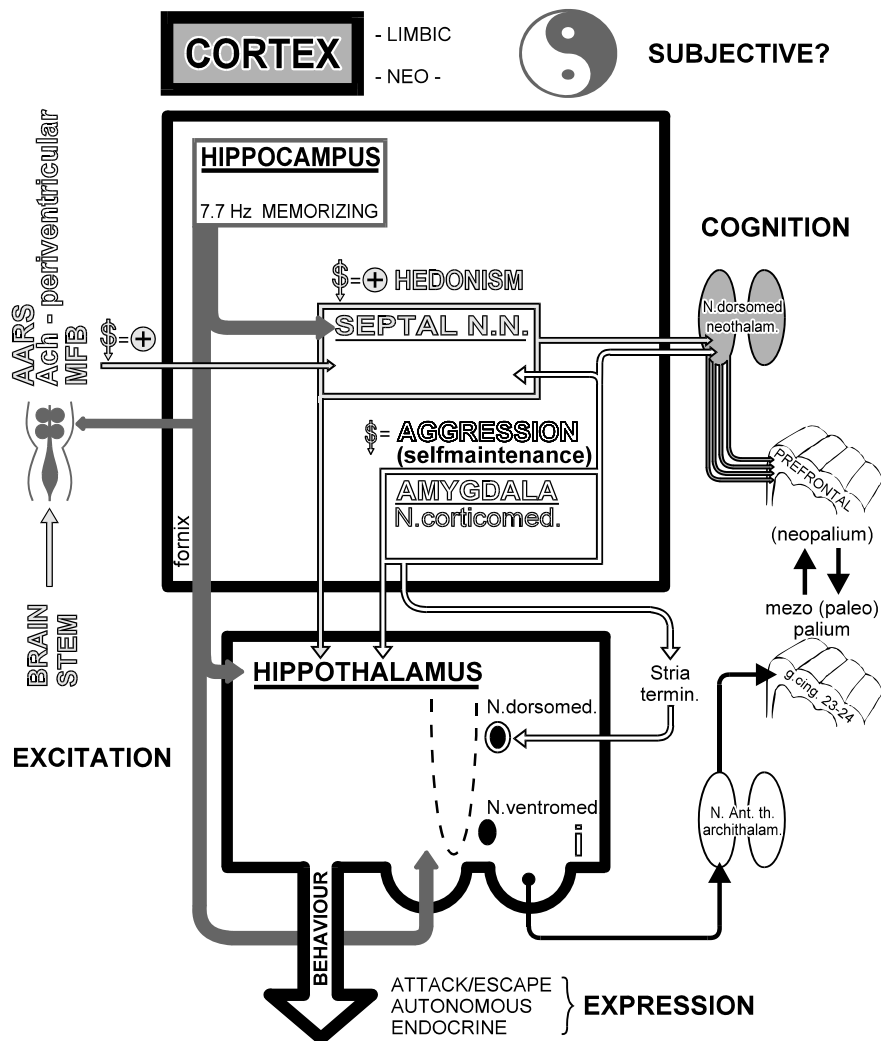


Figure 5 Brain basis of emotion, and selfconsciousness of emotion. This scheme offers an integrative model of brain foundation of four emotional aspects and selfconsciousness regarding emotional experience. Center of the scheme consists of two frameworks: bigger consists of three subsystems: (1) hippocampus (memory function); (2) septal system (hedonism) and (3) amygdala system (aggression). The last two subsystems are organic basis for dividing emotions in two opposed groups - each with *specific* and *subjective* imprint as pleasant or unpleasant emotions. Periventricular cholinergic and monoaminergic MFB of brain stem belong to pleasant/unpleasant organization centered on septal and amygdala nuclei. *Expression* goes through hypothalamus. *Cognitive* aspect of emotion has to do with hippocampus, and through nucleus dorsomedialis with wide associational neocortical zones. *Excitation* is connected with AARS of brain stem. *Basis for selfconsciousness* as an integrative phenomenon might be seen in interplay between dorsomedial nucleus and associational neocortex (e.g. prefrontal cortex) with mesopalium as exponent of limbic emotional brain. All these structures receive abundant inputs and send outputs taking part in the final integrative result - selfconsciousness.

REFERENCES

- [1] Cousin in C. Spearman, *Psychology Down the Ages* (Macmillan and CO., Ltd, London 1937), Ch. 1. and 4.
- [2] V. Desimirović, *Contemporary Medical Psychology* (Nauka, Belgrade, 1994), Ch. 10, in Serbian.
- [3] F. Bremer, Consideration sur l'origine et la nature des ondes cerebrales *EEG and Clin. Neurophysiol.* 1 (1949), pp. 177-193,
- [4] G. Moruzzi and H. Magoun, Brain stem reticular formation and activation of the EEG *EEG and Clinical Neurophysiol.* 1 (1949), pp. 455-473.
- [5] R. Morisson, E. Dempsey and B. Morisson: Cortical responses from electrical stimulation of the brain stem *J. Neurophysiol.* (1940), pp. 732-743.
- [6] V. Desimirović, The knowledge of oneself - selfconsciousness, in Lj. Rakić, D. Raković and Dj. Koruga, A. Marjanović eds., *Consciousness Scientific Challenge of 21st Century* (ECPD, Belgrade, 1996), pp. 67-72, in Serbian.
- [7] V. Desimirović, Biological basis of consciousness, in D. Raković and Dj. Koruga, eds., *Consciousness Scientific Challenge of 21st Century* (ECPD, Belgrade, 1996), pp. 45-86.
- [8] V. Mountcastle, Modality and topographic properties of single neurons of cats somatic sensory cortex *J. Neurophysiol.* 20 (1957), pp. 408-434.
- [9] J. Szentagothai, The local neuronal apparatus of the cerebral cortex, In: *Cerebral Correlates of Conscious Experience*, P. Buser, A and Rouguel-Buser eds. (Elsevier, Amsterdam, 1978), pp. 131-138.
- [10] D.G. Dawson, A summation technique for the detection of small evoked potentials (*EEG and Clin. Neurophysiol.* 6 (1954), pp. 65-84.
- [11] F. Crick, *The Astonishing Hypothesis* (Charles Scribners Sons, New York, 1994), Ch. 11.
- [12] F. Crick, *The Astonishing Hypothesis* (Charles Scribners Sons, New York, 1994), Ch. 17.
- [13] D. Hubel, Visual cortex of the brain, *Scientific American* 209 (1963), pp. 54-62.
- [14] D. Hubel and T. Wiesel, Receptive fields and functional architecture in two nonstriate visual areas (18 and 19) of the cat, *J. of Neurophysiology* 28 (1965), pp. 229-289.
- [15] D. Hubel and T. Wiesel, Stereoscopic vision in macaque monkey, *Nature (London)* 225 (1970), pp. 41-42.
- [16] H. Sherk, The claustrum and the cerebral cortex, in E. Jones and A. Peters, eds., *Cerebral Cortex: Sensory Motor Areas and Aspects of Cortical Connectivity* (Plenum press, New York, 1986).
- [17] J. Rose and C. Wolsey, Organization of mammalian thalamus and its relationships to the cerebral cortex, *EEG and Clin. Neurophysiol.* 1 (1949), pp. 391-403.
- [18] T. Starzl and H.W. Magoun, Organization of the diffuse thalamic projection system *J. Neurophysiol.* 14 (1951), pp. 133-146.
- [19] C. Elliot, *Textbook of Neuroanatomy* (Lipincott Comp., Philadelphia-Montreal, 1963).
- [20] J. Green and A. Arduini, Hippocampal electrical activity in arousal, *J. Neurophysiol.* 23 (1954), pp. 403-420.
- [21] V. Desimirović, Psychophysiology - applied electrophysiology, In *Biological Basis of Psychiatry*, S. Jakulić, and V. Desimirović (Zavod za udžbenike, Beograd, 1990) Ch. 2, in Serbian
- [22] Z. Elazar and W. Adey, EEG correlates of learning in subcortical and cortical structures, *EEG and Clin. Neurophysiol.* 23 (1967), pp. 306-319.
- [23] J. Eccles and R. Vesterman, Enhanced synaptic function due to excess use, *Nature* 184 (1959), pp. 460-461.

- [24] V. Desimirović, Receptors and neurotransmitter systems of the brain In *Biological Basis of Psychiatry*, S. Jakulić and V. Desimirović (Zavod za udžbenike, Beograd, 1990) Ch. 3, in Serbian.
- [25] P. Goldman-Rakić, S. Funahashi and C. Bruce, Neocortical memory circuits, *The Brain* 55 (1990), pp. 1025-1038.
- [26] R. Zucker, Short term synaptic plasticity, *Ann Revue Neuroscience* 12 (1989), pp. 13-31.
- [27] J. McConnel, Biochemistry of memory, *Das Medizin. Prisma* 3 (1968), pp. 1-23, in Serbian.
- [28] K. Lashley, In search of engram, *Symposion of Soc. Exp. Biol.* 4 (1950), pp. 452-482.
- [29] C. Euler and J. Green, Excitation inhibition and rhythmical activity in hippocampal pyramidal cells in rabbit, *Acta Scand. Physiolog.* 48 (1960), pp. 110-125.
- [30] W. Penfield and H. Jasper, *Epilepsy and Functional Anatomy of the Human Brain* (Little Brown, Boston, 1954).
- [31] D. Gibling, Somatosensory evoked potentials in healthy subjects and in patients with lesions of the nervous system, *Annals N.York Acad. of Science* 8.5. (1964), pp. 93-141.
- [32] G. Pampiglione, Some observations on the variability of evoked potentials, *EEG and Clin. Neurophysiol. Suppl.* 26 (1967), pp. 97-99.
- [33] C. Pagni, Somatosensory evoked potentials in thalamus and cortex of man, *EEG and Clin. Neurophysiol. Suppl.* 26 (1967), pp. 147-155.
- [34] A. Bava, E. Fadiga and T. Manzoni, Lemniscal afferents and extracalosal mechanisms for interhemispheric transmission of somatosensory evoked potentials, *EEG and Clin. Neurophysiol. Suppl.* 26 (1967), pp. 182-187.
- [35] R. Cracco, R. Bickford and B. Rochester, Somatomotor and somatosensory evoked responses, *Arch. H. Neurol.* 18 (1968), pp. 52-68.
- [36] H. Perssons, Development of somatosensory cortical functions, *Acta Physiolog. Scand. Suppl.* (1973), p.394.
- [37] J. Desmedt and D. Robertson, Search for right hemisphere asymmetries in event-related potentials to somatosensory cueing signals, In *Language and Hemispheric Specialization in Man: Cerebral Event-Related Potentials*, J. Desmedt ed. (Karger -Basel, 1977), pp. 172-187.
- [38] J. Desmedt and D. Robertson, Differential enhancement of early and late components of the cerebral somatosensory evoked potentials during forced-paced cognitive tasks in man, *J. Physiol.* 271 (1977), pp. 761-782.
- [39] S. Sutton, N. Braren and J. Zubin, Evoked potential correlates of stimulus uncertainty, *Science* 150 (1965), pp. 1187-1188.
- [40] G. Walter, R. Aldridge, V. McCallum and A. Winter, Contingent negative variation an electrical sign of sensorimotor association and expectancy in the human brain, *Nature* 203 (1964), pp. 380-384.
- [41] G. Walter, Slow potential changes in the human brain associated with the expectancy, decision and intention, *EEG and Clin. Neurophysiol. Suppl.* 26 (1967), pp. 123-130.
- [42] D. Irwin, J. Knott, D. Mc Adam and C. Robert, Motivational determinants of the contingent negative variation, *EEG and Clin. Neurophysiol.* 21 (1966), pp. 538-543.
- [43] E. Grunewald-Zuberbier, G. Grunevald and R. Jung, Slow potentials of the human precentral and parietal cortex during goal-directed movements, *J. Physiol.* 284 (1978), pp. 181P-182.
- [44] L. Deecke, P. Scheid and H. H. Kornhuber, Distribution of readiness potential, premotion positivity and motor potential of the human cerebral proceeding voluntary finger movement, *Experim. Brain Research* 7 (1969), pp. 158-168.
- [45] L. Deecke, B. Grozinger and H. H. Kornhuber, Voluntary finger movements in man. cerebral potentials and theory, *Biol. Cybernetics* 23 (1976), pp. 99-119.

- [46] S. Shevitz, Psychosurgery: some current observations, *Am. J. Psychiatry* 133 (1976), pp. 266-270.
- [47] V. Desimirović, Emotional life and neurosis, in S. Jakulić, V. Desimirović: *Biological Basis of Psychiatry* (Zavod za udžbenike, Beograd, 1990), Ch. 12, in Serbian.
- [48] J. Masserman, Is the hypothalamus a center of emotion?, *J. Psychosom. Med.* 3 (1941), pp. 3-25.
- [49] A. Damasio and G van Hoesen, Emotional disturbances associated with focal lesions of the limbic frontal lobe, in K. Heilman and P. Satz, *Neurophysiology of Human Emotion* (Gilford press, New York, 1983).
- [50] F. Crick, A postscript on free will, in F. Crick, *The Astonishing Hypothesis* (Charles Scribners Sons, New York 1994).
- [51] I. Kupferman, Hypothalamus and limbic system, in *Principles of Neural Science* (Elsevier, Amsterdam, 1985), pp. 612-635.
- [52] J. Papez, A proposed mechanism of emotion, *Arch. Neurol. Psychiat.* 18 (1937), pp. 725-744.
- [53] W. Hess and K. Akert, Experimental data on the role of hypothalamus in mechanisms of emotional behavior, *Arch. of Neurol. and Psychiat.* 73 (1955), pp. 127-129.
- [54] J. Masserman, Is the hypothalamus a center of emotion ? *J. Psychosom. Medicine* 3 (1941), pp. 3-25.
- [55] P. Mac Lean, Psychosomatic disease and the "visceral brain", *J. Psychosom. Medicine* 11 (1949), pp. 338-353.
- [56] Z. Elazar and W. Adey, EEG correlates of learning in subcortical and cortical structures, *EEG and Clinic. Neurophysiol.* 23 (1967), pp. 306-319.
- [57] P. Parmeggiani, Of the functional significance of the hippocampal theta rhythm, *Progress in Brain Research* 27 (1967), pp. 413-431.
- [58] Y. Yamaguchi, N. Yoshii, K. Miyamoto and N. Itoigawa, A study of the invasive hippocampal theta waves to the cortex, *Progress in Brain Research* 27 (1967), pp. 281-292.
- [59] P. Gloor, Electrophysiological studies of amygdala (stimulation and recording): their possible contribution to the understanding of neural mechanisms of aggression, *Neural Basis of Aggression and Violence* (Warren Green, St Lous, 1975), pp. 5-15.
- [60] L. Schreiner and A. Kling, Behavioral changes following rhinencephalic injury in the cat, *Journ. Neurophysiol.* 16 (1953), pp. 643-659.
- [61] L. Schreniner and A. Kling, Rhinencephalon and behavior, *Am. J. Physiol.* 184 (1956), pp. 486-490.
- [62] J. Gray, *The Neurophysiology of Anxiety: An Inquiry into Function of the Septohippocampal System* (Oxford University Press, Oxford, 1982).
- [63] N. Tye, B. Everitt and S. Iversen, 5-Hydroxytryptamin and punishment, *Nature*, 268 (1977), pp. 741-741.
- [64] C. Shute and P. Lewis, The ascending cholinergic reticular system: neocortical, olfactory and subcortical projections, *Brain Res.* 90 (1967), pp. 497-520.
- [65] C. Shute and P. Lewis, Cholinergic pathways, *Pharmacol. Ther.* 1 (1975), pp. 79-87.
- [66] H. Fibiger and S. Vincent, Anatomy of the central cholinergic neurons, *Psychopharmacology* (1987), pp. 211-218.
- [67] P. Lewis and C. Shute, The cholinergic limbic system. projections to hippocampal formation, medial cortex, nuclei of ascending reticular cholinergic system and the subfornical organ and supraoptic crest, *Brain* 90 (1967), pp. 521-540.
- [68] M. Mesulam, E. Mufson, A. Levey and B. Wainer, Atlas of cholinergic neurons in the forebrain and the upper brainstem of the macaque based on monoclonal choline acetyltransferase immunohistochemistry, *Neurosci.* 12 (1984), pp. 669-686.

- [69] J. Olds and P. Milner, Positive reinforcement produced by electrical stimulation of septal area and other regions of rat brain, *J. Comparat. Physiol. Psychol* 47 (1954), pp. 419-427.
- [70] J. Olds, Pleasure centers in the brain, *Scient. Amer.* 195 (1956), pp. 105-117.
- [71] J. Olds, Selfstimulation of the brain, *Science* 127 (1958), pp. 315-324.
- [72] J. Olds, Hypothalamic substrates of reward, *Psychological Review* 42 (1962), pp. 554-604.
- [73] C. Wise and L. Stein, Facilitation of brain selfstimulation by central administration of norepinephrine, *Science* 163 (1969), pp. 299-301.
- [74] R. Heath, Electrical stimulation of the brain in man, *Am. J. Psychiatry*, 120 (1963), pp. 571-577.
- [75] R. Heath, Pleasure responses of human subjects to direct stimulation of the brain: physiological and psychodynamic considerations, in *The Role of Pleasure in Behavior* (Harper and Row, New York, 1964).
- [76] M. Baudry and G. Lynch, Properties and substrates of mammalian memory, in *Psychopharmacology* (Raven Press, New York, 1987), pp. 449-462.

THE DILEMMA FOR SCIENCE OF CONSCIOUS EXPERIENCE

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Abstrakt. It is clear that we are a long way from understanding consciousness. Our current science is of little help because it uses an epistemology, which has already excluded consciousness by definition. Even more serious, science has introduced a mode of thinking into our culture, which has led to the alienation of an individual from his sensory experience. We relate to sterile models of the universe which science calls “real” as opposed to the wonders of sensory experience which science calls subjective and so “unreal”. Clearly the way forward is through a new science, the science of the subjective. It is only then that we shall come to understand that consciousness is likely to be the very basis of the universe.

Key words: *objective vs. subjective, science vs. new science, consciousness.*

1 INTRODUCTION

When I look out of my window on a summer's morning I see in front of me a wonderful world. It is colorful, there are birds singing, I can feel the gentle summer breezes blowing across my face. The way the tree is leaning on the horizon has meaning for me in that I can tell its history, I know that it stands in the path of the winter gales, and that its form has been shaped by them. All the world has meaning.

If I was to stand by the same window on another day, with the same blue skies and warm sunshine, the same light gentle breezes, the same waving of the grasses, but I had a depressive illness, all would appear dull and gray, overshadowing me and pointing to destruction.

If I now go to my textbook of neurophysiology and look up the word ‘meaning’ it does not appear in the index. However detailed the textbook or scientific paper I read with regards to the mechanism of the brain and its structure, I see nothing about meaning. How is it that on the one hand I live in a world full of meaning but on the other I have a science which denies its presence?

2 OUR CURRENT DILEMMA

For many centuries there has seemed to be no place in the physical universe for consciousness. Newtonian mechanics in the 18th Century assumed a totally materialistic universe without consciousness, evolving according to a set of immutable physical laws. Descartes had a vision in which he saw the “extended thing of the world” and the universe fulfilling mathematical principles. The mathematician Laplace said that if he knew the position and momentum of every particle in the universe he could predict how the world would evolve. Descartes gave mind and consciousness no physical location and this has been one of the difficulties that science has had to tackle. For how can consciousness be weighed and measured if it does not exist in physical space?

Now, in the 20th Century, most scientists would claim that mind cannot exist as a separate entity. Certainly, so far as neuropsychiatry is concerned, there appears to be no place in the brain for consciousness or mind. Both psychology and psychiatry suffer from the lack of a satisfactory theoretical framework for the explanation and investigation of consciousness. If you cut a brain you cannot find a soul, for soul stuff and brain stuff are different. The unitary “I” of the middle ages and of our own experience become fractionated into a multifaceted psychological structure with numerous functions such as memory, language, facial recognition etc.

But the idea of a mechanical universe which excludes consciousness is unsatisfactory from an experiential point of view. The electrical probe of the neurophysiologist defines only the objective electrical mechanisms of cellular action, while the psychologist defines the objective aspects of subjective experience. There is as yet no clear understanding of how these two are linked. In order to understand why, it is important to understand how consciousness came to be excluded from our science.

3 DESCARTES AND GALILEO'S WORLD

Descartes, in the 17th Century, maintained that there were two radically different kinds of substance, the *res extensor* the extended substance, that which has length, breadth and depth and therefore can be measured and divided; and the thinking substance, the *res cogitans* which is unextended and indivisible. The external world of which the human body is a part belongs to the first category, while the internal world of the mind belongs to the second.

By suggesting that mind is indivisible and unextended with no spatial locale, Descartes shot himself and science in the foot. By definition, mind and consciousness became unavailable for scientific investigation. For how can you investigate that which is nowhere? I suspect that Descartes needed to take this view, so that he did not fall foul of the Church. But the consequences have been enormous. Mind, consciousness and soul have been beyond the realm of scientific investigation for the last 300 years, and it is only now that we are beginning to understand that they are unavailable for examination not because they truly cannot be examined, but simply by Descartes' definition.

Western science is based on the rationalism of Descartes, Galileo, Locke and Newton. Galileo defined a two-stuff universe, composed of matter and energy. These stuffs, he said, had primary and secondary qualities. The primary qualities were those aspects of nature that could be measured such as velocity, acceleration, weight, mass etc. There were also secondary qualities, the qualities of subjective experience, such as smell, vision, truth, beauty, love, etc. Galileo maintained that only primary qualities were the domain of science. Secondary qualities, the stuff of human experience, were non-scientific.

To excite in us tastes, odours and sounds, I believe that nothing is required in external bodies except shapes, numbers and slow or rapid movements. I think that if ears, tongues, and noses were removed, shapes and numbers and motions would remain, but not odours or tastes or sounds. The latter, I believe, are nothing more than names when separated from living beings, just as tickling and titillation are nothing but names in the absence of such things as noses and armpits.

(Galileo, The Assayer, 1623)

It is this view has conditioned science ever since, and which has led to the rejection by science of secondary qualities or subjective experience. Einstein's recognition that mass and energy are equivalent changed Galileo's two-stuff universe into a one-stuff universe, the

universe that we have today. The advent of quantum mechanics has done something to broaden this view. In quantum theory matter, rather than being seen as discrete particles, can also exist in wave packets, each one of which are distributed throughout the universe, but has the statistical probability of appearing in space-time where the particle is. There is thus a possibility that effects in this matter are not necessarily limited to one specific area, but may be non-local. Quantum mechanics also asserts that the presence of an observer in a quantum mechanical experiment interacts with the experiment and its outcome. Although this is a matter of debate among physicists at the present time, it would suggest that subjective experience may be a necessary part of the objective world.

4 PROBLEMS WITH IDOLS

Owen Barfield, in his groundbreaking book *Saving the Appearances* describes the difficulties that we run into when our explanations of events are such that they cannot be witnessed by the senses. He points out that any model of reality which seeks to describe phenomena available to the senses by principles and mechanisms which are hidden from the senses, does an injustice to the world of experience. For it is not long before the model comes to “stand for” the experience, and is taken as real. He points out that we then have an unknown, unexperiencable principle which we use to account for the phenomena of the experienced and knowable world. This process may be taken so far that finally the experience becomes secondary to the covert features of the explanations.

With this idea in mind, let us take an example. From the time of Lucretius, physical matter has been regarded as divisible into smaller and smaller units until we come to atoms. Atoms are said to underpin the structure of matter. The new quantum mechanical theories divide the atoms into quarks, and possibly into further sub-units. But the fundamental principle that the atoms are unavailable for sensory experience remains. It is now important to see what effect this has on the world in which we live. When I open my eyes and the sensory world appears in front of me, I know that it is composed of myriad’s of little particles - atoms - dashing about hither and yon. These particles which used to be likened to billiard balls bouncing here and there, with “hooks” or valences when they combined themselves into molecules, now have charge and valency shells. But they are still inanimate, sterile and meaningless. Thus, I have to conclude that the world I see in front of me is inanimate, sterile and meaningless, because the very nature of its components gives it this quality. This lack of meaning alters the way I feel and think about the world. Instead of approaching it with reverence, as part of creation, I approach it as something I can control and mould. I am not longer of it, but I work on it.

This brings about a subtle change in attitude that I bring to all scientific explanations of the way the universe is created. The model of the universe includes black holes, microwave radiation, and so on, none of which I can see, and none of which have any qualities except the sterile nature of the model. Because I believe that my model is reality, and note here the change from the perception of stars and their mathematical relationships, to models, which cannot be viewed or experienced, I have to conclude that the whole of the universe is sterile. It has no meaning, it has no purpose, it has no qualities apart from the qualities of the model which represents it.

It is not surprising that we have moved from the theocentric culture of the Greeks and Romans to a secular culture dominated by scientific thought and models, which has banished God entirely from the universe. Neither is it surprising that our models tell us that all is random chance and that there is no meaning and no purpose because these are the very facts that we

have used when creating these models. So when we come to look at consciousness, the only vehicle for consciousness that we can see is the brain, but as this is mainly composed of scientific models in which electrically charged particles move about in random fashion, the brain cannot be capable of any quality except that of the sterile universe of which it is part. Thus consciousness is excluded.

5 TAKING THE MODELS FURTHER

Our scientific view carries with it a reassuring and intellectually satisfying consequence. Consider the following thought experiment. When you shut your eyes, the room in which you are sitting ceases to exist for you. Open your eyes and it is again there. Ever since Bishop Berkeley philosophers have given up discussing what happens to the world when it is viewed by none. This phenomenon is no longer thought to be of interest. But it is of fundamental interest, because it shows how subtle our current scientific view is and how it moulds our attitudes to the world around us. When we open our eyes again and see the world we know it will be there because it is composed, in our model, of atoms and molecules that are independent of us and which, in the last resort, cannot be created or destroyed. We thus use our science to confirm the principle that we built into science, of an objective external world, independent of us.

Now imagine that when you shut your eyes, the world truly disappears. One will be left with acute existential anxiety, as there will be no reference point to return to, because the world will be dissolved and created by movement of the eyelids. This, science says, is ridiculous. But it is only ridiculous because we believe in a model which we can't see or feel or touch or know directly with the senses. What is more ridiculous, to say that there are little particles flying about, surrounding by vast voids of space and it is these that make objects? Or to say that the objects disappear when we close our eyes, and reappear when we open our eyes? The first is a story we tell ourselves, the second is an observation. The first is comforting, the second is threatening.

Now to return to Owen Barfield. He points out that the world comes into view not because there is an objective fixed world which impresses itself on the sense, but because of the concept that is in the mind. It is when this concept touches the world that the concept creates the world we see. This view, that the world we know is structured by the mind we have goes back to Kant who pointed out that we can only perceive those things for which we have the brain structures to perceive.

Goethe also argued for the concept being primary and the perception secondary. This is fundamental, as it means that there is no fixed objective world out there, composed of a myriad of small particles, but only a concept of it within the mind, which allows the perceived world to flower in accordance with that concept. This gives quite a different view of the world we live in, because we can see straight away that it is created by our own consciousness. We can also understand that when we see the world in this way, as a subjective world, dependent on us and containing qualities such as love, truth and beauty as part of its fundamental nature this is because these are parts of our own fundamental concepts.

6 PHILOSOPHIES OF CONSCIOUSNESS

There is as yet no explanation of consciousness that satisfies both those who have had the experience of consciousness and those who seek a scientific explanation for consciousness.

Two major philosophical schools currently attempt to explain this difficulty. Dennett's neurophilosophy is at one extreme. He argues that consciousness and subjective experience are neither more nor less than the functions of neural nets. Nothing is required to explain personal consciousness except a detailed knowledge of these neural nets. This is clearly a reductionist approach, equating subjective experience with neural mechanisms (Dennett 1991).

At the other extreme is the philosophy of Nagel (1974), who argues that it is never possible to learn from an objective third-person point of view what it is like to have a first-person experience. Subjective experience is not available to the scientific method, as it is not in the third person and cannot be validated in the public domain. Nagel argues that however much we understand about the neurophysiology of the functioning of a bat's brain, we cannot know what it is like to be a bat. This view suggests that the explanation of subjective experience require a new principle that is beyond neural nets.

Searle, 1992, takes an intermediate position. He regards subjective experience as a property of neural nets, but he does not agree with Dennett that a full understanding of neural net functioning is all we need to explain subjective experience. Searle's view is that we need a "Newton" of neurophysiology to produce an entirely new principle - a synthesis between first and third person experience.

Until there is a satisfactory philosophical explanation of the nature of consciousness it will not be possible to answer questions relating to the nature of subjective experience. Some fields, for example extra-sensory or religious experience, remain outside the realms of science. At present, every scientific theory must explain everything in terms of brain function. However, I expect there are many people who, like Schrödinger, 1967, feel uneasy when asked to accept that the broad sweep of the soul is contained only within the gray porridge of the brain. Will the neurophysiologist ever be able to probe the soul with his micro-electrode?

7 COSMIC CONSCIOUSNESS

The following experience comes from a book written by a 19th Century Canadian psychiatrist, R. Bucke, who was one of the first Western scientists to attempt to define mystical experience.

Now came a period of rapture so intense that the universe stood still as if amazed at the unutterable majesty of the spectacle: only one in all the infinite universe. The all-caring, perfect one, perfect wisdom, truth, love and purity: and with rapture came insight. In that same wonderful moment of what might be called supernal bliss came illumination...what joy when I saw that there was no break in the chain - not a link left out - everything in its place and time. Worlds, systems, all blended in one harmonious world, universal, synonymous with universal love.

Bucke called this type of experience cosmic consciousness, as the individual's subjective consciousness expanded to encompass a full understanding of the universe. These experiences are very common in the population - about 10% in some surveys have deep experiences like this at least once in a lifetime. A fundamental feature of these experiences is that the universe is always seen as perfect and complete. It is never seen as evolving or developing, but always as having been created in its full perfection.

Religious experience as a whole is very common in the population and there are many studies of mystical or religious experience. Gloch and Stark (1965) showed that over 45% of Protestants and 43% of Roman Catholics had had weak mystical experiences when they had had "a feeling that you are somehow in the presence of God". Gallup surveys in the United

States in 1963, 66 and 67, showed that 20.5%, 32% and 44% respectively had had religious or mystical experiences and the percentage increased as the decade advanced. However, by 1978 after the hippie revolution was over, the Princeton Religious Research Center found that in answer to a similar question that the positive response was down to 35%, possibly a reflection of a waning popular interest in the mystical. In Britain, David Hay organized an NOP survey in 1966 asking a similar question, and found a similar rate: about 36% gave positive responses. Of interest is the finding that although about a third of all people had had the experience, only 18% had had it more than twice, and only 8% “often and more”. There was no correlation with age, but positive replies were commonest with those whose education went beyond 20, e.g. the more articulate university graduates. There was also, interestingly, a sex difference: 42% of women gave positive replies against 31% of men.

These experiences raise the question of whether this kind of experience is part of a natural human capacity, or whether it is in some sense pathological. It is difficult to argue for a pathological basis since the experience is so common that it is in some sense normal.

The ecstatic mystical states in which the subject describes a feeling of universal love (as in the experience quoted by Bucke, above) occur much less often. These states can occur spontaneously but they, or fragments of them, may also occur in other circumstances, as in the near death experience, for example. Occasionally they can occur in temporal lobe epilepsy, and frequently in psychosis, when they are often associated with an elevation of mood. Psychedelic drugs can also induce similar experiences. It therefore seems probable that the ability to experience these wide mystical states is a normal part of brain function, and indeed there are techniques in many eastern religions directed at inducing these wide feelings of universal love at will.

8 CONCLUSION

It is clear that we are a long way from understanding consciousness. Our current science is of little help because it uses an epistemology, which has already excluded consciousness by definition. Even more serious, science has introduced a mode of thinking into our culture which has led to the alienation of an individual from his sensory experience. We relate to sterile models of the universe which science calls “real” as opposed to the wonders of sensory experience which science calls subjective and so “unreal”. Clearly the way forward is through a new science, the science of the subjective. It is only then that we shall come to understand that consciousness is likely to be the very basis of the universe.

REFERENCES

- [1] Back, K., and Bourque, L. B. (1970) Can feelings be enumerated? *Behavioural Science* 15: 487-96.
- [2] Barfield, O., *Saving the Appearances*.
- [3] Barfield, O., *The Rediscovery of Meaning*
- [4] Bucke, R. (1961), *Cosmic Consciousness; A study in the Evolution of the Human Mind*., Concord, MA: Ye Old Depot Press.
- [5] Bortoff, H. (1996), *The Wholeness of Nature*, Floris Books.
- [6] Dennett D. C. (1991), *Consciousness Explained*, London, Penguin.
- [7] Gloch, C. Y. and Stark, R. (1965), *Religion and Society in Tension*, Chicago: Rand McNally

- [8] Nagel, T. (1974), 'What is it like to be a bat?', *Philosophical Review* 83: 435-50
- [9] Searle, J. (1992), 'The problem of consciousness' in P Nagel (ed) *CIBA Foundation Symposium no 174 Experimental and Theoretical Studies of Consciousness*, chichester, John Wiley, pp. 61-80.

"WHAT DO MYSTICISM AND THE PARANORMAL HAVE TO TEACH US ABOUT CONSCIOUSNESS?"

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Abstract. Here presented several modalities of mystical experiences point clearly towards a distinction between awareness *per se* and the ordinary functional processes of sensation, perception and thought. They suggest that awareness is not *constructed* out of the material processes of perception or perhaps the brain, but rather they suggest a distinction and / or interaction between consciousness and the brain. Out of body experiences and near death out of body experiences suggest that consciousness can occasionally function at some distance from the brain or even without bodily activity. Furthermore, our experiences suggest that awareness may have a non-localized, quasi-spatial character, much like a field. Finally they tend to suggest that this field may be transcendental to any one person or entity, much like physics' energy fields transcends any one atom or quark.

Key words: *mystical & paranormal, pure consciousness events, out of body & near death experiences, oceanic feelings, unitive mystical states.*

1 INTRODUCTION

When I think of the field we share, Consciousness Studies, only one thing seems absolutely certain: at this point we are in deep darkness. We just do not know the answers. Anyone who claims to really understand how molecules and mute protoplasm can say or think meaningful sentences, is kidding themselves. We don't even know which field the answer will emerge from, neurology, psychology, quantum physics, microbiology, English literature or some yet-to-be-invented discipline. Nor do we know which feature of consciousness may serve as the rosetta stone, as the behavior or light as both particle and wave did for quantum physics. Thus any right-thinking person will remain utterly open to *all* of the data about consciousness. This must include the data from mystics and anyone else with unusually explicit experiences of consciousness.

It is exciting to me then to watch the recent developments in our field. For it has increasingly welcomed not only the data from the mystics but from other unusual phenomena, data that has hitherto been excluded based solely on the unquestioned presuppositions of the modern materialist-reductionistic worldview.

I believe it is important to include these experiences as data. After all, when a biologist seeks to understand a complex phenomena, one key strategy is to look to it in its simplest form. Probably the most famous is the humble bacteria *E. Coli*. Its simple gene structure has allowed us to understand much of the gene functioning of much more complex species. Similarly many biologists have turned to the "memory" of the simple Sea Slug to understand our own more multifaceted memory. To understand the complexities of the religious life, Freud and Durkheim both used totemism, which they construed as its simplest form. The

methodological principle then is this: to understand something complex, turn to its simplest form.

Mystical experiences may represent just such a simple form of human consciousness. Usually our minds are an enormously complex stew of thoughts, feelings, sensations, wants, snatches of song, pains, drives, daydreams and, of course, consciousness itself more or less aware of it all. To understand consciousness *in itself*, the obvious thing would be to clear away as much of this internal detritus and noise as possible. It turns out that mystics are doing precisely that. The technique that most mystics use is some form of meditation or contemplation. These are procedures that, often by recycling a mental subroutine[1], systematically reduce mental activity. During meditation, one begins to slow down the thinking process, and have fewer or less intense thoughts. One's thoughts become as if more distant, vague, or less preoccupying; one stops paying as much attention to bodily sensations; one has fewer or less intense fantasies and daydreams. Thus by reducing the intensity or compelling quality of outward perception and inward thoughts, one may come to a time of greater stillness.

Ultimately one may become utterly silent inside: a gap between thoughts occurs, where one becomes utterly perception and thought free. One neither thinks nor perceives any mental or sensory content. Yet, despite this suspension of content, one emerges from such events confident that one had remained awake inside, fully conscious. This experience, which has been called the pure consciousness event, or PCE [2], thus may be defined as a wakeful but contentless (non-intentional) consciousness. It has been identified in virtually every major tradition. Though PCEs typically happen to any single individual only occasionally, they are quite regular for some practitioners [3].

PCEs, encounters with consciousness devoid of intentional content, may be just the least complex encounter with awareness *per se* that we students of consciousness seek. The PCE may serve, in short, as the E Coli of consciousness studies [4].

But the story does not stop here. Regular and long term meditation and other practices such as contemplative prayer, according to many traditions, leads to advanced experiences, known in general as "enlightenment." Their defining feature is a shift in deep epistemological structure: a change in the experienced relationship between the self and perceptual objects. In many people this new structure becomes permanent [5].

These long term shifts in epistemological structure often take the form of two quantum-leaps in experience which typically develop sequentially [6]. The first is an experience of a permanent interior stillness, which is maintained even while engaged in thought and activity. One remains aware of one's own awareness while simultaneously remaining conscious of thoughts, sensations and actions. Because of its phenomenological dualism — a heightened cognizance of awareness itself plus a consciousness of thoughts and objects — I call it the "dualistic mystical state" (DMS). The second shift is described as a perceived unity between one's own awareness *per se* with the objects around one, an immediate sense of a quasi-physical unity between self, objects and other people. Something like this state has been called "extrovertive" or sometimes "nature" mysticism; but I prefer to call it the unitive mystical state, UMS [7].

Like the PCE, these latter two may serve as fertile fields for students of consciousness. To understand them, I want to introduce the idea of the *relative intensity* of a thought or desire. Some desires have a high relative intensity. Let's say I am walking across the street when I see a huge truck hurtling at me. Virtually 100% of my attention is taken up with the truck, the fear, and getting out of the way. It is virtually impossible for me to think about anything else at that time. I don't even consider keeping my suit clean, how my hair might look, the discomfort in

my tummy, or the classes I will teach later. The fear and running are *utterly* intense, we might say, consuming nearly 100% of my attention. This fear has a very high relative intensity.

That evening, I come home starved, and rush to the fridge. I may be civil to my kids and wife, but I have very little patience. My desire for food is very intense, for it preoccupies most of my consciousness. Yet it consumes less of my attention than did jumping away from the truck. My hunger has a lower relative intensity than did my fear.

Driving to work the next day, I find myself ruminating about my classes, remembering the near miss with the truck, half-listen to the news on the radio, and think about getting that clunking in the car fixed - nearly all at once. None of these thoughts or desires is very intense, for none have a strong emotional load that draws me fully into them. Because these have a low relative intensity, my attention can flow in and out of any of them, or the traffic ahead, effortlessly.

In short the intensity of a thought or desire increases with the amount of my consciousness that is taken up with that thought or feeling. Conversely, when I am able to retain more attention for other issues the thought is said to have a low relative intensity. The higher the relative intensity, the narrower the focus. The lower the relative intensity, the wider the focus or perhaps the perspective.

As I understand them, advanced mystical experiences result from the combination of regular PCEs plus a minimization of the relative intensity of emotions and thoughts. That is, over time one the compulsive or intense cathexis character of *all* of one's desires decreases. The de-intensifying of emotional investments in one's thoughts or desires means that, over the years, one's attention is progressively freer to sense its own quiet interior character more and more fully, until eventually one is able to maintain a subtle cognizance of one's own awareness constantly, i.e. simultaneously with thinking about and responding to the world. This signifies a reduction in the relative intensity of *all* of one's thoughts and desires.

This state of being cognizant of one's own inner awareness while simultaneously maintaining the ability to think and talk about that consciousness offers students of consciousness a unique situation. For these subjects may be able to be both unusually cognizant of features or patterns of their own awareness and also describe them to us: a kind of ongoing microscope onto unusually accessible human consciousness. In short, while not as phenomenologically simple as PCEs, these experiences may provide us with highly useful reports about the character of human awareness.

Several additional preliminary matters: First, perforce we will be drawing conclusions based on the experiences of a very few people. Most of us haven't had experiences like the ones I will describe, and some may sound pretty strange. Yet we often do generalize from the unusual to the general. Just think how much we have concluded about consciousness from a very few epileptics, people with unusual brain injuries, a few individuals with blindsight, a single man who mistook his wife for a hat; etc. From the *pathology* of a very few we have learned a great deal about the relationship of one side of the brain to the other, of two kinds of knowing, of information storage and retrieval, of impulse control, etc. Indeed it is common practice to take data about a few unusual individuals and generalize it to the many. Here again we are studying a few. But rather than the pathological, we will be studying people who may be not "pathological" but unusually self-actualized. Shall we not be as willing to learn from the experiences of the unusually healthy as we are to learn from the unusually diseased?

The second matter is definitional: What do we mean by mysticism? What is generally known as mysticism is often said to have two strands, which are traditionally distinguished as *apophatic* and *kataphatic* mysticism, oriented towards emptying or the imagistically filling. These two are generally described in terms that are *without* or *with* sensory language. The

psychologist Roland Fischer has distinguished a similar pairing as *trophotropic* and *ergotropic*, experiences that phenomenologically involve inactivity or activity. *Kataphatic* or imagistic mysticism involves hallucinations, visions, auditions or even a sensory-like smell or taste; it thus involves activity and is *ergotropic*. *Apophatic* mystical experiences are devoid of such sensory-like content, and are thus *trophotropic*. When they use non-sensory, non imagistic language [8], authors like Eckhart, Dogen, al-Hallaj, Bernadette Roberts, and Shankara are all thus *apophatic* mystics. Because visions and other ergotropic experiences are not the simple experiences of consciousness that we require, I will focus my attentions exclusively on the quieter *apophatic* forms.

Finally, I want to emphasize that phenomenology is not science. When we describe these experiences, we do not gain hard scientific proof thereby. There can be many ways to explain an unusual experience: one might say it was the result of the lima beans one ate for dinner, a faulty memory, some psycho-somatic processes, a quantum micro-tubule collapse, or an encounter with Ultimate Truth. Without further argumentation, phenomenology can not serve as the sole basis for any theory of reality. Rather it may be taken only as a finger, *pointing* in some direction, or as *evidence* for or against a particular thesis. This is how I see my role in this paper. I will simply describe mystical experiences as accurately as I can, and say where I see their fingers pointing. That is, I will attempt to coax hypotheses about consciousness out of these phenomenological descriptions.

Indeed first person reports, especially those that are about unusual experiences are, of course, notoriously unreliable. When an epileptic says that “the table seemed wavy,” or when a man asserts that his wife is a “hat,” these reports are not taken as data about the world, but about their subject’s condition [9]. One may want to assert that a mystic’s report should be regarded similarly.

But we must be careful here, for first person reports can also be veridical or even sources of wisdom. For example, in the kingdom of the blind, the “first person” report of a sighted fellow that “the mountain peak near the village is in the shape of 5 fingers” may be regarded as the rantings of a lunatic or as information about the mountains. Similarly, when Woodward and Bernstein spoke with “Deep Throat,” they could have taken his utterances as paranoid ramblings, data about his developing psychosis, or as information about the Nixon administration.

How can we determine which way to regard the unusual first person reports of the mystics? If we were Woodward and Bernstein, how would we decide? Common sense seems a good place to begin. We might ask, does Deep Throat, or the mystics in our case, *seem* unconnected or delusional? I believe most of us would say no. In fact many regard people like Meister Eckhart, Teresa of Avila, the authors of the Upanishads, and others who tell us of such experiences as unusually wise. Certainly they do not seem utterly unhinged, physically ill, etc. Secondly, we might ask, do others in a situation similar to Deep Throat’s describe things similarly? In our case, assuming the reasonable effects of cultural differences in language and detail, do mystics from around the world describe things largely similarly? Here again the answer is yes. There is a reasonable amount of similarity among their descriptions as we will see, a family resemblance, if you will. They tend to confirm each others reports. Finally is there other confirming evidence for our Deep Throats’ claims? Here the information is not in: just how consciousness works, relates to the world or the brain, is anything but established.

In sum, it makes sense to regard the mystics’ unusual reports about the world more as like those of a Deep Throat than like those of an epileptic. But, also like Deep Throat, the information we can glean from them is not, by itself, reliable enough to base a theory of

consciousness on. It will take the hard working Woodward and Bernsteins in the scientific and philosophical trenches to verify or deny the suggestions of our Deep Throats.

2 THREE MYSTICAL PHENOMENA AND THEIR IMPLICATIONS

Pure Consciousness Events

Let me begin by offering several reports of the first of the mystical phenomena I mentioned above, the Pure Consciousness Event (PCE). First, in the *Interior Castle*, a classic of the Christian mystical literature [10], St. Teresa of Avila writes of what she calls the “orison of union.”

During the short time the union lasts, she is deprived of every feeling, and even if she would, she could not think of any single thing... She is utterly dead to the things of the world... I do not even know whether in this state she has enough life left to breathe. It seems to me she has not; or at least that if she does breathe, she is unaware of it... The natural action of all her faculties [are suspended]. She neither sees, ears, nor understands... [11]

Several key features of this experience jump out. First, Teresa tells us that one reaches this “orison of unity” by gradually reducing thought and understanding, eventually becoming “utterly dead” to things of the world, encountering neither sensation, thought nor perceptions. One becomes as simple as possible, eventually ceasing to think altogether one is unable to “think of any single thing ... arresting the use of her understanding ... utterly dead to the things of the world.” [12]. And yet, she clearly implies, one remains awake.

Meister Eckhart, another famed Christian mystic, describes something similar as *gezucken*, rapture. He describes St. Paul, his archetype of *gezucken*:

"... the more completely you are able to draw in your powers to a unity and forget all those things and their images which you have absorbed, and the further you can get from creatures and their images, the nearer you are to this and the readier to receive it. If only you could suddenly be unaware of all things, then you could pass into an oblivion of your own body as St Paul did, ... In this case ... memory no longer functioned, nor understanding, nor the senses, nor the powers that should function so as to govern and grace the body ... In this way a man should flee his senses, turn his powers inward and sink into an oblivion of all things and himself [13]."

Like St. Teresa, Eckhart specifically asserts the absence of sensory content ("nor the senses"), as well as mental objects ("devoid of" memory, understanding, senses, etc.). One becomes oblivious of one's "own body" and "all things". In short one becomes "unaware of all things," i.e. devoid of all mental and sensory content.

The absence of thought and sensation is described in the classical Hindu *Upanishads*. They call it *turiya*, the "fourth," i.e. a fourth state of consciousness after waking, sleeping and dreaming:

"Verily when a knower has restrained his mind from the external, and the breathing spirit (prana) has put to rest objects of sense, thereupon let him continue void of conceptions. Since the living individual (jiva) who is named "breathing spirit" has arisen here from what is not breathing spirit, therefore, verily, let the breathing spirit restrain his breathing spirit in what is called the fourth condition (*turiya*)" [14].

Here again one has “put to rest objects of sense,” i.e. gradually laid aside all sensations, and continued “void of conceptions,” i.e. stopped thinking. And yet the *Upanishads* are insistent

that one remains conscious, indeed becomes nothing but consciousness itself. The consciousness that one reaches in *turiya* comes to be known later in Samkhya philosophy as "*purusha*," often translated as awareness or consciousness itself, that which "illuminates" or "witnesses" thoughts, feelings, and actions [15]. The *purusha* or awareness that one reaches during this experience is described as "sheer contentless presence (*saksitva*) . . . that is nonintentional." [16]

Here is a report from the present author's own 28 year practice of the neo-Advaitan (Hindu derived) Transcendental Meditation, which more clearly asserts the persistence of consciousness throughout such events.

"Sometimes during meditation my thoughts drift away entirely, and I gain a state I would describe as simply being awake. I'm not thinking about anything. I'm not particularly aware of any sensations, I'm not aware of being absorbed in anything in particular, and yet I am quite certain (after the fact) that I haven't been asleep. During it I am simply awake or simply present.

It is odd to describe such an event as being awake or being present, for those terms generally connote an awareness of something or other. But in this experience there is no particular or identifiable object of which I am aware. Yet I am driven to say I am awake for two reasons. First, I emerge with a quiet, intuited certainty that I was continually present, that there was an unbroken continuity of experience or of consciousness throughout the meditation period, even if there seemed to have been periods from which I had no particular memories. I just know that there was some sort of continuity of myself (however we can define that) throughout" [17].

In Buddhism Pure Consciousness Events are called by several names: *nirodhasamapatti*, or cessation meditation; *samjnavedayitanirodha*, the cessation of sensation and conceptualization; *sunyata*, emptiness; or most famously, *samadhi*, meditation without content [18]. What is most fascinating about traditional Buddhist explorations of this state is that despite the fact that one is said to be utterly devoid of content, according to Yogacara Buddhist theorists, one's consciousness is said to *persist* as "some form of contentless and attributeless consciousness." [19] That is, despite the fact that one is not aware of any specific content or thought, "something persists" in this contentlessness, says Yogacara Buddhism, i.e. consciousness itself: "I, though abiding in emptiness, am now abiding in the fullness thereof." [20] When discussing this possibility that one may abide in the "fullness" of "emptiness" Vasubandhu states:

"It is perceived as it really is that, when anything does not exist in something, the latter is empty with regard to the former; and further it is understood as it really is that, when, in this place *something remains*, it exists here as a real existent" [21].

That is, even though one is empty of content in the experience of *sunyata*, one's consciousness remains in itself, a real existent thing, yet contentless.

In sum, the PCE may be defined as a wakeful but contentless (non-intentional) experience. Though one remains awake and alert, emerging with the clear sense of having had "an unbroken continuity of experience," one neither thinks, perceives nor acts. W.T. Stace:

"Suppose then that we obliterate from consciousness all objects physical or mental. When the self is not engaged in apprehending objects it becomes aware of itself. The self itself emerges. The self, however, when stripped of all psychological contents or objects, is not another thing, or substance, distinct from its contents. It is the bare unity of the manifold of consciousness from which the manifold itself has been obliterated" [22].

Now what implications can we draw from the pure consciousness event about the nature of human consciousness?

- (1) We have a pattern here that is seen across cultures and eras. This, in combination with the reports offered in *The Problem of Pure Consciousness*, suggests that the phenomena is not an artifact of any one culture but is something closer to an experience that is reasonably common and available in a variety of cultural contexts [23].
- (2) Not much can be asserted of consciousness merely from these reports. But we can assert one thing unequivocally. Thomas Clark and other recent theoreticians of consciousness have claimed that consciousness is *identical to* certain of our information bearing, behavior controlling functions, even going so far as to define it thus [24]. Others have suggested that consciousness is an artifact or an epiphenomenon of perception, action and thought, and that it arises *only* as a concomitant of these phenomena. Bruce Buchanan suggests, for example, that “consciousness is inherently evaluative and that’s what it does. According to this view, unintentional consciousness would not be possible.” [25] Our accounts absolutely disprove this claim, which seems to be more an *a priori* view than based on any evidence. Rather these reports unequivocally show that consciousness *does* persist even when one has *no* perception, thought or evaluation. It is therefore not merely an epiphenomenon of perception, an evaluative mechanism, or an arbiter of perceptual functions.
- (3) Some have suggested that if we can understand how we can tie together perceptions and thoughts - the so called binding problem - we will *ipso facto* understand consciousness. [26] Now, how we bind together perceptions *is* a very interesting question for cognitive psychology, neurobiology and philosophy of mind. But even if we understand how we do tie together perceptions, we will not thereby *necessarily* understand the phenomenon of consciousness *per se*, for according to these mystical accounts, it is not a mere binding function [27]. These reports suggest that binding is something done *by* or *for* consciousness, not something that creates consciousness [28].
- (4) Our evidence suggests that we should conceptually and linguistically differentiate *merely* being aware or awake from its functional activities. If so, I propose distinguishing between “awareness itself” or “awareness per se” and “consciousness.” Let us reserve the term “consciousness” for that feature of experience which is cognizant when we are *intentionally* aware of something and reserve “awareness” for that facet of consciousness which is aware within itself and which may persist even without intentional content. This distinction is in accord with Arthur Deikman’s separation of awareness from the other senses of “I”, and with Chalmers’s distinction [29]. It is also in accord with Hinduism’s distinction between consciousness in its active role (*vijnana*) and in its role as only a witness to all that goes on (*Purusha* or *Atman*). (One caveat: because they have entered the scholarly phrase book, I will continue to use the phrases “pure consciousness” and ‘pure consciousness event.’)
- (5) Reports of pure consciousness suggest that, despite the absence of mental content, these people were somehow aware *that* they remained aware throughout the period of the PCE . Apparently they sensed a continuity of awareness through past and present. If they did, even though there was no content, then they must have somehow *directly* recalled that

they had been aware despite the absence of remembered content [30]. This implies human awareness *has* the ability to tie itself together and to know intuitively that it has persisted [31].

We may want to say that being conscious seems to entail this sort of direct self-recollection, a presence to oneself that is distinct from the kind of presence we have to perceptions and other intentional content. In this sense, the pure consciousness event tends to confirm Bernard Lonergan's distinction between our conscious presence to intentional objects and what he calls our "presence of the subject to himself."

"There is the presence of the object to the subject, of the spectacle to the spectator; there is also the presence of the subject to himself, and this is not the presence of another object dividing his attention, of another spectacle distracting the spectator; it is presence in, as it were, another dimension, presence concomitant and correlative and opposite to the presence of the object. Objects are present by being attended to but subjects are present as subjects, not by being attended to, but by attending. As the parade of objects marches by, spectators do not have to slip into the parade to be present to themselves; they have to be present to themselves for anything to be present to them" [32].

In sum, the PCE militates towards a distinction between consciousness or awareness *per se* and its usual binding, relational and culturally trained processes. It suggests that consciousness is more than its embodied activities.

Out of Body and Near Death Experiences

As I was preparing for this paper, I took a survey in one of my Hunter College classes, "how many have had mystical experiences?" Out of a class of 34, much to my surprise a whopping 27 answered positively, and 8 answered "perhaps but they weren't sure." That's between 61.7% and 85.2% who have! [33] Of these, most were of the visitation type (i.e. grandpa came to see me and the next day I heard he had died) or of the near death (NDE) or out of body (OBE) type. In these last two the subjects, either at a time their heart and brain had stopped in temporary death or at some other time, experience themselves as having left their physical bodies and to have had experiences, perceptions from some other locale, and memories of the events. One of my students, Carina Garcia, an apparently well-adjusted and intelligent 27 year old woman, said that she had had frequent out of body experiences between the ages of 16 and 21, often one per day. She writes, they

"generally occur when I am alone and relaxing. They have occurred in several different settings such as when I have been listening to music, watching a boring television show, when I have lain awake in bed, and even when I was taking a hot bath. The only criteria seems to be that I am alone and that my muscles are extremely relaxed. After accumulating experience with these states and the relaxation that precedes them, I have learned to induce the proper state of relaxation so that I could induce one of them" [34].

These do not seem to be the result of prior knowledge, or some psychosomatic enhancement of expectations. Her first out of body experience occurred when she was 6, before she could read and before she had ever heard of out of body experiences.

"I was about six years old, and it was a beautiful spring day, warm and breezy. I was outside and climbed up into my tree house ... [sitting with my back against the wall [35] and staring out the window] almost instantaneously, I felt a vibration in the center of my body, beginning at the base of my spine, working upward, and spreading out through my limbs. All sound stopped. I could only feel this vibration that was going on inside me.

Suddenly, I felt a floating sensation. I looked around me, and I saw only a shadow of the world I was just enjoying. It was as if everything I knew had suddenly taken on a ghostly quality. The vibration I was experiencing diminished, and the sound of the birds returned as only a hollow echo of [the bird songs] I had just been hearing... I felt as flimsy and formless as the wind, and yet, I was aware of where my being was in space. I was not afraid. It was liberating. Then I spotted my body sitting below me. I looked just like I was sleeping, but I knew that I was not asleep. Suddenly, I was swept back toward my body and felt a snapping sensation. I looked around me, and the air was once again filled with the smell of apple blossoms, the birds were singing ... and everything looked solid once again. The world seemed as if it had never changed, but I knew that for those few minutes, something had changed. All this happened in what I believe was about five to ten minutes.

That was the first time I had what I will call an out of body experience. It was as if what and who I knew myself to be had taken on a very different form. For those few moments, I felt as if I were bodiless. Since that time, I have had numerous out of body experiences. I was not quite sure what was going on, or why I was having these experiences. I tried desperately to make sense of what was happening to me. I even went so far as to have myself tested for chemical imbalances... Everything turned out to be normal" [36].

The most important feature of this experience for our purposes is that something of her consciousness seemed to have traveled some distance away from her body. In her case, she seemed perhaps a few feet above her body. Yet she continued to have perceptions during these experiences. Though everything is as if seen through a fog, they were quite detailed, she said.

Carina herself was not able to supply me with enough details that confirmed for me that she had in fact had perceptions from outside her body. But others who have had similar out of body experiences have been able to offer such confirmatory details. Perhaps the best known such case is that reported by Kimberly Clark, a professor at the School of Medicine at the University of Washington. Prior to the case she reports, she had had no encounter with such experiences. This case involved a migrant worker named Maria, who had a cardiac arrest in the Harborview Medical Center in Seattle. Maria reported that, while the doctors and nurses were working on her, she found herself looking down on them from the ceiling. Though she described to Clark what they were wearing and doing, Clark was unimpressed, figuring that Maria had had plenty of time in the hospital to observe their clothes and activities. But then Maria reported that something attracted her outside the hospital building, and she eventually found herself outside the building, and "eyeball to shoelace" with a tennis shoe. She described a worn place in the little-toe area of the shoe and said that the lace was stuck under the heel. Maria asked Clark to verify her tale, and "with mixed emotions" Clark consented. Looking up from outside, she wrote, she could see no such object. Clark continues:

"I went up to the third floor and began going in and out of patients' rooms and looking out their windows, which were so narrow that I had to press my face to the screen just to see the ledge at all. Finally, I found a room where I pressed my face to the glass and looked down and saw the tennis shoe. [Clark could not however see the worn place, the lace, or other details from that perspective. These details she could only confirm when she was eventually able to retrieve the shoe. Clark concludes]. . . . The only way [Maria] would have had such a perspective was if she had been floating right outside and at very close range to the tennis shoe" [37].

A similar veridical perception, again of a misplaced shoe, comes from Kathy Milne, another hospital nurse, who told of a 1985 resuscitation experience:

"[The patient] told me how she floated up over her body, viewed the resuscitation effort for a short time and then felt herself being pulled up through several floors of the hospital. She then found herself above the roof and realized she was looking at the skyline of Hartford ... [O]ut of the corner of her eye she saw a red object. It turned out to be a shoe... I was related this to a (skeptical) resident who in a mocking manner left. Apparently, he got a janitor to get him onto the roof. When I saw him later that day, he had a red shoe ..." [38]

Other similar reports tend to confirm experiences like Carina's and Maria's [39].

In conclusion, we have several reasonable reports here of veridical and confirmed experiences in which people claim to be having experiences some distance from their bodies. They continue to think, have a will (the wish to see an object) and some sort of propulsion. They seem to experience some kind of perception, about which we have absolutely no knowledge. Most important for our purposes, the fact that one can remember that perception from some a distance and integrate it with a sense of the self suggests the persistence of consciousness some distance from the body. In the case of NDEs this consciousness seems to persist before resuscitation, even after bodily activity has ceased.

I consider these reports at least as strong as reports of people who have undergone split brain surgery, who have blindsight, or of people who regard their wife as a hat. But we all know how controversial this material is. And I do not wish to enter into that controversy today. Instead I want to merely ask, *if* these experiences turn out to be true, which is to say generally accepted by the scholarly and scientific community, what would be their implications for the study of consciousness?

- (1) We suggested above that the process of consciousness is distinguishable from the binding together of perception and thought. The evidence here suggests that *consciousness* persists during the out of body experiences. We can say this because *whatever* leaves the body retains the ability to tie together and hold perceptions, thoughts and self perceptions together, and to remember the events.
- (2) When it separates from the body, the experience of the "self" is described as not point-like. Rather the sense of the self is encountered as something more like a dispersed field than a point or particle. This suggests that there may be some sort of interaction between some field-like aspect of the self and the body [40]. It is hard not to think of the parallel between a magnetic field (something field like) that moves something more particle-like (electrons down a wire that move a rotor). Might there be something of human consciousness that is both particle-like and wave-like?
- (3) The most striking ramification of these reports is that the various forms of materialism, the claims that consciousness is an epiphenomenon of the brain, are again very hard pressed to explain the data. The simplest explanation is to either ignore such reports or challenge them on an *ad hoc* basis. But just as a single white crow implies a great deal about the nature of crows, if even a *single* story like Carina's stand up to scrutiny, we are left with the thought that consciousness is not an epiphenomenon of the brain or brain activity, contra John Searle's claims that consciousness is a brain process. If we do want to claim that OBEs like Carina's or Maria's are a product of brain activity, then the brain must be somehow *projecting* an experience of the self some distance away from itself, and doing so with veridical possibilities. In the case of NDEs, patients with no bodily activity are having complex and detailed experiences. Again the suggestion is that consciousness is *not* an

epiphenomenon or even necessarily *correlated with* brain activity. This suggests that brain activity may be required to move the material body, but not a necessary cause of awareness in itself. If this is so, this tends to militate for a dualistic approach to consciousness such as Popper and Eccles's "interactionism" or John Beloff's "radical dualism." [41] It also supports David Ray Griffin's pan-experientialist interactionism [42].

- (4) These experiences imply that consciousness itself has mobility. Something of consciousness demonstrates the ability to separate itself from the body, and as incredible as this sounds, to move outside the body with no obvious means of propulsion. Several reports suggest that the consciousness moves by being attracted to this or that (a shoe, a color), but moves effortlessly. The sense of liberation Carina describes may be associated with this unusual mobility, for the ability to move without muscular flexion might very well be experienced as liberating.
- (5) Carina remembered looking down on her body; Maria remembered the shoe and its placement. This implies the ability to remember throughout these experiences, and the persistence of something akin to memory throughout these experiences. This suggests that memory is not stored in something akin to a computer's memory banks, or at least not *exclusively*, but rather that consciousness itself "holds" memories in some sense. The role of memory "banks" in the brain then begins to look more like some kind of *reinforcement mechanism* than the sole source of memory.
- (6) Reports like these challenge so many of our views about the world and human possibilities that it boggles the mind. To name a few, it means some sort of perception without the senses, propulsion without muscles, thinking without synapses, self-perception without a body, and an entirely disembodied sense of a unified self, all in ways entirely unlike what we generally believe. It also opens the door to ghosts, specters, channeling spirits, and many other beings that many of us would prefer did not exist. It is hard to know how to close this Pandora's box if once we open it. But it is our job as thinkers to follow the evidence wherever it leads, and truth is not true because it is convenient. If this evidence turns out to be veridical, then down these shadowy alleys we may very well have to wander.

The Dualistic Mystical State, The Peculiar "Oceanic Feeling"

Our third phenomenon, which is our first potentially permanent experience, bears a dualistic pattern. Let us look at a few reports. The first comes from the autobiography of a living American mystic, Bernadette Roberts, middle aged ex-nun, mother, housewife, and author of *The Experience of No-Self*. Roberts had been in the practice of meditating in a nearby monastery, she tells us, and had often had experiences of complete silence as we described above. Previously such experiences had sparked fear in her, perhaps a fear of never returning. But on this particular afternoon, as her meditation was ending,

"once again there was a pervasive silence and once again I waited for the onset of fear to break it up. But this time the fear never came... Within, all was still, silent and motionless. In the stillness, I was not aware of the moment when the fear and tension of waiting had left. Still I continued to wait for a movement not of myself and when no movement came, I simply remained in a great stillness" [43].

She became silent inside but, to her surprise, did not emerge from that silence. She stood up and walked out of her chapel, "like a feather floats in the wind," while her silence continued unabated. No temporary meditative experience, this was a permanent development of that quiet empty interior silence [44]. "... Once outside, I fully expected to return to my ordinary energies and thinking mind, but this day I had a difficult time because I was continually falling back into the great silence." [45] She "remained in a great stillness," driving down the road, talking on the phone, and cutting the carrots for dinner. In fact that inner stillness was never again to leave her.

She experienced her interior silence as her original "consciousness," by which I understand that she experienced it as devoid of the intellectual self-reflection that generally accompanies experiences. She describes this new state as a continuation of what she had encountered when she was in her meditative silence (PCE); only here she remained fully cognizant of her own silent awareness even while active.

Here is my own (previously published) autobiographical report of such a state. It also associates a permanent interior silence with consciousness:

"This began in 1972. I had been practicing meditation for about 3 years, and had been on a meditation retreat for 3 1/2 months. Over several days something like a series of tubes (neuronal bundles?) running down the back of my neck became, one by one, utterly quiet. This transformation started on the left side and moved to the right. As each one became silent, all the noise and activity inside these little tubes just ceased. There was a kind of a click or a sort of "zipping" sensation, as the nerve cells or whatever it was became quiet [46]. It was as if there had always been these very faint and unnoticed activity, a background of static, so constant that I had never before noticed it. When each of these tubes became silent, all that noise just ceased entirely. I only recognized the interior noise or activity in these tubes in comparison to the silence that now descended. One by one these tubes became quiet, from left to right. It took a couple of weeks and finally the last one on the right went *zip*, and that was it. It was over.

After the last tube had shifted to this new state, I discovered that a major though subtle shift had occurred. From that moment forward, *I was silent inside*. I don't mean I didn't think, but rather that the feeling inside of me was as if I was entirely empty, a perfect vacuum [47]. Since that time all of my thinking, my sensations, my emotions, etc., have seemed not quite connected to me inside. It was and is as if what was *me*, my consciousness itself, was (and is) now this emptiness. The *silence* was now me, and the thoughts that have gone on inside have not felt quite in contact with what is really "me," this empty awareness. "I" was now silent inside. My thinking has been as if on the outside of this silence without quite contacting it: When I saw, felt or heard something, that perception or thought has been seen by this silent consciousness, but it has not been quite connected to this interior silence" [48].

Here the silence is explicitly associated with awareness. It is experienced as "the I", "what was really 'me' "my consciousness itself." Somehow this area in the back of the head seems to be associated with being aware. As it became silent, a sense of the self or consciousness itself within became more articulated, and was now experienced as silent. Like Roberts's, this shift to an interior silence was permanent [49]. Thus we call it a state, the dualistic mystical *state* or DMS.

Descriptions of a DMS are surprisingly common in the mystical literature. Teresa of Avila writes of such a state. Speaking of herself in the third person, she writes:

However numerous were her trials and business worries, the essential part of her soul seemed never to move from [its] dwelling place. So in a sense she felt that her soul was divided... Sometimes she would say that it was doing nothing but enjoy[ing] itself in that quietness, while she herself was left with all her trials and occupations so that she could not keep it company [50].

She too describes an experience in which, even while working and living, one also maintains a clear sense of the interior awareness, a persisting sense of an unmoving silence at one's core.

Meister Eckhart describes something similar, calling it the Birth of the Word In the Soul. One of Eckhart's clearest descriptions is from the treatise "On Detachment." It analogizes the two aspects of man with a door and its hinge pin. Like the outward boards of a door, the outward man moves, changes, and acts. The inward man, like the hinge pin, does not move. He - or it - remains uninvolved with activity and does not change at all. This Eckhart concludes is the way one should really conduct a life: one should act yet remain inwardly uninvolved. Here is the passage:

"And however much our Lady lamented and whatever other things she said, she was *always in her inmost heart in immovable detachment*. Let us take an analogy of this. A door opens and shuts on a hinge. Now if I compare the outer boards of the door with the outward man, I can compare the hinge with the inward man. When the door opens or closes the outer boards move to and fro, but the hinge *remains immovable* in one place and it is not changed at all as a result. So it is also here ..." [51] (Emphasis mine)

A hinge pin moves on the outside and remains unmoving at its center. To act and yet remain "in her inmost heart in immovable detachment" depicts precisely this dualistic life. One acts, yet at an unchanging level within retains a sense of something unmoving. One lives a dichotomous existence. Inside, she experiences an interior silence, outside she acts. Elsewhere he describes what this is like:

"When the detached heart has the highest aim, it must be towards the Nothing, because in this there is the greatest receptivity. Take a parable from nature: if I want to write on a wax tablet, then no matter how noble the thing is that is written on the tablet, I am none the less vexed because I cannot write on it. If I really want to write I must delete everything that is written on the tablet, and the tablet is never so suitable for writing as when absolutely nothing is written on it."

The emphasis in this passage is on the achievement of emptiness within. One has "deleted" everything inside; one comes to a "Nothing" inside; the tablet is "blank". When one is truly empty within, comes to "the Nothing," what goes on "outside" is of lesser significance, for it is unconnected to the inner "nothing". Only once this interior "Nothing" is established does one truly begin "acting rightly." This is highly reminiscent of the empty interior silence achieved by our other reporters.

In sum then, in this DMS the subject has a sense, on a permanent or semi-permanent basis, of being in touch with his or her own deepest awareness, experienced as a silence at one's core, even while remaining conscious of the external sensate world. Awareness itself is experienced as silent and as separate from its intentional content.

This dualistic mystical state seems to evolve gradually into another state. First the present author's own experience:

"Over the years, this interior silence has slowly changed. Gradually, imperceptibly, this sense of who I am, this silence inside, has grown as if quasi-physically larger. In the

beginning it just seemed like I was silent inside. Then this sense of quietness has, as it were *expanded* to permeate my whole body. Some years later, it came to seem no longer even limited to my own body, but even wider, larger than my body. It's such a peculiar thing to describe! It's as if who I am, my very consciousness itself, has become bigger, wider, less localized. By now it's as if I extend some distance beyond my body, as if I'm many feet wide. What is *me* is now this expanse, this silence, that spreads out" [52].

While retaining something of the dualistic character, the sense of the self or awareness itself here seems to have become as if quasi-physically expanded, extending beyond the felt borders of the usual physical frame. It is important to note that exterior perception has not changed here, only the sense of what consciousness itself is. That will change in the next state.

Freud, following Ramakrishna's disciple Romain Rolland, called this a "peculiar oceanic feeling," which seems to communicate both the ineffability and the expanded quality of such a sense of consciousness [53]. Yet at this point this sense of an inner expanse does not yet seem to "touch" or effect the perception of objects.

Being in the middle of an expanse is reminiscent of the well known passage from Walt Whitman. As if having a conversation with his soul, he recalls, I mind how once we lay, such a transparent summer morning, Swiftly arose and *spread around me* the peace and knowledge that pass all the argument of the earth [54].

Here the sense of inner silence, the peace, seems to have expanded through and around him. But it is interesting to note that Whitman does not suggest that the peace is *within* the world.

The sense seems to be that what one is, one's awareness itself, is experienced as oceanic, unbounded, expanded beyond the limits of the self. Here, I believe, a theist might plausibly associate this silence that seems to be both inside and yet quasi-physically expansive in terms of God. If this is true, then St. Teresa's "Spiritual Marriage" is very much like this one. In it, one is permanently "married" to the Lord,

"... the Lord appears in the center of the soul . . . He has been pleased to unite Himself with His creature in such a way that they have become like two who cannot be separated from one another: even so He will not separate Himself from her. [In other words, this sense of union is permanent.] The soul remains all the time in [its] center with its God... When we empty ourselves of all that is creature and rid ourselves of it for the love of God, that same Lord will fill our souls with Himself" [55].

To be permanently filled within the soul with the Lord may be phenomenologically characterized as experiencing a sense of a silent but expansive "something" at one's core. If so, this becomes remarkably like the other experiences of expansiveness at one's core that we have seen before. (Once again, the expanse is not described as permeating the world, as it might in the next "state.")

This sense of an interiority that is also an expanse is reconfirmed by her disciple St. John of the Cross, who says, "the soul then feels as if placed in a *vast* and profound solitude, to which no created thing has access, in an *immense* and *boundless* desert (my emphasis)."

In sum then, the interior silence at one's core sometimes comes to be experienced as expanded, as if being quasi-physically larger or more spacious than one's body. Now, what might this DMS suggest? It offers several tantalizing hints about consciousness:

- (1) Human capacity includes more epistemological modalities than is generally imagined. It is clear from these reports that one can be self-reflexively cognizant of one's own awareness more immediately than usual. The contemplative life can lead one to the ability to be aware of one's own awareness *per se* on a permanent or semi-permanent basis. This

is not like taking on a new *awareness*. None of our sources describe this as a sense of becoming a different person, or as a *discontinuity* with what they had been. Rather the descriptions are that of becoming more *immediately* cognizant of the awareness they had always enjoyed.

- (2) When speaking of the pure consciousness event, we suggested that consciousness should not be defined in terms of perceptions, content, or its other functions, for there awareness continued even when perceptions did not. Here awareness is not only not implicated with thoughts and perceptions, but is *experienced* as entirely different in quality or character - unchanging, without intrinsic form - than its content. It is also experienced as unconnected with its intentional content. Even thoughts do "not quite contact it." Awareness itself is experienced as still or silent, perceptions as active and changing. Therefore instead of defining awareness in terms of its content, we should think about awareness and its mental and sensory *functions* as two independent phenomena or processes that somehow interact. This again tends to militate for a dualistic approach to consciousness such as Popper and Eccles's "interactionism" or John Beloff's "radical dualism" [56] or David Ray Griffin's pan experientialist interactionism [57].
- (3) The sense of being expanded beyond the borders of one's own body, what Freud called the "peculiar oceanic feeling," is a very peculiar sense indeed. Yet if we take these surprisingly common reports seriously, as I think every open-minded thinker should, what do they suggest? The phenomenology, simply put, suggests that consciousness is not limited to the body. Consciousness is encountered as something more like a field than a localized point, a field that transcends the body and yet somehow interacts with it [58]. This mystical phenomenon tends to confirm William James's hypothesis in his monumental *Principles of Psychology* that awareness is field-like. This thought was picked up by Peter Fenwick and Cris Clarke in the Mind and Brain Symposium in 1994, that the mind may be non-localized, like a field, and that experience arises from some sort of interplay between non-localized awareness and the localized brain. It is seen also in Pockett's suggestion that awareness is akin to physics' four fields [59], and in Benjamin Libet's hypothesis of a "conscious mental field." [60] It is as if these mystical reporters had an *experience* of just the sort of field-like non-locality of awareness these theories hypothesize [61]. The heretical suggestion here is not that there is a ghost in the machine, but rather that there is a ghost in and *beyond* the machine! And it is not a ghost that thinks, but a ghost *for which* there is thinking and perception.
- (4) The experience of awareness as some sort of field can be understood in two ways. First it may mean that like a magnet, the brain may "produce" a field which extends well beyond its own physical borders. The slow growth of the sense of an expanse suggests this. Secondly the field-like experience may mean that the mystic is coming to a perception of what is, that awareness itself may somehow transcend individual brain cells and perhaps the entire brain, and there is a dawning recognition of this fact. If this is so, this would imply an entirely new way to think about the role of the physical brain. In this theory, brain cells may receive, guide, arbitrate, or canalize an awareness which is somehow transcendental to them. The brain becomes more like a receiver or transformer for the field of awareness than its generator: less like a magnet than like a TV receiver.

- (5) If consciousness is indeed field-like, akin to physics' four fields, it opens a Pandora's box of basic and potentially revolutionary questions. Just what is that field and how might it relate to physicists' four established fields? Is it a new field, an addition to the established four? If so why haven't physicists stumbled across it already? [62] Or might it relate to one or several of the other four? If so, how? If it is connected with only one field, the obvious question is why might this one be subjectively conscious while the other three are not? [63] Many more questions are implicit in this tantalizing suggestion. To these questions we have no answers. But just because it generates unanswered questions, clearly this does not mean its suggestions must be false. Only interesting.

The Unitive Mystical State

Our last commonly reported mystical experience is sense of becoming unified with external objects. It is nicely described by the German idealist Malwida von Meysenburg:

"I was alone upon the seashore... I felt that I ... return[ed] from the solitude of individuation into the consciousness of *unity with all that is*, [that I knelt] down as one that passes away, and [rose] up as one imperishable. Earth, heaven, and sea *resounded as in one vast world encircling* harmony... I *felt myself one* with them..." [64] (Emphasis mine)

The defining mark of Malwida's experience is that in some sort of immediate or intuitive manner she sensed that she was connected with the things of the world, as if she was a part of them and they part of her. It is as if the membranes of her experienced self became semi-permeable, and she flowed in, with, or perhaps through her environment.

A similar experience is described in Starbuck's 19th century collection of experience reports. Here again we see a sense of unity with the things of the world.

"... something in myself made me feel *myself a part of something bigger* than I ... I *felt myself one* with the grass, the trees, birds, insects, everything in nature. I exulted in the mere fact of existence, of being apart of it all, the drizzling rain, the shadows of the clouds, the tree-trunks and so on."

The author goes on to say that after this experience he constantly sought these experiences of the unity between self and object again, but they only came periodically. This implies that for him they were temporary phenomena, lasting only a few minutes or hours.

We see the sense of the unity between self and object, the absence of the usual lines between things, in Plotinus's *First Ennead* (8:1).

"He who has allowed the beauty of that world to penetrate his soul goes away no longer a mere observer. For the object perceived and the perceiving soul are *no longer two* things separated from one another, but the perceiving soul has [now] within itself the perceived object" [65].

Again we have a lack of boundaries between consciousness and object.

It is not clear from this passage if Plotinus is describing a transient or a permanent experience. Yet some reporters clearly tell us that such an experience can be constant. Though it is often hard to distinguish biography from mythology, Buddhist descriptions of Sakyamuni Buddha's life clearly imply that his Nirvana was a *permanent* change in epistemological structure. Similarly the Hindu term for an enlightened one, *jivanmukti* (enlightened in life), clearly suggests that this experience can be permanent.

Notice how different these reports are from our DMS descriptions of an inner expanse. There we saw no change in the relationship between the subject and the perceived world. Here

“the object perceived and the perceiving soul” are now united. “I felt myself one with the grass, the trees, birds, insects, everything in nature.”

One of the clearer descriptions of this state comes from Krishnamurti, who wrote of his first experience of this sort, in August, 1922:

"On the first day while I was in that state and more conscious of the things around me, I had the first most extraordinary experience. There was a man mending the road; that man was myself; the pickax he held was myself; the very stone which he was breaking up was a part of me; the tender blade of grass was my very being, and the tree beside the man was myself. I also could feel and think like the roadmender and I could feel the wind passing through the tree, and the little ant on the blade of grass I could feel. The birds, the dust and the very noise were a part of me. Just then there was a car passing by at some distance; I was the driver, the engine, and the tires; as the car went further away from me, I was going away from myself. I was in everything, or rather everything was in me, inanimate and animate, the mountain, the worm and all breathing things. All day long I remained in this happy condition."

Perhaps the most unmistakable assertion that these shifts can be permanent comes from Bernadette Roberts. Sometime after her initial transformation, she had what is clearly a development *on* her earlier dualistic sense of an expanded consciousness. She writes:

"I was standing on [a] windy hillside looking down over the ocean when a seagull came into view, gliding, dipping, playing with the wind. I watched it as I'd never watched anything before in my life. I almost seemed to be mesmerized; it was as if I was watching myself flying, for there was not the usual division between us. Yet, something more was there than just a lack of separateness, "something" truly beautiful and unknowable. Finally I turned my eyes to the pine-covered hills behind the monastery and still, there was no division, only something "there" that was flowing with and through every vista and particular object of vision... What I had [originally] taken as a trick of the mind *was to become a permanent way of seeing and knowing.*" (Italics mine)

She describes this “something there” that flowed with and through everything, including her own self, as a “that into which all separateness dissolves.” She concludes with an emphatic assertion: “I was never to revert back to the usual relative way of seeing separateness or individuality.” [66] We have a state, not a transient episode.

We could multiply these examples endlessly. This unitive mystical state (UMS), either temporary or permanent, is another common mystical phenomenon. It is clearly an evolution on the previous sense. First one continues to sense that one’s awareness is expansive, field-like, and that the self is experienced as larger, expanded beyond the usual boundaries. One feels oneself to be “a part of something bigger,” which is to say, senses a lack of borders or a commonality between oneself and this expanse. Indeed, in Bernadette Robert’s case, her sense of “something there” *followed* and was an evolution of her initial dualistic mystical state. But now this perceived expansion of the self is experienced as none other than, permeating with and through, the things of the world. One’s boundaries become as if permeable, connected with the objects of the world. The expanded self seems to be experienced as of the same metaphysical level, or of the same "stuff," as the world. Despite the grammatical peculiarities, “what I am *is* the seagull, and what the seagull is, *I am.*”

From this fascinating phenomenon we may draw several implications about consciousness.

- (1) The perceived "spaciousness" of awareness suggests, I said above, that consciousness is like a field. These unitive experiences reaffirm this implication and suggest that such a

field may not only transcend our own bodily limits, but somehow may interpenetrate or connect both self and external objects. This is of course reminiscent of the physical energy fields and/or the quantum vacuum field said to reside at the basis of matter, for these too are both immanent within and also transcendent to any particular expression, a parallel that Fritjof Capra, Lawrence Domash and others have been quick to point out.

- (2) The perception of unity suggests that the field of awareness may be common to all objects, and however implausibly, among all human beings as well. It suggests that my own consciousness may be somehow connected to a tree, the stars, a drizzle or a blade of grass and, paradoxically, to yours. Thus these unitive experiences point towards something like De Quincey's and Griffin's suggestion of a pan-experientialism, that experience or some sort of consciousness may be "an ingredient throughout the universe, permeating all levels of being." This opens up another Pandora's box of peculiar questions: most obviously what might the consciousness be of a dog, flower, or even a stone? Does the claim of a perceived unity merely point to some ground of being, and not a consciousness that is in any sense self-reflective like our own consciousness? Or if you and I share consciousness, can I experience what you do? If not, why not?
- (3) Not everyone who meditates encounters these sorts of unitive experiences. This suggests that some may be genetically or temperamentally predisposed to mystical ability; borrowing from Weber, the "mystically musical". One might suggest that the mystic's awareness is categorically different than other peoples', i.e. that it is connected to the world in an ontologically deep way that the rest of ours is not. I find this unconvincing, since every mystic I have read says he or she began as an "ordinary," i.e. non-mystical, person and only came to realize something of what he or she "had always been." Whichever explanation we opt for, however, it is clear that there is some ability the mystics have been able to develop - through meditation or whatever - that most of us have not.

3 CONCLUSIONS

Our four modalities of mystical experiences point clearly towards a distinction between awareness *per se* and the ordinary functional processes of sensation, perception and thought. They suggest that awareness is not *constructed* out of the material processes of perception or perhaps the brain, but rather they suggest a distinction and/or interaction between consciousness and the brain. Out of body experiences and near death out of body experiences suggest that consciousness can occasionally function at some distance from the brain or even without bodily activity. Furthermore, our experiences suggest that awareness may have a non-localized, quasi-spatial character, much like a field. Finally they tend to suggest that this field may be transcendental to any one person or entity, much like physics' energy fields transcends any one atom or quark.

I want to end by restating my earlier caveat. Phenomenology is not science. There can be many ways to explain any experience, mystical or otherwise, and we should explore all of them. But in the absence of compelling reasons to deny the suggestions of their reports, we would be wise to seriously examine the direction towards which the finger of mysticism points. If the validity of knowledge in the universities is indeed governed, as we like to claim, by the

tests of evidence, openness and clarity, then we should not be too quick to dismiss the baby swimming in the bathwater of mysticism.

4 A SPECULATIVE THEORY: THE COALESCENT FIELD THEORY OF CONSCIOUSNESS

If I might be permitted to speculate about the direction towards which the finger of mysticism points for a moment, I believe we have evidence here from our mystical experiences of several things:

- (1) Consciousness is distinct from mental processes;
- (2) Awareness *per se* is distinct from the brain, though it is clearly related to brain processes for most perception and activity;
- (3) Consciousness is experienced as field-like and expanded by "advanced" mystics, sometimes even being permanently so perceived;
- (4) Consciousness is experienced as the same "stuff" as whatever is at the basis of the material world; and
- (5) Human Beings sometimes exhibit the capacity to know or perhaps influence things in paranormal ways. This is not a matter that I have explored in this article. However I believe it to be the case, both from my own experience, many of my students, and that of others [67].

It seems to me that the various forms of materialism, the claim that consciousness is an epiphenomenon of the brain, are very hard pressed to explain this concatenation of data. Thus their repeated tendency is to rule out the evidence for both mystical and paranormal phenomena by either ignoring the data or by *ad hoc* and unconvincing arguments. But this is sign of a dismissal of the evidence based on expectations *a priori*, not good scientific consideration of all the evidence.

In his recent and refreshingly open exploration of the paranormal, David Ray Griffin offers a pan experientialist theory of consciousness that attempts to account for such data [68]. This thesis suggests that each thing at every level enjoys experience. His claim is that each individual which has a natural structure has experience: humans, animals, bacterial and even perhaps molecules and atoms. He points to the increasingly strong evidence that animals have experience [69]. Even quite "low level" animals such as bees seem to have consciousness [70]. There is evidence that bacteria employ memory in making decisions [71]. Even DNA molecules and, going further down, even atoms, may "show signs of spontaneity and self organization" [72]. Experience, according to this theory, may go all the way down the scale of matter.

The virtue of Griffin's pan-experientialism is that it makes sense of the increasingly compelling evidence for animal consciousness, bacterial awareness, etc. Its focus on monads does not, however, readily account for the kind of mystical perception of consciousness as field-like we have seen. Furthermore, it does not readily account for that which the theory is purported to explain, i.e. how we might "perceive" something at a distance (paranormal perception). If there are a series of more or less discrete monads, we still do not know how one might gain knowledge of those monads *across* distances.

I propose that what does best account for ordinary conscious experience, the mystics' experiences and paranormal data like ours is a *Coalescent Field Theory of Consciousness*

(CFT). I suggest that the mystics are perceiving what they *prima facie* seem to be perceiving: that our consciousness is in fact field like, sometimes expandable beyond the self. In the UMS, one perceives that this field-like phenomenon is of a piece with other humans, animals and with objects of the world. This suggests that the field of consciousness is not limited to human beings, but runs in and through “grass, the trees, birds, insects, everything in nature,” and that the mystic is experiencing this omnipresent field of consciousness. Consciousness may indeed be like a field that runs in and through self and nature.

Of course in everyday life, for most of us our sense of self is not expanded like this. For most of us, consciousness seems generally restricted to us, our bodies, our thoughts and history. Descartes didn’t say, “*Il pense, donc il est*,” but “*je pense*,” *I* think. Clearly consciousness tends to be found in something more bounded, like a monad or a particle.

Thus I hypothesize that consciousness has the ability to coalesce into more or less discrete monads: humans, animals, bacteria, whatever. I imagine consciousness as something like a cloud or field which takes a particular shape, be it fish or face. Even though it coalesces into a particular locale or form, it remains at the core “cloud-stuff” and of a piece in some sense with the wider cloud. Though always remaining field-like, consciousness becomes bounded, individuated through some sort of coalescing process. In this sense, consciousness is something like a wave/particle, now experienced as particle, now as a field.

When we become individuals and have perceptions, embodied hunger pangs and specific fears, we lose to such high relative intensity feelings our sense of our wider but quiet connection to this field-like breadth. But as these desires diminish in relative intensity, the nature of consciousness itself begins to reveal its own broader field-like nature more clearly. In this way, the growth towards mysticism restores the perception of awareness’s field like character itself.

The CFT has the virtue of accounting for, with a minimum of or *ad hoc* explanation, much of the evidence. First it makes sense of mystical experiences. It suggests that such experiences are (roughly speaking) veridical. Second, it offers room for paranormal phenomena, for consciousness in its field-like nature would connect us to what is happening in the next room or the next block. The field of consciousness could conceivably allow communication at a distance, much as those renowned quarks can somehow “communicate” instantaneously at a distance. Thus consciousness in its field-like nature may serve as something like a communications field.

The CFT is admittedly a hypothesis, and a highly speculative one at that. And if true, it opens up its own Pandora’s box of paradoxes and peculiarities. What might cause a conscious field to coalesce into monadic individuals? If it moves, how? How might one coalescence of the conscious field relate to another? How might this theory be verified or denied? Yet it has the virtue of giving us a new direction to begin to look to plausibly explain the paradox of consciousness as well as some seemingly inexplicable data.

REFERENCES

- [1] See R. Ornstein’s chapter, “The techniques of meditation and their implications for modern psychology,” in, C. Naranjo and R. Ornstein, eds., *On The Psychology of Meditation* (Penguin, NY, 1976), pp. 137 - 235.
- [2] In R.K.C. Forman, ed., *The Problem of Pure Consciousness* (Oxford University Press, New York, 1990).
- [3] See Ref. 2, Sect. 1

- [4] B. Mangan, Language and experience in the cognitive study of mysticism - Commentary on Forman, *Journal of Consciousness Studies* Vol. 1, no. 2, p. 251 suggests this when he says that "mystic[al] encounters ... would seem to manifest an extreme state of consciousness." The psychologist of religion William Parsons, in a private communication, pointed out that Freud and Durkheim turned to "Totemism," which they thought were the simplest forms of religion, to understand the more complex religions.
- [5] This piece of James's famous characterization of mysticism in *The Varieties of Religious Experience* (Longmans, Green and Co., New York, 1902, reprinted in Penguin Edition, 1983), p. 381, states that a defining feature of mysticism is "transiency." My evidence says this is simply wrong.
- [6] I say typically because sometimes one may skip or not attain a particular stage. K. Wilber in *The Atman Project* (Wheaton, Ill.: The Theosophical Publishing House, 1980) claims sequence. W. Barnard, however, in his "Response to Wilber" unpublished paper delivered to the Mysticism Group of the American Academy of Religion, 1995 disputes this claim of sequence.
- [7] One key element of the UMS is that it is a *permanent* shift in the structure of awareness. "Extrovertive" mysticism, a term coined by W.P. Stace, implies that one has mystical experiences out in the world, while we are "extrovertively" aware. Zaehner coined the term "Nature "mysticism" to describe such paths as Zen or Taoism, which describe mystical experiences in nature. This he distinguishes from the theistic traditions, among others. But in the UMS, as I understand this form of life, the sense of being in contact with the expansive emptiness that extends beyond the self, *never* fades away, whether one is in nature or in the city, whether the eyes are open or closed, and whether one is a Zen Buddhist, a Jew or a Christian. Thus each of these accepted terms define this experience form too narrowly, and thus I coin my own broader term.
- [8] Cf. N. Smart, "Interpretation and mystical experience," *Sophia* Vol. 1, no. 1, p. 75.
- [9] I am grateful for J. Goguen, private communication, for articulating this question so clearly.
- [10] *The Problem of Pure Consciousness* offers a rich compendium of reports of the PCE. I have intentionally offered here several reports of this experience that are not included there.
- [11] St. Teresa of Avila, *Interior Castle*, in *Oeuvres*, trans. by Bouix, Vol. 3, pp. 421 - 424. Quoted in W. James, *Varieties of Religious Experience*, p. 409.
- [12] The mystic apparently remains conscious throughout. Although Teresa does not explicitly say the mystic is not asleep, but I cannot imagine anyone spilling so much ink on merely sleeping or blacking out, or on something like a coma. See below for more explicit statements to this effect..
- [13] M. O'C Walshe *Meister Eckhart, Sermons and Tractates* (Watkins, London, 1982), Vol. 1, p.7.
- [14] Maitri Upanishad 6:19, translated by R. Hume in *The Thirteen Principle Upanishads* (Oxford University Press, London, 1931), p. 436.
- [15] These two are not quite equivalent. Atman, when seen in its fullest, according to the Upanishads and to Advaita Vedanta, merges with Brahman, and thus is experienced as including the object or content of perception. Purusha, according to Samkhya, is more an independent monad. It thus remains forever separate from its content. But the two both represent the human awareness, however differently understood.
- [16] J.G. Larson, *Classical Samkhya: An Interpretation of its History and Meaning* (Ross/Erikson, Santa Barbara, 1979), p. 77.

- [17] This is an autobiographical taken from my *Mysticism: Forgetting or Remembering?* (State University of New York Press, Albany, forthcoming, 1997).
- [18] See here P. Griffiths, "Pure consciousness and Indian Buddhism," in *The Problem of Pure Consciousness*.
- [19] *Ibid*, p. 83.
- [20] The Culasunnata-Sutta ("Lesser discourse on Emptiness," trans. G. M. Nagao, "What Remains" in *Sunyata: A Yogacara Interpretation of Emptiness*, in M. Kiyota ed., *Mahayana Buddhist Meditation* (Honolulu: University Press of Hawaii, 1978), p. 67.
- [21] Vasubandu commentary on Vs. 1.1 of the *Madhyanta Vibhaga*. Quoted in Nagao. Vasubandu is here wrestling with just the focus that made Yogacara so distinctive and clear. In its focus on the *alayavijnana*, it deals directly with the question of what remains in "cessation meditation." S. Collins, *Selfless Persons* (Cambridge University Press, Cambridge, 1982) believes this is a mistaken view of the nature of *samadhi*, though unfortunately he never directly confronts such Yogacara texts.
- [22] W.T. Stace, *Mysticism and Philosophy* (Macmillan Press, London, 1960), p. 86.
- [23] See especially Part I in Ref. 2.
- [24] T.W. Clark, Function and phenomenology: Closing the explanatory gap, in *Journal of Consciousness Studies*, Vol. 2, no. 3, p. 241.
- [25] B. Buchanan, JCS-Online, March 9, 1996.
- [26] Cf. V. Gray Hardcastle, Psychology's Binding Problem and Possible Neurobiological Solutions, *Journal of Consciousness Studies*, Vol. 1, no. 1, pp. 66- 90. My apologies to her: while throughout her essay she hints at this connection, she does not make the connection as baldly as I have suggested here.
- [27] If we think in a socio-cultural way here, we might note that our long western worldview, with its roots in the Judeo-Christian past, in the Protestant capitalistic history, and in the history of science, would tend to favor a definition of consciousness in active, masculine, intentional, and "doing" terminology. Thus consciousness is, in this view, always vectorial, intentionally pointing towards this or that. Such a definition fits how people are expected to act in such a culture. Contemplative traditions and the east, on the other hand, tend to be more open to defining consciousness as *awareness per se*, or just being. In the west we may take these to be too passive, feminine, but they "fit" the more station-oriented caste and natal-status behavioral patterns. My thanks to B. Parsons for this observation.
- [28] Logically: awareness is a necessary but not sufficient condition for binding; binding is neither a necessary nor sufficient condition for awareness.
- [29] A. Deikman, "The I of Awareness," forthcoming, *Journal of Consciousness Studies*. David Chalmers, "Facing Up to the Problem of Consciousness," *Journal of Consciousness Studies*, Vol. 2, no. 3, 1995, pp. 200-219. I have reversed his terms. Chalmers calls awareness in itself "consciousness" and connects its various functional phenomena with the term "awareness." I believe that my usage is closer to ordinary usage. My thanks to J. Shear for pointing out this difference.
- [30] See the extended discussion of this possibility in my *Mysticism, Mind, Consciousness* (SUNY Press, Albany, forthcoming 1997).
- [31] Here language fails us. The awareness is not in any sense conscious of the passage of time; rather I am suggesting that awareness ties itself together through what an external observer would note as the passage of time.

- [32] B. Lonergan, Collection, in F. Crowe ed. (Herder and Herder, New York, 1967), p 226. Quoted in M.H. McCarthy, *The Crisis in Philosophy* (State University of New York Press, Albany, 1990) p. 234.
- [33] To retain as much neutrality as possible, I asked my students to answer this question on paper and anonymously. That this number exceed by x% D. Hay's findings on a national scale that x % have had a mystical experience may be explained by either the class's self-selection or by its younger age than the national median.
- [34] Self-report of C. Garcia, Feb. 20, 1997.
- [35] This seems to be important, since these experiences only occur when she is in a state of muscular relaxation.
- [36] Self report of C. Garcia, Feb. 20, 1997.
- [37] K. Clark, Clinical Interventions with near-Death Experiences, Greyson and Flynn, *the Near Death Experience* 242-3. Quoted in D. Ray Griffin, *Parapsychology, Philosophy, and Spirituality: A Postmodern Exploration* (SUNY Press, Albany, NY, 1997), p. 251.
- [38] K. Ring and M. Lawrence, Further Evidence for Veridical Perception During Near Death Experiences, *Journal of Near Death Studies* 11/4 (Summer, 1993), pp. 226 - 7.
- [39] *Ibid.* See also R. Crookall, *The Study and Practice of Astral Projection* (The Citadel Press, Secaucus, NJ, 1988).
- [40] Of course, that implies that one has some sort of non-sensory sense, the ability to sense one's own expansive presence even though there are no visible mechanisms of sensation. But is that so strange after all? If we can sense our own awareness directly in the pure consciousness event, why shouldn't we be able to sense something of its non limited character on a more permanent basis?
- [41] J. Beloff, Minds and machines: A radical dualist perspective, *Journal of Consciousness Studies*, Vol. 1, no. 1, p. 35.
- [42] D. Ray Griffin, *Parapsychology, Philosophy and Spirituality: A Postmodern Exploration* (SUNY Press, Albany, 1997). See especially pp. 96 - 149.
- [43] B. Roberts, *The Experience of No-Self* (Shambala, Boulder, 1984), p. 20.
- [44] W. James's thought that mysticism is "transient," i.e. short lived, clearly does not capture B. Roberts' experience, nor many of the experiences documented in this section.
- [45] *Ibid.*
- [46] Here I am struck by the parallel with the rapid shifting of a physical system as it becomes coherent. Disorganized light just "shifts" or "zips" into laser light nearly instantaneously.
- [47] Writing this, I think of the parallel between this sense and B. Robert's sense of having lost the usual "unlocalized sense of herself."
- [48] This is an autobiographical report of the present author. Cf. my *Mysticism, Mind, Consciousness*, (Ref. 30).
- [49] It is my impression that the awareness of the specific locations within the body is not essential to this transformation.
- [50] Teresa of Avila, *The Interior Castle*, trans. E. Allison Peers (Doubleday, New York, 1961), p. 211.
- [51] Clark and Skinner, *Meister Eckhart: Selected Treatises and Sermons* (Faber and Faber, London, 1958), p. 167.
- [52] Cf. my *Mysticism, Mind, Consciousness*, (Ref. 30).
- [53] Freud was employing a phrase from his correspondence with R. Rolland. See W. Parsons, *The Enigma of the Oceanic Feeling* (Oxford University Press, forthcoming)
- [54] W. Whitman, quoted in James, *Varieties*, p. 396, no reference.
- [55] St. Teresa, *Interior Castle*, pp. 213 - 216.

- [56] J. Beloff, Minds and machines: A radical dualist perspective, *Journal of Consciousness Studies*, Vol. 1, no. 1, p. 35.
- [57] D. Ray Griffin, *Parapsychology, Philosophy and Spirituality: A Postmodern Exploration* (SUNY Press, Albany, 1997). See especially pp. 96 - 149.
- [58] Of course, that implies that one has some sort of non-sensory sense, the ability to sense one's own expansive presence even though there are no visible mechanisms of sensation. But is that so strange after all? If we can sense our own awareness directly in the pure consciousness event, why shouldn't we be able to sense something of its non limited character on a more permanent basis?
- [59] See Pockett's, Physics and consciousness, *The Journal of Consciousness Studies*, forthcoming.
- [60] B. Libet, A testable field theory of mind-brain interaction, in *Journal of Consciousness Studies*, Vol. 1., no. 1, 1994, pp. 119-126. See also his "Solutions to the Hard Problem of Consciousness", talk delivered at "Toward a Science of Consciousness", 1996.
- [61] See the report in *The Journal of Consciousness Studies*, Vol. 1, no. 2, p. 283-4.
- [62] Perhaps they have, in the well known and little understood interaction of consciousness with fine particles.
- [63] For the substance of this paragraph, I am indebted to a private communication from J. Shear. He notes that F. Capra and L. Domash pointed out this parallel long ago.
- [64] *Memoiren einer Idealistin*, 5th Auflage, 1900, iii. 166. Quoted in James *Varieties*, p. 395.
- [65] Quoted in R. Otto, *Mysticism East and West*, trans. B. Bracey and R. Payne (Macmillan, New York, 1930), p. 67.
- [66] Roberts, *The Experience of No Self*, p. 30.
- [67] The most compelling case I have seen is in Griffin, (Ref. 57), especially pp. 7 - 95.
- [68] In Ref. 57, See also Christian de Quincey, Consciousness All the Way Down? An Analysis of McGinn's Critique of Panexperientialism, *Journal of Consciousness Studies*, Vol. 2, no 2, p. 218.
- [69] S. Savage-Rumbaugh's Language and Non-Human Minds: What the Evidence is Trying to Tell Us"; D. Reiss, Communication and Cognition in Dolphins, I.M. Pepperberg Comparative Cognition: The Capacities of a Bird Brain; P. Bloom Language and Consciousness; all papers delivered at Tucson II: Toward a Science of Consciousness, 1996. It is hard to imagine anyone hearing these presentations still denying all consciousness of animals!
- [70] D.R. Griffin, *The question of Animal Awareness: Evolutionary Continuity of mental Experience* (Rockefeller University Press, NY, 1976).
- [71] J. Adler and W.-W. Tse, Decision-making in bacteria, *Science* 184 (June 21, 1974), 1292-94; A. Goldbeter and D.E. Koshland, Jr., Simple molecular model for sensing and adaptation based on receptor modification with application to bacterial chemotaxis, *Journal of Molecular Biology* 161 (1982), pp.395-416.
- [72] In Ref. 57, p. 132.

THE NEURODYNAMICS OF CONSCIOUSNESS^a

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Abstract. The search for an understanding of how human beings create themselves through their actions arising in their brains inevitably leads to the study of chaos. Deterministic chaos is characterized by complexity that is selforganized in accordance with simple underlying rules. Examples are found at all levels of organization of nervous systems, from molecular assemblies within neurons to dynamics of single neurons, and up through networks to the whole brain. It is seen in structural outcomes of growth processes, the branching patterns of axonal and dendritic trees, and in spatial and temporal patterns of neural activity. The search for simple rules is one good reason for using the tools of the theory of chaos to model neural functions. The level appropriate for researchers who are interested in perception, cognition and consciousness is the level of macroscopic neural populations, because in animals from insects to man that is where the organization of perception and goal-directed behavior with respect to the external environment occurs. The dynamics of these populations is shaped by learning from the sensory consequences of intentional actions, and it uses chaotic attractors in the cerebral cortex to provide the background, "spontaneous" activity that is required for the creation of novel trials in trial-and-error learning. Humans learn by, in and through chaos.

The global dynamical structure of the neural populations constitutes the self. A biologically based distinction is advanced between the foundation of the self and its superstructure, which is the sense of self. The foundation is the intentional operation of the limbic and sensory systems, dynamic and nonrational, with behavior subject to societal observation and assignment of responsibility. The derivative aura from the bulk of the forebrain, by ingenious backdating and rationalization, attains an illusion of conscious control.

Key words: *consciousness, neurodynamics, deterministic chaos.*

^a This (video) lecture was given initially to the Society for Chaos in Psychology, summer 1996.

INCONSISTENCY AND AMBIGUITY IN THE USAGE OF THE TERM ALTERED STATES OF CONSCIOUSNESS

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Abstract. Since it was first coined in the late fifties by Gill and Brenman, the term *Altered States of Consciousness* (ASCs) has become one of the widely used terms in scientific debates in many areas. The term has become too common that its users usually treat as a well-defined term and rarely show interest in investigating and examining its definition and what it stands for. Indeed, its meaning is taken to be quite obvious that the term itself is often given explanatory functions in the study of other complicated phenomena, such as healing. However, the term ASCs is in fact far from being the accurate and clearly defined term that many seem to think it is. In this paper we trace back the origin of the term ASCs and examine the way its usage has developed. We find that the term ASCs has inconsistently been used by different researchers and that this inconsistency, which is often glossed over, has been detrimental to the understanding of consciousness and also to the understanding of the phenomena this term is usually invoked to explain.

Key words: *consciousness, altered states of consciousness, trance, terminology, characteristics, phenomenology, psychology, EEG.*

1 INTRODUCTION

Every normal person, who need not be a scientist or highly-educated, could easily recognize the fact that his consciousness, and of course everybody else's, does not remain in one state. This is so simple to observe because everybody must have experienced a number of deliberate procedures and spontaneous circumstances that could bring about sensible changes in his/her mental, emotional, and perceptual state, which could be felt in terms of quality and/or quantity. The most common among such experiences is sleep and its dreaming, hypnagogic, and hypnopompic states. Hence, from the experiencer's viewpoint, it would thus seem entirely reasonable to label these states as *altered* states of consciousness (ASCs) in contrast to his/her *ordinary* state of consciousness (OSC).

Despite the fact that ASCs represent common experiences for every human being, and although there has been extensive research into this area, developing a comprehensive and objective understanding of these various states has so far proved extremely difficult. Given that it is not known sufficiently, clearly, and satisfactorily what actual components constitute a state of consciousness (SC), it is natural to find far more ignorance of what characterizes each of these numerous states. With our modest knowledge of OSC itself it is no wonder that our understanding of ASCs is sketchy, and our ability to differentiate between the different ASCs and to break them down to their basic constituents is extremely primitive.

In fact, even assigning an absolute sense to the term OSC might well turn out to be an unjustified oversimplification of the matter. Tart, for instance, believes that the definition of OSC is culture-sensitive. He writes that the “ordinary state of consciousness for two different cultures is different in important ways” [1]. Hence, what is seen as an OSC in one culture might well be considered an ASC in another, and vice versa. Tart has also suggested that, at least in some cases, certain differences between individuals who have the same cultural background might prove influential in building the OSC of each person differently, and accordingly, he criticized the assumption that “because two people are normal (not certified insane), their ordinary SoC's [States of Consciousness] are essentially the same.” He maintains, “A realm of knowledge that is ordinary for [person] A is then specific for an ASC for [person] B. Similarly, some of the experiences of B in his ASC may not be available for direct observation by A in his ordinary SoC” [2]. This view, however, has been overlooked by other researchers who undervalued differences between people's experiences. For instance, Aaronson writes, “The word, *altered* [of ASC], itself may be excessive when we consider that some people live in these states of consciousness always, or nearly always” [3]. Tart would prefer to explain this apparent contradiction by suggesting that these are not people who are “always, or nearly always,” in ASCs but that their OSCs differ from norms.

This is yet one example of the many differences in viewpoints and difficulties that permeate the research on SCs. Rossi who noticed the irony behind the limitedness of our understanding of our consciousness, has beautifully described the paradox writing, “It is a curious but undeniable fact that consciousness, the essence of knowledge, does not know itself very well” [4]. Sutherland has even gone as far as to state in the *International Dictionary of Psychology* that, “Consciousness is a fascinating but elusive phenomenon: it is impossible to specify what it is, what it does, or why it evolved. Nothing worth reading has been written about it” [5]. Güzeldere explains why our uncertainty about the nature of consciousness is a striking fact:

“It seems that confusion reigns in the study of the phenomenon of consciousness. But this must strike everyone, upon a moment's reflection, as nothing short of startling. Not only is consciousness the most familiar aspect of our lives but it has also been under systematic investigation in several fields for a long time” [6].

Researchers in general seem to agree that the scientific knowledge of ASCs is flimsy due to some considerable difficulties inherent in the study of ASCs [2]. Nevertheless, the extent of the unreliability of this knowledge has been greatly underestimated because the scientific terminology used has effectively concealed many of its weak points. This has resulted in the advancement of satisfactory scientific knowledge of human consciousness being further hindered by artificial obstacles that have been created by the current *scientific* terminology. Unfortunately, little concern has been given to these semantic problems despite their influential role in impeding the development of a reliable knowledge of ASCs. Needless to say, a clear, accurate and specific definition of the scientific terminology is an indispensable requirement for making the language of any branch of science understandable to and manageable by different scientists. Sadly, the vocabulary of our scientific language of human SCs represents an unmatched violation of this vital condition.

2 THE TERM ASCs BETWEEN DEFINITION AND MISUSE

The term ASCs has never reached a clear definition since it was first coined in the late fifties by Gill and Brenman [7]. Ludwig who borrowed the term *altered states of consciousness* for the title of his famous paper, which in its turn popularized this term, has defined it as:

“[A]ny mental state(s), induced by various physiological, psychological, or pharmacological maneuvers or agents, which can be recognized subjectively by the individual himself (or by an objective observer of the individual) as representing a sufficient deviation in subjective experience or psychological functioning from certain general norms for that individual during alert, waking consciousness” [8].

It is thus obvious that the term was originally used in a very broad sense to refer to *all* SCs of a person that are different from his/her OSC. It refers, for instance, to the various SCs that prevail during the stages of sleep, daydreaming, hypnosis, meditation, and all the many other practices, and circumstances that are believed to induce shift in the consciousness. Obviously, the term ASCs was given a general and broad meaning, and therefore, it was not in any way meant to refer to a specific ASC. In other words, just as the term SCs is general and refers to all of the innumerable, known and unknown, mental states of a person, ASCs is also a general term that refers to all these same SCs except the OSC. Considering Tart's [1] and others' suggestion that different people can have different OSCs, then the ASCs of a person would thus be referring to all the SCs of that person other than his OSC.

For the science of human consciousness, as it is the case for any other branch of science, general terms as well as those of specific sense are both equally needed to classify data and facilitate manipulating them in different ways and for various purposes. However, using such terms in improper contexts could seriously obstruct the progress of the scientific knowledge. An example of such misuse concerns employing *general* terms in contexts where *specific* ones should be used. This particular misuse has systematically accompanied the term ASCs since it appeared more than three decades ago. With this in mind, one can understand Tart when he argues that “the terms *state of consciousness* and *altered state of consciousness* are used so imprecisely to cover so many different things and not only in popular usage but frequently in scientific usage” [emphasis in original] [1]. Obviously, from the scientific point of view, a layperson's misuse of these terms is almost insignificant, but the specialists' must not similarly be tolerated, simply because scientific language plays a great part in leading and advancing scientific knowledge [9].

In the aforementioned quotation it is evident that Tart is not objecting to the general nature of the terms SC and ASCs, as these terms had not originally been assigned any specific sense. What Tart criticizes is the misuse of these general terms in contexts where specific, specially coined terms need to be used instead. In this regard, numerous examples could be cited, in particular, from the literature of the effects of ASCs in facilitating healing from a variety of diseases [10,11]. In such studies, one very often reads statements such as “ASC[s] have been a key ingredient in the healing arts” [12], and “there are important therapeutic utilizations of ASC[s]” [13]. Such statements are meant to describe certain ASCs which could have a positive effect on human health but, inaccurately, they use the general term ASCs to refer to these states ignoring the existence of numerous maladaptive ASCs that could well be self-destructive for the experiencer, such as ASCs that result from ingestion of drugs, epileptic seizures, and psychological diseases [8]. Thus, while the incorrect view that ASCs are pathological in nature has rightly been criticized by many researchers [1,12,14], here we seem to have a counter tendency as ASCs are treated as absolutely healthy and beneficial.

Since ASCs represent a wide variety of mental states, then on so many occasions and in so many contexts a need arises to refer only to *specific* ASCs or, inversely, to exclude some of them. Therefore, there should be sufficient and suitable terms to differentiate the various ASCs from each other, i.e. specific terms for specific states. In fact, it is the absence of needed terms that has paved the way to and has encouraged the misuse of the *general* term ASCs as a *specific* one. But, certainly, the introduction of such specific terms should be done with care, as it is most important to avoid introducing vague or loosely defined terms to be added to, or to just replace, the confusing heap of terms already extant, such as the different derivatives of the term *trance*. According to Tart's systems theory, the SCs are “*discretely* different from one another” [emphasis in original] [1], qualitatively and quantitatively. As for ASCs he gives the following definition:

“An altered state of consciousness for a given individual is one in which he clearly feels a *qualitative* shift in his pattern of mental functioning, that is he feels not just a quantitative shift, but also that some quality or qualities of his mental processes are *different*” [15].

This may be a good *working hypothesis*, which requires *defining* these discrete SCs clearly, and, of course, coining new terms to label them. That is to say, in the case of Tart's systems approach the *qualities* and *quantities* that are assumed to differentiate the discrete states from each other must be clearly and satisfactorily defined first. In fact, designing methods and criteria for defining the various SCs is a requirement that must be met once human consciousness is viewed as discrete states rather than continua. This is required independently of whether the host of ASCs are thought to differ from each other only in quantity [3], or in both quantity and quality [15].

The rampant misuse of the *general* term ASCs in the literature to refer to *specific* ASCs seems to indicate that very little concern has been given to studying ASCs as discrete states. If the human consciousness can be understood in terms of separate states rather than continua, then this would tacitly mean that there should be essential differences between these states, as predicted by Tart's systems theory, for example. Therefore, this indifference toward the versatility of SCs indicates a reductionistic tendency in research. If the irresponsible misuse of the term ASCs is to be terminated, then much more effort should be dedicated to investigating how to break down this term into its basic components, i.e. the specific ASCs.

Unfortunately, the term ASCs is not the only problematic and confusing one that has come to be widely used in the science of human consciousness. Other vague terms are also used in scientific contexts, usually to label particular ASCs or some of their characteristics. These terms have seriously contributed to impairing the progress of scientific knowledge of ASCs. They have led, exactly like the term ASCs, to the underestimation on the part of researchers of the sketchiness of the nature of the scientific knowledge of human SCs. The most widely used of these ambiguous terms, that have hampered the establishment of reliable scientific knowledge of ASCs, has undoubtedly been the term *trance*.

3 TRANCE: YET ANOTHER CONFUSING TERM

The term *trance* derives from the Latin *transitus* (a passage) and *transire* (to pass over), implying a passage from one SC into another. In their classic dictionary of psychological terms, English and English define *trance* as “A sleeplike state marked by reduced sensitivity to stimuli, loss or alteration of knowledge of what is happening, substitution of automatic for

voluntary activity. Trances are frequent in hysteria, and they may be hypnotically induced. In extreme form trance resembles (or is) coma. Religious or emotionally marked trances are called ecstasy.” [16] A brief survey of other definitions assigned to the term is given by Shaara and Strathern [17]. In fact, despite some verbal and superficial differences between the definitions, they all have a common essence which could be summarized by quoting the concise definition of Pattison *et al* who state that trance states (TSs) are “a mode of consciousness in which the person is conscious, but seemingly unaware or unresponsive to *usual* external and internal stimuli” [emphasis in original] [18]. Needless to say, just like ASCs, a definition in this form is a *general* one that does not refer to any *specific* SC(s). It is, as Baldwin has noted, “a general term covering certain very varied conditions of modified consciousness with their physical accompaniments, e.g., hysteria, hypnosis, ecstasy, medium(ship)...” [19]. However, as it is the case with the term ASCs, having a general and broad sense is not itself a criticism of a term, but a valid criticism arises when this general term is used in contexts that require the use of specific terms. This inaccuracy is also true of the concept *trance*. This is what Baldwin meant when writing, “The term is used variously and often vaguely” [19]. An example of the inaccurate use of the term *trance* is Winkelman's statement that “Trance states have healing effects and facilitate other human processes” [20]. Identical statements have been made by a large number of other researchers. However, such statements neglect the fact that the term TSs is usually used to refer to scores of mental states some of which are believed to have maladaptive effects. Some of these maladaptive TSs which are pointed out by Winkelman himself include those resulting from nervous system liabilities and epileptic-like states.

It is very important to notice that even after about a century that witnessed and still witnesses increasing interest in and extensive research on *trance-phenomena*, Baldwin's criticism of the term *trance* is still valid. Katz who criticizes the current use of *trance* in the scientific language, writes that “The term “trance” has been used to describe a variety of altered states of consciousness, including possession states and meditation states. Its referents remain ambiguous, its use inconsistent” [21]. Apart from the inconsistency in the use of the term *trance* which contributed to the ambiguity of the this term, the other unpleasant fact that Katz's statement stresses is that TSs are widely looked at as *special cases* of ASCs, and even sometimes defined in terms of ASCs [22,23]. This view of *trance* could have had valid implications only if *trance* would refer to *specific* ASCs that are understandably and clearly separable from the remaining ASCs, i.e. non-*trance* ASCs. The truth is that, so far, not only the differences between the various so-called TSs are totally unknown, but most importantly, it has been almost impossible to differentiate *trance* from non-*trance* ASCs. In fact, currently ASCs seem to be hardly distinguishable from each other in terms of any criteria. Hence, the term *trance* seems to have a very illusive nature: while it refers to *specific* ASCs, such states have not proved separable from other ASCs.

Bourguignon who argued against the loose use of terms in science, instanced the use of “trance” and “shamanism” in a broad sense in anthropology. She stresses the importance of defining the scientific terms clearly, and builds her strong argument on the facts that:

“[T]hese definitions and their usage are heuristic and have implications for the collection and classification of ethnographic data, for the formulation and testing of hypotheses, and ultimately for the development of models and theories. There are also implications for communication with readers, be they cultural insiders or outsiders” [9].

Bourguignon here touches on many sensitive points, not the least important of which is whether confusing terms such as *trance* and ASCs do really mean the same thing to different

researchers. The translations of these terms from one language to another could provide the best evidence on the extent to which researchers have differed in their understanding of such terms. In this regard, an impressive example is given by the Japanese psychiatrist Kho Nishimura who states:

“The word “trance” has been used in a variety of ways. The Japanese words used to translate the English “trance” include, for example, those of coma, unconsciousness, dreaming, rapture, ecstasy, and religious exhortation. Furthermore, it has been considered to include Eliade's soul loss, possession, or both” [24].

Just to make matters worse, the vagueness and inaccuracy that have accompanied and still accompany *trance* have deliberately been overlooked even by researchers who show special interest in clarification of scientific terminology. For instance, Winkelman has pointed out that “terms such as *shaman*, *medicine man*, *diviner*, *witch doctor*, *medium*, *healer*, and others are often used interchangeably and without specification of the assumed common characteristics or consideration of the possible differences among such practitioners” [20]. However, his attempt to clarify these terms was through distinguishing between “shamans, shaman/healers, and mediums,” whom he considers as “trance-based magicoreligious practitioners” [25], on the one hand, and “healers” who “generally do not engage in trances, and when they do, the trances appear to be less important than they are for shamans, shaman/healers, and mediums,” on the other [25]. In this instance, clarification of scientific terms is sought, but the attempt employs as a means of clarification the term *trance* which itself lacks clarity of definition and consistency in usage [9,19,21]. Such attempts to clarify scientific terms can by no means escape failure as the definitions they offer are themselves based on other unclearly defined terms.

As a consequence of the common view that TSs are *special cases* of ASCs, all the weak points that associate the use of the term *trance* naturally add up themselves to the shortcomings of the term ASCs itself, and thus increase the vagueness of the latter. In fact, careful reading of the literature of ASCs and TSs gives indications that these terms, due to their ambiguity and closeness in the *linguistic* sense, have even often been used interchangeably, as pointed out by Peters and Price-Williams [26].

4 CHARACTERISTIC PSYCHOLOGY OF ASCs?

ASCs are believed to be inducible by many methods and under various circumstances. Winkelman, for instance, introduced a lengthy list of agents and procedures that, in his belief, induce “trance.” These are, of course, also ASCs-inductive, just as trances themselves are ASCs. Winkelman's list includes:

“[H]allucinogens, opiates, and other drugs; extensive running or other motor behavior; hunger, thirst, and sleep loss; auditory stimulation and other forms of intense sensory stimulation, such as physical torture or temperature extremes; sensory deprivation, sleep states, and meditation; and a variety of psychophysiological imbalances or sensitivities resulting from hereditarily transmitted nervous system liabilities, epileptic-like states resulting from injury, disease, or other trauma to the central nervous system like extreme temperatures, or other sensitive conditions of the temporal lobe and the associated structures of the hippocampal-septal system and amygdala” [20].

Despite its versatility, Winkelman's list does not include all ASCs induction procedures. It is believed that ASCs could also be induced by many other methods. Field, for instance, believes that ASCs can be induced during "childbirth," and that "serious illness, accident, falling in love, air raids, breakdown of society, near-death experiences, and even coma may facilitate them" [10].

It is of interest to note that none of the above mentioned procedures, agents, and methods would *necessarily* induce ASCs. Several factors, such as personality traits, and certain other details that pertain to the application of some ASCs induction procedures, such as the ingestion of drugs, or the spontaneous occurrence of specific ASCs induction circumstances, such as certain diseases, might play an influential role in deciding whether or not any shift in consciousness would be induced. Therefore, it is often almost impossible to know in advance whether ASCs would be induced upon the application or occurrence of any of the aforementioned procedures and circumstances. This remark is of special importance when investigating the possibility of defining ASCs and determining their characteristics because it suggests that neither the deliberate application of any of the mentioned procedures nor the spontaneous occurrence of certain circumstances could be used as an indicator of the induction of ASCs.

The above mentioned lengthy list of ASCs induction procedures suggests that ASCs could be induced by diverse methods of psychological and biological stimulation. Some of these stimuli may appear spontaneously in the course of daily life without interference from the experiencer, such as sleeping and dreaming, whereas others require deliberate preparation, such as the ingestion of drugs. Obviously, the numerous procedures and circumstances which are believed to induce ASCs are essentially different in nature in that, apart from assuming them ASCs-inductive, there is no common features between them, and hence, there is hardly any point in attempting to group these numerous procedures and circumstances under any comprehensive description whatsoever. Furthermore, some of these ASCs induction procedures even cause entirely opposing psychological and biological effects. For instance, Ludwig notices that ASCs could be induced through procedures that cause "*Increase*," or inversely, "*Reduction of Exteroceptive Stimulation and/or Motor Activity*," and that while they may be brought about by methods that cause "*Increased Alertness or Mental Involvement*," ASCs could also be engendered by "*Decreased Alertness or Relaxation of Critical Faculties*" [8]. However, there have been many attempts to find features common to all ASCs.

One of the first studies that concentrated on investigating characteristics of ASCs was conducted by Ludwig [8]. Leading a psychological approach, Ludwig listed a number of cognitive changes that, in his opinion, underlie "most" ASCs. These changes are "Alteration in Thinking, Disturbed Time Sense, Loss of Control, Change in Emotional Expression, Body Image Change, Perceptual Distortions, Change in Meaning or Significance, Sense of the Ineffable, Feelings of Rejuvenation, and Hypersuggestibility" [8]. Although he also notes that there are "apparent differences among ASCs," Ludwig considers the said psychological changes as "common denominators or features which allow us to conceptualize these ASCs as somewhat related phenomena" [8].

The characteristics suggested by Ludwig have, more or less, been adopted by many researchers who have considered a psychological approach to ASCs [27,28]. However, the assumed characteristics are subject to criticism. Although Ludwig refers to certain beneficial aspects of ASCs, details of his suggested characteristics make it clear that these represent *mostly* pathological changes in the consciousness and refer to states that are inferior to the OSC. Obviously, they indicate deterioration in the person's basic cognitive faculties. Additionally, the characteristics suggested by Ludwig are in fact a collection of possible

psychological alterations which may accompany *some* mental states that are considered as ASCs. However, these changes are by no means *characteristics* underlying *all* ASCs. The truth is that many of the numerous mentations that are today labeled as ASCs- for instance, some of the meditative states- do not share at least some of these characteristics.

There is, additionally, a general criticism that could be directed at any purely psychological approach toward the investigation of ASCs. The unproved assumption that is implied in such an approach is that ASCs could really be distinguished, defined, and categorized using psychological parameters only. Needless to say, relying on psychology to investigate ASCs would assign the experiencers of these states a great role in revealing the actual contents of their experiences. However, there are several considerable difficulties inherent in this approach, as discussed below.

Since the accuracy of a psychological approach to ASCs depends almost entirely on the subject's account of the phenomenology of his experience, then the failure of the subject in reporting with accuracy his psychological changes would undermine the whole approach. Investigating the phenomenology of ASCs is usually performed either introspectively or retrospectively. As for introspection, it has been suggested that "self-observation may change the subject's ongoing state of consciousness" [27]. Therefore, when reporting, a self-observing subject may not be describing his original ASC, but simply a new SC that he developed as a result of the act of introspection itself. Similarly, Pekala and Levine have indicated, though dismissed, that retrospection was ridiculed for "freezing" and hence destroying the most fundamental property of consciousness, its evanescent and fleeting quality" [29]. Such objections are almost impossible to reject, and they seem to invalidate techniques for assessing ASCs utilizing introspection and/or retrospection, such as the Phenomenology of Consciousness Questionnaire [29,30], Phenomenology of Consciousness Inventory [31], and Assessment Schedule for Altered States of Consciousness [28]. It should be noted also that in such techniques the formulation of terms of the inventory could be effectively biased by the experimenter's prior understanding and expectancy of the nature of ASCs. This might well result, as Shapiro notes in the case of meditation, in a situation where the "subjects' experiences are filtered through hypotheses generated by different individual experimenters who may or may not be sensitive to subtle nuances of meditation experience" [32]. Obviously, Shapiro's remark applies to ASCs in general.

In his review of the research on the phenomenology of meditation, Shapiro has pointed out many problems that could effectively limit the accuracy of the results expected from a phenomenological approach to ASCs, and hence, undermine their reliability. For instance, He indicates that "many of the experiences of an ASC are described as ineffable and therefore beyond conceptualization" [32]. This problem, as Tart [2] has noted, could come in two forms: inability of the subject to conceptualize the experience himself, and/or his failure to communicate it adequately to others. These implicitly represent criticism of the introspective and retrospective approaches respectively. The presence of any of these two problems would undermine the phenomenological approach to ASCs. In fact, Tart saw conceptualizing and communicating ASCs too much a problem before understanding these states that he suggested his well known concept of creating "state-specific sciences" where scientists are trained to experience specific ASCs and study their own experiences in detail [2]. Shapiro [32] also referred to another considerable problem concerning the generalizability of ASCs. He cites the find from research on state-dependent learning that what is learned in one state, although stored, is not always recallable in other states. This has been referred to as "state-bound knowledge" [33]. This is yet another criticism of retrospection which Shapiro describes as being "subject to the vagaries of *post hoc* subject "memory"" [32].

Moreover, further suspicions are thrown on the subject's ability to explore his own ASCs by the widely accepted view that every individual can be totally *unaware* while *continuously* moving in and out of various ASCs [10]. Rossi asserts the individual's ignorance of the continuous alteration in his consciousness and writes that "the average person in the course of a normal day does not recognize the many subtle alterations that are constantly taking place in his/her own consciousness" [4]. This view has serious implications for the subject's ability to access his own ASCs as an observer.

It is obvious that there is little hope that approaching ASCs from merely phenomenological perspectives would enable crucial access to the very nature of these most elusive aspects of man. This approach cannot be a reliable indicator whether an ASC has been induced or not; it has not been of much usefulness in revealing the differences between the various ASCs, and hence, it could not be used for providing a reliable classification of these states. The failure of the phenomenological approach in studying SC was only one face of its general failure in dealing with matters related to consciousness. This failure was so strongly felt that it led to the appearance of an alternative school in psychology: behaviorism.

Behaviorism was very much the outcome of the failure of the phenomenological approach, and in particular introspectionism, in studying consciousness. Yet behaviorism was so much a revolutionary methodology that it not only rejected introspectionism as a tool for exploring consciousness, but also discarded consciousness altogether. Naturally, SCs had no place in this new school of psychology. The behaviorists' argument was, as Güzeldere notes, "not only that *whatever psychology - the discipline - could study* could be studied by observing behaviour, but also that *all there was to psychology - the phenomenon -* was observable behaviour." [6]. Watson, a pioneer behaviorist, believed that:

"The time seems to have come when psychology must discard all reference to consciousness; when it needs no longer delude itself into thinking that it is making mental states the object of observation.... This suggested elimination of states of consciousness as proper objects of investigation in themselves will remove the barrier from psychology which exists between it and the other sciences" [34].

Although behaviorism declined, due to some inherent weakness in its fundamental argument, it seems that its goal of studying the psychology of man through objective observation rather than subjective descriptions has influenced even the study of consciousness. Rather than accepting the argument, which is still adopted by some researchers, that the main source of information on ASCs is the subjective accounts of those who experience these states [15,35], investigators started to try to replace the subjective descriptions and anecdotal accounts with some objectively observable and/or measurable criteria. This would enable the study of ASCs by *outsiders* rather than *insiders*, i.e. open ASCs to third party observation. The efforts in this direction have revolved around attempting to understand ASCs through investigating their physiology.

5 CHARACTERISTIC PHYSIOLOGY OF ASCs?

Many researchers have suggested the existence of characteristic physiology that underlies all ASCs, and hence, differentiates these states from the OSC [26, 36, 37]. Winkelman states that these common physiological characteristics include:

[R]eplacement of the normal physiological condition of sympathetic dominance and desynchronized fast wave activity of the frontal cortex with a parasympathetic dominant

state characterized by cortical synchronization by high-voltage slow wave EEG activity originating in the hippocampal-septal area [20].

In fact, several researchers have pointed out that ASCs are characterized by increase of slow EEG frequencies. Deikman [14], for instance, expected such a physiological pattern of ASCs which represent the receptive mode in his bimodal model of consciousness.

It is important to note, first, that these physiological changes are not strictly confined to the mental states that are customarily labeled as ASCs. Similar physiological alterations of decreased electrocortical arousal might also appear due to relaxation only. Additionally, and more importantly, there are many ASCs that do not share the assumed physiological pattern, whereas others even show opposite physiological changes. In support of this critical view, many examples could be cited from the literature of the physiology of meditation, which is believed to be the source of some major techniques for inducing ASCs and TSs. In fact, meditation has been the target of a great part of the research on the physiology of ASCs. The discussion here will be confined to the observed changes in EEG, which are central to the suggested model of physiology of ASCs, and on which advocates of the assumed model usually build up their argument.

Despite the fact that many researchers have reported a slowing of the electrocortical activity of meditators [38,39,40], these findings were not always reported by investigators of the physiology of meditation. For instance, Bagchi and Wenger [41] found no changes between the meditative and rest EEG alpha of fourteen yogis. Tebecis also noticed no changes in the EEG of some of the practitioners of Transcendental Meditation (TM) whom he studied, whereas the changes that he noticed on others were not necessarily repeated in subsequent experimental sessions. Hence, he came to the conclusion:

“EEG changes during TM were rarely as pronounced or consistent as previous reports suggest. There was considerable variation between subjects, some displaying no EEG changes at all during TM compared with an equal period of non-meditation. Any changes that did occur in a particular individual were not necessarily repeated in a subsequent session. A comparison of mean EEG parameters of the experimental group revealed no consistent significant differences between meditation and non-meditation” [42].

On the other hand, also investigating practitioners of TM, Banquet [43] has reported the appearance of high-level beta waves during the transcendence phase. Similarly, increase in beta activity during the samadhi stage of Yoga meditation has been observed by Das and Gastaut [44], and Fenwick [45]. Another important piece of research that could be cited here is the more recent study of the EEG of Tibetan monks during their practice of *g Tum-mo* yoga [46]. Benson and his collaborators have also observed increased beta activity in their subjects. Another significant finding of these researchers was a marked asymmetry in both beta and alpha activity between hemispheres, with greater right-to-left power ratios for beta activity and greater left-to-right power ratios for alpha activity.

With regard to the inconsistency of the findings of researchers in this field, it is also of interest to note that there are cases where the same group of researchers reported contradictory results from different experiments. For instance Anand and his collaborators in the study referred to above investigated the EEG of four experienced practitioners of Raj Yoga and found a persistent and well modulated alpha activity, more marked during samadhi [38]. However, these same researchers reported in that same year different results from their

experiments with a Yogi meditating in an air-tight and sealed box. This time, the EEG of their subject showed mostly a low voltage fast activity throughout the experiment [47].

The above asserts that no specific pattern of cerebral electrocortical activity characterizes all meditative states. Schuman who reviewed the literature on the psychophysiology of meditation notes that “Although there is some consistency in the reports of psychophysiological changes during meditation, the data are clearly not sufficiently robust to warrant the conclusion that any particular pattern of psychophysiology is invariably associated with the meditative ASC” [48]. Davidson [49] also has affirmed that there is no evidence on physiological changes that are unique to meditation. Obviously, the inconsistency in the findings on physiology of ASCs would be more striking if results of investigation of physiological changes that occur during ASCs induction procedures other than meditation are considered. For instance, a pilot investigation by Hughes and Melville of changes in the electrocortical activity of ten experienced subjects during their practice of what these researchers term “trance channeling” has revealed, “large, statistically significant increases in amount and percentage of beta, alpha, and theta brainwave activity” [50]. Absence of agreed characteristic physiology has also been noticed for other subclasses of ASCs including hypnosis [51].

In fact, overestimating the usefulness of the EEG in studying ASCs has been criticized by several researchers. Gauld has noted that “the EEG is a fairly weak indicator of changes in mental state- it is perfectly possible for someone under the influence of a major hallucinogen to register a normal EEG” [51]. This fact has been exceptionally emphasized in the case of hypnosis. For example, Ravitz notes, “hypnosis had continued to elude any objective, quantifiable, reproducible measure, even with the EEG and with secondary skin-resistance changes” [52]. Prince agrees and writes that “The electroencephalogram (EEG) of an individual in hypnotic trance is indistinguishable from his EEG while he is in a normal waking state (nor does the EEG of the hypnotically blind differ from normal)” [53].

Another physiological change that has been suggested to be characteristic of ASCs is the activation of special capacities of the right cerebral hemisphere during ASCs [54, 55]. Gowan has even defined ASCs in terms of this change stating that “an altered state of consciousness [is] any state where left hemisphere function is in abeyance” [56]. This model, however, has been rejected by other researchers. Earle, for instance, in his review of the literature on cerebral laterality and meditation confirms that there is no evidence for an increase in the activity of the right cerebral hemisphere or a decrease in that of the left during meditation:

“[I]n the early stages of meditation, relative right hemisphere activation may be induced through the control of attention, the use of visual imagery and the inhibition of verbal-analytical thought. During the advanced stages of meditation, however, cognitive functions associated with each are either automatised or inhibited, leading to a reduction in cortical activity or diminished cortical participation in the generation of mental phenomena” [57].

Research on hypnosis has also shown that there is not such a simple and direct relation between ASCs and increase in the activity of the right hemisphere. Although Crawford and Gruzelier refer to “evidence in low hypnotizable individuals of an imbalance of function favoring the right hemisphere, both in nonhypnotic baseline conditions and, importantly, during hypnosis induction” [58], they maintain that:

“[H]igh susceptibles have imbalances of activity favoring the left hemisphere. Performance on validated neuropsychological tests contrasting left- and right-hemisphere processing,

such as word versus design fluency and word versus face recognition memory, has also disclosed left-hemispheric processing advantages in highs [highly hypnotizable persons]" [58].

In fact, relating ASCs to increased activity of the right hemisphere has not been the result of direct observation of such relation, but rather indirect conclusion from matching frequent appearance/acquisition or loss by experiencers of ASCs of certain abilities known to be associated with capacities characteristic of either of the cerebral hemispheres. In this regard, researchers have given great importance to the *ineffability* with which many experiencers of ASCs tend to describe their experiences [8]. For instance, Lex who investigated what she terms as "ritual trance" concludes that "if the capacity to conceptualize motion and process is absent in the right hemisphere, then the inability to describe trance experiences points to right-hemisphere dominance in such states" [59]. Davidson [49] also suggests that the absence of sequential and analytic thinking, and the appearance of intuitive, holistic, and non-verbal mental processing- the two modes of cognition supported by the left and right hemispheres respectively- indicates right-hemisphere dominance during ASCs. A similar trend of indirect conclusion has led to the "commonly espoused *hypothesis*," Sabourin and his collaborators note, "that hypnosis [per se] involves greater right hemisphere involvement". These researchers assert that the physiological (mainly EEG) findings are "inconsistent," and that hypothesizing on the involvement of right hemisphere activity in hypnosis is usually evidenced by "enhanced imagery and/or holistic processing that are commonly believed to be right hemisphere functions" [60].

Davidson himself asserts the speculative nature of this physiological model of ASCs. He also mentions, yet rejects, factors other than right hemisphere dominance, that may lie behind the inability of the subject to describe his experience verbally [49]. However, his dismissal of these other factors as possible causes of the *ineffability* of ASCs instead of the proposed right-hemisphere dominance is not convincing. Now, apart from the considerable problem of establishing the genuineness of this *ineffability*, the other fact that should not be overlooked and which researchers generally accept is that *not all* ASCs are *ineffable*. At least those ASCs the investigation of which is done through experimenter-experiencer communication should be expressible, otherwise this sort of investigation could not be validated. This point is very important because the right hemisphere dominance model is built on the *ineffability* of ASCs. It would thus seem reasonable to conclude that there is a large number of ASCs which give no indication of dominant right hemispheric activity.

It seems obvious now that ASCs cover a wide variety of phenomena that are significantly different from each other in terms of physiology. Although some ASCs seem to share some common physiological characteristics, this cannot be generalized to all other ASCs also. The conclusion here is that ASCs cannot be defined or understood in terms of any specific physiological pattern.

One last point that should be emphasized is that the claim of the existence of characteristic physiology of ASCs is not reconcilable with what has been suggested by some researchers [1] that not all people have the same OSC, and that the OSC of a certain person might be an ASC to another, due to personality- and/or culture-based differences. Evidently, if both these views are to be accepted then the implication would be that *different persons have different physiology in their ordinary consciousness*. To date, there is no evidence for this implication, especially as the assumed physiological characteristics of ASCs are of the kind discussed above.

6 SEARCHING FOR OR IMPOSING CHARACTERISTICS OF ASCs?

The above discussion has affirmed that it is extremely difficult to validate any *psychologically* defined characteristics of ASCs. It has also been shown that the search for *physiological* characteristics of ASCs has yielded contradictory results, and the evidence is in fact strikingly against the existence of such characteristics. Besides the failure in using phenomenology and/or physiology to differentiate ASCs from the OSC, categorization of the various ASCs using phenomenological and/or physiological variables has also proved impossible. In this regard, Jilek notes:

“Altered states of consciousness has become an accepted designation for phenomena experienced and observed during hypnotic or meditative trance, in so-called hysterical dissociation, in ecstatic states of religious revelation, or during “possession” by a defined power or spiritual entity, usually of ancestral, celestial, or infernal provenance. The differences between these variously labeled states [ASCs] depend on the situational and sociocultural context. They are not psychologically or neurophysiologically based distinctions” [61].

Jilek's conclusion tells us the reality of experimental findings of the psychology and physiology of ASCs.

In fact, any argument that has suggested the existence of characteristics of ASCs in general [8, 20, 25, 36, 37], or of subclasses of ASCs such as meditation [14, 62] has had to ignore some weighty theoretical problems as well as findings of many experimental studies. Hence such arguments reflect selective rather than comprehensive readings of the literature. Consideration of the literature in its entirety reveals an enormous diversity of ASCs that might by far exceed the tools that current psychology and physiology can provide for realistic and reliable categorization. Although reports have shown that a number of ASCs do share some psychological and/or physiological correlates, there is not even a single attribute that is proved to underlie all these ASCs. Moreover, some ASCs seem to show psychological and/or physiological behavior opposing that of other ASCs.

Some researchers have conceded the existence of inconsistency and contradiction in experimental findings on the physiology of ASCs, but suggest that these discrepancies do not indicate the absence of common physiology of ASCs. Their argument usually implies that though yet unrevealed, there is physiology characteristic of ASCs. For instance, Gittelson criticizes the used measuring tools stating that “determining where the relaxation factor ends and other state-of-consciousness factors begin is impossible without a more precise measurement than is currently available” [63]. Gittelson is implicitly concluding that categorization of ASCs would be possible should higher precision in measurement be reached. Lex's speculation is that “investigation of ritual trance cannot be restricted to brain behavior, because the organs of the body are homeostatically interconnected by the nervous system” (Lex, 1979: 119) [59]. In this context, it is rather surprising to note that dissatisfaction with the results of research on physiology of ASCs [and trance] has entailed special criticism of anthropologists, being the main collectors of ethnographic data of ASCs. For instance, Lex says in her severe criticism:

“[A]nthropologists have not equipped themselves to understand and apply perspectives from the biological and psychological sciences to ethnographic observations; the subjects of inquiry, theories, and methods of these disciplines do not readily coincide with traditional anthropological interests in culture or social structure. Instead, anthropologists

usually elect either to confine their disquisitions of trance phenomena to social or cultural matters or to rely uncritically on the few findings of other scientists that directly treat ritual trance, incorporating these narrowly focused, and often ethnocentric, interpretations into their analyses” [59].

Prince seems to have taken a similar stance, yet moderated it by extending the responsibility for the absence of research on the neurochemistry of ASCs to neurochemists in addition to anthropologists. His explanation is that, “A basic problem in the field has always been that neurophysiologists and neurochemists have had little interest in religious experience, and anthropologists have lacked competence in the basic sciences.” [64].

On the other hand, on the grounds of the revealed diversity of ASCs, Wright doubts the existence of any form of physiological characteristics of these states and hence writes, “It is not clear whether or not a variety of ASC[s] represent a common set of psychophysiological changes” [65]. Schuman was more confident in denying the existence of common physiology of ASCs as she believes that such commonality cannot be established even for a subclass of ASCs, namely, the meditative states. She believes that “it seems unlikely that the complex phenomenology of meditation can be accounted for in terms of a very few (and rather crudely defined) psychophysiological data” [48].

It seems then reasonable to speculate that many researchers appear to address ASCs with the preconception that these mental states *must* have common physiology. Besides what has already been mentioned, there are many examples in the literature that obviously attest to this conclusion. For instance, Jilek who investigated the dancing ceremonies of North American Indians *predicts* that “What awaits clarification are the biochemical and neurophysiological mechanisms underlying those altered states of consciousness that are associated with a peak experience of potential therapeutic significance” [61]. Although Jilek has rejected the existence of psychology or physiology of ASCs in general [61], he speculates that those ASCs that are associated with healing have specific physiological mechanisms that could be revealed if examined (for a discussion of the adverse effects of using the vague terms ASCs and TSs to understand healing phenomena see Hussein *et al* [66, 67]).

It is of relevance to this discussion to note how much researchers could disagree while interpreting almost the same experimental reports of the physiology of ASCs. For instance, the contradictory findings of various investigators have urged Schuman [48] in her excellent review of the physiology of meditation to generalize her conclusions to other ASCs, quoting Johnson:

“EEG and autonomic activity cannot be used to define states of consciousness. The state of consciousness of the subject must first be known before the physiological significance and possible behavioral meaning of the EEG and autonomic responses can be inferred” [68].

However, these same contradictions, though mentioned, have been glossed over in another review of the EEG of meditation that was published in the same year by West who concluded: “The work on meditation and the EEG has produced results which suggest that meditation might be differentiated from other altered states and is therefore of some importance” [62].

The above examples expound how the growing body of evidence on the versatility of ASCs and the existence of major psychological and physiological differences between these states have been carelessly overlooked, deliberately undervalued, and unhesitatingly classified as irrelevant, and that all that matters for the analysts of the enormous amount of data from field reports and laboratory experiments of ASCs is a *few* ostensible similarities between *some* ASCs. It is clear, therefore, that much effort in this field was directed toward *forcing*

observations to *prove* the existence of universal characteristics of ASCs rather than considering these observations in an unbiased manner to *explore* whether such characteristics exist or not.

Awareness of considerable differences in the phenomenology and physiology of the different ASCs [and TSs] has not prevented some researchers from attempting to propose the existence of other sort of similarity between these states. An example on this attitude is Van Der Walde's [69] approach to TSs. Van Der Walde has stressed:

“[B]ecause the differences among trance states are far more numerous than are their similarities, it has been difficult to generalize meaningfully about basic similarities. Attempts by past workers to describe various kinds of trance states as closely related phenomena were usually undertaken from too specialized a frame of reference, so that researchers were never fully able to reconcile different trance-state manifestations within a unifying theoretical framework” [69].

However, this clear view of the differences between TSs has not prevented Van Der Walde from trying to unify all TSs by supposing that one common etiology stands behind the occurrence of these states. He has written that “despite the many external differences of various trance states, all trance states have basic, underlying ego mechanisms in common” [69], that allows for the “discharge of basic drives in a goal-oriented manner,” as well as serves other “adaptive and defensive purposes” [69]. In this example, Van Der Walde could not overlook the psychological and physiological differences between TSs, therefore, he looked to psychoanalysis for assumed underlying commonalities between all TSs. This is yet another attempt to unify the TSs at all costs.

In terms of psychology and physiology it is not possible to differentiate ASCs from OSC, the various ASCs from each other, TSs from non-TSs, or the numerous TSs from each other. The previous discussion has shown that in order that the term ASCs encompasses all states that include change in consciousness it can only be assigned a very poor, negative definition: ASCs of an individual refers to *all the mental states of that individual that are different from his OSC*. Since ASCs are changes in consciousness, and given that TSs are special cases of ASCs, then TSs should represent *specific changes* in consciousness. Therefore, associated with this amount of vagueness, it should not be surprising that the term TSs has successfully defied definition, and thus, proved to be one of the most incommunicable terms.

Now, even if the serious theoretical and practical difficulties that surround the psychological approach to ASCs are ignored and subjective phenomenological evaluation of these states is accepted as a criterion for distinguishing ASCs from the OSC, would it be possible to overcome the difficulties of differentiating various ASCs from each other, TSs from non-TSs, and TSs from each other? In other words, provided that a psychological model for distinguishing ASCs from OSC is accepted as a working hypothesis, would such an approach really yield tangible evidence that these numerous ASCs form a unity in any scientific sense at all? Is there any indication of the existence of objectively and/or subjectively observable, measurable, and/or describable similarities between these various states that justify the attempt to study them as related manifestations of one phenomenon? On the grounds of the available data, there are good reasons to believe that the answer is no.

Lex [59], Gittelsohn [63], Prince [64], and others have suggested different explanations to account for the failure in uncovering the physiology that is assumed to characterize all TSs and ASCs; whereas others were simply satisfied with predicting its discovery in some future time [61]. The common misleading element in all of these attempts and the like is that they confidently, explicitly or implicitly, suggest the existence of some objective standards that could be used to define ASCs and TSs. Studies such as those cited above discuss why

extensive research could not reveal *the* characteristic physiology and/or *the* psychology of ASCs and TSs, but they never consider the possibility that there are no such characteristics at all. According to the available data, it seems legitimate to conclude that the truth is not that characteristics of ASCs and TSs *have not been discovered* but that they *cannot be*, and this is simply because such characteristics *do not exist* at all. It seems, therefore, that the criticism here should not be addressed to measuring tools, measuring procedures, incompetence of researchers, or researchers' lack of interest to explore characteristics of ASCs, but it should be directed to the unfounded belief in the existence of such characteristics. In brief, the strong tendency to ignore the versatility and prove the universality of ASCs reveals unwarranted reductionism. This attitude, which has often taken a physicalistic form, neglects the compelling fact that there might be a myriad of ASCs which are essentially different from each other.

It is interesting to read Winkelman, who is himself one of the advocates of the idea that all ASCs represent one phenomenon, referring to the prejudice in research in this area stating that “most investigators have implicitly or explicitly assumed that trance states of different practitioners and in different societies are similar or identical without explication of the grounds for such assumptions” [37]. An expressive example here is Goodman's treatment of the “religious altered state of consciousness.” A relevant quotation from this author reads: “I *assume* that there is only one religious or ritual state of consciousness, and that differences in experience are surface phenomena only” [emphasis added]. She continues by saying “Analogously, I am *proposing* that the physiological changes observed during the religious altered state of consciousness (RASC) represent the common deep structure, and the variety of religious experiences is the surface structure” [70]. Other examples of researchers who *assumed* similarity between the various ASCs and suggested that these states should be lumped together are Aaronson [3], Peters & Price-Williams [26], and Prince [71].

The fact that all ASCs are *mental* activities does not necessarily mean that these states represent a unity or could be studied as similar or directly related activities. In fact, the differences between ASCs might be as many as, or even more than, those found between the functions of different biological organs and systems of the human body. Mind, with its various aspects and manifestations, is still very much of a mystery, and in fact there is no reason to presume that it is not more complicated than the biological body. Unfortunately, the current status of the research into ASCs indicates undeniable and indefensible reductionism that has so far led research to give a highly simplified picture of these states. There is no convincing evidence whatsoever that this simplistic view represents the truth or something close to it. This reductionistic tendency is clearly manifested through using a few vague terms, such as ASCs and TSs, to refer to the numerous ASCs, and neglecting the need for accurate categorization and labeling.

It should be emphasized that although the previous discussion suggests that ASCs represent a wide range of totally different phenomena, it does not imply that these phenomena would not therefore lend themselves to scientific investigation. This would not be a fair conclusion, as it would be a premature one. What is rather suggested is that research on ASCs must not be built on the mistaken assumption that all ASCs are necessarily similar in essence, this assumption that seems to have been the outcome of undervaluation of essential differences between ASCs on the one hand, and aspiration to a simplified structure of the mental phenomena, on the other. However, it is not necessarily true that the structure and functioning of the human consciousness are as simple as many would like them to be.

In order to terminate the improper use of the terms ASCs and TSs and the confusion it has created, sufficient attention should be given to investigating *specific* ASCs rather than studying groups of entirely different states which have mistakenly been gathered under the confusing

terms ASCs and TSs and worsening matters by generalizing findings on certain ASCs to all other ASCs. That is to say, the need here is for distinguishing the different ASCs from each other and, of course, to label them with different names, as Murphy [72] hoped. General statements on ASCs should be supported by clear evidence or otherwise avoided. In fact, it might well be necessary to reconsider the validity of a great part of the current typology of ASCs. Other than ASCs and trance, terms that indicate *sub-classes* of ASCs might be subject to the same problem of referring to many ASCs among which there are major differences. This criticism has indeed been directed, for example, to hypnosis [73] and meditation [48].

Logically speaking, the process of classifying the numerous ASCs would first require the determination of criteria for categorization, i.e. specifying the qualities of each category. However, a glance at the current knowledge of ASCs reveals absence of substantiated criteria of classification. This is evidenced by the appearance and survival of highly obscure categories, such as hypnosis, under which totally different phenomena are lumped together. Needless to say, designing criteria for classifying ASCs is by no means a simple task, yet it is inevitable if a justified typology of ASCs is sought. This might well require holistic investigation of the various aspects of these states. Therefore, in principal, an ASC should not be categorized unless it is proved to have the criteria of a certain class. In other words, if an ASC escaped categorization then it should be considered a unique state, and the criteria of categorization should be improved to take into consideration the existence of such a state rather than trying to force this state into one of the already available categories. In fact, it is due to the absence of such criteria for categorizing ASCs that the few attempts to classify the later have met obvious failure. For instance, Krippner attempted to identify twenty ASCs. However, his classified states came with “considerable overlapping,” as Krippner himself notes. This was due to the fact that Krippner's classification was not built on clearly and properly defined criteria. Therefore, while he claims that his identification of the “Dreaming State” and the “Sleeping State” is based on the EEG, he identified other states, such as the “States of Rapture” and the “States of Fragmentation” on phenomenological basis. It is interesting to note that Krippner also indicates that “the relationship between the cortical electrical activity and states of consciousness [is] a very complicated one,” and therefore, he doubts the assumption that “the EEG might provide a reliable indicator of states of consciousness” [74].

The absence of agreed criteria for categorizing the ASCs is by no means a minor problem. It has led research into much confusion by creating inconsistent use of terminology by different researchers, and it has also caused different ASCs to be unjustifiably lumped together. Unfortunately, the research on ASCs has shown that there is little interest in contrasting the ASCs with each other and grouping them accordingly. This has urged some researchers to take a different approach that treats undefined (new) ASCs as unique states unless shown otherwise, as in the example below.

Some researchers thought that the research into human consciousness would develop into investigation of specific ASCs. For instance, in an article titled “Psychology in the year 2000” published in 1969, Murphy speculated that:

“[I]t is highly probable that before the year 2000 there will be both identification of many kinds of phenomenological states that are anchored upon particular types of EEGs, and the invention of appropriate *names*, appropriate language to describe the newly identified and newly integrated components. I am thinking particularly of cognitive states, conceptualizing states, creative states that may, while retaining all their charm and all their majesty, become far more describable, controllable, and achievable” [72].

However, the almost three decades that have elapsed since Murphy expressed his expectations have not converted this dream into reality. There has been hardly any success in identifying the different ASCs, and our terminology is still much of an obstacle to making any real progress in the knowledge of human consciousness. Without radical changes in the methodology of research and abandonment of prejudice in investigating phenomena, much progress would not be expected to be reached by the year 2000. Most probably, it is terms such as ASCs and TSs which will make progress into further obscurity and confusion.

REFERENCES

- [1] C.T. Tart, A systems approach to altered states of consciousness, in J.M. Davidson and R.J. Davidson, eds., *The Psychobiology of Consciousness* (Plenum Press, New York, 1980), pp. 243-269.
- [2] C.T. Tart, States of consciousness and state-specific sciences, in R.E. Ornstein, ed., *The Nature of Human Consciousness* (W. H. Freeman Company, San Francisco, 1973), pp. 41-60.
- [3] B.S. Aaronson, ASCID trance, hypnotic trance, just trance. *American Journal of Clinical Hypnosis* 16 (1973), pp. 110-117.
- [4] E.L. Rossi, Altered states of consciousness in everyday life: The ultradian rhythms, in B.B. Wolman and M. Ullman, eds., *Handbook of States of Consciousness* (Van Nostrand Reinhold Company, New York, 1986), pp. 97-132.
- [5] S. Sutherland, Consciousness, in *Macmillan Dictionary of Psychology* (Macmillan, London, 1989).
- [6] G. Güzeldere, Consciousness: What it is, how to study it, what to learn from its history? *Journal of Consciousness Studies* 2 (1995), pp. 30-51
- [7] M.M. Gill and M. Brenman, *Hypnosis and Related States: Psychoanalytic Studies in Regression* (International Universities Press, New York, 1959).
- [8] A.M. Ludwig, Altered states of consciousness. *Archives of General Psychiatry* 15 (1966), pp. 225-234.
- [9] E. Bourguignon, Trance and shamanism: What's in a name? *Journal of Psychoactive Drugs*, 2(1) (1989), pp. 9-15.
- [10] N. Field, The Therapeutic function of altered states. *Journal Of Analytical Psychology*, 37 (1992), pp. 211-233.
- [11] E. Frecska and Z. Kulcsar, social bonding in the modulation of the physiology of ritual trance. *Ethos* 17 (1989), pp. 70-87.
- [12] S. Ramaswami, and A.A. Sheikh, Meditation East and West, in A.A. Sheikh and K.S. Sheikh, eds., *Eastern and Western Approaches to Healing* (John Wiley and Sons, New York, 1989), pp. 427-469.
- [13] M.J. Winkelman, Physiological and therapeutic aspects of shamanistic healing. *Subtle Energies* 1(2) (1991), pp. 1-18.
- [14] A.J. Deikman, Bimodal Consciousness, in R.E. Ornstein, ed., *The Nature of Human Consciousness* (W. H. Freeman Company, San Francisco, 1973), pp. 67-86.
- [15] C.T. Tart, ed., *Altered States of Consciousness* (John Wiley and Sons, New York, 1969).
- [16] H.B. English and A. C. English, eds., *A Comprehensive Dictionary of Psychological and Psychoanalytic Terms* (Longmans, Green, New York, 1958).

- [17] L. Shaara and A. Strathern, A preliminary analysis of the relationship between altered states of consciousness, healing, and social structure. *American Anthropologist* 94 (1992), pp. 145-160.
- [18] E.M. Pattison, J. Kahan and G.S. Hurd, Trance and Possession States, in B. B. Wolman and M. Ullman, eds., *Handbook of States of Consciousness* (Van Nostrand Reinhold Company, New York, 1986), pp. 286-310.
- [19] J.M. Baldwin, ed., *Dictionary of Philosophy and Psychology* (Macmillan Company, New York, 1902), Vol. I.
- [20] M.J. Winkelman, Shamans and other "magico-religious" healers: a cross-cultural study of their origins, nature, and social transformations. *Ethos* 18 (1990), pp. 308-352.
- [21] R. Katz, Accepting "boiling energy": The experience of! Kia-healing among the! Kung, *Ethos* 10 (1982), pp. 344-368.
- [22] W.G. Jilek, Therapeutic use of altered states of consciousness in contemporary north American Indian dance ceremonials, in C.A. Ward, ed., *Altered States of Consciousness and Mental Health: A Cross-Cultural Perspective* (Sage Publi., California, 1989), pp. 167-185.
- [23] M. Lambek, From disease to discourse: Remarks on the conceptualization of trance and spirit possession, in C.A. Ward, ed., *Altered States of Consciousness and Mental Health: A Cross-Cultural Perspective* (Sage Publi., California, 1989), pp. 36-61.
- [24] K. Nishimura, Shamanism and medical cures. *Current Anthropology* 28(4) (1987), pp. S59-S64.
- [25] M.J. Winkelman, A cross-cultural study of shamanistic healers, *Journal of Psychoactive Drugs* 21(1) (1989), pp. 17-24.
- [26] L.G. Peters and D. Price-Williams, A phenomenological overview of trance. *Transcultural Psychiatry Research Review* 20 (1983), pp. 5-39.
- [27] J. Glicksohn, Altered sensory environments, altered states of consciousness and altered-state cognition. *Journal of Mind and Behavior* 14(1) (1993), pp. 1-12.
- [28] R. Van Quekelberghe, C. Altstotter-Gleich and E. Hertweck, assessment schedule for altered states of consciousness: a brief report. *Journal of Parapsychology* 55 (1991), pp. 377-390.
- [29] R.J. Pekala and R.L. Levine, Mapping consciousness: development of an empirical phenomenological approach, *Imagination, Cognition, and Personality* 1(1) (1981), pp. 29-47.
- [30] R.J. Pekala and R.L. Levine, Quantifying states of consciousness via an empirical-phenomenological approach, *Imagination, Cognition, and Personality*, 2(1) (1982), pp. 51-71.
- [31] R.J. Pekala and V.K. Kumar, The differential organization of the structures of consciousness during hypnosis and a baseline condition, *Journal of Mind and Behavior* 7 (1986), pp. 515-539.
- [32] D.H. Shapiro, Meditation as an altered state of consciousness: contributions of western behavioral science, *Journal of Transpersonal Psychology* 15(1) (1983), pp. 61-81.
- [33] R. Fischer, State-bound knowledge, in D. Coleman, and R.J. Davidson, eds., *Consciousness: The Brain, States of Awareness, and Alternate Realities* (Irvington Publishers, New York, 1979).
- [34] J. Watson, Psychology as the behaviorist views it, *Psychological Review* XX (1913), pp. 158-177.

- [35] C.A. Ward, The cross-cultural study of altered states of consciousness and mental health, in C. A. Ward, ed., *Altered States of Consciousness and Mental Health: A Cross-Cultural Perspective* (Sage Publications, California, 1989), pp. 15-35.
- [36] A.J. Mandell, Toward a psychobiology of transcendence, in D. Davidson and R.J. Davidson, eds., *The Psychobiology of Consciousness* (Plenum, New York, 1980), pp. 379-464.
- [37] M.J. Winkelman, Trance states: a theoretical model and cross-cultural analysis, *Ethos* 14 (1986), pp. 174-203.
- [38] B.K. Anand, G.S. Chhina and B. Singh, Studies on Shri Ramanand Yogi during his stay in an air-tight box. *Indian Journal of Medical Research* 49 (1) (1961), pp. 82-89.
- [39] A. Kasamatsu and T. Hirai, An electroencephalographic study on the Zen Meditation (Zazen), in C.T. Tart, ed., *Altered States of Consciousness* (John Wiley and Sons, New York, 1969), pp. 489-501.
- [40] R.K. Wallace and H. Benson, The physiology of meditation, in R.E. Ornstein, ed., *The Nature of Human Consciousness* (W. H. Freeman Company, San Francisco, 1973), pp. 255-267.
- [41] B.K. Bagchi and M.A. Wenger, Electrophysiological correlates of some yogi exercises, *Electroencephalography and Clinical Neurophysiology* 7 (1957), pp. 132-149.
- [42] A.K. Tebecis, A controlled study of the EEG during Transcendental Meditation: Comparison with hypnosis, *Folia Psychiatrica et Neurologica Japonica* 29 (1975), pp. 305-313.
- [43] J.P. Banquet, Spectral Analysis of the EEG in Meditation. *Electroencephalography and Clinical Neurophysiology* 35 (1973), pp. 143-151.
- [44] N.N. Das and H. Gastaut, Variations de L'activité électrique du Cerveau, du Cœur, et des Muscles Squelettiques au Cours de la Méditation et de L'extase Yogique, *Electroencephalography and Clinical Neurophysiology* Suppl. 6 (1955), 211-219.
- [45] P. Fenwick, Computer analysis of the EEG during Mantra Meditation, *Paper presented at Conference on the Effects of Meditation, Concentration and Attention on the EEG* (1960), University of Marseilles.
- [46] H. Benson, M.S. Malhotra, R.F. Goldman, G.D. Jacobs and P.J. Hopkins, Three case reports of the metabolic and electroencephalographic changes during advanced buddhist meditation techniques, *Behavioral Medicine*, Summer (1990), pp. 90-95.
- [47] B.K. Anand, G.S. Chhina and B. Singh, Some aspects of electroencephalographic studies in yogis. *Electroencephalography and Clinical Neurophysiology* 13 (1961), pp. 452-456.
- [48] M. Schuman, The psychophysiological model of meditation and altered states of consciousness: a critical review, in J. M. Davidson and R.J. Davidson, eds., *The Psychobiology of Consciousness* (Plenum Press, New York, 1980), pp. 333-378.
- [49] J.M. Davidson, The physiology of meditation and mystical states of consciousness. *Perspectives in Biology and Medicine* 19 (1976), pp. 345-379.
- [50] D.J. Hughes and N.T. Melville, Changes in brainwave activity during trance channeling, A pilot study, *Journal of Transpersonal Psychology* 22(2) (1990), pp. 175-189.
- [51] A. Gauld, *A History of Hypnosis* (Cambridge University Press, Cambridge, 1992).
- [52] L.J. Ravitz, Electromagnetic field monitoring of changing state-function, including hypnotic states. *Journal of the American Society of Psychosomatic Dentistry and Medicine* 17(4) (1970), pp. 119-127.
- [53] R. Prince, Shamans and endorphins: Hypotheses for a synthesis. *Ethos* 10 (1982), pp. 409-423.

- [54] D. Galin, Implications for psychiatry of left and right cerebral specialization, *Archives of General Psychiatry* 31 (1974), pp. 572-83.
- [55] R.E. Ornstein, *The Psychology of Consciousness* (Jonathan Cape, London, 1975).
- [56] J.C. Gowan, Altered states of consciousness: A taxonomy, *Journal of Altered States of Consciousness* 4(2) (1978), pp. 141-156.
- [57] J.B. Earle, Cerebral laterality and meditation: a review of the literature, *Journal of Transpersonal Psychology* 13 (1981), pp. 155-173.
- [58] H.J. Crawford and J.H. Gruzelier, A midstream view of the neuropsychophysiology of hypnosis: recent research and future directions, in E. Fromm and M.R. Nash, eds., *Contemporary Hypnosis Research* (Guilford Press, New York, 1992), pp. 227-266.
- [59] B.W. Lex, The neurobiology of ritual trance, in E.G. d'Aquili, C. D. Laughlin and J. McManus eds., *The Spectrum of Ritual: A Biogenetic Structural Analysis* (Columbia University Press, New York, 1979), pp. 117-151.
- [60] M.E. Sabourin, S.D. Cutcomb, H.J. Crawford and K. Pribram, EEG correlates of hypnotic susceptibility and hypnotic trance: spectral analysis and coherence. *International Journal of Psychophysiology* 10 (1990), pp. 125-142.
- [61] W.G. Jilek, Altered states of consciousness in north American Indian ceremonials. *Ethos* 10 (1982), pp. 326-343.
- [62] M.A. West, Meditation and the EEG, *Psychological Medicine* 10 (1980), pp. 369-375.
- [63] B. Gittelson, *Intangible Evidence* (Simon and Schuster Limited, London, 1987).
- [64] R. Prince, Introduction. *Ethos* 10 (1982), pp. 299-302.
- [65] P.A. Wright, The nature of the shamanic state of consciousness: A review. *Journal of Psychoactive Drugs* 21(1) (1989), pp. 25-33.
- [66] J. N. Hussein, N. Almuchtar, L.J. Fatoohi and S.S. Al-Dargazelli, The role of ambiguous terminology of consciousness in misunderstanding healing phenomena, *Frontier Perspectives* 6(1) (1996), pp. 27-32.
- [67] J.N. Hussein, L.J. Fatoohi, H. Hall and S.S. Al-Dargazelli, Deliberately caused bodily damage phenomena. *Journal of the Society for Psychical Research* (1997), in press.
- [68] L.C. Johnson, A psychophysiology for all states, *Psychophysiology* 6 (1970), pp. 501-516.
- [69] P.H. Van Der Walde, Trance states and Ego Psychology, in R. Prince, ed., *Trance and Possession States*, Proceedings of the Second Annual Conference of R. M. Bucke Memorial Society- March 1966 (l'Imprimerie Electra, Montreal, 1968), pp. 57-68.
- [70] F.D. Goodman, Body posture and the religious altered state of consciousness: an experimental investigation, *Journal of Humanistic Psychology* 26(3) (1986), pp. 81-118.
- [71] R. Prince, Variations in psychotherapeutic procedures, in H.C. Triandis and J.C. Draguns, eds., *Handbook of Cross-Cultural Psychology; Volume 6: Psychopathology* (Allyn and Bacon, Boston 1980).
- [72] G. Murphy, Psychology in the year 2000, *American Psychologist* 24 (1969), pp. 523-530.
- [73] G.F. Wagstaff, *Hypnosis. Compliance and Belief* (Harvester Press, Brighton, 1981).
- [74] S. Krippner, Altered states of consciousness, in J. White, ed., *The Highest State of Consciousness* (Doubleday and Company, New York, 1972), pp. 1-5.

EEG AND THE SLEEP DISORDERS: A NEW QUANTITATIVE APPROACH

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Abstract. The electroencephalogram (EEG), electrooculogram (EOG) and electromyogram (EMG) are the basic measurements performed in all sleep laboratories (EEG+EOG+EMG = PSG or polysomnography). The Electrophysiological Profile of Sleep (EPS) is derived from PSG and contained 130 variables of nocturnal sleep. The results of our investigations demonstrate that *the index of endogenous sleep perturbation* (IEP-P1=REM-1/NREM-1) is a highly reliable indicator of the development/regression of endogenic perturbation of sleep in depression, mania, schizophrenia, delusional state, organic brain syndromes and other psychotic states/altered states of consciousness ("transcommunication states"?). The Index of Endogenous Perturbation (IEP-P1) is either very *high* (I):

I *model* - "*delta deficit type*" (with reduction of "delta-sleep") in endogenous *depressed, manic, and paranoid* states ("*hyper-communication states*", IEP-P1 > 2.40); or very *low* (II): II *model* - "*REM deficit type*" (with reduction of "REM-1 phase") in *schizophrenia-like* states ("*hypo- and a-communication states*", IEP-P1 < 0.3) (N. Ilanković, 1986, 1995).

Key words: *sleep, sleep disorders, mathematical models, index of endogenous sleep perturbation, psychosis*

1 EEG AND A SLEEP DISORDERS

1.1 The Sleep Process

Sleep is a regular, recurrent, easily reversible state of the organism that is characterized by relative quiescence and by a great increase in the threshold of response to external stimuli relative to the waking state [1].

The most important question in sleep research is: Why sleep? What are the functions of sleep? Some researchers have even implied that sleep is a "vermiform appendix" that may have once served the function of keeping ancestors out of harm's way for a portion of the day but has no remaining function now. Most researchers believe that the sleep is - adaptive behavior (adaptation to day/night, light/darkness natural rhythm; or bioenergetic / thermoenergetic process which saves energy; or that sleep serves some restorative function...

In our point of view, we hypothesized two most important functions of sleep: (1) the physiological function of sleep as an adaptive behavior is "saving the brain from critical cooling", and (2) the psychological function of sleep is "keeping the continuity of mental functions/psychic life through the dream process (Ilanković, 1989) [2].

The Neurophysiology of Sleep

The waking state depends on the activity of the ascending reticular activating system (ARAS), which sends impulses to the forebrain for maintenance and physiological fluctuation of cortical activity ("cortical tonus") as a basis for all cognitive functions. For some time after the discovery of the ARAS (Moruzzi & Magoun, 1949) it was assumed that sleep supervenes whenever ARAS activity falls below a certain level ("the passive theory of sleep"). The synchronized, "slow sleep" (NREM sleep) in animals probably depends on the activity of certain "centers" in brain stem - especially the raphe nuclei (Moruzzi 1962, Jouvet, 1962, 1966) and certain areas in the medial forebrain ("the active theory of sleep"); other areas in the hypothalamus and the thalamus cannot be excluded. On the other hand, a brain stem system is necessary for the initiating and maintenance of paradoxical "fast sleep" - REM (Rapid Eye Movement Sleep). A region in the lower brain stem containing giant cells - the frontal gigantocellular field (FTG) may play a direct role in initiating REM sleep. McCarley and Hobson (1975) proposed that the states of sleep are regulated by a process of reciprocal inhibition between those FTG cells and the locus coeruleus. It seems likely that a reciprocal relationship involves the raphe nuclei and other areas in the addition to the relation between the FTG cells and the locus coeruleus (Hartmann, 1980).

Within that broad area, specific monoamine-containing pathways seem to be implicated in arousal or waking. The serotonin-containing raphe system is definitely necessary for normal sleep of both kinds (NREM, REM) to occur. The ascending noradrenergic system originating from the locus coeruleus and other brain stem norepinephrine regions play an inhibitory role in REM sleep (Hartmann, 1973) [1].

New Frontiers in Sleep Research

We are inclined in our new approach in explanation of sleep mechanism, to support the hypothesis that sleep patterns and circadian wakefulness-sleep cycle, are building blocks in some greater natural rhythms, shaped by interaction of external stimuli and internal performances of CNS, with certain adaptive and protective feature.

Having that in mind, we have created the hypothesis about *passive and active protective "help" systems*, which, through sleep, *protected the brain from critical cooling* (Ilanković, 1986, 1990) [2]!

In fact, reducing brain tissue's temperature would lead to regression of brain's electrical activity during NREM sleep, while through active processes of REM sleep metabolic homeostasis and homeothermic conditions would be regained. NREM periods are the time when nature is trying to cut down some energy spending by "passively preserving it" - "*passive help system*". This is managed by progressive inhibition of telencephalic activity and by marked reduction in muscle tone (disconnection of telencephalic region from rhombencephalic motor mechanisms). Since inactivation of great muscle groups is offering bad "saving plan" due to their significant role in thermoproduction, "*active help system*" is handling this thermoneuroenergetic disbalance and keeping the brain away from critical cooling point - through REM sleep active neuronal and metabolic processes in brain stem are released. They include increased cerebral blood flow, increased glucose utilization and rising brain tissue's temperature! Thanks to these active processes, brain is protected from critical cooling and yet another life saving and function preserving mechanisms are in effect.

This hypothesis tackles not only well known electro-chemical processes in neuronal function, but also some phenomena concerning *electromagnetic induction* (Ilanković, 1990). Investigations of these phenomena are in focus of scientific work and research in our "Sleep Center" of the University Clinical Center in Belgrade.

Sleep and Dream

Many psychological and psychophysiological studies indicate that the both electrophysiological types of sleep are identifiably different in mental activity.

The mental activity in NREM sleep is generally less vivid, less visual, less well recalled, more conceptual, more plausible, less bizarre, more like thinking than dreaming, less emotional, more concerned with contemporary waking experience and under greater volitional control.

On the other hand, the mental activity in REM sleep - dreaming, has the opposite characteristic. The dreams have other language, different symbolism with individual and collective meaning, altered dimensions of time and space (similar to the altered state of consciousness).

Freud's observation that state of sleep makes the formation of dreams possible by a reduction of the power of the censorship ("the way to unconscious..."), may have a neurophysiological analogy in the activation of REM through the activation of rhombencephalic and associated limbic circuits in relation to the reduction of controlling influences flowing from the corticofugal inhibitory systems...

Freud also viewed the dream process as a regressive mental functioning in the sleep state (1933). The regressive form of mental functioning in the dream process can be connected to the rhombencephalic pattern of sleep that is both ontogenetically and phylogenetically the more primitive form of sleep activity - Jouvet (1966) referred to such REM activation is "archisleep".

Modern neurophysiological research has opened up new vistas in the understanding of the mechanisms of the dreaming process. Two basic and conflicting hypotheses remain: (1) Freud's basically psychological hypothesis of diminished endopsychic censorship; and (2) Psychophysiological hypothesis of spontaneous activation of neuronal circuits as the underlying cause of dreaming activity. In our hypothesis (Ilanković, 1986) the REM sleep (as a one dimension of very complex dreaming process) has the underlying mechanisms in electromagnetic phenomena through the sleep [2].

The explanations of functions of dreaming activity are hypothetical too. Some scientist said: all is in Freud's works; other (psychophysiolgist) - in "dream activity" the important process is the work up of visual informations, selection and memorizing some of them. The hypothesis about "cleaning" function and tendency to "equipotentiality" of information through dreaming, is the very current theory today [3].

1.2 The Sleep Disorders

Sleep disorders are major psychiatric disorders that affect up to 30 percent of the population. In many sleep disorders a careful diagnostic workup reveals a specific cause of the insomnia and a specific treatment aimed at the cause may be used.

There are two major categories of sleep disorders in the revised third edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R) [4]:

- (1) The *dissomnias* and
- (2) The *parasomnias*.

The *dissomnias* are:

- (a) Insomnia (difficulty in falling asleep),
- (b) Hypersomnia (excessive amounts of sleep or complaints about excessive daytime somnolence), and
- (c) Sleep-Wake schedule disorder.

The *parasomnias* are a heterogeneous group of disorders in which episodic nocturnal events occur during sleep or at threshold between wakefulness and sleep.

Diagnostic classification of the Association of Sleep Disorders Centers (ASDC) is very similar with about 80 sleep disorders in 4 diagnostic group's [5]:

- (1) Disorders of Initiating and Maintaining Sleep (DIMS),
- (2) Disorders of Excessive Somnolence (DOES),
- (3) Disorders of the Sleep-Wake Schedule, and
- (4) Parasomnias.

1.3 Electroencephalography (EEG) of Human Sleep - A History

Scientific sleep research began little more than 120 years ago and may be divided into two eras: Pre-EEG era, the period from about 1860 to 1935, and EEG era, the period from 1935 to the present.

Pre-EEG Era

Prior to the development of EEG researchers employed a variety of measures to describe human sleep. These included threshold determinations, physiological measures such as body temperature, heart rate, respiration, pupillary size, metabolic rate, galvanic skin response (GSR) and electromyogram (EMG). In addition, monitoring of body movement was an extensively used technique.

Wohlich (1957) documented the beginning of scientific inquiry into sleep in his account of the thresholds experiments of Kohlschuter in 1860. Wohlich also described Fechner's account of what may be the first attempts to measure sleep "whereby the strength of sound necessary to awaken a sleeping person can be used for the measurement of the depths of sleep" (Fechner, 1860). Over the years many attempts have been made to measure and describe the depth of sleep in relationship to the strength and subjective relevance of various stimuli required producing arousal.

Body movement during sleep was also extensively measured prior to the period of EEG, but one of the most commonly used indices was sleep duration. In the midst of these widespread efforts to peer into to dark world of the sleeping subject came the interesting but seemingly irrelevant news in 1875 that Caton had detected currents from electrodes placed on the skull or the exposed brains of rabbits and monkeys.

However, it is a cause for some wonder that no one was interested in the work of *Hans Berger* some fifty years later, when in 1924 he recorded the first human EEG from electrodes on the scalp. Sleep researchers of the day paid no attention whatsoever, and when Berger undaunted, published his work in 1929, the scientific community in general greeted the news with incredulity. It is interesting to note that Berger was not the only one whose EEG findings were not accepted. A medical student at Harvard Donald McPherson in 1918, noted regular 10 per second waves recorded from electrodes placed on an exposed cat brain. However, when his superior criticized his findings as artifact, he pursued the discovery no further and the tracing was not found until 1944 when the laboratory was being cleaned of old materials! Gibbs and Gibbs (1951) suggest that Berger's work unheralded because he was a psychiatrist and published his work in psychiatric journals under titles that were "not especially informative", and that if Berger had "divided his work into discrete short studies, with satisfactory descriptive titles, and had avoided the psychiatric implications of his data, he might have been accepted more readily as a great neurophysiologist..." Herbert Jasper (1969) comments:"... It seemed highly unlikely at that time that the simple rhythmic waves, the "Alpha und Beta Wellen" of Hans Berger could possibly represent the true electrical

activity of such complex nerve tissue as the cerebral cortex especially in man, recorded not by experienced electrophysiologists but by a *psychiatrist* with rather crude and simple apparatus..." Whatever the reason, Berger's work did not receive recognition until prominent fellow investigators such as Lord Adrian (1934) began to confirm his studies [6].

The EEG-Era

The history of human EEG essentially begins with the acceptance of the work of Hans Berger. Sleep research, developing along other lines, did not immediately take advantage of this technique.

The EEG era in sleep research may be said to have begun in 1935 when *Loomis*, Harvey and Hobart, made the first classification of the electrical activity of the human brain during sleep. These investigators described five different patterns of electroencephalographic activity which they labeled A through E, and which they reported could be observed with different states of or levels of sleep. They suggested that a change in level of consciousness was connected with each change in wave-type. However, it was not until 1953 when *Aserinsky* and *Kleitman* first reported that sleeping subjects typically exhibited two kinds of eye movements, slow and rapid, that the scientific world was really awakened to the implications of the Loomis et al. work. In expanded study reported in 1955, Aserinsky and Kleitman investigated the rapid eye movement (REM) sleep state and its relation to dream reports and found that the slow eye movements occurred in three-to-four second intervals and the REM appeared in clusters that recurred several times during the night. When subjects were awakened during the REM periods, 20 out of 27 replies detailed dream descriptions; in contrast 19 out of 23 subjects awakened during Non-REM (NREM) periods reported no recall of dreaming.

The importance of Aserinsky and Kleitman's discovery was emphasized by *Dement's* classic demonstration of the "need" for REM sleep (1960). Dement found that after repeated awakenings from REM sleep, on subsequent night of undisturbed sleep a higher average amount of REM was observed (REM-compensation). The discovery of the REM state sparked renewed interest in the examination of physiological measures during sleep. It has now been shown that REM periods are accompanied by: a general increase in autonomic activity including heart and respiration rates and systolic blood pressure; a greater frequency of nocturnal penile erections; an increase in level of oxygen consumption; a decrease in oxygen supply; an increases in the secretion and osmolality of urine and changes in the circulating levels of plasma 17-hydrocorticoids; a general desynchronization of neural firing and an increase in neural activity in the motor and sensory areas of the brain; an increase in cerebral blood flow; a rise in brain temperature; and a decrease of tonic muscle activity (muscle tone in head and neck, reduction in spinal H-reflex).

Williams, *Agnew* and *Webb* began at the University of Florida Sleep Laboratories in the early 1960s to establish baseline for EEG sleep in normal humans. The original objective in investigating normative sleep EEG patterns of all age groups was to describe the ontogenetic progression of human sleep pattern and to provide baseline data for later studies of sleep disorders and for studies of the relationship of sleep and sleep disturbances to psychopathology.

1.4 EEG and a Sleep Disorders

The discovery of the human electroencephalogram (EEG), followed by the technology to study the electrophysiology of sleep, has made possible objective measurements of patients suffering from sleep disorders. The advent and development of computer technology has made the storage and the analysis of EEG sleep data quicker, less complicated and less expensive.

The electroencephalogram (EEG), electrooculogram (EOG) and electromyogram (EMG) are the basic measurements commonly performed in all sleep laboratories (EEG + EOG + EMG =

PSG, *polysomnography*). In addition, the electrocardiogram (ECG), blood pressure, respiration rate and amplitude, plus a variety of special measurements such as penile tumescence, penile blood pressure, blood oxygen saturation, temperature, and others.

The etiology of most sleep disorders is not known; however, PSG studies have made it possible to describe both qualitatively and quantitatively the electrophysiological characteristics of normal and disturbed sleep. Numerous sleep-variables have been examined and although may differ from laboratory to laboratory and from study to study, there are certain dimensions of sleep which are being examined in sleep disorders. Some of more frequently used include [7]:

- (1) The *time in bed* (TIB) which is measured from the time the subject is settled in bed until the EEG is turned off in the morning (mean by 20-29 old males - 442.23 min);
- (2) The *sleep period time* (SPT) which is the time in bed less the time it took the subject to fall asleep after the lights were out and less the time he lay in bed after awakening in the morning (mean - 424.64 min);
- (3) The *total sleep time* (TST) which is the sleep period time less any time the subject spent awake during the night after the initial sleep onset;
- (4) The *percentage of each sleep stage* (stage 1,2,3 and 4 NREM, and REM-period) which is usually computed as a percentage of the sleep period time that is occupied by a given sleep stage;
- (5) The *sleep onset latency* which is considered to be the time from lights out until the appearance of the first or second sleep stage;
- (6) The *number of stage shifts* which is the number of times sleep changes from one stage to another;
- (7) The *number of awakenings* (NAW) as indicated by the presence of "stage 0" are commonly counted;
- (8) The *latency of each sleep stage* which is the time from sleep onset to the appearance of a given stage;
- (9) The *stage sequencing* which is the order of appearance of each sleep stage; it has been reported in the normal sleep profiles and in the study of some sleep disorders;
- (10) The *sleep efficiency index* which is measure derived by dividing the total sleep time by time in bed;
- (11) The number of *rapid eye movement* (REM) *periods*, the *REM period length*, the *REM interval* and the *REM density*, all of which are measures which have been examined in normals and may be important in understanding certain sleep disorders; and
- (12) The *ratio of REM sleep to NON-REM sleep* (I.E.P, Index of Endogenous Perturbation; Ilanković, 1983.) has been studied in normals and appears to be important in understanding sleep disorders [8].

In our studies ("Sleep Center Belgrade") after analysis of polysomnogram (PSG), 130 basic and derived parameters were designated as the "*electrophysiological profile of sleep*" (EPS) [9].

The Advances in Technology of Polysomnography

The classical registration and analysis of polysomnography (EEG + EOG + EMG) is made according to accepted standards (Rechtschaffen and Kales, 1971) [8]. In sleep laboratory it is a registration over the night (from 10 p.m. to 6 a.m.) or over 24 hours with many limitations.

The big advance in technology of polysomnography is the utility of *ambulatory polysomnography*, which implies the recording of physiologic data during sleep from a subject who is free from attachment to stationary physiologic recording devices.

The earliest methods of ambulatory monitoring employed the transmission of data to a remote display and/or recording device. Data transmission was accomplished using radio frequencies and telephone. These methods were employed as early as 1921 for EKG, and 1949 for the recording of EEG. However, the technologist must go to the home of the patient at the beginning and end of study to attach electrodes, set up equipment, establish the telephone connection and reverse the process at the end of the study.

More recently developed ambulatory monitoring systems allow for the recording of data on a tape recorder directly attached to the patient /subject - *cassette polysomnography*. These devices currently record in an analog mode and can store large amounts of data on an inexpensive medium (audiotape). Although the "Holter Electrocardiographic Monitor" was first designed in 1961, a multichannel recorder suitable for polysomnographic application did not become available until 1971. *Wilkinson* was the first to report polysomnographic cassette monitoring of acceptable technical quality in 1973 [10].

Clinical Applications of Cassette Polysomnography in Sleep and Sleep-Related Disorders

The ASDC (Association of Sleep Disorders Centers) nosology divides the sleep disorders into four large groups: (1) DIMS (insomnia), (2) DOES (excessive somnolence), (3) Disorders of sleep-wake schedule, and (4) The dysfunctions associated with sleep, sleep stages, or partial arousals (parasomnias).

- (1) *Insomnia* is a disorder of initiating or of maintaining sleep (DIMS). Ambulatory cassette polysomnography (ACPSG) in patients with insomnia has demonstrated sleep apnea, narcolepsy and periodic (leg) movements (PLM) in more than 70 % of cases. Many patients has elevated Number of Awakenings (NAW) - fragmentation of nocturnal sleep, according to our Model of Exogenous Sleep Perturbation (Ilanković, 1983) [8].
- (2) *Hypersomnia* disorders are also known as disorder of excessive somnolence (DOES). The patients with hypersomnia have two groups of symptoms: complaints about excessive amounts of sleep and complaints about excessive daytime sleepiness (somnolence). According to a recent survey, the most common conditions responsible for hypersomnolence severe enough to be evaluated by all-night recordings or by ambulatory cassette polysomnography (ACPSG), were sleep apnea and narcolepsy. ACPSG in-patients with narcolepsy has demonstrated: multiple brief spontaneous naps, many with sleep-onset REM periods (SOREMPs), and disrupted nocturnal sleep. A day times Multiple Sleep Latency Tests (MSLT) - several recorded naps at two-hour intervals show very rapid sleep onset and usually one or more SOREMPs. NREM-narcolepsy is an idiopathic or symptomatic (!) hypersomnolence and it is characterized by recurrent daytime sleepiness, but sleep attacks (cataplexy, sleep paralysis) do not occur, because the sleepiness is not as irresistible as in narcolepsy (REM-narcolepsy).
- (3) Extended monitoring (ACPSG) may be most directly applicable to *disorders of the sleep-wake schedule*. These disorders are characterized by the patients inability to wake at desired times despite achieving normal overall amounts of unimpaired sleep or to sleep at the desired time despite a normal preceding period of wakefulness. These disorders are truly circadian in nature and demand extended monitoring for thorough evaluation. Among the more common of the disorders of sleep-wake schedule is that occurring with changing work shift. The implications

for worker safety and productivity are enormous. "Jet lag syndrome" is the other most common type of this disorder. Long-term ambulatory temperature monitoring has been useful in understanding delayed sleep phase syndrome.

- (4) Reports concerning the use of ACPSG for PARASOMNIAS are yet forthcoming. The combination of ambulatory monitoring and videotape monitoring is helpful in diagnosis for certain parasomnias e.g. sleepwalking, sleep terror disorders (stage 3,4 NREM), nightmare (REM), head banging (pre-sleep period or light sleep), etc.

In addition to these applications, ACPSG has begun to uncover the relationship between sleep and various medical disorders. The peak time of day for sudden cardiac death occurs at the REM-sleep rich period 5 to 6 a.m. ACPSG has been employed to study the relationship of ventricular ectopia to sleep stages.

Ambulatory monitoring has been applied to other systemic dysfunctions associated with sleep, including esophageal reflux, impotence, etc.

2 A NEW QUANTITATIVE APPROACH

2.1 Aim of Our Study and Methodology

In our study on the example of the depressive disorders, we would like to point out the importance of the measurable variables of Electro-physiological Profile of Sleep (EPS) as the components in differential diagnosis of reactive and endogenous mental diseases (EPS= 130 variables of nocturnal sleep derived from PSG = polysomnography = EEG + EOG + EMG).

The sleep disturbance very frequently seen in depressive conditions is the initial basis for the discovery of certain neurophysiological parameters of nocturnal sleep that could be used as indicators of endogenic perturbation in chronobiological functions of brain [9].

Selection of the sample (90 patients with "maior-depression" according DSM-III-R, 30 reactive + 30 endogenous depression; and 30 patients with acute schizophrenia), precise neurophysiological measuring (PSG) and exact statistical testing (MVA, Discriminative analysis "step by step") result in establishing new indicators of changes in internal sleep organisation as factors used in the appraisal of the qualitative switch from the biologically adapted state to the development of biological/endogenic perturbation.

2.2 Discriminative Profile of Sleep (DPS)

In this way, using only 2 parameters of EPS (of 130 available) of the first period of nocturnal sleep (registration time is shortened from 8 to 1 hr!), the problem of exact classification of new patients in group with and without endogenic perturbation of sleep (with reactive and with endogenic depression), seems easier to solve.

Practical application can be seen in the following example of classification function - Discriminative Profile of Sleep, DPS) for STAD-1,4 (4th stage of the 1st period) and REM-1 (first REM period, SOREMP):

$$(k_1 - k_2) \times \text{STAD-1,4} + (k_1 - k_2) \times \text{REM-1} \begin{cases} > K_1 - K_2 \text{ (exogenous depression)} \\ < K_1 - K_2 \text{ (endogenous depression)} \end{cases}$$

where

$k_1=1.023$, $k_2=0.135$ (for STAD-1,4);
 $k_1=1.263$, $k_2=1.935$ (for REM-1); and

K1=-44.565, K2=-66.789.

2.3 The Models of Exogenous and Endogenous Sleep Perturbation®

The statistical *model of exogenous perturbation of sleep*, characteristic of exogenous/reactive (depressive) states consists of:

- (1) The increased Number of Nocturnal Awakenings (NAW) -statistically the most important phenomenon
- (2) Shortened REM-sleep,
- (3) Prolonged first sleep period,
- (4) Decreased REM/NREM Ratio.

The *indicators of development (progress/regression)* of endogenic perturbation are also determined:

- (1) Decreased NAW,
- (2) Reduction of "delta-sleep" (stages 3 and 4 NREM),
- (3) Shortened first period of night,
- (4) Increase of total Wakefulness.

The statistical *model of endogenous perturbation of sleep* found in endogenic depression (but in mania, OMD, schizophrenia, paranoid states, anorexia, alcoholism, and at different time of development/maturation of human brain, too!), is composed of the following parameters of nocturnal sleep in two opposite situations:

I MODEL - "DELTA DEFICITE TYPE": (with reduction of "delta-sleep")

- In *endogenous depression and delusional states* (Ilanković, 1996):

- (1) Shortened REM-latency,
- (2) reduction of "delta-sleep",
- (3) increased of index of endogenic perturbation (IEP),
- (4) Prolonged REM-1 phase (SOREMP)

II MODEL - "REM DEFICITE TYPE": (with reduction of REM-1 phase)

- In *schizophrenia-like states* (Ilanković, 1996):

- (1) Prolonged REM-latency,
- (2) Disturbed "delta-sleep",
- (3) *Decreased of index of endogenic perturbation* (IEP)
- (4) *Reduction of REM-1 phase* (SOREMP)

2.4 Index of Endogenous Perturbation of Sleep (IEP)[®]

Neurophysiological measurements of the internal organization of sleep (REM/NREM alteration) in our studies was exposed to special statistical testing - the parameter approach in discriminative analysis [10].

The results of our investigations demonstrate that the parameter *index of endogenous perturbation of sleep* (IEP, Ilanković, 1983,1986,1995) is a highly reliable indicator of the development /regression of *endogenic perturbation of sleep* in depression, mania, schizophrenia and other psychotic states (altered states of consciousness), organic brain syndrome, etc.:

$$\text{IEP-P1} = \text{REM-1/NREM-1 (Index of Endogenous Perturbation)}$$

2.5 Age, IEP-P1 and the Specific Mental States

In healthy child who is 30 weeks old IEP = 4, in 1st year >1, in a healthy adult (25 years old) the mean value of IEP = 0.44, in old men (60 - 70 years old) < 0.4.

In *reactive* (depressive) states the IEP value is lightly elevated IEP-P1= 0.77.

In *endogenous* (depressive) states and in other states of altered mental function, altered states of consciousness and in *specific psychotic states* (schizophrenia-like and delusional states or hypothetically "*transcommunication states*" according clinical phenomena, Ilanković, 1986, 1995, 1996) [11] the alteration of sleep periodicity is very deep and the Index of Endogenous Perturbation (IEP-P1) is or very HIGH (I) or very LOW (II):

I MODEL - "DELTA DEFICITE TYPE" : (with reduction of "delta-sleep")

- In *endogenous depressed, manic, and paranoid states*:

"*hyper - communication states*", (Ilanković, 1986)
with IEP-P1 > 2.40 !

II MODEL - "REM DEFICITE TYPE": (with reduction of "REM-1 phase")

- In *schizophrenia-like states*:

"*hypo - and a - communication states*", (Ilanković, 1986)
with IEP-P1 < 0.30 !

3 CONCLUSION

The importance of this INDEX (IEP) can be seen in clinical approach (in classification of different states/type of mental illnesses, evaluation of therapy, course and prognosis) and in further research of: chronobiological mechanisms of brain, chronobiological plasticity of brain, *biological aging of brain*, *specific states of altered consciousness* and *specific psychotic "transcommunication states"* (?); and in biophysical modelling of brain mechanisms of sleep ("Electromagnetic nature of sleep", Ilanković, 1995 [11]).

REFERENCES

- [1] E.L. Hartmann: Sleep, in H. I. Kaplan, A.M. Freedman, and B.J. Sadock: *Comprehensive Textbook of Psychiatry*, 3rd ed. (Williams & Wilkins Baltimore/London 1980), Vol. 1:165-177.
- [2] N. Ilanković, *Sleep Disorders*, in D. Kecmanović : Psychiatry (Medicinska knjiga Beograd-Zagreb, Svjetlost Sarajevo, 1989); pp.1142-1176, in Serbian.
- [3] H.I. Kaplan, and B.J. Sadock, *Synopsis of Psychiatry*, 6th ed. (Williams & Wilkins, Baltimore, USA, 1991).
- [4] *American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders*, 3rd ed., revised (American Psychiatric Association, Washington, DC, 1987).
- [5] *Association of Sleep Disorders Centers: Diagnostic Classification of Sleep and Arousal Disorders*, First edition, prepared by the Sleep Disorders Classification Committee, HP Roffwarg, Chairman, *Sleep 2* (1979), pp. 1-137.
- [6] R.L. Williams, I. Karacan and C.J. Hirsch, *EEG of Human Sleep Clinical Applications*, (John Wiley & Sons, Inc., New York, 1974).
- [7] R.L. Williams and I. Karacan: *Sleep Disorders Diagnosis and Treatment* (John Wiley & Sons, New York, 1978).
- [8] N. Ilanković et al: Models of exogenous and endogenous sleep perturbation as diagnostic and therapeutic predictors in depression, *Meth. and Find. Exptl. Clin. Pharmacol.* 8(8) (1986), pp. 513-517.
- [9] N. Ilanković, *Electrophysiological Profile of Sleep in Depression*, PhD Thesis, University of Belgrade, 1983.
- [10] I.V. Dixon, ed., *B.M.D.P.* (Health Sciences Fac. Program, Dept. of Biomathematics, School of Medicine, University of California, Los Angeles, USA, 1976).
- [11] N. Ilanković and A. Ilanković: EEG and the Sleep Disorders, in D. Raković and Dj. Koruga: *Consciousness: Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1995), pp. 188-200.

MAGNETOENCEPHALOGRAPHY (MEG): SEQUENCING OF EVENTS IN THE BRAIN FROM MILLISECOND TO SECOND AND ITS RELATION TO PERCEPTION, AWARENESS AND CONSCIOUSNESS

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Abstract. The living state depends on electrical processes encompassing a wide spatial and temporal range, from the very small and swift (e.g. the electrical events associated with the opening of neuronal ion channels) to the large and slow (e.g. the near dc fields around limbs and developing embryos). These processes are interwoven in space and time, forming organised sequences of complex electrical events. In some cases the sequences are hierarchically and precisely ordered (e.g. the action potential of neurons or the sinus of the heart), with different stages associated with well understood physiological processes at anatomically well-defined places.

The most direct way of studying the brain involves recordings of the actual electrical activity. Such invasive studies either on animals or on humans, whenever presurgical evaluation procedures provide the opportunity, have greatly advanced our understanding of brain processes. On a different scale, the same generators that are mapped by the invasive electrodes generate a minute magnetic field that can be mapped non-invasively in Magnetoencephalography (MEG), with ultra-sensitive superconducting devices, operating just a few degrees above absolute zero. The magnetic field recorded in MEG is the complementary analogue of the more familiar electroencephalogram (EEG) which consists of differences in electrical potential on the scalp. The very presence of the MEG and EEG signal and the fact that consistent patterns are generated when the brain is exposed to similar stimuli, or a similar task is attempted demonstrates that the electrical activity in the brain is organised at the macroscopic level. This must be so because the electrical activity generated by a single or a few neurons is far too small to be measured by either MEG or EEG. The signal which can be picked up by the sensors is many millions of times stronger than what a single neuron can produce. The very presence of strong EEG and MEG signals suggest that the generators must be widespread distributions of neuronal populations acting coherently. The shifting patterns of EEG and MEG have characteristic times which range from a few milliseconds, to seconds or minutes. Other techniques like Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI) can also measure correlates of function, which however are surrogates measures because they rely on hemodynamic processes. The key property of MEG and EEG methods is that the changes in the signal correspond to instantaneous changes in the (coherent activity of the) generators because the signal travels from the generator to the detector with the speed of light. In contrast for PET and fMRI the measured activity is a few seconds (for fMRI) or minutes (PET) down stream the neuronal activations.

Measuring patterns of electrical potentials on the scalp or of the magnetic field around the head is however not easily related to the changes in the generators. In fact it is impossible to extract the distribution of generators even if the EEG and MEG signal is measured precisely and everywhere outside the head. It is nevertheless possible to extract reliable estimates when modest constraints are imposed on the nature of the generators. Furthermore the specific electrical properties of the intervening matter

between the generators and the detectors, and in particular the high resistivity of the skull makes the extraction of spatial information about the generators easier from MEG rather than EEG signals.

Measurements over wide area are needed for the reliable extraction of information about the generators. Also brain activity is characterised by habituation and variability (which is not the same as noise). For these reasons it was only recently that the potential of MEG has become apparent, with the advent of systems with well over one hundred channels covering the whole head. With these systems it is possible to analyse the response of the brain in each single trial, and begin to map out how the sequence of events in different brain regions leading to perception. The link between single epochs and what is generated after averaging has always been elusive. This now appears to be because it is not based entirely on properties of single neurons, or even the hardwired connections between neuronal assemblies. Hardwired connections are surely involved, but other mechanisms may also contribute.

Just like the atomic nucleus is bound by the mean nuclear field, to which every nucleon contributes, and which influences every constituent nucleon, so the consistency which supports awareness and the unity of perception may emerge, at least in part, from the mean pattern of activity, governed by volume conduction. The return currents may turn out to be more than a mathematical inconvenience; they have the capacity to carry information instantly and efficiently, across large cortical areas. Changes of the intensity and direction of volume currents generated by rhythmic impressed currents in primary sensory areas associated with a stimulus, and deep brain nuclei, could serve as a 'wireless' controller, pacing mechanisms which recruit and correlate parallel processes going on across the brain. The direction of flow could be used as a guide for population coding of continuous variables. The common theme in each epoch appears to be the overall self-consistency and smoothness of the current generated over key, task-specific areas. Not every neuron, not even every area has to be activated in each epoch, particularly if the same, biologically irrelevant stimulus is presented many, many times.

We have used the simplest of paradigms in studies aiming to determine what exactly survives and what is eliminated by averaging MEG signals time-locked to the onset of simple stimuli. We find strong training effects which even for the simplest of stimuli take long time (days of repetition) to reach a stability (in terms of the trial to trial statistical properties of the response). After removal of the baseline activity (computed at some earlier time for each single trial) and the evoked response (computed from the average across trials) we find a residual oscillatory activity which increases as training progresses, at the expense of the evoked response which is confined to narrower spatial and temporal windows. These narrower windows correspond to the latencies and areas that are classically associated with the task and stimuli used in the experiment.

Beyond perception, more complex MEG experiments, are used to map correlates of cognitive processes. During a cognitive task with simple stimuli (e.g. odd ball experiment) we find that the areas activated by the simple stimuli are re-activated at late latencies (e.g. reactivation of the auditory cortex after 300 ms in an auditory odd ball experiment). Similarly we find a reactivation of areas associated with processing of faces when judgment of affect is added to simple recognition task.

When we come to consciousness we are faced with the problem of defining what exactly we mean by this term. In the interface of awareness and consciousness we can make inroads by designing experiments where correlates are sought between changes in localised activity or global patterns and changes in the level of awareness. Such experiments have already started in PET and fMRI showing selective activations. It is expected that MEG will take these studies further by showing how the activity in these nodes is modulated in time, and get us closer to understanding how the very human aspects of perception, awareness and consciousness arise, or at least how their brain activity correlates manifest themselves.

Key words: *magnetoencephalography (MEG); MEG vs. EEG, PET & fMRI; brain temporal patterns; perception, awareness and consciousness.*

SOFTWARE SUPPORT FOR MONITORING EEG CHANGES IN ALTERED STATES OF CONSCIOUSNESS

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Abstract. Since computer technology has been used in the recording, processing and analysis of brain electrical activity, a lot of time and efforts have been spent in quantitative EEG analysis for clinical applications. It was mostly detection of gross pathologies and epilepsies and quantification of central effects of pharmacological agents. Altered states of consciousness, although seldom analyzed, represent a valuable basis for consciousness studies. Exploration of EEG correlates of different conscious states may reveal the nature of conscious processes itself. Therefore, an analysis of altered states of consciousness requires subtle signal processing methods, and powerful result visualization. This paper surveys EEG correlates, basic signal processing and visualization methods, and their use for qualification of altered states of consciousness.

Key words: *EEG, consciousness, signal processing, spectral analysis, altered-states, methodology, computer analysis.*

1 INTRODUCTION

Correlation of EEG changes with the gross neurophysiological changes has been used for diagnostic purposes and clinical practice since 1924, when Hans Berger recorded rhythmic electrical activity from the human scalp [1-3]. Although characterization of normal states of consciousness (wakefulness, sleep, coma, epileptic seizures, etc.) has been routinely used, correlates of brain electrical activity during altered states of consciousness are still not clear. Altered states of consciousness, as boundary phenomena, represent valuable basis for an analysis of consciousness itself [4].

Brain electrical activity is the most important mean of accessing human information processing and control mechanisms. It can be assessed using scalp potentials (EEG), change of magnetic field in the vicinity of the head (MEG), or potentials on the cortex (ECoG) [5]. Action potentials are too brief and irregular to generate EEG, which is mostly generated by the summed dendritic extracellular changes in ion concentrations [6]. Recorded on the scalp, this activity is further modified by inhomogeneities of liquor, skull and skin resistance.

The MEG provides a different view on the brain electrical activity, as the head is nearly transparent for neuromagnetic fields. However, the typical strength of neuromagnetic fields is eight orders of magnitudes smaller than the geomagnetic field, and only SQUID sensors made recordings possible. The main advantage of MEG is better spatial resolution of the site of origin of cortical activity (represented as dipoles within the head). Another advantage (and at the same time disadvantage) of MEG is its greater sensitivity to radial than tangential

component of the brain electromagnetic field, which is hardly detected by EEG, and vice versa. This is the reason why the EEG is still needed in experimental settings. Another promising technique is combination of records obtained by MEG and EEG, calculation of current source localization and its superposition on 3-D NMR (Nuclear Magnetic Resonance) brain images [5-8]. MEG technology is mostly used in analysis of cognitive tasks, and its price prevented a broader use for consciousness studies.

ECoG represents a method of registration of brain electrical activity directly from the cortical surface, mostly used in humans in preoperative evaluation in neurosurgery, and in animal models. It is mostly used to localize epileptic focus, with better spatial resolution. Therefore, it is hardly applicable to consciousness studies.

Although activation of certain regions could be traced using PET images, representing brain metabolic changes [9], only studies of brain electrical (and magnetic) signals can trace changes that take a fraction of a second. Therefore, these methods are convenient for an analysis of fast changes in the activity of neural systems, i.e. for an analysis of rapidly changeable spatio-temporal patterns of brain electrical activity that occur during mental operations (or psychic processes in general) [10,11].

This paper deals with efficient support for analysis of EEG correlates related to altered states of consciousness. Commercial software packages are often rather inflexible, with restricted number of channels and few tools for quantitative EEG analysis. Many of the advantages which could be obtained by a computer-assisted analysis usually are not achieved, e.g. variable length of epochs analyzed (adaptive segmentation of EEG signal), analysis of waveforms, feedback control of external stimulators (e.g. stimulus delivery triggered by some characteristic of EEG signal), integration of user-developed algorithms, etc. As it was not clear what are the most prominent features of different states of consciousness, it is necessary to probe various signal-processing methods and find out the most appropriate one for a given problem. New software environments make feasible fast development of application prototypes, which can significantly accelerate the analysis. We will present here rapid development of signal processing applications, and survey of signal processing methods applied for EEG analysis in altered states of consciousness.

2 COMPUTER-ASSISTED EEG ANALYSIS

Computers revolutionized electroencephalography, improving both temporal resolution and the precision [12]. Moreover, once digitized and stored digital records provide the means of different signal processing and statistical analysis on the same data set. However, digital storage places substantial storage requirements. For instance, 16-channel EEG with 128 Hz sampling rate and 12-bit precision requires 240 KB of storage per minute. This problem could be resolved using hierarchically organized storage and retrieval. Today, standard DAT tapes and CD-R present medium of choice for EEG record storage.

EEG signals may be classified as spontaneous on-going activity, spontaneous transient and evoked activity. The analysis is usually performed in time or frequency domain, and calculation of different scores is performed [13]. The time domain analysis evolved from classical, paper based EEG analysis. Waveform period can be estimated by period analysis, either estimated time between two zero-crossings or between two consecutive peaks in the waveform [14]. This method could be applied to waveforms that are almost pure sines (like alpha bursts), but regular EEG is usually composed of few superimposed frequency components. Therefore it is necessary to apply band-pass filter and then analyze its

components (usually slow and fast derivative). The advantage of period analysis is its simplicity, which allows real-time execution and signal analysis. The other important time domain analysis method is investigation of EEG signal modulation [15, 16]. EEG can be represented as both amplitude and frequency modulated signal, and its amplitude and frequency modulation index determined. It has been shown that amplitude modulation index represent correlate of cerebral blood flow [15].

Spectral analysis became common for computer based EEG systems since Cooley and Tukey in 1965 introduced computer efficient Fast Fourier Transform method (FFT). Typical measures of EEG activity are:

- *absolute power*, calculated as the amount of energy within a particular frequency band;
- *relative power* is the proportional contribution of certain frequency band in the total power spectrum, and reduces intersubject variance caused by differences in skull and scalp conductance;
- *mean frequency* is the average frequency in each frequency band;
- *asymmetry* compares the power or amplitude for the matched electrode pairs (usually left and right hemisphere electrode pairs);
- *anterior/posterior differences* compare electrode pairs within an given hemisphere (intrahemispheric gradients); and
- *coherence* as a measure of synchronicity between two electrode sites, which can be also inter or intra-hemispheric.

Spectral analysis parameters should be carefully chosen. The most important parameters are epoch length and type of data window [13]. Fundamental requirement for signal analysis is stationarity of the signal. Unfortunately, EEG signals are stationary only for very short periods of time. Usually, the segment is continued as long as signal satisfies the criteria of stationarity [12]. On the other hand, experience from the cognition studies suggests that the range of 10 s is the first level of composed operations in controlled processing mode [17]. It has been reported that the EEG signal is stationary, depending on ongoing activity, from several tens of milliseconds to a few seconds, and that is mostly a range from 500 to 1000 msec [18,19].

In the last decade the theory of nonlinear dynamics has found a place in EEG analysis as well. It has been shown that dimension of chaotic attractor of EEG signal represents significant feature related to global brain and consciousness states [19]. Therefore, dimensionality analysis and other procedures such as bispectral analysis provide exploration into the complexity of a nonlinear dynamical system [20-26]. Bispectral EEG analysis could be also used to assess phase relationships, which is also of great importance.

Most signal processing methods are based on the assumption that the EEG is a linear, gaussian process, which is often not true in the case of human EEG. It has been reported that during a mental arithmetic task EEG exhibits significant nongaussian behavior. The degree of deviation from gaussian distribution, depends on behavioral state, with the state of slow-wave sleep showing less gaussian behavior than quiet wakeful state, which is less gaussian than the REM sleep [20].

Another interesting feature of the EEG signal is current source localization [27]. It is particularly important for epileptic foci localization. In general, EEG presents two-dimensional measurement of a three-dimensional vector field, where unique localization of current sources is not possible. The main problem is passive current flow in the head volume conductor and dynamic properties of neocortical current sources.

3 EEG CORRELATES OF CONSCIOUS STATES

EEG signals vary as a function of the state and of the area of the brain. These signals reflect spatio-temporal patterns of brain electrical fields that consist of a series of short-lasting quasi-stationary epochs corresponding to brain functional microstates. The EEG signal reflects more readily changes in the state of the underlying neural network than specific aspects of the information processing. Functional significance of particular EEG frequency bands must be interpreted in respect to the brain region from which it was registered, and to the age of subject and his behavioral (mental) state. Even with these precautions in mind, there are still great inter-individual variations of EEG characteristics during idle state and mental operations. This is one of the reasons why there has not yet been made a normative database of normal EEGs. An example of complexity of interpretation of functional significance of brain rhythms is correlation of regional alpha power and brain metabolic rate measured by glucose utilization [28, 29] in which there is a high negative correlation for occipital regions, but positive for frontal, lower central and parietal regions. Here it is clearly shown that alpha rhythm can not be simply interpreted as "idle state" of cortex. Another example is occipital alpha that attenuates when subject becomes drowsy, but this happens only if the eyes are closed; if a person is keeping eyes open, then the appearance of alpha signifies drowsiness. Therefore, generalizations such as 'alpha activity is characteristic for relaxed awake state', or 'beta is typical of brain state of attentive information processing' must be taken with caution.

Table 1: Psychological states and their EEG, conscious and behavioral correlates; From: D.B. Lindsley, Attention, consciousness, sleep and wakefulness, In: J. Field, H.W. Magoun, and V.E. Hall, eds., *Handbook of Physiology*, Sect. I, *Neurophysiology* Vol. III (American Physiological Society, Washington DC, 1960)

Behavioral Continuum	EEG Characteristics	State of Awareness	Efficiency
Strong, excited emotion; fear, rage, anxiety	Desynchronized: low to moderate amplitude; fast mixed frequencies	Restricted awareness; divided attention; diffuse, hazy; "confusion"	Poor: lack of control, freezing up, disorganized
Alert attentiveness	Partially synchronized: mainly fast low-amplitude waves	Selective attention, but may vary or shift; "concentration" anticipation; "set"	Good: efficient, selective, quick reactions; organized for serial responses
Relaxed wakefulness	Synchronized: optimal alpha rhythm	Attention wanders – not forced; favors free association	Good: routine reactions and creative thought
Drowsiness	Reduced alpha and occasional low-amplitude slow waves	Borderline partial awareness; imagery and reverie; dreamlike states	Poor: uncoordinated, sporadic, lacking sequential timing
Light sleep	Spindle bursts and slow waves (larger); loss of alphas	Markedly reduced consciousness (loss of consciousness); dream state	Absent
Deep sleep	Large and very slow waves (synchrony but on slow time bases); random irregular patterns	Complete loss of awareness (no memory of stimulation or dreams)	Absent
Coma	Isoelectric to irregular large slow waves	Complete loss of consciousness; little or no response to stimulation; amnesia	Absent
Death	Isoelectric: gradual and permanent disappearance of all electrical activity	Complete loss of awareness as death ensues	Absent

EEG, as a relatively inexpensive and noninvasive form of functional neuroimaging, was frequently used to assess changes related to altered states of consciousness. It should be noted that liquor, skull and skin resistance, acting as a low-pass filter, attenuate high frequencies modifying original cortex activity. We expect that application of MEG technology to consciousness studies will enrich our knowledge of brain electrical activity during altered states of consciousness. To the best of our knowledge wider clinical and experimental use of MEG is at present mostly related to cognitive studies.

Most experiments and published papers were dealing with meditation like states of altered consciousness. The most important features of EEG changes related to meditation, reported in the literature, are:

- (a) Establishing alpha activity in spite of open eyes (Hirai [30]);
- (b) Increased amplitude of alpha activity (Hirai [30], Banquet [31,32], Wallace [33]);
- (c) Slower frequency of alpha rhythm (Hirai [30], Banquet [31,32], Wallace [33]);
- (d) Rhythmical theta waves (Hirai [30], Banquet [31,32], Wallace [33]);
- (e) Increased synchronization (*hypersynchronization* - Banquet [31,32]);
- (f) Dissociation of perception from the external sense organs (Hirai [30], Ray [34]);
- (g) Transcendent signal (Ray [34-36]);
- (h) Occasional fast wave activity (Banquet [32], Das and Gastaut [33], and Ray [35]);
- (i) Synchronous Theta Bursts [38];
- (j) Increased intrahemispheric coherence in the alpha and theta frequency bands [40]; and
- (k) Autonomous nervous system changes [39,40,41,42,44].

The first four changes are reported during the study of EEG changes related to Zen meditation [30]. Kasamatsu and Hirai ranked the changes in this order and find out that the changes directly depend on the mental state and experience in meditation. During zazen (Zen meditation) alpha was slowing down to 7-8 Hz, and rhythmical theta waves at six to seven cycles per second appeared in the last phase (attained only by skilled monks with long meditation experience). Wallace reported episodes of rhythmical EEG theta activity in frontal region [37], while synchronous theta bursts have also been found [38]. Very high EEG coherence during meditation has been frequently reported [37,39,42,43]. It may indicate increased orderliness of brain functioning.

Fast wave activity was occasionally reported [24,25,27]. Banquet identified synchronous beta waves from all brain regions of almost constant frequency and amplitude [24]. That activity was found in four advanced meditants during the subjectively reported deepest meditation. Das and Gastaut performed electroencephalographic examination of seven yogis and observed that as the meditation progressed the alpha waves gave way to fast-wave activity at the rate of 40-45 Hz, and that these waves subsided with a return of the slow alpha and theta waves [25]. Ray has found unusually large activity in the frequency range 16-18 Hz, during highly amused states as well as state of deep aesthetic appreciation [27].

In addition to the standard frequency bands, Ray has found so called "focused arousal" frequency component at 38 Hz. This frequency component was found during the *Dharana* stage of *Rajayoga* [34]. Ray supposed that it could represent possible functional component in the process of attention (*Dharana* means holding the mind at a certain point).

Changed perception during meditation is frequently reported. Subjects usually define it as a relaxed awareness with stable reception. The main cause of this phenomenon is dissociation of perception from the external sense organs. Quantitative investigation of this phenomenon is performed by Hirai, and alpha block dehabituatation was found [30].

Significant change of function of Autonomic Nervous System (ANS) has been found in different altered states of consciousness. Meditation state is often characterized as hypometabolic, with decreased oxygen consumption and carbon dioxide elimination, reduced heart beat and ventilation rate [37,40]. Wallace defined this state as "wakeful hypometabolic physiological state" [33,37]. Reported changes in respiration include also periodic breath suspension [39,40,42]. As an opposing phenomenon Ray have found sympathetic burst during music induced highly amused state [44,45]. It is characterized by increased heart beat rate (Heart Rate Variability or HRV) and larger number of spikes in EEG.

Pronounced change in basal skin resistance is often visible [33,40]. It should be noted that EEG, as it is measured on the skin, is influenced by this change of ANS. Therefore it is not possible to resolve genuine change of function induced by CNS from the change caused by altered skin resistance. This is also the main obstacle for investigation of very low frequency phenomena that may play significant role. In standard EEG analysis all frequencies below 1.5 Hz are at least "suspicious" and usually discarded from further analysis as artifacts. We believe that they should be taken into account using different signal processing procedures [16]. These methods may resolve some very low frequency changes (below 1 Hz), that would be otherwise missed using standard computerized EEG analysis.

Precious results could be obtained in experiments related to transpersonal experience. Healing sessions [46], as intensive conscious effort to establish inter-personal communication and help the patient, represent particularly interesting experiments [47,48]. To the best of our knowledge EEG changes related to the healing process are rarely investigated. Zhang reported the EEG alpha activity during the Qi Gong state that occurred predominantly in the anterior regions. The peak frequency of EEG alpha rhythm was slower than the resting state, and the change of EEG during Qi Gong between anterior and posterior half had negative correlation [48]. It has been reported that group of meditators can influence other subjects on long range distance, changing intersubject EEG coherence [41].

Another important path of analysis is represented by correlation of EEG power spectral parameters and subjective, conscious, spontaneous cognition during relaxation-drowsiness-sleep onset [17]. In this no-input, no-task, no-response paradigm correspondence has been determined between EEG states and cognitive-emotional states. As an example, prominent 2-6 Hz EEG power related to reality remote, sudden ideas lacking goal orientation, and low recall quality, while prominent 4-7 Hz and low 10-13 Hz power showed again sudden ideas without goal-orientation, but of good recall quality, of the visual imagery type, and without emotional load.

Ray has raised particularly provocative question, by defining *transcendent signal*. Ray hypothesized that recorded EEG may represent transcendental state of mind, that is not bound to any law of time or space domain. Therefore, it would not be possible to apply any existing signal processing procedure to this signal. Two signals visible in EEG that are not related to time domain are random noise and spike. Ray investigated transcendent signal in relation to the highly amused states of a child as well as state of deep aesthetic appreciation [27]. These states are correlated with enlarged number of impulses (spikes), and increased low frequency waves (theta and specially delta waves) [36].

Survey of EEG correlates of altered states of consciousness, and applied signal processing procedures from the open literature given in this chapter was given to imply plethora of functions and processing procedures required in characterization of phenomena related to altered states of consciousness.

4 RESEARCH METHODOLOGY

Existing software packages do not provide enough flexibility for studying subtle EEG changes. Therefore, we decided to develop own open software environment for at least two reasons: (a) total control of procedure parameters, and (b) the possibility to develop original and improve existing signal processing algorithms.

In addition to the basic characteristics of the environment, an improved methodology of tracing spatio-temporal EEG changes is given. We propose a methodology of characterizing certain neurophysiological states by tracing characteristic spatio-temporal patterns of EEG activities. A novel methodology is based on a combination of *static* (artifact-free EEG) and *dynamic* analysis to characterize underlying neurophysiological changes related to alteration of state of consciousness [49,50].

Static analysis uses artifact-free EEG to characterize long-term (average) activity. However, by removing signal sections with artifacts we lose temporal information as well.

Dynamic analysis is performed on original signal to trace temporal patterns of activities as well as short-term changes in brain activities.

The analysis starts by expert's off-line manual artifact removing. In spite of some promising results in automatic artifact removal, manual removing using expert's knowledge is still preferred method in analysis. Then, topographic maps of artifact-free signal are built to indicate channels that have dominant activity in certain frequency bands (delta, theta, alpha, beta, etc.) [27]. The most interesting EEG channels are used for further signal processing procedures (spectral, coherence, wavelet, chaos and other analyses).

During spectral analysis, frequency bands should not be preselected, as some frequency components may reside on the boundary of two frequency bands. As an example, frequency peak on 8Hz contributes both alpha and theta frequency band, therefore rendering results of analysis. It is much better to analyze the spectrum first, justify separation into frequency bands and then perform the rest of analysis. This is particularly the case in states like meditation, where shift toward lower frequencies is often present, and sigma spindles whose frequencies span both alpha and beta range.

The rhythms of different parts of the cortex have different frequencies. Therefore, the frequency shift may suggest activation of different parts of the cortex, rather than shift in frequency. For an analysis requiring good spatial resolution, it is necessary to have sufficient number of electrodes (recording sites).

Dynamic analysis is then performed on selected channels by constructing graphs with temporal dependencies of selected parameters (spectrogram, dominant band frequency, animation of topographic maps, coherence, etc.). Moreover, dynamic analysis can indicate time intervals with significant changes of basic parameters (mean frequency, intensity, etc.), that are then subjected to additional static analysis.

According to our experience this interaction between static and dynamic analysis yields the best characterization of underlying neurophysiological changes.

In addition, suitable signal processing procedures support interdependence analysis providing subtle information on simultaneous changes in brain electrical activity recorded from two electrode sites or two subjects, or canceling their interference [20-24].

4.1 Rapid Prototype Development

Inherent nature of brain electrical activity and its role in information processing make characterization of underlying changes very difficult. Therefore, in every research experiment,

it is necessary to investigate different signal processing and statistical procedures in order to find the most informative features of the process. The same EEG record should be analyzed with different procedures and their results compared. The process itself is interactive, and usually the course of investigation hardly depends on the intermediate result [51].

New software environments provide the possibility of rapid prototype development. Application prototype may use set of standard applications for data processing and result presentation. We developed dedicated application (using *Visual Basic*) as a shell for interactive user interface and integration of specialized applications [52]. Dedicated application use:

- *MATLAB* to perform different signal processing procedures [53],
- *ACCESS* to store results of analysis, and
- *EXCEL* for flexible postprocessing, statistical analysis and result presentation [54].

Visual Basic makes possible fast and efficient development of application prototypes with reach and configurable user interface. Interface between different applications is realized using OLE and DDE standards [54], supported by specialized applications. Although it was primary designed to provide support for signal processing functions, a great deal of efforts was spent to organize database of subjects and their records, as well as efficient visualization procedures and methods.

The application is an interactive open environment, developed under *Windows* operating system. Most signal processing procedures are executed using *MATLAB* 4.2 [52], and some procedures are developed in C language and integrated into the environment as DLL libraries. Procedures provide the following support (for more details see [51, 52]):

- Spectral and correlation analysis of EEG (with optional removing of artifacts);
- Spectrogram analysis;
- Cepstrum analysis;
- Topographic mapping of various parameters such as:
 - ◊ absolute and relative power in frequency bands,
 - ◊ power ratios between bands,
 - ◊ z score values, and
 - ◊ coherence;
- Monitoring temporal changes of relevant spatial characteristics (cross-correlation values, animation of topographic maps);
- Wavelet analysis (decomposition on the wavelet orthonormal basis using different types of filters); and
- Chaos analysis (the correlation dimension of strange attractors).

4.2 Possible Improvements

From our experience with EEG analysis during different states of consciousness we concluded that first crucial characteristics of software research environment must be *openness*. Other improvements and suggestions could be summarized as follows:

- (a) Limits of frequency bands for topographic mapping should not be preselected. The concept of four bands (delta, theta, alpha, and beta) is more than 50 years old and was made on the basis of visual inspection of paper EEG trace. Today, frequency bands should be adjusted according to the type of signal analyzed and to statistical clustering of relevant properties of calculated very narrow bands (up to 1 Hz).

- (b) Digital filtering should be used for band-pass filtering of EEG signal, to isolate stationary epochs in different spectral bands (not all bands have the same duration and stationarity). In other words, different epoch lengths should be used not only for different types of mental states (tonic and phasic mental events), but also for different frequency bands. It is particularly important for time-domain analysis.
- (c) Some kind of filtering (e.g. nonlinear digital) to eliminate short-term physiological variations in EEG signal that often adds undesirable variance in analyzed segments.
- (d) Integration of algorithms for transformation of EEG scalp potentials into orthogonal source derivations (computation of Laplacian operator). This results in reference-free data, and increased signal-to-noise ratio for small local events. The only inconvenience is that this procedure requires at least 64 electrodes.

5 RESULTS PRESENTATION

Results of EEG analysis during different states of consciousness are often hard to interpret, and contain subtle information about correlates of observed process. Therefore it is necessary to support efficient presentation of results in time or space domain.

Usual presentation of temporal changes is represented using graphs of certain variables in time (like dominant peak in one frequency band). Spectral power change is presented using spectrograms (axis are time and frequency, and spectral values are represented in 2D color values, or third axis values representing changing EEG spectrum), and "waterfall" spectrum with a series of 2D spectrum plots.

The most frequently spatial presentation of brain electrical activity makes use of color-coded topographic maps. Color-coded scales facilitate interpretation of the selected EEG feature. Therefore it is possible to become aware of spatial patterns of cerebral activity. Spatial distribution of statistically significant results in large group of experiments could be also mapped using Z-scores.

Efficient understanding of hidden spatio-temporal patterns of brain electrical activity is possible using systems for 3D visualization, like the one we have been using in last two years [55]. Animated topographic maps of selected parameter (power, phase, or any other feature) on human head model gives better four-dimensional "feeling" of observed changes. Therefore, hidden spatio-temporal changes of brain electrical activity are better resolved, which would not be possible using set of graphs.

New generation of computerized systems supports source localization integrating MRI and EEG data. Therefore, it is possible to map calculated source of EEG activity to precise anatomic model. As it was already mentioned, for most cases it is not possible to obtain unique result.

5.1 New Trends

Present information systems are characterized with trend toward *perceptualization* of scientific results. Scientific data are represented in a way close to our senses. As an example, method called *sonification* alters different sound characteristics (such as volume, pitch, etc.) according to received data [56]. Most of present multimedia computer systems are equipped to support efficiently this kind of operation. This method is applied for presentation of EEG correlates of cognitive task [57]. Rapid and short time synchronization during cognitive events and perception are presented using sound as an aid to enrich visual display. EEG channels are presented as a set of independent MIDI instruments playing together. Short synchronization of

EEG channels is represented using possibility of human ear to detect synchronization events. Values of calculated EEG parameter are converted to MIDI pitch values, with 4.5 notes per second, and possible staggered onset.

Future trend in data presentation will be creating virtual world feeling - data landscape. Immersion in virtual reality (world) of real and calculated data will further improve our possibility to trace spatio-temporal dependencies in brain electrical activity.

6 CONCLUSION

Quest for EEG correlates of altered states of consciousness requires a carefully chosen methodology and subtle processing and visualization procedures. We presented here a survey of reported correlates of altered states of consciousness, and our view of necessary software support for its research. As in other scientific fields, consciousness studies necessitate a carefully chosen methodology of EEG analysis, requiring substantial trial and error in the design of experiments.

An important trend of future computerized EEG systems will be integration of high temporal and spatial resolution EEG with MRI and functional MRI. Combined with ever increasing computer power and near real-time presentation, it will provide dynamic picture of brain electrical activity necessary to assess relevant changes during altered states of consciousness.

REFERENCES

- [1] A. Rémond, ed., *Handbook of EEG and Clinical Neurophysiology* (Elsevier, Amsterdam, 1972).
- [2] E. Basar, *EEG Brain Dynamics* (Elsevier, Amsterdam, 1980).
- [3] E. Basar, ed., *Dynamics of Sensory and Cognitive Processing by the Brain* (Springer Verlag, Berlin, 1988).
- [4] C. Tart, ed., *Altered states of consciousness* (Academic, New York, 1972).
- [5] C. Baumgartner, MEG, EEG and ECoG: Discussion, *Acta Neurol. Scand.* 89 (1994), pp. 91-92.
- [6] F.A. Ulam and J. Johnstone, Some Considerations on Quantitative Analysis of Brain Electrical Activity, Part 1 (<http://www.neurodata.com/qeegpg.html>) and Part 2 (<http://www.neurodata.com/qeeg2.html>)
- [7] A. Reeve, D.F. Rose, and D.R. Weinberger, Magnetoencephalography: Applications in Psychiatry, *Arch. Gen. Psychiat.* 46 (1989), pp. 573-576.
- [8] T. Blum, E. Saling, and R. Bauer, First magnetoencephalographic recordings of the brain activity of a human fetus, *Brit. J. Obstetrics & Gynaecology* 92 (1985), pp. 1224-1229.
- [9] J. Horgan, Fractured Functions, Does the brain have a supreme integrator?, *Scientific American*, December 1993, pp. 16-17.
- [10] P.L. Nunez, *Neocortical Dynamics and Human EEG Rhythms*, (Oxford University Press, 1995).
- [11] E. Basar, C. Basar-Eroglu, T. Demiralp, and M. Schurmann, Time and Frequency Analysis of the Brain's Distributed Gamma-Band System, *IEEE EMBS*, July/August 1995, pp. 400-410.

- [12] J. Hasan, Past and Future of Computer-Assisted Sleep Analysis and Drowsiness Assessment, *Clin. Neurophysiol.* 13 (1996), pp. 295-313.
- [13] B.W. Jervis, M. Coelho, and G.W. Morgan, Spectral analysis of EEG responses, *Med. & Biol. Engin. & Comput.*, May 1989, pp. 230-238.
- [14] P.Y. Ktonas, and N. Papp, Instantaneous envelope and phase extraction from real signals: Theory, implementation and an application to EEG analysis, *Signal Processing* 2 (1980), pp. 373-385.
- [15] J.G. Okyere, P.Y. Ktonas, and J.S. Meyer, Quantification of the Alpha EEG Modulation and Its Relation to Cerebral Blood Flow, *IEEE Trans. Biomed. Engin.* 33, (1986), pp. 690-696.
- [16] E. Jovanov, D. Raković, V. Radivojević, and D. Kušić, Band power envelope analysis - a new method in quantitative EEG, *Proc. 17th Ann. Int. Conf. Proc. IEEE/EMBS*, Montreal, 1995.
- [17] D. Lehmann, P. Grass, and B. Meier, Spontaneous conscious covert cognition states and brain electric spectral states in canonical correlations, *Int. Psychophys.* 19 (1995), pp. 41-52.
- [18] P.E. Rapp, T.R. Bashore, J.M. Martineire, I.D. Zimmerman, and A.I. Mees, Dynamics of brain electrical activity, *Brain Topography* 2 (1989), pp. 99-118.
- [19] J.E. Skinner, J.L. Martin, C.E. Landisman, M.M. Mommer, K. Fulton, M. Mitra, W.D. Burton, and B. Saltzberg, Chaotic attractors in a model of neocortex: Dimensionalities of olfactory bulb surface potentials are spatially uniform and event related, in E. Basar, ed., *Chaos in Brain Function* (Springer-Verlag, Berlin, 1990), pp. 119-134.
- [20] J.D. Bronzino, ed., *The Biomedical Engineering Handbook* (CRC Press, 1995).
- [21] C.L. Nikias, and M.R. Raghuveer, Bispectrum Estimation: A Digital Signal Processing Framework, *Proc. IEEE* 75, July 1987, pp. 869-891.
- [22] M. Sun, S. Qian, X. Yan, S.B. Baumann, X. Xia, R.E. Dahl, N.D. Ryan, and R.J. Scabassi, Localizing Functional Activity in the Brain Through Time-Frequency Analysis and Synthesis of the EEG, *Proc. IEEE* 84, September 1996, pp. 1302-1311.
- [23] S. Haykin, R.J. Racine, Y. Xu, and C.A. Chapman, Monitoring Neuronal Oscillations and Signal Transmission Between Cortical Regions Using Time-Frequency Analysis of Electroencephalographic Activity, *Proc. IEEE* 84, September 1996, pp. 1295-1301.
- [24] W.J. Williams, Reduced Interference Distributions: Biological Applications and Interpretations, *Proc. IEEE* 84, September 1996, pp. 1265-1280.
- [25] N. Pradhan, and D.N. Dutt, Use of running fractal dimension for the analysis of changing patterns in electroencephalogram, *Comput. Biol. Med.* 23, (1993), pp. 381-388.
- [26] N. Pradhan, and D.N. Dutt, A nonlinear perspective in understanding the neurodynamics of EEG, *Comput. Biol. Med.* 23 (1993), pp. 425-442.
- [27] F.H. Duffy, ed., *Topographic Mapping of Brain Electrical Activity* (Butterworths, Boston, 1986).
- [28] D. Ingvar, B. Sjolund, and A. Ardo, Correlation between dominant EEG frequency, cerebral oxygen uptake and blood flow, *EEG Clin. Neurophysiol.* 41 (1976), pp. 268-272.
- [29] M.S. Bushbaum, E. Hazlett, N. Sicote, N. Ball, and S. Johnson, Geometric and scaling issues in topographic electroencephalography: Correlation between EEG and brain metabolism in: F.H. Duffy, ed., *Topographic Mapping of Brain Electrical Activity* (Butterworths, 1986), pp.332-336.

- [30] T. Hirai, Electroencephalographic Study of Zen Meditation, *Psychiat. Neurol. Jap.* 62 (1960), pp. 76-105.
- [31] J.P. Banquet, EEG and Meditation, *EEG Clin. Neurophysiol.* 33 (1972), pp. 449-458.
- [32] J.P. Banquet, Spectral Analysis of the EEG in Meditation, *EEG Clin. Neurophysiol.* 35, (1973), pp. 143-151.
- [33] R.K. Wallace, and H. Benson, The Physiology of Meditation, *Scientific American*, 226 (1972), p. 84.
- [34] G.C. Ray, Higher Stages of Rajayoga and Its Possible Correlation with Process of Evolution, *Instit. Engin. (India)* 68, (1988), pp. 37-42.
- [35] G.C. Ray, and A.Y. Kaplan, Transcendent Signal and its Possible Signature on Electroencephalogram, *Instit. Engin. (India)* 74 (1994), pp. 22-31.
- [36] G.C. Ray, r-parameter: A new measure of level of consciousness, *Inst. Engin. (India)* 76, (1995), pp. 7-12.
- [37] R. K. Wallace, et al., A wakeful hypometabolic physiologic state, *Physiol.* 221 (1971), pp. 795-799.
- [38] R. Hebert, and D. Lehmann, Theta bursts: An EEG pattern in normal subjects practicing the Transcendental Meditation technique, *EEG Clin. Neurophysiol.* 42 (1977), pp. 397-405.
- [39] D. W. Orme-Johnson, EEG coherence during transcendental consciousness, *EEG Clin. Neurophysiol.* 43 (1977), pp. 581-582, E 487 (Abstract).
- [40] J. T. Farrow, and J. R. Hebert, Breath suspension during the Transcendental Meditation technique, *Psychosom. Medic.* 44 (1982), pp. 133-153.
- [41] D.W. Orme-Johnson, M. C. Dillbeck, R. K. Wallace, and G. S. Landrith III, Intersubject EEG coherence: Is consciousness a field?, *Int. Neurosci.* 16 (1982), pp. 203-209.
- [42] K. Badawi, R. K. Wallace, D. Orme-Johnson, and A.M. Rouzer, Electrophysiologic characteristics of respiratory suspension periods occurring during the practice of the Transcendental Meditation program, *Psychosom. Medic.* 46 (1984), pp. 267-276.
- [43] M. Tomašević, E. Jovanov, D. Raković, V. Radivojević, and M. Car, EEG correlates of the altered states of consciousness in Transcendental meditation, in Lj. Rakić, D. Raković, Đ. Koruga, and A. Marjanović, eds., *Consciousness Scientific Challenge of the 21st Century*, Proc. ECPD Seminar, Belgrade, 1996, pp. 121-128, in Serbian.
- [44] G.C. Ray, Likely sympathetic burst on autonomic system just on landing ultimate reality, *Inst. Engin.*, April 1997.
- [45] G.C. Ray, A. Y. Kaplan, and E. Jovanov, Morphological variations in ECG during music-induced change in consciousness, *19th Ann. Int. Conf. IEEE/EMBS*, Chicago, USA, 1997.
- [46] K.C. Markides, *Fire in the Heart. Healers, Sages and Mystics*, (Paragon House, New York, 1990).
- [47] Y. Omura, T.L. Lin, L. Debrececi, B.M. Losco, S. Freed, T. Muteki, and C.H. Lin, Unique changes found on the qi gong (chi gong) master's and patient's body during qi gong treatment: Their relationship to certain meridians & acupuncture points and the re-creation of therapeutic qi gong states by children & adults, *Acup. & Electro-Therap. Res., Int. J.* 14 (1989), pp. 61-89.
- [48] J.Z. Zhang, J. Zhao, and Q.N. He, EEG findings during special psychical state (Qi Gong State) by means of compressed spectral array and topographic mapping, *Comput. Biol. Medic.* 18 (1988), pp. 455-463.

- [49] E. Jovanov, D. Raković, V. Radivojević, D. Kušić, P. Šuković, and M. Car, *Evaluation of state of consciousness using software support for monitoring spatio-temporal EEG changes*, Proc. ISCA Int. Conf. Comput. Appl. Engin. Medic., Indianapolis, 1995.
- [50] E. Jovanov, On methodology of EEG analysis during altered states of consciousness, in D. Raković, and Dj. Koruga, eds., *Consciousness: Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1995), also on <http://www.vxm.com/21R.94.html>
- [51] D. Kušić, Integration of the software environment for EEG analysis, B. Sc. Thesis, Faculty of Electrical Engineering, University of Belgrade, 1994, in Serbian.
- [52] M. Rakić, Integrated information system for EEG analysis in Windows environment, B. Sc. Thesis, University of Belgrade, 1995, in Serbian.
- [53] *MATLAB 4.0 User's guide*, (The MathWorks, Inc., Natick, 1994).
- [54] *Microsoft Office User's manual*, or <http://www.microsoft.com>
- [55] A. Samardžić, E. Jovanov, and D. Starčević, 3D Visualisation of Brain Electrical Activity, *Proc. 18th Ann. Int. Conf. IEEE/EMBS*, Amsterdam, (1996), pp. 1138-1139.
- [56] T.M. Madhyastha, and D.A. Reed, Data Sonification: Do You See What I Hear, *IEEE Spectrum*, Vol. 12, March 1995, pp. 45-56.
- [57] G. Mayer-Kress, Sonification of Multiple Electrode Human Scalp Electroencephalogram (EEG), <http://www.ccsr.uiuc.edu/People/gmk/Projects/EEGSound/>

EEG MICROSTRUCTURE OF THE DIFFERENT SLEEP STAGES IN HUMANS: METHOD AND APPLICATION

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Abstract. Segmentation of the EEG into stationary intervals by detection of the moments of sharp changes in its characteristics is important for the extraction of the structural information from the EEG. Parametric methods usually used for the EEG segmentation are inherently contradictory, because they are based on the procedures requiring stationary realization, while the EEG signal represents a nonstationary process. We applied nonparametric methodology to the EEG segmentation, which does not require any assumptions about the analyzed signal.

The method described in this paper provides, for the first time, the detection of sharp changes in almost every EEG characteristic for a given level of false alarm probability and computation of the confidence intervals for the moments of those changes. The analysis of sleep EEG data showed high effectiveness of the method. It was shown that the well known classification of the EEG stages has a more detailed structure in terms of operative states of brain activity.

It was suggested that the time organization of the conscious process reflected in the EEG has hierarchical piece-wise structure. The basic level of that structure is the restricted number of quasi stable operative blocks of EEG activity and the highest hierarchical level is unique composition of those blocks in time and space (cortex area) domain. One of the main heuristic load of the piece-wise conception is the possibility to explain the self-organization of brain activity as gluing of the complementary operative block. The state-shift analysis of the sleep EEG is a first step to the understanding of piecewise structure of the different states of consciousness.

Key words: *sleep, EEG state-shift analysis, operative states.*

1 INTRODUCTION

Sleep is non-homogenous biological state which has been subdivided into different stages according to the brain activity. Although the definition of these stages and their application in sleep EEG scoring is fully justified in the well known scale of [1], the results of such visual description of sleep may contribute to misinterpretation of underlining neurophysiological processes as rigid for each sleep stage.

Indeed the EEG signal in each sleep stage has stable macrostructure, as it was shown by calculation of nonlinear parameters D2 and L1 [2-4]. But possibly it may be proposed that each so called sleep stage is not homogeneous one at the microstructure level when using an adequate analysis.

A common conception for spontaneous brain electrical activity assumes that rather short homogenous EEG segments represent the basic blocks [5] or operative states [6] of brain information processing.

This is the reason to study the microstructure of the EEG in different sleep stages during the night. There are some approaches to check whether given segment of EEG is homogeneous or not. All these approaches based on the idea that the EEG signal can be described as a piecewise stationary process, i.e. "glued" from random stationary processes with different probabilistic characteristics [7-9].

2 METHOD AND RESULTS

To obtain an adequate description of a piecewise stationary realization, the EEG record must be first divided into segments with different characteristics by determining the points of the "gluing" or boundaries between quasi-homogeneous segments. Therefore, it is important to determine the moments of the sharp EEG changes with some probabilistic characteristics as precisely as possible.

In mathematical statistics the problem described above is known as the change-point problem. In this paper we use a nonparametric change-point analysis for detection of quasistable states in different sleep stages. The main advantage of nonparametric approach is that it needs no *a priori* mathematical models for description of random process and for this reason very useful from the practical point of view because in practice it is always hard to find *a priori* information to construct mathematical models.

Our approach is based on two main ideas [10]. The first idea is that the problem of detection of changes in any probabilistic characteristic can be reduced to the basic problem, detection of changes in mathematical expectation for some new random sequence which is constructed from the initial one. Let us clear this point by the following example. Let us assume that $X(t)$, $t=1,2,\dots,N$, is given random sequence. Consider a new sequence $Y(t)=\{y(t)\}$ such that $y(t)=x(t)x(t+r)$, $t=1,2,\dots,N-r$, for some fixed r . If sequence X is "glued" from several sequences with different correlation functions then there exists r such that mathematical expectation of $y(t)$, e.g. $Ex(t)x(t+r)$, where E is the symbol of mathematical expectation, will change at the moments of "gluings". So if we have a method for detection of changes in mathematical expectations we will detect the changes in correlation function as well. We call such new sequence (Y for our example) as a diagnostic sequence. The same ideas can be used to detect changes in any other probabilistic characteristics of random sequences.

The second idea of our approach is detection of changes in mathematical expectation as change-points in the EEG using the following family of statistics:

$$Y_N(n, \delta) = \left[\left(1 - \frac{n}{N}\right) \frac{n}{N} \right]^{\delta} \left[\frac{1}{n} \sum_{k=1}^n x_k^N - \frac{1}{N-n} \sum_{k=n+1}^N x_k^N \right], \quad (1)$$

where $0 \leq \delta \leq 1$, $1 \leq n \leq N-1$, $X = \{x_k^N\}_{k=1}^N$ is the observed realization, and some derivatives of these statistics.

Family (1) is a generalized variant of the Kolmogorov-Smirnov statistics, which is used to test coincidence or difference of distribution functions of two samples (with a fixed n).

It can be shown that such family gives asymptotically optimal estimates for change-points under wide assumption [11].

Based on our approach we calculated change-points for different stages of sleep EEG for 7 healthy subjects. For change-point processing we previously extracted from sleep EEG record

segments defined as stages REM and NREM (stages 2 and 4 separately) on the basis of expert scoring. Each such segment has 16,384 data points and for every subject we extracted 5 realization of each stage without any artifacts.

Then, the number of change-points and total distribution of segment lengths between change points was calculated into given EEG stage of sleep.

For change-point analysis we used the correlation-type diagnostic sequences, e.g. the change-points correspond to changes in correlation function (in particular, in a dispersion).

It can be noted that characteristics of change-point process have individual peculiarities across subjects. But for each subject it was a strong difference between stages 2 and 4. The stage REM engages intermitted position.

For the seven healthy subjects SBCP for stage N 4 had clear tendency to decrease up to 68-85% compare with stage N 2 (Table 1). These changes of the SPCP are statistically reliable (Table 2) For the stage REM SPCP varied up and down compare with stage N 2 (Table 1) with good statistical reliability.

Table 1 Means (M) of the distributions between sequential change-points in the different sleep stages (2, 4 and REM) for seven subjects. Comparison of means in % to stage 2.

N	M-2 (mc)	M-2 (%)	M-4 (%)	M-REM (%)
1	1358	100	68	69
2	2991	100	70	99
3	1703	100	72	136
4	1643	100	85	89
5	1640	100	73	143
6	1501	100	74	99
7	1773	100	85	105

Subjects: 1 - EEG 5531; 2 - EEG 5532; 3 - EEG 5422; 4 - EEG 5456; 5 - EEG 5458; 6 - EEG 5420; 7 - EEG 5412.

Table 2 The evaluation of the distribution parameters for the distances between sequential change-points in the different sleep stages (2, 4, REM); Comparison of sleep stages by Kolmogorov-Smirnov (KS) and Student (St) tests.

NN	KS							St						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Stage 2 - Stage 4	+	+	+	+	+	+	-	+	+	+	+	+	+	+
Stage 2 - Stage REM	+	-	+	+	+	+	-	+	-	+	+	+	-	-
Stage 4 - Stage REM	-	+	+	-	+	+	+	-	+	+	-	+	+	+

+ there is a difference with confidence probability $p > 0.05$; - there is no difference; Subjects: 1 - EEG 5531; 2 - EEG 5532; 3 - EEG 5422; 4 - EEG 5456; 5 - EEG 5458; 6 - EEG 5420; 7 - EEG 5412.

3 CONCLUSION

A new approach to structural analysis of the EEG allows us to describe microstructural differences in the EEG of different sleep stages in addition to the well-known spectral and nonlinear evaluation of these sleep stages. One of the next steps of this approach will be more precise microstructure EEG evaluation of the same sleep stages for the different periods across the night sleep. It may be possible that such approach allows us to discover long-term dynamic

peculiarities of brain mechanisms underlining nonhomogeneity of the same sleep stages across night.

There is another approach to investigate piecewise organization of the different states of consciousness: the study of so called operational synchrony [12] of the different cortical areas. We hope that this approach will lead us to an understanding of the microevolution of the different stages of conscious process in time and space domain.

Acknowledgment. We are grateful to Boris Brodsky and Sergey Shiskin for software development and to Cornelius Shaeffner for excellent technical assistance.

REFERENCES

- [1] A. Rechtschaffen and A.A. Kales, A manual of standartized terminology, techniques and scoring system for sleep stages of human subjects, *NIH Publication* No. 204, Us Public Health Service, US Goverment printing office, Washington, DC, 1968.
- [2] J. Roeschke and J.B. Aldenhoff, A nonlinear approach to brain function: deterministic chao and sleep EEG, *Sleep* 15 (1992), pp. 95-101.
- [3] J. Roeschke, J. Fell and P. Beckmann, The calculation of the first positive Lyapunov exponent in sleep EEG data, *EEG Clin. Neurophysiol* 86 (1993), pp. 348-352.
- [4] J. Fell, J. Roeschke, K. Mann and C. Schaeffner, Discrimination of sleep stages: Comparison between spectral and nonlinear EEG measures, *EEG Clin. Neurophysiol.* 98 (1996), pp. 401-410.
- [5] D. Lehmann, H. Ozaki and I. Pal. EEG alpha map series: Brain microstates by space-oriented adaptive segmentation, *EEG Clin. Neurophysiol.* 67 (1987), pp. 271-288.
- [6] E. Basar and T. H.Bullock, *Induced Rhythms in the Brain* (Birkhaeuster, Boston-Basel-Berlin, 1992).
- [7] G. Bodenstein and H. M.Praetorius, Feature extraction from the electroencephalogram by adaptive segmentation, *Proc. IEEE* 65 (1977), pp. 642-652.
- [8] T.S. Barlow and O.D. Creutzfeld, Automatic adaptive segmentation of clinical EEGs, *EEG Clin. Neurophysiol.* 51 (1981), pp. 512-525.
- [9] B.H. Jansen, A. Hasman and R. Lenten, Piece-wise EEG analysis: An objective evaluation, *Internat. J. Bio-Med. Comput.* 12 (1981), pp. 17-27.
- [10] B.E. Brodsky, B.S. Darkhovsky and A.Ya Kaplan, Change-point detection method for EEG signal analysis, In *Proc. IMACS Int. Symp. Signal Process., Robotics & Neural Networks*, Lille, France, 1994, pp. 439-441.
- [11] B.E. Brodsky and B.S Darkhovsky, *Nonparametric Methods in Change-Point Problems*, (Kluver Acad.Publ., Dordrecht the Netherlands, 1993).
- [12] A.Ya. Kaplan, B.S. Darkhovsky, A.A. Fingelkurts and An.A. Fingelkurts, Topological mapping of the sharp state-shift moments in the multichannel EEG in humans, *Journal of Higher Nervous Activity* 47 (1997), pp. 32-37, in Russian.

COSMOPLANETARY ASPECTS OF UNKNOWN MENTAL PHENOMENA

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Abstract. Experiments were carried out underlying the hypothesis according to which the field forms of brain neurons of protohominids were united into a common soliton-holographic formation synchronously 3.5 millenniums ago in several regions of Earth as a result of immense cosmic events. A phenomenon arose which we referred to as intellect. The evolution of intellect did not proceed as a co-evolution but, vice versa, adaptation of mankind on Earth was accompanied by something like disevolution, by the loss of basic soliton-holographic features of the intellect which were constituents of different cosmic forms of the living cosmic space.

The fundamental soliton-holographic forms of intellect were preserved up to the present in several ceremonies of religious institutions, in phenomena of higher sensority of individuals. They may reveal as both helpful tools of man's activity and unhealthy, distorted fashions of man's behavior. A number of specific mental states, not fitting the adopted mode of life, the established semantic signal fields of arts, commonly accepted habits of social relationships, are representative of the primary cosmoplanetary soliton-holographic space.

The use of hypomagnetic devices, laser mirror and torsion constructions for our research allowed us to obtain new data on actual divulgence of distant interactions between cells, cells and man, man and plants, on regularities of transpersonal distant informative communications. Supporting experimental evidence was obtained for the idea that the higher but evolutionary retarded forms of intellectual instrumental array are available and can be restored and developed in the name of salvation of the civilization.

Key words: *intellect, mental phenomena, evolution, cosmoplanetary space.*

1 FUNDAMENTALS

The advent of the notion of 'living space' as a natural phenomenon of the cosmoplanetary scale, following the increasingly recognized term 'living matter', is representative of the new level of the world cognition. It is assumed here that, unlike the commonly used concept of the four-dimensional spatial-temporal continuum, time is no more than a property here [1].

Therefore, the living space is an array of giant cosmic living flows and formations, among which the protein-nucleic form of life is only one of allowable forms, and the known astrogeophysical fields are only markers of irregular information flows of unknown nature [2].

Techniques for distant perception is a subject widely discussed in the world literature of the last decades; a practicability of distant perception of information from the sites remote to thousands kilometers without conventional technical devices used. We will only discuss those

of them which involve the spatial-temporal relationships as determining the effect of distant informative interactions.

The hypothesis is stated concerning the wave nature of psychological coding based on quantum-mechanical neuroholographic mechanisms that prove feasibility of simultaneous recognition of instant actualization of the past experience [3].

The neutrino-photon hypothesis [4] is set up on the assumption that a wave package, while propagating through space, is as though 'smeared' from the soliton to generate weak pre- and postsignals going gradually away from each other. This is the basis for a possibility of advanced perception of the presignals from remote events.

V.V.Nalimov treats the man's continual intuitive reflection as a constituent of the planetary information field [5].

I.P.Shmelev develops a hypothesis on the holographic nature of the information field. He considers the world as a global dynamic duplex-sphere, something like a stationary field and an unachieved thought. It is his opinion that a singular state is characteristic of the duplex-sphere as an information field at all the stages of the cosmic system, the past, the present, and the future being always 'now' [6].

E.A.Rauscher's theoretical model of foreseeing shows in terms of physics and mathematics that time remote events, which cannot be seen by an observer in the four-dimensional space, appear in close proximity within an eight-dimensional space and, thus, observable [7].

The general theory of relativity allows a possibility of closing world lines, admits the occurrence of cyclic time when the past, the present, and the future are closed in a ring (models by de Citter, Hedel, *etc.* [8]).

According to V.Tiller's hypothesis, positive and negative 'space-times' coexist in Universe. The positive and negative time cases penetrate into each other and take the same space but at different frequency levels, *i.e.*, the future coexists with the present but at various levels of state of the Universe matter [9].

N.A.Kozyrev believes that the reverse time world is equivalent to the world of ours but reflected in a mirror. Since there is no difference between directions but an absolute difference between the right and the left in the space, the time course must be determined by a term having a mean of the linear rotation speed. Thus, time, by N.A.Kozyrev, possesses a peculiar property, *i.e.* course, that makes differences between cause and effect, past and future. There are dissimilar time courses at various latitudes of Earth: over 73° North we fall into a hypothetical zone of reverse time, 'from the future to the past' [10].

N.A.Kozyrev supposes that the effect of energy-time does not propagate but appears instantly everywhere. For this reason a variation in the time density generated in laboratory must be perceived at the same instant by the most remote galaxies. Next, he states that a biological connection through time must be not only possible but necessary, that it may be a key for understanding mysterious phenomena of human mentality [10-12].

2 METHODS AND AIMS

A particular series of research in 1989-1991 dealt with development of methodology for assessment of regularities of the Earth information space. We admitted that the interpersonal distant informative interactions represent the regularities we looked for.

Numerous researchers focused their attention on examination of paradoxes of distant perception [13-21]. Techniques for studying the distant perception was step-by-step improved. For example, a method for description of a remote arbitrary target alongside a man under the condition of sensory isolation from the percipient was suggested [19]. The utility of emotional

stimulation and personal concern in the problems of image transmission was proved by a number of authors [21-24] using the perception under the conditions of sensory retardation. Up-to-date techniques of mathematical processing were used to demonstrate the non-accidental nature of perception of information on remote targets [25-27]. A procedure for independent expert examination of the results to avoid a possibility of sensory 'prompting' [28], methods based on the binary descriptor alphabet (target:perception) and estimation of the signal:noise ratio during the transmission were suggested. Thus, the recognition of information elements, preset and then rated, was substituted for the subjective descriptive approach [29,30].

Much attention is paid to examination of conditions affecting the efficiency of the distant perception. Experiments were carried out on reproduction of images, pictures, and registration of light flashes in an electrically shielded chamber. A pronounced dependence of the results obtained on activity of the geomagnetic field was demonstrated [31,32].

The inhomogeneous field structure of the Earth space could be among essential factors for emergence and development of intellectual fields. According to our hypothesis [1,2,33-35], the evolution, revealed in the way of concurrent formation of specific 'intellectual spots' in several regions of the planet (due to their particular cosmotelurian structure) [36], the 'spots' being cross-linked through channels of distant informative communications, led men gradually to overcoding of their brain to verbal systems. At the same time the relic subconscious world of distant image-bearing communications did not disappear but was kept as a finely tuned intellectual instrument [37] capable of long-distant vision and dependent on high gradient geophysical fields and, probably, on inhomogeneity of the living space. This instrument, as a cosmoplanetary property of humankind [38], was used for our studies at the paleopsychological horizon. The aims of the study were as follows:

- (1) Comparative historical and ethic evaluation of inhomogeneity of the planet living space at ancient cultures' ritual sites with pronounced geophysical anomalies;
- (2) Development of technology for informative indication of the noosphere under the conditions of its technocratic modifications; and
- (3) Investigation of spatial-temporal aspects of distant informative interactions of men during various cosmoplanetary events.

A method of interpersonal distant image-bearing communications implying a free-forced choice of the transmitted images and a free form of the reference person's answer was chosen as basic. A kind of 'meccano' was designed following the technique proposed by the authors of [2,39]. This original set of 77 image fragments consisted of symbols of various epochs, cultures, and nations represented on them. The investigations were conducted using a hypogeomagnetic installation or a 'mirror system' to model the inhomogeneous multidimensional space, as well as under natural conditions, *viz.* at the places of inhomogeneous field (geophysical) flows coinciding with ritual sites of ancient cultures in various sites of our planet [40-42].

3 RESULTS

3.1 Interpersonal Distant Informative Interaction in the Living Space of Earth

Research expeditions to Khakassia and Yakutia

The Kashkulak cave, an abnormal geophysical zone in Khakassia was one of the first research sites. Ethnographic and archeological studies discovered it to be used as a ceremonial place during several thousand years.

We established by means of Kirlian-photography that the outer projection of a man staying in the ceremonial area varies abruptly at certain moments and sometimes disappears. At first we assigned this effect, as well as specific psychophysical state of a man in the ceremonial cave, to sudden high amplitude low-frequency fluctuations of the geomagnetic field. Then the fluctuations were observed to be as if initiated by a group of persons of certain kind and quantity. All the cases of anomalous geophysical fluctuations happened when there were 3 or 7 people in the group. A higher anomalous effect was observed when the group members were the people born under full moon or underwent severe influence of the natural magnetic medium during their embryonic growth. No anomalous fluctuation of magnetic field was recorded in the course of automated long-term observation (for 5 days) of the magnetic field in the cave in the absence of people in the ceremonial zone. Among the aims of the speleological experiment was to achieve distant image transmission from a group of three operators who were within the ceremonial area of the cave at the moment of the anomalous magnetic fluctuations.

It was of extreme importance not to make an error while choosing the image message. There was an element, called 'hand', in the repertoire of the primitive artists. This is an intentionally made spot replicating the shape of the artist's hand. Some researchers believe this element was the origin of fine arts of Upper Paleolith.

Engravings of 'hands' dated from the Paleolithic period were discovered in caves in Spanish and French Pyrenees early in the 20th century.

The Paleolithic artist's hand image from the French cave Pesh-Merle fixed as an actual photograph was inserted in the program of distant image transmission from the ritual zone of the Khakassian ancient cave (Fig.1). The experimental program was based on two sites for perception of image information. One of them was a hypogeomagnetic installation in Novosibirsk, and another in Diring-Yurakh, Yakutia, the so-called 'North foremotherland of mankind' discovered by Professor Yu.A.Mochanov [36].

During the experiment of distant image-bearing communication the Paleolithic 'hand' symbol was conceived by a contemporary man staying in Yakutia and by an operator in an installation modeling the hypogeomagnetic medium in Novosibirsk.

Research expeditions to Bulgaria

The research aimed at studying specific features of distant informative interactions at the places of Thracian culture were carried out in collaboration with Bulgarian scientists Stoev, Maglova, Todorov, et al.

The materials obtained by this interdisciplinary expedition helped us to take a new insight into the role the distant informative interactions in the intellectual history of mankind.

One of the oldest Thracian sanctuaries is Kabile (1 millennium BC) where the tribes referred to by Herodotus and Darius. The top of a small mountain houses the sanctuary, and the bottom another culture, a Byzantine settlement of three or two centuries BC with several preserved basilicas. The central part of the Kabile sanctuary looks like a cross gallery about 2.5 m in depth cut off in a rock. The gallery exits are oriented strictly along the corners of the world. Bulgarian astronomers (A.Stoev of the National Astronomic Observatory in Stara Zagora, Yu.Varbanov and P.Todorova of Yambol, and others) suggest that this ceremonial complex was also used for astronomic observations. The magnetometric monitoring discovered that the rock galleries, being aligned with zones of magnetic anomalies, generate heterogeneous magnetic fluxes. While passing through them in a certain rhythm, man probably heard peculiar field score sounds following the successively varied magnetic fields of different induction.



Figure 1 Image of a hand of a Paleolithic man transmitted from a Khakassian cave during the experiment on distant-image communication. The image was perceived exactly by an operator in Diring-Yurakh (Yakutia)

Zh.Daskalova, a Bulgarian researcher, made a dozen of trials of image transmission in various mentality states from a number of points of the Kabile sanctuary. As a result the key elements were established that allow for reproducible results of transmitting and perceiving the image information over large distance. Among them are:

- (1) Triple passing by a man through the magnetic corridor following particular speed and rhythm;
- (2) Generation of the 'thought-image' within the sacrificial zone nearby the rock drawing of goddess Kabile and a trident-like constellation; and
- (3) Nighttime sessions under the starry sky.

Only those of the experiments were successful (3 among the 10 ones) when all the three conditions were met. From our point of view, these conditions reflect a specific state of the space.

The image-bearing information transmitted during these sessions was perceived exactly by a group of 11 persons in Novosibirsk.

An attempt was also made to establish the interpersonal distant-image interactions from another cultural historical flow, *i.e.*, from various sites of the Byzantine basilicas dated from the 4th century BC. The image information was perceived exactly by a group of 5 persons in Novosibirak but only during the sessions when they were transmitted from the altar and baptismal of the Byzantine temple. The images transmitted from other sites of the temple (9

sites in total) were not perceived in Siberia. It was found from the magnetometric mapping that the altar and the baptismal were located within the zones of negative magnetic anomalies (with respect to the background magnetic induction in the temple), *i.e.*, in the regions of high gradient magnetic field.

The additional research was carried out not far from village Dal'noslav in the Eneolithic settlement dated from the 4th millennium BC. There is one of the oldest and largest ritual complex of Bulgaria (20 sanctuaries at the area of ca. 4,000 sq.m). No variation in magnetic induction against the background and no abnormal magnetic zones were found by magnetometric monitoring. None of the sessions of image transmission of that day was successful. We think that was due to the absence of one of the key conditions for junction with the Earth's information field: either amplified or slackened local magnetic flux representing a particular state of the planet.

Sanctuary Belintash at the top of a mountain in the Rhodopes is a complex system of interconnecting vessels (cut off in the rock) for ceremonial liquids and water. Magnetometric and biotective monitoring showed a particular ceremonial site, the 'Sabazia's Throne', as well as the centers of the stone vessels to be located in energy-active points of Earth within the regions of micromagnetic anomalies with a very high gradient of the magnetic field. We suggest that the place for this sanctuary, where ancient Thracian priests and physicians were trained, was chosen due to specific features of the geophysical structure of this mountaintop. The distant informative transmission from the magnetic anomalous 'Throne' appeared perceived over thousands of kilometers in Novosibirsk. Three other attempts of transmission from neighboring non-anomalous points were unsuccessful. The 'strength' of the 'Throne' is obviously the insertion of a man into the united cosmoplanetary system through key zones of the Earth information field, initiation and strengthening of psychophysical reserves of the organism that were actively used by Thracian physicians.

A session of distant image-bearing communication between the Thracian cave sanctuary (5 km away from the village Bailovo) and Sophia was held. The Bailovo ritual cave stores a great number of ancient drawings. Like in the other Bulgarian sanctuaries, the magnetometric monitoring of the cave surface was conducted before the communication session. No anomalous magnetic zone but a difference in rocks magnetic induction of up to 1,000 Tl was found at the sites of various drawings.

Only those images of the series of successively transmitted ones which occurred at the regions of high magnetic induction were perceived in Sophia. The transmission procedure implied that the face of a transmitting operator was at the distance of 20 cm from the drawing. Here an important question arises which needs further thorough examination. What is the role of magnetic structure of the closed compartments of the cave and of the distant image-bearing communication channel for the works of ancient artists? The question is valid if for no other reason than that the geophysical peculiarities of ritual caves were twice decisive, in Khakassia and in Bulgaria, for the success in the distant image-bearing interaction.

Thus, the investigations on assessment of distant image-bearing communications in Thracian ritual places revealed the role of inhomogeneous geophysical structure of sanctuary space. The distant image-bearing interaction was not achieved but when the operator with a high magnetosensitive organism was within magnetoanomalous regions where man's field structure is as if integrated into the global field of the Earth living space.

Investigations in Serbia

Participants in the first Russian-Serbian experiment in Belgrade (16 March 1992) tried to receive an image-bearing message transmitted at that moment from a hypomagnetic chamber in Novosibirsk. About 26% of the total number of participants (860 persons) perceived correctly at least one of the transmitted image fragments. A peculiar point is that the most successful were those of them who were at the sites of biotective anomalies of the auditorium. Perhaps, the high result was affected by the collective field of the large group of individuals within the 'perception' zone who were united by the desire to receive the message. That was our first successful experience on collective perception of the remote image information by persons staying in one geographical point, one compartment but in various regions of the inhomogeneous space.

The next Russian-Serbian experiment was held on 19 January 1993. This is the day when Earth occurs within a specific cosmoplanetary flow, probably influencing the channels of distant interactions. At the fixed time our researchers and colleagues came to spiritual repositories of two nations: to the treasury of ancient Serbian arts in the National Museum in Belgrade and to the Novosibirsk Picture Gallery, where the hall of Ancient Russian Painting with icons of predominantly Siberian School was opened on the occasion of Orthodox Epiphany. 343 of 410 records of the experiment participants were taken into consideration; 210 of them (61%) reported the information corresponding to elements of the transmitted programs.

The high efficiency of perception of distant image-bearing information transmitted from repositories of culture and arts of two Slavic nations was demonstrated.

The effect of 'mosaic collective' perception of images was discovered; it means that the entire image is compiled in a collective way from icon fragments perceived and described in reports of a number of participants.

The following subjects were perceived as fragments and details: Fire Ascent of Ilya the Prophet (88 fragments), Archangel Michael the Voevode (36 fragment), and other icons of the Siberian School.

Table 1. Results of perception of distant image-bearing information in Sava-Center, Belgrade, during image transmission from the Hall of Ancient Russian Painting (icons dated 14th-19th centuries) of the Novosibirsk Picture Gallery

Perception regime	Exact perception of subject fragments of the image		Exact perception of isolated elements		Total	
	n	%	n	%	n	%
At the moment of perception	94	74	7	6	101	80
15 min behind	14	11	0	0	14	11
15 min ahead	10	8	1	1	11	9
Total	118	93	8	7	126	100

Investigations in Far North

To examine representatives of North ethnoses, little nations of Far North distinguishing in the historical periods of their housing on the Taimyr peninsula (Nganasanians who have lived there for some thousand years and Dolganians) with respect to their capability for distant

image-bearing communications seemed of importance during our North series of research. Both nations live in the polar settlement Ust-Avam, which was the place of our paleopsychological experiment with 56 aboriginal inhabitants ranging from 3 through 70 years of age.

Nganasanian and Dolganian children of pre-school age (42 persons) took part for the first time in such a study. They were proposed to make a free drawing during the session of distant 'transmission' from another settlement Dikson located northward. According to the procedure, the children were isolated from each other and could not communicate in a sensory manner.

The data obtained showed only Nganasanian children to possess a pronounced capability for distant perception of image-bearing information as interpreted in their conventional North stylistics. The reference examination of Russian children who were born and live in Far North and of children living in Novosibirsk demonstrated them not to reveal, though more than adults, such a capability.

The study of children's extrasensory perception becomes increasingly attractive to scientists throughout the world (J.Salles, 1987; A.Tanous, K.Donelly, 1980 [48, 49]). The projects on schools of the future which will employ extrasensory channels for training (R.Cervantes, C.Castaneda, 1983 [50]) are proposed.

The results of the Ust-Avam experiment allowed us to make another conclusion of great importance. Representatives of shaman dynasties of Far North nations were shown to be specific keepers of the unique potentiality of their ancestors to distant image-bearing communications. During the image transmission session from Dikson, a great-granddaughter of a famous shaman T.Aksenov, when being in Ust-Avam, perceived the image of three mountain tops she never saw before. A representative of another shaman dynasty, great-grandson of shaman I.Kosterkin, perceived precisely in Dikson and drew the image of 'shaman-camp', a riverside ceremonial place where he was only once together with his shaman great-grandfather.

Far North is a unique place for paleopsychological studies on distant image-bearing interactions. We chose it not only with regard to specific features of polar magneto- and ionosphere (for example, the occurrence of the circuited flow of charged particles, electrojet, that changes its sense of rotation twice a day) but also, according to N.A.Kozyrev, owing to the particular role of the polar regions of Earth in the cosmoplanetary interaction of temporal flows.

Following N.A.Kozyrev's ideas, we designed an installation ('mirrors') allowing for examinations of distant image-bearing interactions within a modeled multidimensional space. Thus, we kept trying to develop notions on paranormal phenomena through adopting fundamental physical laws to the system of not four but more coordinates [43].

The Global experiment 'Arctic Circle'

The participants in the global experiment 'Arctic Circle' who transmitted image information were specially trained during a preliminary course. They transmitted the information when they were in ordinary or particular mental state in multidimensional space of the 'Kozyrev mirrors' in Far North. The transmitted program was a graphic set of 77 symbols (Fig.2).

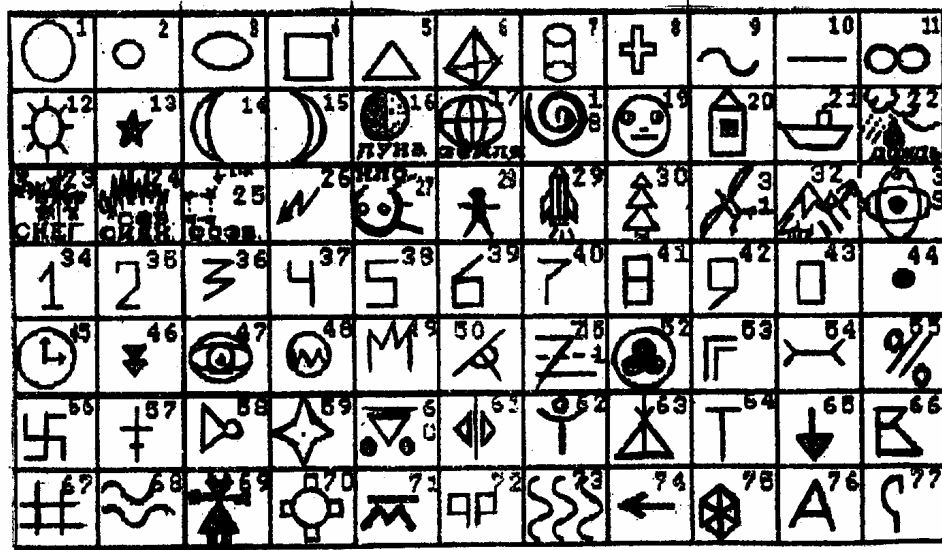


Figure 2 Image set of 77 graphical symbols originated from various cultures, epochs, and nations was used for experiments on distant-image communication

Three or five elements of the set were drawn randomly by a computer five minutes before the session. An operator used the chosen elements to compile the image to be transmitted.

More than 4,000 people from a number of countries throughout the world took part in the experiment. Those who wished to receive the image-bearing information were either in their habitual living and working rooms or in the places of high cultural, historical, and spiritual significance as well as in the anomalous geophysical zones. All of them were ready (not using special meditation techniques) to note the image information appearing in front of their 'interior eyes'.

After primary processing of the reports, the experimental data base was developed as well as the program for calculation of the numbers of all elements perceived by each percipient during a given session; all the data were added to the array, compared to the transmitted image array, and the number of elements perceived precisely was found. The results were summed up and normalized to determine the experimental distribution function for correctly perceived elements which was compared to the theoretical (expected) function. The experimental conditions represent the classical case of random sampling over the range of 1 to 77; then the distribution obeys the hypergeometric law.

The distribution function were plotted on the basis of the experimental and calculated data. The difference between the experimental and calculated functions was found using the Kolmagorov-Smirnov conformity criterion.

In order to find what elements were best perceived, the polygon of relative perception frequencies and the Monte-Carlo frequency polygon were constructed for the elements from first to seventy seventh; mathematical expectation and standard deviation were determined.

Processing of the large statistical array (4,233 participants) showed the empirical data to be higher than the calculated and computer generated probability for 'guessing' the transmitted graphic images. Therefore, the information transmitted from Dikson was *perceived indeed* simultaneously in various geographical sites of Eurasia! It should be pointed out that only the

information transmitted under the conditions of a new ingenious technology in 'Kozyrev mirrors' appears perceived [2, 44, 45].

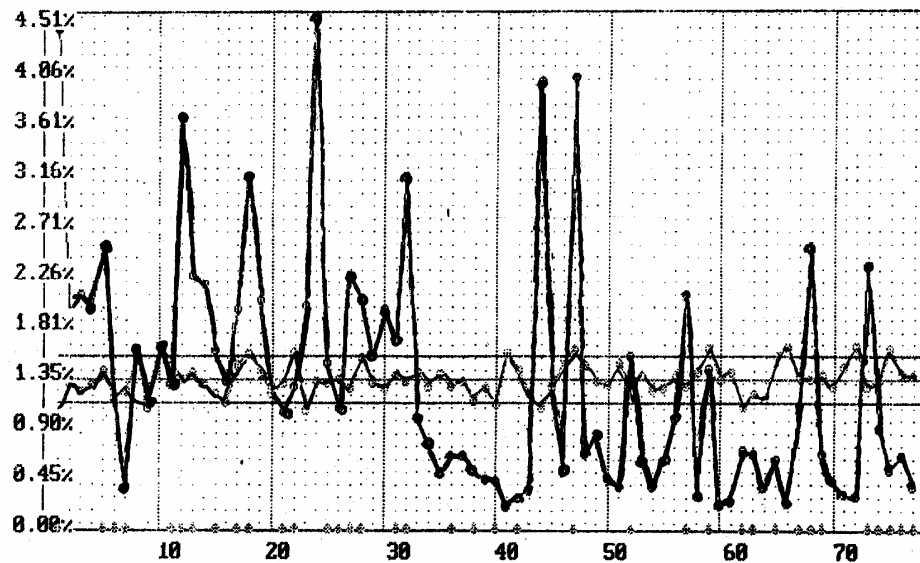


Figure 3 Number of images (%) correctly perceived by participants in the Polar Circle experiment. (Comments: The calculated 'guessing' probability corridor is plotted.)

Fig.3 shows the overall result on perception of image-bearing information by all the participants. Cross symbols (+) on the x-axis mark the images transmitted in the course of 10 experimental sessions. The curve inside the distinguished corridor means the calculated and computer generated probability of image 'guessing'. The peaks in the curve above the upper boundary of the corridor are first documented scientific evidence for the occurrence of interpersonal distant-image communications [2].

The data were obtained on the dependence of the phenomenon of perceiving the information on the cosmic situation of the prenatal period and birth. In particular, the result of distant-image communication is affected by the Moon phase in the Sun-Moon-Earth system. Individuals born under full Moon appear incapable of effective communications: for them the probability of symbol 'guessing' is much higher of the probability for symbol 'reception'. A more exact 'reception' is characteristic of those who were born under new Moon. People whose embryonic growth and birth occurred at the highest solar activity also reveal good potentialities in 'reception'. These facts support the literature data on the effect of cosmic situation during the embryonic period on the organization of man's mental functions [46]. We have shown a very specific pattern of distribution of heliogeophysical factors during the embryonic life to be characteristic of a family of psychological diseases [47].

Again, the influence of factors treated by astrology was revealed. From an analysis of the Zodiac dependency, a man demonstrates the best 'reception' if at the moment of the experiment Sun is in the same ecliptic sector as it was when the man was born [2].

The most effective communication was demonstrated by 'Sagittariuses' and 'Capricorns'. It should be mentioned that the experiment was performed at the interface between the two Zodiac periods.

It seems of importance that the experiment participants born not long before and after Christmas, *i.e.* in the sector of projection of certain constellations on Earth, were most successful in achievement of distant-image communications during sessions conducted on the eve of Christmas.

The dependence of the efficiency of distant-image communications on the amount of technogenic distortions of the natural habitat was found. The participants staying in brick buildings demonstrate the accuracy of perception of image-bearing information other than those in ferro-concrete buildings. There is a more accurate perception in brick buildings, while for the work in ferro-concrete buildings the probability of 'guessing' transmitted symbols lays above the empirical values of the true reception of the information [2].

Thus, the commonly known difference between buildings made of bricks and of reinforced concrete are also decisive for the level of interaction of a man with the Earth informative space; they behave as factors strengthening the inhomogeneity of his space.

The distant-image iterations are shown to be a cosmoplanetary phenomenon. It is the most pronounced when specially designed installations are used; the installations model the multidimensional space of arctic regions of Earth which are of particular importance to formation, evolution, and reservation of the information field, the 'living space' of our planet.

3.2 Temporal Paradoxes at Interpersonal Distant Informative Interactions in the Living Space of Near Cosmos

The experiments held in Far North, Dikson, in July 1990 are the evidence of the advanced dependence of interpersonal distant image-bearing communications on the planetary-cosmic interactions. The trend toward an increase in the number of correctly perceived images was revealed as long as 7 days before the solar eclipse (22 June). The highest result (perception of up to 90% of the information transmitted) was demonstrated 30 min before the earliest phase of the solar eclipse and just in the moment. The result of the day after was the same as that of the day before the eclipse. Of particular importance is that this best result was shown by a group of individuals born during the periods of new and full moon. No influence of the solar eclipse on performance of distant image reception was observed with the reference group of participants born under the other moon phases. Specific technologies were used to show a possibility of the 'programmed input' of image-bearing information into the information space of Earth for a great number of participants to reproduce it on a given date and at a given time. For example, an operator born under full moon generated a package of image information (three or more images) in an intellectual fashion in Far North in a laser mirror system oriented towards a sky object (full Moon); many operators who were also imprinted by Moon at the moment they were born perceived reliably the signal three and more days after the information input [45]. During the same experiment the image package formed in the Kozyrev's 'mirror system' during the period of heliophysical compatibility of the operator and the medium was shown to be perceived reliably nine and more days after by many hundreds of operators in various sites of Earth. An experiment achieved also within the zone of 'paradoxical time course' (above 73° North) has showed the package of image-bearing information introduced using a geophysical system of vertical probing of the ionosphere into the fluxes of west and east electrojet in the morning or evening to be reliably perceived by operators in the trans-polar regions at the evening-night or morning time (depending on the periods of activity of either west or east electrojet). The data obtained elucidate the probable mechanisms of the phenomena we recorded during the experiment 'Aurora Borealis': ca. 30% of the information transmitted from

‘mirror systems’ in Far North are perceived with the same retardation of 3, 6, 9, and 12 hours [39].

Additional data on time distribution of the effects of distant informative interaction were obtained from accomplishment of the research project ‘Jupiter – Shumeikero-Levi Comet in the Living Space’. Two groups of temporal effects for distant communications were classified:

- (a) Reliable reproduction of information introduced before into the information space. A better perception of image-bearing information transmitted 72 hours earlier was shown to occur two days after the first meeting of Jupiter and the comet.
- (b) Advanced perception of image-bearing information. A day before the first meeting of Jupiter and the comet the effects of advanced perception of the information to be transmitted during the next 72 hours after the session start revealing. The maximal ‘advance’ is attained during the day of the first meeting, then the effects of ‘advancement’ decrease and reach zero point on 22 July 1994.

Table 2 Temporal shift of interpersonal distant-image interactions in the binary system Dikson-Novosibirsk in July 1994 during the period of meeting of Jupiter and Shumeikero-Levi comet

Days	5	7	9	11	13	15	17	19	21	23	25	27
1	7.0	10.0	9.0	11.0	12.0	8.0	4.0	2.0	1.0	1.0	4.0	18.0
2	–	–	3.0	3.0	5.0	4.0	3.0	19.0	45.0	40.0	12.0	–
3	1.0	1.0	1.0	1.0	2.0	2.0	72.0	40.0	8.0	–	–	–

(Comments: 1 - the percentage of images perceived correctly at the moment of transmission; 2 - the percentage of correctly perceived images against the images transmitted 72 hours before the session; 3 - the percentage of correctly perceived images against the images transmitted 72 hours after the session).

Earlier experiments showed that ca. 30% of image information transmitted from ‘mirror systems’ in Far North is perceived in advance of the transmission by 3, 6, and 9 hours (the project ‘Aurora Borealis’). No effect of advanced perception of image-bearing information was revealed by the experiments carried out in the zone of middle latitudes using the ‘mirror systems’ or in Far North using no ‘mirror system’.

4 DISCUSSION

The results obtained during the global experiments allow us to approach an evidence for the occurrence of interconnection of intellectual fields of Earth inhabitants, as well as the recognition of potentiality of human’s mind to acquire information irrespectively of geography and time. Of vital importance becomes the scientific prediction of fundamentally different psychological situation, when general recognition of interrelation between human intellect and his cosmoplanetary essence has far-reaching geopolitic, social, and medical consequences. The preceding experimental studies, as well as the data of sample querying of the participants in the global experiment (105 person’s) 3 years after its accomplishment may be the basis of such a prediction. Compared to the reference group (82 persons), the experiment participants claim for three- or fivefold decrease in the number of catarrhal, infection, and psychosomatic diseases. This is an indirect evidence of an advanced level of ‘field immunity’ of their organisms. At present the development of fundamentally new technologies nears completion; the technologies are based on mirror systems in which the preserved ‘thought-shape’, retro- and provision become of correcting and valeological significance.

The channels of transpersonal interactions at the scale of individuals were considered rather well by European and American researchers engaged in the field of transpersonal psychology [14,15,20,29,30].

We think it important to stride further: to set a research probe of new generation going to the planet's information space we think to be living; the principal here is the method of distant estimation of interpersonal interactions.

What waits for this messenger? Is it sequential change over of the paradigm of Euclid space, time, and special relativity theory? Or addressing the rhythms of the Universe's memory [51], our own past becoming the present, the resonance of morphogenic, social, cultural, and spiritual fields of ethnic spaces [52]?

We stay at the limits of habitual reality behind which the classical nature science has already lost its scientific potential. An infinite area of new kind of vision is opened [30]. The horizon of the living planet – Gea, a pearl in the shell of the living space related through invisible flows to all its elements on Earth and in Universe in the past, present, and future.

Where will our 'Wanderer' penetrate? Into a parallel world of 'superlight space-time' involving the consciousness of the entire mankind and information on the past, present and future [53]? Into an infinite space of the conscious living substance [54]? Into a multidimensional world, simulated by 'mirror systems', with compacted time that probably changes its course in high latitude of the planet [10]?

Many of these secrets are hidden in particular regions of the living Earth in the zones of direct connections with cosmos, treasures of the spatial-temporal memory of Universe, nerve knots of the planet, peculiar trigger points of cultures and civilizations which seem to be gone [40].

The answers to the questions posed, and may be the questions themselves have not reached our mind as yet.

5 CONCLUSION

While waiting for that and summarizing the data obtained, we state some conclusions:

- (1) The method of transpersonal distant informative communications may be an indicator of the state of the living space and technocratically induced distortions of the noosphere;
- (2) The interpersonal distant informative interactions, as considered at the paleopsychological, cultural historical horizons, are in essence a cosmoplanetary intellectual phenomenon, they are representative of inhomogeneity of space and time;
- (3) The geophysical inhomogeneity of the planet structure, along with the inhomogeneity of circumterrestrial space, is a necessary condition for emergence, progress, and preservation of cultural spiritual centers of individual ethnoses and the civilization as a whole;
- (4) Periodic and extreme events in the near cosmos appear related to psychophysical processes, intellectual systems on Earth and temporal coordinates in the living space of Universe;
- (5) Time, its course as an element of inhomogeneous living space of Universe can provide the interaction of cosmic intellectual spaces;
- (6) Interpersonal distant informative interactions as a constituent of intellectual cosmic communications is achieved in the most effective way when 'mirror systems' are used within the zone of paradoxical time course, *i.e.* in arctic regions of Earth; and
- (7) The availability of channels of interpersonal distant informative interactions dependent on heliophysical circumstances make it of urgent importance for science and medicine of the coming millennium to study the role of information transmissions in aetiology,

pathogenesis, and epidemiology of mental diseases, as well as to develop advanced techniques for their prevention and treatment.

6 PROSPECTS

The international Institute of Cosmic Anthroecology plans to aim its further investigations in a series of transcontinental experiments at various sites of the planet, in anomalous geophysical zones, historical cultural spiritual centers of Europe Asia, North, Central, and South America, Australia and Oceania, as well as in Arctic and Antarctic regions in order to study regularities of the formation and preservation of Earth's information space and to accomplish the project on development of the global network of distant informative communications free of traditional technical communication devices.

Several scientific medical projects suppose the establishment of an international research center in Far North, Dikson, in arctic zone above 73° North, where 'mirror systems' will be used in this unique heliophysical circumstances for investigations of potential application of multidimensional and hypogeomagnetic space in discovering man's psychophysical reserves for struggle against almost incurable diseases, such as cardio-vascular disasters, tumors, neurotic and mental disorders.

Accomplishment of the enumerated and other projects in the area of transpersonal psychology and medicine implies a public union of scientists of various countries on the basis of high ethic responsibility for the future of the world.

That and only that will be the time when we can see the hand of the man from the Pesh-Merle cave stretched out from the profundity of times and Universe to us.

REFERENCES

- [1] В.П. Казначеев and А.В. Трофимов, Новые данные о взаимодействии человека с информационным полем Земли в приполярных районах, *Бюллетень СО РАМН*, N 4, 1992, с 46-48.
- [2] В.П. Казначеев and А.В. Трофимов, *Проблемы Новой космогонии (выживание в живом пространстве)*: (Препринт - СО РАМН Новосибирск:, 1993).
- [3] W. Barret, B. Westlake and K. Pribram, *Зарубежные исследования по психологии и познанию* (Moscow, 1975).
- [4] Б.И. Исаков, *Квантово-статистическое моделирование биоэнергетических явлений и лептонная гипотеза о природе физических полей биообъектов*. (Moscow, 1988.)
- [5] В.В. Налимов and Ж.А. Дрогалина, *Реальность нереального. Вероятностная модель бессознательного*. (Изд-во "Мир идей" АО АКРОН, Moscow, 1995), с. 432.
- [6] И.П. Шмелев, *Общественный подход к психотронике* (Рукопись С.И, 1984.)
- [7] E.A. Rauscher, *Some Physical Models Potentially Applicable to Remote Reception* (The Iceland Papers / Ed. A. Pucharich Amherst. Wisc., 1979) pp. 50-99.
- [8] J.L. Synge, *Relativity: The General Theory* (North-Holand Amsterdam, 1960).
- [9] W.A. Tiller, *The Positive and Negative Space-Time Frames as Congate Systems* (Stanford, 1975), pp.1-25.
- [10] Н.А. Козырев, *Избранные труды* (Изд-во Ленинградского университета, 1991).
- [11] Л.Л. Васильев, *Таинственные явления человеческой психики* (Госполитиздат, Moscow, 1963), p. 168.
- [12] M. Fridjung, Time: A Challenge to Physics? *Network*, N 63, April 1997, p. 17

- [13] А.Е. Акимов, Эвристическое обсуждение проблемы поиска новых взаимодействий. EYS'-концепции, *Сознание и физический мир*, Вып. 1, Моасов, 1995, с.36-85.
- [14] А.П. Дубров, Роль парапсихологии в смене парадигмы современного естествознания, *Парапсихология и психофизика*, Журнал фонда парапсихологии имени Л.П.Васильева, № 1(23) 1997, с.11
- [15] А.Г. Ли, Парапсихология - наука и социальнокультурный феномен, *ibid*, с.12-14
- [16] H. Brugmans, A Report on Telepathic Experiments Done in the Psychology Laboratory at Croniugen, *Le Comple Rendu officiel du Premier Congres International des Recherches Psychiques*, Copenhagen, 1922.
- [17] G. Estabrooks, A contibution to experimental telepathy, *Bulletin of the Boston Society for Psychic Research, J. of Parapsychology* 25, 1961, pp.190-213.
- [18] L.A. Troland, Technique for the Experimental Study of Telepathy and other Alleged Clairvoyant Processes, *J. of Parapsychology* 40, 1976, pp.194-216.
- [19] Y. Puthoff and R. Targ, A perceptual channel for information transfer over kilometer distances: Historical perspective and recent research, *Proc. IEEE* 64 (3), 1976, pp.329-354.
- [20] E. May, J. Utts and B. Humphrey, Advances in remote-viewing analysis, *J. Parapsychology* 54 (1990), pp.193-228.
- [21] D. Bohm, Qantum theory as an indication of a new order in physics, *Part B./Foundations Phys.* 1, 1971, pp.359-381.
- [22] J. Utts, Replication and Meta-Analysis in Parapsychology, *Statistical Science* 6, 1991, pp.363-403.
- [23] W. Brand, Psi conductive conditions: Exploration and interpretations. Psi and states of awareness, *Proc. Int. Conf.*, Paris, France, Aug. 1977, B. Shapin and L. Coly, eds.: (Parapsychology Foundation, New-York, 1978).
- [24] C. Honorton, Psi and internal attention systems, *Handbook of Parapsychology*, B. Wolman, ed. (Van Nosttrand Reinhold, New-York, 1977), pp. 435-472.
- [25] C. Scott, On the evaluation of verbal material in parapsychology: A discussion of Dr. Pratt's monograph, *J. Soc. Psych. Res* 46 (1972), pp.79-90.
- [26] R. Morris, Parapsychology and biology, *Handbook of Parapsychology*, B. Wolman, ed. (Van Nostrand Relnhold, New York, 1977), pp.687-715.
- [27] G. Solfvin, Kelly and D. Burdick, Some new methods of analysis for preferential ranking data, *J. Amer. Soc. Psychical Research* (1978), p.93.
- [28] D. Marks and R. Kammann, *The Psychology of the Psychic* (Prometheus Books, Buffalo, N.Y., 1980).
- [29] R. Jahn, *The role of Consciousness in the Physical World* (Westview, Press, Boulder, CO, 1981).
- [30] R. Jahn and B. Dunne, *Margins of Reality. The Role of Consciousness in the Physical World* (, Bear comp., USA, 1990).
- [31] W. Brand and S. Dennis, Autonomic activity, hemolysis, and biological psychokinesis: possible relationships with geomagnetic field activity, *Perceptual and Motor Skills* 68, (1989), pp. 1243-1254.
- [32] C.B. Schaut and M.A. Persinger, Subjective telepathic experiences, geomagnetic activity and the ELF huphthesis: Part I. Data analyses, *Psi Research* 4, N 1, (1985), pp.4-20.
- [33] В.П. Казначеев and А.В. Трофимов, Энерго-информационные взаимодействия в биосфере : опыт теоретических и экспериментальных исследований, *Русская мысль. Реутов* 1, (1992), с.22-27.

- [34] В.П. Казначеев and А.В. Трофимов, Полевая форма живого вещества - перспектива XXI века, *Тез. докл. межд. конф. биоэкстрасенсорика и научные культуры здоровья на рубеже веков*, Moscow, 1996, с. 47-49.
- [35] V. Kaznatcheyev, Pour une medecine du troisieme millenaire, *Energie Sante* 29 (1995), pp. 9-15.
- [36] Ю.А. Мочанов, Древнейший палеолит Диринга и проблема внетропической прародины человечества, *Археология Якутии*, Якутск: Изд-во ЯГУ, (1988), с. 15-53.
- [37] H. Stapp, *A quantum Theory of Consciousness. - The Interrelationship Between Mind and Matter*, Proc. Conf. Center for Frontier Sciences, 1992, pp. 207-217.
- [38] G. Michel, *Cosmic Influences on Human Behavior* (Aurora Press, New York, 1973).
- [39] V.P. Kaznacheev and A.V. Trofimov, *Cosmic Consciousness of Humanity*, Problems of New Cosmogony (Elendis-progress, Russia, Tomsk, 1992).
- [40] J. Swan, *Sacred Places*, How the living Earth Seeks our Friendship (Bear comp, USA, 1990).
- [41] P.B. Tompkins, *Christopher Secrets of the Soil* (Harper and Row, New York, 1989).
- [42] K.C. Markides, *Fire in the Heart* (Paragon House, USA, 1990).
- [43] G. Feinberg, Possibility of faster-than light particles, *Phys.Rev.* 159 (1967), p. 1089.
- [44] А.В. Трофимов, Парадоксы времени при дистантно-информационных взаимодействиях в живом пространстве Земли, *Вестник МИКА*, Выпуск 1, (1994), с.28-35.
- [45] A. Trofimov, Paradoxes vivants dans l'espace de la Terre, *Enengie Sante* 30 (1995), pp.58-64.
- [46] G. Marzullo, *Month of Birth Creativity and the Two Classes of Men* (Per Aspera Books, 1996), p. 287.
- [47] А.В. Трофимов and А.А. Гадалов, Гелиогеофизический баланс пренатального периода развития и его роль в стратегии здоровья человека, *Вестник МИКА* 4 (1997), с.27-36.
- [48] S.J. Ferraz, Identification of the gifted: A prospective view, *Gifted Int.* 4 (1987), pp.51-58.
- [49] A. Tanous, Donnelly and K. Fair, *Your Kids are Psychic*, *Instructor* 89 (1980), pp.65-67.
- [50] R.A. Cervantes and C.Z. Castaneda, Classroom" of the future: 2058 AD., *Educational and Societal Futures: Meeting the Technological Demans of the 1990 s. Proceeding of Conference California*, Apr. 1983.
- [51] I.I. Dardik, The great law of the universe, *Cucles*, March/April 1994, pp. 265-277.
- [52] R. Duthei and B. Dutheit, *L'homme superlumineux* (Sand, 1990).
- [53] R. Sheldrake, *La Memoire de l'Univers* (Editions du Rocher, 1988).
- [54] R.A. Charman, The field substance of mind, A Hypothesis, *Network*, N 63, April 1997, pp. 11-13.

HOLOPENT AND INFORMATION PHYSICS

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Abstract. In this paper a scientific interdisciplinary approach to consciousness is considered. Connections between biology and consciousness, and between consciousness and physics through a new physical theory - *information physics* can be explained. This approach leads to a relativistic model of the information theory, and opens up the possibilities of linking *information* with *mass* and *energy*. By considering Neurocomputing and Consciousness, a new field of science emerges which can be named: Information Physics. In the final discussion, one extra problem is considered: Can a machine, as a form of artificial life, possess consciousness?

Key words: *golden mean, information physics, holopent, consciousness.*

1. INTRODUCTION

From the point of view of importance the question: *What is consciousness?* comes after the questions: *Why is there anything rather than nothing?* [1], and *What is time?* Consideration of the relationship between neurocomputing and consciousness opens up new possibilities of closer answers to these questions.

In the scope of our recent research [2,3] in the field of bioinformatics, we have shown that information processes as space-time patterns depend on the volume of the unit sphere in the N-dimensional space [4,5]. The values of the unit spheres in N-dimensional space are given in Table 1. In this table appear the positive dimensions, the negative dimension and the dimension $N = 0$.

Considered from the informational aspect the optimal space is five-dimensional, and it appears as both positive and negative. Having in mind that a $N=0$ space also exists, we will assume that the main informational state represents the unity of $N=5$ and $N=0$. ${}^{\kappa}\aleph_0(5^{\circ}) = 1$ where κ means the information code of dimension $N=5$ and $N=0$ (Fig. 1a). The unity sphere $N=0$ contains the entity whose dimension is $d = 3/2$ and volume is $C_0 = 1$ which is equivalent to the value of the space information code ${}^{\kappa}\aleph_0(5^{\circ})$. In other words there is a correspondence between ${}^{\kappa}\aleph_0(5)$ and C_0 .

In order to establish a connection between the *informational approach*, the result of which is Table 1, and the physical approach, it is necessary to find a *physical entity* which in five-dimensional space has a dimension $d_m=3/2$ and whose volume is $C_0 = 1$.

It is well known from quantum field theory [6] that the dimension of mass, as a real physical entity, is calculated from the expression:

$$d_m = \frac{d}{2} - 1 \quad (1)$$

where d is a dimensional space-time value. In the main information state $^{\infty}\aleph_0$ (5°) the mass dimension based on the expression (1) is $d_m = 3/2$. In other words, the real physical entity which contains information code is *mass or/and gravity waves* in the state $d(3/2, C_0)$.

Table 1 Value of the unit sphere for $N = 6$ to $N = 4$ [2, 3]

$N = 6$	$C_6 = \frac{2\pi}{n} C_4 = \frac{2\pi}{6} \cdot \frac{\pi^2}{2} = \frac{\pi^3}{6} = 5.1677$
$N = 5$	$C_5 = \frac{2\pi}{n} C_3 = \frac{2\pi}{5} \cdot \frac{4\pi^2}{3} = \frac{8\pi^3}{15} = 5.2637$
$N = 4$	$C_4 = \frac{2\pi}{n} C_2 = \frac{2\pi}{4} \cdot \pi = \frac{\pi^2}{2} = 4.9348$
$N = 3$	$C_3 = \frac{2\pi}{n} C_1 = \frac{2\pi}{3} \cdot 2 = \frac{4\pi}{3} = 4.1887$
$N = 2$	$C_2 = \frac{2\pi}{n} C_0 = \frac{2\pi}{2} \cdot 1 = \pi = 3.1415$
$N = 1$	$C_1 = \frac{2\pi}{n} C_{-1} = \frac{2\pi}{1} \cdot \frac{1}{\pi} = 2 = 2$
$N = 0$	$C_0 = \frac{2\pi}{n} C_{-2} = \frac{2\pi}{\frac{3}{2}} \cdot \frac{1}{\frac{4\pi}{3}} = 1 = 1$
$N = \bar{1}$	$C_{-1} = \frac{2\pi}{n} C_{-3} = \frac{2\pi}{4} \cdot \frac{1}{\frac{\pi^2}{2}} = \frac{1}{\pi} = 0.3184$
$N = \bar{2}$	$C_{-2} = \frac{2\pi}{n} C_{-4} = \frac{2\pi}{5} \cdot \frac{1}{\frac{8\pi^2}{15}} = \frac{1}{\frac{4\pi}{3}} = 0.2387$
$N = \bar{3}$	$C_{-3} = \frac{2\pi}{n} C_{-5} = \frac{2\pi}{6} \cdot \frac{1}{\frac{\pi^3}{6}} = \frac{1}{\frac{\pi^2}{2}} = 0.203$
$N = \bar{4}$	$C_{-4} = \frac{2\pi}{n} C_{-6} = \frac{2\pi}{7} \cdot \frac{1}{\frac{16\pi^3}{105}} = \frac{1}{\frac{8\pi^2}{15}} = 0.1899$

From our results shown in Table 1 it is implicated that $N = 0$ as $d(3/2, C_0)$ may, from the aspect of information, pass into the new state $d(3/\bar{2})$, because $N(3) \cdot N(\bar{2}) = N(0)$. In this case we again have $d = 5$ in $N = \bar{2}$, but we also have $d = 3$ in $N = 3$ (Fig. 1b).

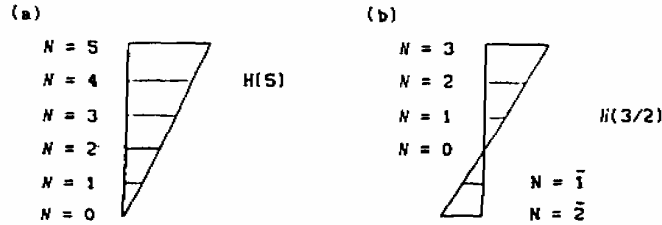


Figure 1 Two solutions of Holopent: (a) optimal and (b) quasi optimal

We know that our awake consciousness is a result of *brain information processing* with interactions from the *real world*. We present every event of objective reality as:

$$x = x_1, y = x_2, z = x_3, t = t \quad (2)$$

and this is our four-dimensional world. One of the difficulties is to visualize four-dimensional space, as we observe a three-dimensional world through our visual system and through information processing in the brain which makes us conscious of it.

In Minkowski's approach [7] to four-dimensional space there exists the speed of *light* as a cofactor of four-dimensional space. It is possible to write this as

$$x_1^2 + x_2^2 + x_3^2 - (ct)^2 = 0 \quad (3)$$

This means, having in mind Fig. 1b and Table 1 that ct is of the dimension $N = \bar{1}$. But from our results given in Table 1 there must be one more relationship between the three-dimensional space (x_1, x_2, x_3) and time (t). From a dimensional point of view we can write a four-dimension as follows:

$$m \frac{s}{s} (=) \frac{m}{s} s (=) ct \quad (4)$$

and there is only one more possibility for a relation of one of three dimensions (x_1, x_2, x_3) and time (t) as

$$m \frac{s}{s} (=) ms \frac{1}{s} (=) {}^k\aleph_0 {}^\omega\aleph_0 \quad (5)$$

where ${}^k\aleph_0$ is a *cardinal dimensional measure* as a *main information code* of space - time structures and ${}^\omega\aleph_0$ is a *frequency* of anisotropic rotation or radiation. Now we can write:

$$x_1^2 + x_2^2 + x_3^2 - (ct)^2 - ({}^k\aleph_0 {}^\omega\aleph_0)^2 = 0 \quad (6a)$$

or

$$x_1^2 + x_2^2 + x_3^2 = (ct)^2 + ({}^k\aleph_0 {}^\omega\aleph_0)^2 \quad (6b)$$

and we can see that it is equivalent to Fig. 1, where $N = \bar{1}$ is ct and $N = \bar{2}$ is ${}^k\aleph_0 {}^\omega\aleph_0$.

Dimension $N = \bar{2}$ is the product of *cardinal dimensional measure* as a unity of space-time, and *frequency*. According to Eq. (5) ${}^k\aleph_0$ has to have the opposite meaning of velocity in the classical sense, because it represents the *space-time code* as a state of rest being the same value as *light velocity* as an *invariant measure* of space-time.

Table 2 Holopent and main states of consciousness

	State of Holopent	States of consciousness	COMENTS
1.	$x^2+y^2+z^2=(ct)^2 + ({}^k\aleph_0 \circ \aleph_0)^2$	Awareness Feeling	
2.	$x^2+y^2+z^2 \uparrow (ct)^2 + ({}^k\aleph_0 \circ \aleph_0)^2$	Death in awareness state	
3.	$x^2+y^2+z^2=(ct)^2 \uparrow ({}^k\aleph_0 \circ \aleph_0)^2$	Clinical death	
4.	$x^2+y^2+z^2=(c\uparrow t)^2 + ({}^k\aleph_0 \circ \aleph_0)^2$	Hallucination	
5.	$x^2+y^2+z^2=(ct)^2 + ({}^k\aleph_0 \uparrow \circ \aleph_0)^2$	Awareness without feeling	Under influence of analgesics
6.	$x^2+y^2+z^2-(ict)^2=({}^k\aleph_0 \circ \aleph_0)^2$	Sleeping with dream	
7.	$x^2+y^2+z^2-(i\uparrow t)^2=({}^k\aleph_0 \circ \aleph_0)^2$	Sleeping without dreaming	
8.	$x^2+y^2+z^2-(ict)^2=({}^k\aleph_0 \uparrow \circ \aleph_0)^2$	Sleeping with dreaming, without memory of dream	
9.	$x^2+y^2+z^2-(ict)^2 \uparrow ({}^k\aleph_0 \circ \aleph_0)^2$	Hypnosis	
10.	$x^2+y^2+z^2-(ict)^2-(i \circ \aleph_0 \circ \aleph_0)^2=0$	Precognition	
11.	$x^2+y^2+z^2-(ic\uparrow t)^2-(i \circ \aleph_0 \circ \aleph_0)^2=0$	Prediction	
12.	$x^2+y^2+z^2-(ict)^2-(i \circ \aleph_0 \uparrow \circ \aleph_0)^2=0$	Intuition	
13.	$x^2+y^2+z^2=(c\uparrow t)^2 + ({}^k\aleph_0 \uparrow \circ \aleph_0)^2$	Non -awareness Non-dreaming Without feeling	Under influence of anesthetics
14.	$x^2+y^2+z^2-(ic\uparrow t)^2=({}^k\aleph_0 \uparrow \circ \aleph_0)^2$	Depression	
15.	$x^2+y^2+z^2-(ic\uparrow t)^2-(i \circ \aleph_0 \uparrow \circ \aleph_0)^2=0$	Hysteria	
16.	$x^2+y^2+z^2-(ict)^2-(i \circ \aleph_0 \circ \aleph_0)^2 \uparrow 0$	Death during sleeping	

\uparrow -split operator of wave functions of Holopent. \aleph_0 - power of set of al natural numbers (1, 2, 3, ... n)

2. INFORMATION PHYSICS

According to our results. from both information and physics point of view there exist realities which can be called *Holopent*, marked $H(5)$, $H(3/2)$. In Greek *holos* means entire, and *pente* means five, so we named this reality *Holopent* since its base is five-dimensional.

We will define consciousness as the informational state of Holopent, marked cH . It should be noticed that there exist $cH(5)$ and $cH(3/2)$. $cH(5)$ is defined as mapping:

$$cH(5): H(5) \rightarrow {}^k\aleph_0(5^0),$$

and $cH(3/2)$ is defined as mapping:

$$cH(3/2): H(3/2) \rightarrow H(3/\bar{2}),$$

while there are two levels, First level:

$$cH(3/\bar{2})_{N=\bar{1}=4} = cH^4, \quad (7a)$$

and Second level:

$$cH(3/\bar{2})_{N=\bar{2}=5} = cH^5, \quad (7b)$$

where we define the perceptive consciousness cpH as:

$$\begin{aligned} cp_1H: N(3) &\rightarrow cH_4 - (\text{lower level}), \\ cp_2H: N(3) &\rightarrow cH_5 - (\text{higher level}), \end{aligned} \quad (8)$$

the *non-perceptive* consciousness $cucH$ as:

$$cucH: N(\bar{1}) \rightarrow cH^5, \quad (9)$$

and the self consciousness csH as:

$$csH: N(0); cH(3/2) \rightarrow Cho(3/\bar{2}). \quad (10)$$

It was shown in Eq. (3) that ${}^{\kappa}S_0$ from the Eq. (5), as a cardinal information code, is a space-time pattern with the value $3 \cdot 10^{10}$ [cms]. Since this entity (${}^{\kappa}S_0 = 3^{N_0}$) participates in cH^5 (Eq. 7b) and $cucH$ (Eq. 9), i. e. in determination of the second level of our consciousness, and in mapping of the contents from the first level of the consciousness into the second level, then it necessarily means that there is a direct connection between the *consciousness* cH^5 and the biophysical state of brain and body [$3^{N_0} \rightarrow 2^{N_0} + (1+2+3+\dots+n)$]. According to Eq. (6b) the *frequency* as the co-factor H^5 which gives different states of consciousness. First assumptions on the connection between consciousness and electromagnetic waves, based on intuition and without the knowledge of the nature of this connection, are given in the studies [9,10].

A cardinal information code ${}^{\kappa}S_0$ as a property of *Holopent* $H(3/\bar{2})$ according to Eqs. (6a) and (6b) directly correlates with speed of light (as a space - time invariant) and biomolecular and brain frequencies. In other words basic molecular information "hardware" of the brain and its frequency are coupling.

Table 3. Parameters of biological neuro-computing [8]

REALITY $N(4) = (p, E)$	PICTURE OF REALITY IN THE BRAIN $cH^4 = I(R^3, t)$
$ih \frac{\partial}{\partial p_1}$	x_1
$ih \frac{\partial}{\partial p_2}$	x_2
$ih \frac{\partial}{\partial p_3}$	x_3
$-ih \frac{\partial}{\partial E}$	t
p_1	$-ih \frac{\partial}{\partial x_1}$
p_2	$-ih \frac{\partial}{\partial x_2}$
p_3	$-ih \frac{\partial}{\partial x_3}$
E	$ih \frac{\partial}{\partial t}$

Table 4. Parameters of the artificial neuro-computing which leads to the phenomenon of the artificial consciousness [8]

REALITY $N(\bar{3}) = (R^3, E)$	PICTURE OF REALITY IN ARTIFICIAL BRAIN $I(p_i, t) = H(\bar{3})$
x_1	$ih \frac{\partial}{\partial p_1}$
x_2	$ih \frac{\partial}{\partial p_2}$
x_3	$ih \frac{\partial}{\partial p_3}$
$-ih \frac{\partial}{\partial E}$	t
$-ih \frac{\partial}{\partial x_1}$	p_1
$-ih \frac{\partial}{\partial x_2}$	p_2
$-ih \frac{\partial}{\partial x_3}$	p_3
E	$ih \frac{\partial}{\partial t}$

3. INFORMATION THEORIES AND PHYSICS

In information theories, coding is one of the crucial points to define information. Shannon's famous theorem gives us one possible solution, which has been implemented in human-made information systems with great success. The basic idea is simple: given a data source which emits letters $L_1, L_2, L_3, \dots, L_n$ with probabilities $p_1, p_2, p_3, \dots, p_n$ respectively, each letter emitted being chosen independently of all other symbols, there exists a binary code which gives the best data compression. Bearing in the mind that data compression is one of the fundamental

questions in communication theory, it is understandable why Shannon's noiseless coding theorem has been so popular in classical communications engineering approach. However, success in the application of this technical approach to the theory of information on biological systems was partial. One of the main reasons for this is quite different biological solutions: self-organization and self-control of living matter versus bulk matter and system control from outside.

According to Shannon's coding theorem we can always reliably distinguish between different letters (or symbols). Different symbols mean different states of a physical carrier of information. If the physical carrier of information is macroscopic, Shannon's theorem works well, while for quantum mechanical systems it needs to be reformulated. Why do quantum systems make a difference? In quantum systems the physical bit is any quantum object for which the state is described by a vector in two-dimensional Hilbert space. For these systems quantum mechanics states that only states represented by mutually perpendicular vectors can be perfectly distinguished from each other. If symbols-states are non-perpendicular, which is usually the case, any deduction procedure is imperfect. For the link between classical mechanics and quantum mechanics the important question is: which N -dimensional Euclidean space of coding will give 90° angle between the vector pointed from the origin $(0, 0, \dots, 0)$ to the point $(1, 1, \dots, 1)$ - and any coordinate axis? If that one Euclidean space (macroscopic) of coding exist, then correct mapping of information contents between it and quantum systems can exist. In the search for this kind of Euclidean space, we will consider the problem of unit spheres as the most perfect symmetrical object.

4. INFORMATION PHYSICS

It was indicated that trajectorial behavior of the quantum mechanics objects is characterized by a fractal [11]. A "thought experiment" was done, in which objects are confined to move on fractal space-time trajectories, treating the case of a Peano-Moore trajectory in detail [12]. Also, it is known that chaos may generate stochastic and fractal behavior [13]. A connection between chaos and quantum, as "quantum chaos", was noted by research groups independently [14-17]. A disadvantage of these attempts was that quantum stochasticity had not been included in the quantum chaos theory. One approach to include the quantum stochasticity is called "chaos quantum" [13]. A major problem with chaos quantum has been its place in the theory of stochastic mechanisms of an "objective" background radiation ("noise") which have pervaded the Universe, giving every object of mass m a diffusion-type perturbation of intensity \hbar/m , where \hbar is Planck's constant divided by 2π . This means that if one can smoothly transit fractal space-time (with Hausdorff dimension) to Minkowskian space-time (with Euclidean dimension) with random perturbation of source of mapping, it will be possible to unify classical mechanics and quantum mechanics. Our approach to solve this problem is through unification dimensions $N = 0$ and $N = 1$, what we named information physics.

To unify $N = 0$ and $N = 1$, an invariant set with the following properties has to exist: (1) the measure is zero; (2) the value is one; (3) the value of the transformation $T(x)$ map of R_w (macro world) into S_w (micro world), and vice versa, has to be $3/2$ (this is because for dimension $N = 0$ dimensionality is $n = 3/2$, Table 1.). If we use Cantor's random middle third set with $T(x) = (3/2)(1 - |2x - 1|)$ all our conditions are satisfied [18,19].

One of the most beautiful and sublime results in the last decade in mathematics is the Mauldin-Williams theorem, which shows that the Hausdorff dimension $D_H^{C(0)}$ of a randomly

Cantor middle third set for $N = 0$ is $D_H^{C(0)} = GM^-$ or ϕ , where $GM^- = (\sqrt{5} - 1)/2$ is the Golden Mean. If we extrapolate the random construction of the Cantor set to N dimensions with GM properties than the Hausdorff dimensions [20]:

$$D_H^{C(N)} = \left(1/D_H^{C(0)}\right)^{N-1}. \quad (11)$$

Based on Eq. (11), solution for $D_H^{C(4)} = 4 + D_H^{C(-2)}$ is $(1/GM)^3$ or $(GM)^{-3}$. In other words we can write Eq. (11) in form

$$D_H^{C(N)} = \left(D_H^{C(0)}\right)^{1-N}, \quad (12)$$

If we summarize our calculation based on Eq. (12) in Table 5, we see that the results are same as in Table 1.

Table 5 Values of Hansdorff dimensions of a randomly Cantor middle third set for different dimension N , calculated from Eqs. (11) or (12) (ϕ - means Golden Mean)

N	$D_H^{C(N)}$	$\left[1/D_H^{C(0)}\right]^{N-1}$
0	ϕ^0	ϕ
1	ϕ^1	1
2	ϕ^2	ϕ^{-1}
3	ϕ^3	ϕ^{-2}
4	ϕ^4	ϕ^{-3}
5	ϕ^5	ϕ^{-4}
...
∞	ϕ^∞	0

We found that one of the main properties of dimension $N = 0$ is the Golden Mean (GM) based on random Cantor set. One more interesting question arises: what does $n = 3/2$ of $N = 0$ represent? To answer this question we need to consider our system, in Table 1, from the quantum mechanical point of view. It is well known from a quantum field theory [21] that the dimension of mass (d_m) is calculated from the Eq. (1). Only for $d = 5$ (whose unit sphere C_5 is maximal in system) value of d_m is $3/2$, what indicates: (1) mass is manifestation of $N = 0$ in 5-D space structure; (2) we see our world as 3-D (in spite of it being 5-D), because we are space-time entities of $N(-2)$ properties ($N(3) \cdot N(-2) = N(0)$); (3) solutions of fundamental questions, including the question about consciousness, may exist ($N(5)$ and $N(-2)$ have similar 5-D space structure, and consciousness may explain the Universe and Itself), and (4) $N = 0$ is the Nothing, which, through 5-D space and $[(-4)_7]$, as monad of mass, becomes Everything.

5. CONCLUSION

In this paper we considered the phenomenon of consciousness and its connection with the neurocomputing from both aspects: the fundamental physical laws based on the quantum field theory, and the neurocomputing based on the topological-geometric approach. It has been noticed that the consciousness as the global property of the brain has its point of departure on the molecular level. Phenomena that appear in the relation sub-neural oscillatory processes - brain, are based on the relativistic phenomena. This shows that the information physics applied

to the biological systems is actually relativistic. These results throw new light on the problem of the subjective, and open up a new field - relativistic cybernetics, as a science based on information physics.

With our goal being to propose a realistic model of consciousness, we find that it is necessary to establish a new physical theory, which we named *information physics*. It was shown that biological information processing from DNA to proteins is information inversion itself. DNA is a 1-D (one-dimensional) information matrix, mapping itself into proteins as 3-D information entities, which crystallizes around an axis - microtubule (1-D) and point - clathrin (0-D). Biological consciousness is the solution of the 1-D information entity (DNA) which invert itself into proteins (tubulins and clathrin), which interact with water clusters giving 0-D information entity - consciousness. According to this model the Hausdorff dimension of Cantor middle third set of zero-dimension is Golden Mean, as one of the major properties of consciousness. Although we see our outer world as 3-D, according to this model it is 5-D, because mass is a manifestation of dimension $N = 0$ in 5-D space structure. Biological information matrix, based on microtubules, is also 5-D, and there is hope that someday, someone will be able to understand indeed the Universe and Consciousness itself.

6. DEUS EX MACHINA OF CONSCIOUSNESS

Holopent $H(5)$ is *Being-in-itself* and *Being-for-self*.

holopent $H(3/2)$ is *Nothing*.

holo-pent $H(3/\bar{2})$ is *Being-for-other*.

- $H(5)$ and $H(3/2)$ go together as one.
- $H(3/2)$ and $H(3/\bar{2})$ are one and the same.
- Other is not an absolute other, but an other of self.

Superstring is the $N(1)$ space of something as *two*.

Determinate Being is *two* which is *one* through *three*.

- Superstring and Being-for-other together.

Infon is a measure *in itself* and *for self*.

Information is a measure *for self* and *for other*.

Communication is a measure *for other* and *within itself*.

Measure is a relation of *quantity* and *quality*.

Relation is *immediate* or/and *mediate* unity.

Quantity is unity of *continuity* and *discreetness*.

Quality is unity of *Being* and *Nothing*.

Mass is quality of $H(3/2)$ and $N(1)$ in $H(3/\bar{2})$.

Energy is quantity of unity of *mass* and *cardinal measure* for self and for other of self.

Time is *Being-within-self* of *Nothing* through *Being-for-other*.

- Being-within-self means *negation-negation*.

Space is *Pure Being*.

Space-time cardinal measure is $3 \cdot 10^{10}$.

Force is quantity of $H(5)$, $H(3/2)$, $N(1)$ in $H(3/\bar{2})$.

Consciousness is measure of $H(5)$ in $H(3/2)$ and/or $H(3/\bar{2})$ in *Determinate Being*.

Machine is *Being-within-self* of $N(1)$ space through *Being-for-other*.

REFERENCES

- [1] M. Heidegger, *An Introduction to Metaphysics* (Yale University Press, Yale, 1987).
- [2] D. Koruga, Biocomputing, *HICS-24* (IEEE Computer Society Press, 1991), pp. 269-275.
- [3] D. Koruga, Neurocomputing: A geometric-topological approach, in M. Novak, and E. Pelikan, eds., *NEURONET-90* (World Scientific Pub., Singapore 1991).
- [4] R. Hamming, *Coding and Information Theory* (Prentice-Hall, Englewood Cliffs, 1986).
- [5] T. Kohonen, *Self-organization and Associate Memory* (Springer-Verlag, Berlin, 1988).
- [6] H.L. Ryder, *Quantum Field Theory* (Cambridge University Press, Cambridge, 1985).
- [7] S.W. Hawking, and G.F.R. Ellis, *The Large Scale Structure of Space-Time* (Cambridge University Press, Cambridge, 1973).
- [8] W. Schommers, Space-time and quantum phenomena, in W. Schommers, ed., *Quantum Theory and Pictures of Reality* (Springer-Verlag, Berlin, 1989).
- [9] D. Raković, D. Koruga, Z. Martinović, and G. Stanojević, Molecular electronics and neural networks: Significance of ionic structure, *Proc. 11th Ann. Int. Conf. IEEE/EMBS* (1989), pp. 1136-1367.
- [10] D. Raković, D. Koruga, D. Djaković, Z. Martinović, V. Desimirović, and D. Minić, Ultralow frequency "optical" biocomputers: Biophysical arguments, in F. Hong, ed., *Molecular Electronics: Biosensors and Biocomputers* (Plenum Press, New York, 1989).
- [11] L. Nottale, Fractals and the quantum theory of space-time, *Int. J. Mod. Phys. A* 4 (1989), pp. 5047-5117.
- [12] G.N. Ord, Fractal space-time: A geometric analogue of relativistic quantum mechanics, *J. Phys. A: Math. Gen.* 16 (1983), pp. 1869-1884.
- [13] O.T. Rosler, Intra-observer chaos: hidden root of quantum mechanics? *Chaos, Solitons & Fractals* 4 (1994), pp. 415-421.
- [14] R.S. Shaw, Strange attractors, chaotic behavior, and information flow, *Z.Naturforsch.* 36A (1981), pp. 80-105.
- [15] L. Galgani, Statistical mechanics of weakly coupled oscillators presenting stochastic thresholds, *Lett. Nuovo Cimento* 31 (1981), pp. 65-72.
- [16] O.T. Rossler, Chaos and chemistry, in C. Vidal and A. Pacault, eds., *Nonlinear Phenomena in Chemical Dynamics* (Springer, New York, 1981) pp. 79-87.
- [17] K. Tomita, Conjugate pair of representation in chaos and quantum mechanics, *Found. Phys.* 17 (1987), pp. 699-711.
- [18] R.D. Mauldin and S.C. Williams, Random recursive constructions: Asymptotic geometric and topological properties, *Tran. Amer. Math. Soc.* 295 (1986), pp. 325-347.
- [19] D. Koruga, Neurocomputing: A geometric-topological approach, in E. Peliksn and M. Novak, eds., *Theoretical Aspects of Neurocomputing* (World Scientific, Singapore, 1991), p. 1939.
- [20] M.S. El Naschie, Is quantum space a random Cantor set with a Golden Mean dimension at the core? *Chaos, Solitons and Fractals* 4 (1994), pp. 177-179.
- [21] H.L. Ryder, *Quantum Field Theory* (Cambridge University Press, Cambridge, 1985).

MOBILIZATION OF THE HIDDEN RESERVES OF THE BRAIN INDUCED BY TRANSCENDENTAL MEDITATION

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Abstract. In previous years the new concept of reserves of the brain (of coexistent mechanisms of conduction, steering and conditioning) was presented by us on the basis of our experimental and clinical investigations (N.N. Lyubimov, 1980, 1986). This concept seemed to be very fruitful for study and mobilization of the reserves of the brain not only in the conditions of pathology but also in normal individuals. Transcendental Meditation (TM and TM-Sidhi programme created by Maharishi Mahesh Yogi in the middle of our century) has perspectives in this respect.

However to the present time neuronal mechanisms of the cortical reactivity of the brain during TM remained not clear. Studies of the cortical reactivity during TM were focused in the main on the spectral analysis of EEG during TM (P.H. Levine et al., 1975; R.K. Wallace, 1986; D.W. Orme Johnson and P. Gelderloos, 1988; D.W. Orme Johnsona, and C.N. Alexander, 1992).

In our work we tried to estimate the distribution of the cortical EP induced by the electrical stimulations of the median nerve before and during TM. Topographical brain mapping techniques were used to study subjects practicing TM for 15-20 years. The results show that during TM some early components of somatosensory EP (0-100 ms) associated with sensory input have wider distribution in additional brain structures of the cortex, in contralateral and ipsilateral hemispheres. These results witness that during TM there is an increase in the area of the cortex taking part in the perception of specific information and an increase in the functional relationship between the two hemispheres. This phenomenon correlates well with the subjective experience of consciousness expansion that takes place during TM. The activation of areas of the cortex at some distance from the primary response center can be seen as a result of a more integrated functioning of the brain involving more comprehensive processing of the received stimuli.

Key words: *Transcendental Meditation, brain reserve mobilization, brain integrated functioning, consciousness expansion.*

ASSOCIATED DISTURBANCES OF CONSCIOUSNESS AND COGNITIVE FUNCTIONS DURING SEIZURES - AN EEG CLINICAL STUDY

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Abstract. The basis for the differentiation between simple and complex partial seizures in the international classification of seizures relies on the postulate that impaired consciousness before the secondary generalization occurs only in the complex ones. However, an adequate documentation of associated disturbances of consciousness and cognitive functions during seizures is seldom provided. In this paper, the neuropsychological assessment of ictal and postictal events was used during video EEG recording and the application of various methods for the activation of electroencephalogram. It was shown that the degree and/or kind of associated disturbances of consciousness and cognitive functions during seizures in our patients formed a complex pattern that documented clear differences between complex partial seizures and absences as well as between various types of absence seizures. Further neuropsychological, neuroimaging and neurophysiological study of the chronotopography of ictal events should improve the diagnostics of seizures and provide some understanding of complex and inextricable relations of consciousness and cognitive functions.

Key words: *consciousness disorders, cognition, seizures, electroencephalogram*

1 INTRODUCTION

Disturbances of consciousness during ictal clinical epileptic events are very important for the semiology of seizures. Their identification is the basic condition for the international classification of seizure [1] and in relation with the etiology it provides two indispensable axes for the classification of epilepsy and epileptic syndromes [2]. However, the disturbances of consciousness during seizures in the international classifications are designated by such loose terms as “impairment” and “loss of consciousness”. Regarding the importance of this issue, it is surprising how few studies deal with this problem. Gloor [3] analyzed the ictal disturbances of consciousness on the basis of the patients’ awareness and reactivity and noted that only “aspects of conscious experience such as perception, cognition, memory, affect and voluntary motility.. are open to neurobiological research.”

Recent developments in neuropsychology and neuroimaging were parallel with renewed attempts to introduce the testing of cognitive functions during video EEG recording. The methods of testing during interictal state to uncover transitory cognitive impairment (TCI) during epileptiform paroxysms have been used by various authors [4-6]. Recently, the mental activation tests of the electroencephalogram (EEG) [7,8] have been used during standard EEG recording and in another test the patients with spike-wave paroxysms were asked to count their breaths during other activation procedures such as hyperventilation [9]. The latter method was

useful in the video EEG differentiation of various types of absence seizure [10]. The purpose of the present paper was twofold: 1. to assess the use of simple neuropsychological methods performed during video EEG recording in the differentiation of absence seizures from complex partial seizures and 2. to analyze the ictal and postictal EEG paroxysms and associated disturbances of consciousness and cognitive functions of patients with these seizure types.

2 METHODS

The subjects studied were 9 patients sent for clinical and neurophysiological investigation of their seizures. They were chosen from a larger sample of patients who underwent video EEG investigation with the aim to activate seizures and establish the seizure type [11]. Their age range was 8-24 years, mean 16.7, standard deviation 2.4 years; 4 of them were girls. All patients were of normal intelligence and were cooperative for investigations. All subjects satisfied the selection criteria for this study: 1. the presence of interictal epileptiform paroxysms of various types and 2. the occurrence of one or more seizures during video EEG recording and 3. the application of mental activation tests. The tests of mental activation used in this work were described previously [8]. In short, they consisted of eight tasks aimed to test the subject's orientation in time and space, immediate and delayed digit recall, the visuospatial functions of right hemisphere and the verbal function of the dominant (left) hemisphere. The counting test was performed during hyperventilation. The tests were first applied in the interictal period and in the case of seizure occurrence, the part of the test was repeated during ictal paroxysms and the answer to all tasks was required in postictal state.

3 RESULTS

By definition, all subjects had interictal epileptiform paroxysms, always bilateral in 7, bilateral or unilateral regional in 2 subjects. The mental activation test was associated with decreased epileptiform paroxysms in 7 subjects and the increase of paroxysms in two patients, one with bilateral and one with focal discharges. The answers to 2-5 items of the test of mental activation were not correct in 5 of 9 patients, 4 of whom had bilateral discharges.

Patient 1 (a 12-year old girl) had a seizure which started 2 minutes after the correct completion of the mental activation test. Seizure onset was with eyes and head aversion to the right followed by a period of 23 seconds of staring and unresponsiveness. The next period of 65 seconds was the phase of reorientation preceding to the recovery of her usual conscious state. EEG showed an earlier onset of bilateral ictal discharge over left hemisphere, predominantly over left fronto-central region. On repeated questioning during ictal and postictal period, her recall of only 4 of 6 digits of the test was not achieved until 3 minutes from the end of reorientation phase.

Patient 2 (a 23-year old man) had an onset of his seizures (diagnosed as absences and generalized tonic clonic seizures) at the age of 10 years. His seizures were always difficult to treat. Recently, he noted that in his everyday life some seizures were provoked by emotional stress and anger caused by "annoying questioning of his friends". He agreed to do the mental activation test, but got angry when he could not imagine various geometrical figures or recall the digits. In this period, his EEG recorded several bilateral discharges (lasting 1 to 2 seconds) with lateralization over left hemisphere (left frontal region). They proceeded to a 9-second ictal discharge. During this short seizure with staring he was unable to answer the question: "do you have a seizure?" but one second after its end he was able to talk. His speech was coherent and

only slight stuttering was noted in the first few words pronounced. There was not postictal slowing in his EEG. The patient boasted that the witnesses are unable to recognize this type of his short seizures and attributed the episodes to his nervousness.

In seven patients (3-9) various types of recorded absence seizures belonged to following epileptic syndromes:

- ◆ patients 3 and 4 had absences forming the syndrome of childhood absence epilepsy (CAE),
- ◆ patient 5 had the syndrome of myoclonic absences (MA),
- ◆ patients 6 and 7 - juvenile absence epilepsy (JAE)
- ◆ patients 8 and 9 - juvenile myoclonic epilepsy (JME).

The impairment of consciousness tested by calling the patients' name and by the use of mental activation tests was the most severe in the CAE and MA syndrome. The patients were unreactive almost to the end of seizure discharge. The interruption of seizure discharge was achievable by calling the patient's name and commanding him to open the eyes only when a period of 11-14 seconds from ictal onset elapsed. The patients were completely amnesic for the seizure period. Two patients with the JAE syndrome also had severe degree of impairment but each reported that he heard the command to open the eyes but was unable to respond.

One patient with JAE had a series of absence seizures provoked by his voluntary sleep deprivation and noncompliance. On this occasion of his prolonged semiresponsiveness, video EEG recording revealed that he would lapse into an absence status associated with eye closure. The status was easily controlled with midazolam and valproates. This patient will be reported in detail elsewhere (Martinovic 1997, in preparation).

The impairment of consciousness was mild in patients 8 and 9 with JME syndrome and their seizure discharges were often fragmented and could be easily interrupted by the external influences. In contrast to our patient 1 and other patients (3-7) with other absence types, these patients reported that they were partly aware of their seizure as if they had "a momentary lack of concentration", "a feeling of being at a distance", or "unable to react properly". The ictal EEG pattern in patients with CAE and JAE showed regular bilateral 3 Hz spike-waves. These discharges in MA syndrome were associated with severe myoclonic jerks. On the other hand, the seizure discharges of absences in JME syndrome characterized by polyspikes or multiple spike-waves were short and fragmented. In patients with other types of absences, there was a positive correlation between the longest duration and continuity of spike-wave discharges and the highest degree of concomitant unreactivity.

4 DISCUSSION

Although the tests used for the testing of consciousness and cognition during the seizures (in ictal and early postictal period) are by necessity simple, their use is justified by the clinical importance. The results of the present study agree with findings of Panayiotopoulos et al. (1993, 1994) [9,10] who discovered that various degrees of disturbed consciousness may be helpful in clinical differentiation of various types of absence seizures. To acquire their full clinical validity, these disturbances should be seen in the context of other clinical and EEG seizure patterns.

Our results have shown that this testing might be useful in differentiating the types of associated disturbances of consciousness in complex partial seizures (patients 1-2) from various types of absences (patients 3-9). On the basis of these preliminary results, we suggest that systematic diagnostic testing during video EEG recording should include: a) the tests of

mental activation, b) the breath counting test to be performed during hyperventilation which should include “combined” method - 2 minutes of breathing with mouths closed followed by two minutes breathing with mouths open (Komarek 1994, Martinovic 1997b). The tests of mental activation and testing of the responsiveness of the patient remain the only method available to define the “impairment” or “loss” of consciousness and disturbed cognitive functioning during absences and complex partial seizures. It should be emphasized that they should be used during ictal and early postictal period. The cognitive deficits in the postictal period of partial seizures may indicate the transient local or unilateral hemispheric dysfunction (analogous with Todd’s paralysis). The same dysfunction, for example, speech arrest, may occur with the various location of the epileptogenic zone. Thus, verbal fluency depends on the integrity of the left frontal lobe, but involves a wide bilateral temporo-parietal area in execution, as indexed by increased metabolic activity (Parks et al. 1988). In the patients with pharmacoresistant epilepsy, the need for an exact localization of speech, memory and other dysfunctions would require standard or invasive EEG recording and the use of other neuroimaging methods [14,15].

The operational view including the testing of awareness and reactivity in the concept of consciousness [3] was the first step in the analysis of disturbed consciousness and other cognitive functions during seizures. In a more developed scheme, consciousness is based primarily on vigilance, mental contents and selective attention (Niedermeyer 1994). Applied to epileptology, this scheme is more useful to discern different patterns of disturbed consciousness and cognitive functions during various seizure types. Thus, a majority of seizures would preferentially occur in a state of decreased vigilance favouring either increased hypersynchronization in neuronal circuits (in patients with primary generalized seizures) or enhanced influence of epileptogenic zone on its vicinity and upon remote regions which favours seizure discharge onset and its propagation (in subjects with partial epilepsy). This form the basis for EEG paroxysms and seizures activation by drowsiness, sleep, sleep deprivation and other states of decreased vigilance. The selective attention could be shifted under the influence of external factors (sensory stimuli in reflex epilepsy) or internal factors (emotional, endocrine and other effects) or with the combination of these factors (as in provoked seizures in our patient 2). Finally, disturbed mental contents would depend upon the location of epileptogenic zone and the progressive spread of seizure discharge to other hodologically linked brain regions (Wieser and Williamson 1993).

Beside the neural substrate, the time factor is crucial in the study of normal consciousness and mental contents of each subject since these contents fluctuate from moment to moment. Furthermore, the patients with active epilepsy are prone to sudden and rapid fluctuations in vigilance, selective attention and mental contents. Some of these fluctuations may provoke TCI which could be detected by the use of neuropsychological testing. The degree of these fluctuations is enormously increased during ictal and postictal periods. Overall, functional neuroimaging methods (single photon computerized tomography and/or positron emission tomography) can reveal the dynamics of these fluctuations in relation to the occurrence of seizures. These methods can prove hypermetabolic cerebral state during an actual seizure which is diffuse with a generalized seizure and regional or localized with partial seizure. On the other hand, regional hypometabolic cerebral zone(s) are seen in the interictal periods (Duncan 1995).

5 CONCLUSION

The testing aiming to define the dysfunctions of higher mental functions during the seizures encounters great difficulties due to the unpredictability and short duration of ictal periods. In spite of these limitations, the systematic use of neuropsychological testing may reveal that the disturbances of consciousness and cognitive functions almost always occur in combinations. These ictal disturbances have an obvious diagnostic importance for seizure classification and for the recognition of their cerebral substrate by the use of EEG and/or other neurophysiological or neuroimaging studies. In addition, the associated ictal and postictal neuropsychological disorganization proves that the consciousness and cognitive functions form a permanent complex unity. The latter is essential for the highest order functional integration in the central nervous system of human beings.

REFERENCES

- [1] Commission on Classification and Terminology of the ILAE. Proposal for revised clinical and electroencephalographic classification of epileptic seizures, *Epilepsia* 22 (1981) 489-501.
- [2] Commission on Classification and Terminology of the ILAE. Proposal for revised classification of epilepsies and epileptic syndromes, *Epilepsia* 30 (1989b) 389-399.
- [3] P. Gloor, Consciousness as a neurological concept in epileptology: a critical review, *Epilepsia* 27, Suppl.2 (1986), pp. S14-S26.
- [4] J.H.P. Aarts, C.D. Binnie, M.A. Smith, and A.J. Wilkins, Selective cognitive impairment during focal and generalized epileptiform EEG activity, *Brain* 107 (1984), pp. 293-308.
- [5] C.D. Binnie, Significance and management of transitory cognitive impairment due to subclinical EEG discharges in children, *Brain and Development*, 15 (1993) 23-30.
- [6] Ž. Martinović, Video EEG recording and the assessment of transitory cognitive impairments, *Proc. 6th Yugoslav Congress of Clinical Neurophysiology*, Herceg Novi, 1997a, p. 42, in Serbian.
- [7] E. Niedermeyer, G.L. Krauss, and C.E. Peyser, The electroencephalogram and mental activation, *Clin. Electroencephalogr.* 20 (1989), pp. 215-227.
- [8] Ž. Martinović, Do we need new standard methods for the activation of the electroencephalogram, *Proc. 6th Yugoslav Congress of Clinical Neurophysiology*, Herceg Novi, 1997b, p. 43, in Serbian.
- [9] C.P. Panayiotopoulos, A. Baker, R. Grunewald, S. Rowlinson, and P. Welsh, Breath counting during 3 Hz generalised spike and wave discharges, *J. Electrophysiol. Technol.* 15 (1993), pp. 15-23.
- [10] C.P. Panayiotopoulos, The clinical spectrum of typical absence seizures and absence epilepsies, in A. Malafosse, P. Genton, and E. Hirsch, eds., *Idiopathic Generalized Epilepsies* (Churchill Livingstone, London, 1994), pp. 73-83.
- [11] Ž. Martinović, Video EEG recording and activation techniques in the diagnostics of epileptic syndromes and pseudoseizures, *Proc. 6th Yugoslav Congress of Clinical Neurophysiology*, Herceg Novi, 1997c, pp. 35-41, in Serbian.
- [12] V. Komarek, Olfactory activation in epilepsy, in P. Wolf, ed., *Epileptic Seizures and Syndromes* (John Libbey, London 1994), pp. 107-114.
- [13] R.W. Parks, D.A. Loewenstein, and K.L. Dodrill, Cerebral metabolic effects of a verbal fluency test, *J. Clin. Exp. Neuropsychol.* 10 (1988), pp. 565-575.

- [14] J. Duncan, Neuroimaging in epilepsy, in S.I. Johannessen, L. Gram, M. Silanpää, and T. Tomson, eds., *Intractable Epilepsy* (Wrightson Biomedical Publishing, Petersfield, 1995), pp. 125-152.
- [15] Ž Martinovic, *Epilepsies* (Dečje novine, Gornji Milanovac, 1997d), pp. 100-101, in Serbian.
- [16] E. Niedermeyer, Consciousness: Function and definition, *Clin. Electroencephalogr.* 25 (1994), pp. 86- 93.
- [17] H.-G. Wieser and D. Williamson, Ictal semiology, in J. Jr. Engel, ed., *Surgical treatment of epilepsies*, 2nd ed. (Raven Press, New York, 1993), pp. 161-171.

CONSCIOUSNESS AS A COMPOSITION OF COGNITIVE FUNCTIONS

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Abstract. Consciousness is understood as composition of cognitive functions of different phylogenetic status. This approach is based on: (a) investigation of effect of hypoxia (oxygen deprivation) on cognitive functions on the one hand and, (b) cognitive analysis of dreams on the other hand. Several "internal screens" (memory) on which the picture of external world is organised, and which appear in certain order, are described in detail. In principle, if the "screen" is deeper, its picture will be less veridical and more abstract. This allows for greater number of degrees of freedom which, in turn, enables system to be more efficient in manipulating information. It is assumed that this tendency could also be applied to the construction of some deeper internal (symbolic) realms like, for example, art and other kinds of human spirituality. Position of an object is investigated in a 3-D space of consciousness (defined through cognitive, conative and emotional co-ordinate). Subsequent analyses indicated the existence of five categories into which objects could be classified. Broader look at those categories indicates dimension of instrumentalization.

Key words: *consciousness, hypoxia, objects, sleep, instrumentalization, reification.*

General system theory (GST), primarily mathematical discipline, applied on the biological systems [1,2], more specifically, on the functioning of nervous system [3-6], offered the possibility of getting new view to the chaotic findings of the brain science. It gave molar insight based on the investigation of organisational principles of the multilevel, alternative functioning systems.

Namely, existing global brain theories, theory of localization of brain functions and holistic theory are not satisfactory, because they are not able to include both experimental and clinical findings. Present researches indicate *high dynamics* of brain processes, much higher than it can be explained by relatively simplified theories. First, particular brain regions are not strictly specialized for a single, unique action. In addition, few regions are often alternatively engaged in the same task having specific role in it. There are also exchanges of competencies and conducts of actions between different brain regions. Finally, same task based on identical stimulation, arousing identical response could be executed by different brain regions, the functioning of which varies in time [7]. In addition, we must not forget that brain is divided into larger sections in three dimensions: *up - down* direction shows many "brains" originating from the evolution of the human species [8]; *left - right* direction shows two complementary hemispheres organized by different operational principles; *forward - backward* direction shows large blocks - cognitive, conative and emotional. In each ME there are, as we see, few of us. That's the reason why brain researchers often use term "sociology of the mind" [9].

General system theory goes in the opposite direction - from upward to downward. Namely, the fact is that certain system exists not only because it consists of certain components, but also because of its *specific organization* which gives a good reason to science to concentrate on that topic. Bertalanffy developed basic terms of GST [1]: *hierarchy, open system and equifinality*. All

three are directly connected with neurologically based understanding of the phenomena of the consciousness.

Hierarchy, naturally, implies multi-leveled organization of the system, for example brain. Few alternative actions at one level are controlled by strictly one region at the higher level. The more such levels we have in one system, the more "power" will be concentrated in the smaller region of the system. How far can that go? Evidently - not till the very end, in which case we would face *reductio ad infinitum*. Here we are dealing with partial model, appropriate for the lower, executive, subsystems. The main deficiency of the model is lack of flexibility - such an organization makes system being rigid.

That's why hierarchical model explains well lower neural functions with less degrees of freedom and smaller number of alternative solutions. But, higher human brain functions must be organized in different, less rigid way - mainly because of the need for acquiring new types of actions, that is to say, to allow learning and thinking. In Bertalanffy's words, such a system has to be capable of acquiring of new operations, in order to be an open system.

Heterarchical model is alternation and opposition to hierarchical. There is no supreme command instance assumed. The various components of the system are "in charge of" or "competent for" certain type of action, those components being relatively autonomous. If we take into consideration an open system dealing with unpredictable situations, consensus between subsystems which gives temporary competence to certain instance, i.e. subsystem, is obligatory. However, if permission for action from all of the subsystems is required, such a system would be slow and uneconomical. That's why heterarchical model fails to explain organization of higher neural functions.

On the other hand, the main problem of the open bio-systems is how to learn and not become the servant of the learnt? Neuroscience has proved that establishing the new neural pathway gives an advantage to this pathway in future actions. A simple task, once solved, would lead to fixation, durable competence of neural elements of the same pathway, toward stronger and stronger confirmation of that solution. At the same time, all alternative solutions would be suppressed and, finally, will disappear. That would lead, as we see, toward closing of the system and toward robotisation. Luckily, this doesn't always happen. There are, evidently, mechanisms responsible for eliminating the rigidity.

Our assumption is that among such mechanisms sleep is the most important one. Namely, for a long time sleep was subject of mystification and prejudices. One of them is the belief that the only task of sleeping is to provide physical recovery. But, as science shows, we are physically recovered after an hour or two of sleep. What do we need 6 - 8 hours (or more) of sleep for? Why do we lose consciousness if we need physical rest? Why, then, do we need the dreams?

As indicated by the analysis of the types of motor response and the total scope of human activities, freedom to correct actions and to select alternatives increases, going afferently through neural stem [10]. Even the simplest neural actions are functioning as a conflict of competencies, as a dynamic synergy of few potential actors, they do not emerge from the steady state. This is the general phenomenon in neural organization. We can see the conflict of competencies almost everywhere - the peripheral neuron could become important in decision making only as a result of complex process of inhibition of other neurons; neural nucleuses are in opposition to each other; there is rivalry between brain hemispheres.

The dynamics of competencies among neural units is much lower at the lower levels. The number of degrees of freedom is smaller, as well as number of potential alternatives. Also, the level of the "programmed" behavior is lower at higher neural levels. The degrees of freedom increase rapidly, so for the highest functions we have an unrestricted number of alternatives. Of course, lower functions are organized hierarchically. This does not imply for higher functions

which have to stay more autonomous. The higher functions are probably forming a special type of hierarchical organization with *subsequent consensus*, this consensus being the main purpose of sleep [5,6].

Subsequent consensus is mechanism which cleans the system and removes the rigidity, thus preserving the flexibility of the system. During normal daily activities in heterarchical system with dynamic competencies there is no time to achieve direct consensus. Action has to be executed rapidly. The establishing of consensus would slow down the action, therefore consensus has to be delayed. Brain regions which are alternative conductors of the behavior and are characterized by the highest degree of freedom, take temporary competence for direct actions according to the constellation of the input. This causes the unbalance in the system which has to be annihilated, in order to prevent permanent advantage of once effectively activated brain instance. This is what sleep and dreams do. While body rests there are no direct actions, and the brain has time to achieve subsequent consensus. The competencies of certain subsystems from immediate past are “discussed” or tested for the future. Temporarily established competencies are going to be annihilated. This brings back probability for selecting other alternatives in the future - freedom is regained!

Naturally, not all the competencies are annihilated. Some of them are confirmed and preserved as permanent mode of behavior. But this process has its price - those functions have to back down, toward the “programmed” behavior, and leave higher position, the area of free decision making.

Thus the brain constantly balances between two unpleasant extremes which could be ludicrously phrased as *Idiot savant* (too ordered system) and *Intelligent Tabula Rasa* (too chaotic).

In conclusion, we can say that the purpose of the sleep and dream is to remove the rigidity of the system and regain flexibility, i.e. to return freedom in making original and adequate decisions in the future.

Sleeping is not the only way to remove rigidity of the system. There are few others as well that are related to the level (lower or higher) which needs to be liberated. As psychological studies of problem solving indicate, sometimes it is sufficient to make simple pause, to rest, or change the current activity. Sleeping is one, the most complex among those mechanisms. As we see, the model of liberation is structured according to the type of freedom disturbance.

Therefore, there are two principles of human brain organization: (a) the algorithm acquiring principle that is related to quick and adequate action as a response to recognized stimulus, and (b) construction of action related to unexpected situation as a response to stimulus combination we never encountered before. Neural system is prepared for two types of actions by forming: (1) *hard* (rigid) brain functions, and (2) *soft* (flexible) brain functions [7].

This principle of division is further transposed into two types of psychological activities: (a) *reproductive* and (b) *productive*. The first type is related to “hard” brain functioning organization, while the second type refers to “soft” organization. Thus, for example, genetically inherited programs of actions and operations of memory during information processing could be classified into the first category. Specific operations of “coders” by which established forms of (re)actions are overcome and new algorithms for previously non-existing set of action is formed, could be classified into the second category. The work of the latter cognitive operations depends on occasional elimination of rigidity, since the nervous system in general tends to simplify and automatize actions already acquired. The sleep is the principal “cleaner” who removes or decreases rigidity of the nervous system. It is clear, therefore, why the man is smarter in the morning as many proverbs say, or less flexible if the dreaming is disturbed, as many researchers claim [11-13].

In the scope of these organizational principles of brain work we can also discuss the phenomena of human consciousness. Naturally, consciousness is the traditional topic in psychology, but it is also indirectly discussed from the position of many other scientific

disciplines. We believe that understanding of consciousness and some other traditional topics in psychology could be advanced by applying this molar views of neuroscience on the function of the brain on the one hand, and by "weaving in" the results of experiments on the molecular level, on the other hand.

Before we start this discussion, let's mention briefly how psychology treated the traditional topic of human consciousness. In the course of the last hundred years, psychologists were interested in consciousness indirectly through investigation of conscious processes. It started with the *psychophysics* and so called psychology of the consciousness in the 19th century and was continued with the *Gestalt theory*. In the second half of this century it was experimentally investigated within *Information processing* approach. This approach treats the cognition as an act of communication between environment and individual consciousness. In addition, it also applies the communication theory model to processes inside us! The experimenters are scanning the order of cognitive operations, the properties of inputs and outputs, the capacities of particular sub-operations, the structuring of sub-operations into unique cognitive process. They conduct simple but rigorously controlled experiments in which the speed and accuracy of response to cognitive task is recorded. The models of communication are constructed, and cognition is treated as a whole not being divided into distinct processes of perception, thinking, remembering, etc., as it was the case with traditional psychology. At the end of 20-th century, the Information processing approach appears to be the major breakthrough in experimental psychology. It gave new impulse to experimental psychology - the rats, favorite experimental subjects of behaviorists are abandoned, while the human being is entering psychological laboratory as a main subject, the events in his mind are again the most important issue of scientific exploration.

It should be emphasized that Information processing approach doesn't offer coherent theoretical view for the phenomena of consciousness. It implicitly involves new variant of structuralism. Unlike the structuralists from the end of last century, here we do not deal with elements of psychological processes but with composition, i.e. structure of cognition. Instead of some psychological elements, here we have discrete sub-operations in order. It should be noted that consciousness is an issue that is not favorable in contemporary experimental psychology. However, it's composition is a matter of debate.

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In the course of the last three decades, in our Laboratory for Experimental Psychology, a great amount of researchs was conducted that indirectly enabled us to say something about consciousness which is, no doubt, one of the most challenging topics in contemporary psychology. Our approach to the phenomenon of consciousness is primarily based on two empirical sources: (a) the effect of hypoxia on cognitive processes, and (b) researchs related to the composition of dreams.

Ad (a). Hypoxia is the lack of oxygen in tissues. It is well established fact that different tissues are not uniformly sensitive to this deprivation - nerve tissue, for example, is more sensitive than other tissues. The brain is most sensitive to the lack of oxygen, but within brain there are differences in sensitivity as well. Thus, for example, cortex requires more oxygen than the gray mass, while the gray mass on the other hand requires more oxygen than the white mass. Furthermore, in gray mass there are cortical neurons which are not equally sensitive. Of special interest is the fact that nerve functions exhibit different sensitivity due to their phylogenetic status. Phylogenetically younger functions are more sensitive than older functions and in the case of oxygen deprivation tend to break down earlier than older functions [14]. This enables special kind of experimentation where oxygen deprivation level is varied in order to decompose complex functions and stratify them according to their phylogenetic status.

Experiments conducted on human subjects were done in baro-comora which allows simulation of different levels of height. As a consequence, the reduced amount of consumed oxygen causes variable hypoxic effects. In principle, more complex functions are more sensitive to oxygen deprivation. Reasoning appears to be the most fragile function, subjects become uncritical, their visual field span becomes reduced, selective attention decreases, while emotions are harder to control. In addition, it was demonstrated that hypoxia has some global consequences as well - it causes regression of consciousness. Test batteries indicate this even in mild hypoxia (2500 - 3000 meters). The increase of oxygen deprivation is followed by significant change in organization of functions - the organism is reacting to stressful situation not only by reducing the less important functions, but with some global change of system solution [15]. In such situations our subjects exhibit behavior that seemingly resembles the one of prehistoric man. However, one general principle becomes transparent in all these situations: the reduction of functions is aimed at preservation of few basic functions at expense of those of that are less relevant. Finally, the order of functions that are lost includes consciousness as well! The loss of consciousness as a consequence of oxygen deprivation takes place before the loss of vital biological functions. In other words, consciousness has its own place in a hierarchy of brain functions.

Ad (b). In the last few decades, the investigation of dreams has made substantial progress, since the influence of psychoanalysis and its dynamic derivatives became negligible. The techniques of analyzing the composition and content of dreams were developed, the emphasis being put on language of dreams, semiotics and syntax of dreams [16-19]. This approach is known as *the cognitive analysis of dreams*, although it includes emotional and conative aspects of dreams as well. The gist of this approach is an attempt to apply the language of communication and model construction (which proved to be successful in information processing research) to investigation of dream organization.

The research conducted primarily on students in our laboratory in the course of the last two decades was two-folded. On the one hand it was aimed at better understanding of the language of dreams, i.e. cognitive material the dreams are made of [20], while on the other hand it was aimed at gaining some insights about the composition of dreams, i.e. ways in which the “dream story” is made [21]. On the basis of such studies it is possible to make few ad hoc claims about the phenomenon of consciousness as well.

There is, of course, “consciousness of dream”, i. e. some specific consciousness in the course of dreaming that differs from “ordinary” consciousness when we are awake. It could be assumed that the two phenomena are so different that findings about one could not be extrapolated into the other. To our opinion the analysis of consciousness of dream and language used in dreams can tell us a lot about consciousness as such. As the matter of fact, the consciousness of dream allows for some analyses that are not available to the consciousness when we are awake.

The idea that dream resembles regression of consciousness derives from Greek philosophy. Likewise, K. G. Jung claimed that dreams are an archaic language which expresses the subconscious contents. On the other hand, phylogenetic aspect of dream was explicitly elaborated by S. Freud who believed that some day we will be able to distinguish the individual aspect of dream from the one that has phylogenetic origin [22]. Such considerations are also related to the ideas of E. Fromm exposed in his “Forgotten Language”. They are also in accordance with our earlier exposed ideas of dream being a subsequent consensus between brain’s subsystems, where some subsystems are clearly phylogenetically distinct [5,6]. The general aspect offered by our cognitive analysis of dreams, which could also say something about consciousness, turned to be (unexpectedly) compatible with findings of seemingly remote investigations, like those on the effect of hypoxia. They seemed to complement the same picture.

From our cognitive analysis of dreams the following could be incorporated in our understanding of consciousness. First, it is finding about the dominance of motor representations in dreams. Commonly, descriptions of dreams are dominated by visual and to a lesser extent, auditory contents. With some practice in introspection, the descriptions of dreams are substantially altered; the number of motor representations is increased and they are put at the very core of the story as *relations* or *primary space of meaning*. Corroborating evidence comes from the description of dreams when subjects are suddenly (purposefully) awakened. In this type of studies (as well as in some others) somewhat modified introspective report regained credibility and became a significant source of reliable scientific evidence [23,24].

The second area of interest is the phenomenon of “access” into a sleep. Using its specific terminology, physiology provided us with detailed description of phases that constitute entering into sleep. However, here we are not referring to those phases. In our investigation we used introspective descriptions of entering into a sleep which were spontaneous, as well as those which were obtained during awakening of a subject by interrupting him while entering into a sleep. It was demonstrated that during entering into a sleep a place of contact with reality gets shifted towards inside, or, as often described by our subjects, the shift of “screens with projected events” takes place so that events are “pushed” deeper inside the person. This process starts with the 3-D space being eliminated and the contact with reality being organized in terms of a 2-D surface (the analogy with screen seems to be derived from this impression) which is settled somewhere at body’s periphery. This seems to parallel the distinction between epicritic and protopathic sensitivity described at the beginning of this century, i.e. the shift from awareness about objects to awareness about the stimulated place of the body [25]. This, however, is not yet the characteristic of sleep, it is a mere condition for entering into a sleep. It looks like a prelude to a sleep - the elimination of rich and provocative external surrounding and reduction of an imminent experience to more simple frame. Couldn’t this be treated as some kind of reduction of conscious as well?

It seems that for some period of time representations take place independently within one sensory space only, and then get merged into a common story. There are number of hypotheses about this mechanism - from ideas developed at Pavlov’s school that this is due to remaining excitation within dominant inhibition in cortex, to the ideas that phase brain excitation (in REM) activates hippocampal-neocortical memory system which produces sensory images - i.e. representations. The dreamer merges those images (the law of associations?) and from their succession creates a dream story [26]. No matter what mechanism might be responsible for that, the fact is that images are merged into some inner cognitive space (“screen”, as referred by our subjects), which is not equivalent to the one when we are awake. It looks like a cognitive space for representations in “conscious consciousness”. In contrast, the cognitive space in dream seems to be characterized with somewhat more stable images and possibility of simultaneous influx of information of different modalities. Obviously, shift to this level appears to be a step towards some deeper inner space of information processing.

These findings support the following conclusion which is relevant for our topic - *consciousness is composition of cognitive functions*. The experiments with hypoxia clearly support the idea that consciousness is characterized by number of levels. In addition, they indicate that this composition is made of functions that differ with respect to their phylogenetic status. Information processed could either be from the outside (the effects of imminent stimulation) or from the inside (memory, emotions, conative aspect). One of its most prominent characteristics is the reduction of parallel processing to linear information processing. Here consciousness tends to prolong and enhance the tendency to create unbalance (if necessary) among information - i.e. to enhance processing of one part of stimulation from the vast number of information that emerge in parallel. It should be noted that this principle was observed in perception, i.e. at the very surface of cognition, as was

demonstrated by Gestalt psychologists and formulated in their laws of perception. However, this tendency is even more pronounced in deeper levels of cognition. The logic of information selection is rooted in obligatory distinction of critical and relevant information from those that are irrelevant. Consciousness could be focused on itself as well. This, in turn, is the basis for emergence of self-consciousness. In principle, this inside look does not allow for immediate experiencing of cognitive complexity - consciousness observed from “inside” appears to be unified.

Let's turn back to the discussion about principles of organization of brain functions. It was demonstrated that one of the fundamental problems of brain functioning appears to be exclusion of (temporary) competencies, this being in accordance with the view proposed by Crick and Mitchinson [27,28]. In their permanent struggle against rigidity, nerve organizations adopt new and complex operations which are not part of inherited inventory, as is the case with dream. This is related to the requirement for the system to be opened, as emphasized by Bertalanffy [1]. We assume that in this context we could also discuss the acquisition and development of the so called spiritual nature of man. The important aspect of “the need” for spirituality (which we think is essential) could be treated as requirement of the neuro-psychological system for freedom, for overcoming the routine solutions in exchange with both social and physical environment. Thus, in creation and usage of spiritual values we face the separation from immediate physical and social reality, we experience the leap into meta-reality, reality of a different level, or metacode with new system of meaning - counter-reality as referred to by semioticians [29].

In those newly opened realms of meaning, according to the described mechanisms, subsystems could be formed with their specific operational characteristics. They, in turn, appear to be more or less autonomous and/or formalized, not unlike numerical, aesthetic or linguistic systems [30].

Consciousness, previously described as a system of cognitive operations aimed at selection of adequate mode of behavior [31] develops spiritual subsystems, providing them new (semantic) realms. The empirical studies of object transition in consciousness clearly support this claim.

Position of an object in consciousness is, of course, dynamic. However, from more general perspective, it was demonstrated that objects are distributed only in five categories (or groups) in a (hypothetical) space of consciousness [32]. This space is characterized by three coordinates: cognitive, conative and emotional, where each object is represented by a point derived from judgments on scales of cognitive distance, conative frequency and emotional value. The principal parameter of change, i.e. transition from one category into another, is the object instrumentalization, which could be seen in categorization of individual spiritual values as well [33].

In the following paragraphs the empirical evidence related to position and transition of an object in consciousness will be elaborated in detail. It should be emphasized, however, that the domain of meaning is one of the most complex areas of cognitive psychology. Only empirically grounded issues could constitute reliable material for epistemological and gnoseological theories. As a consequence, studies in this field always had broader influence, primarily in philosophy, but also in some technical disciplines like, for example, communication theory.

Experiments aimed to investigate meaning of an object were conducted from 1982 to 1991. Subjects were mainly students and upper grade high school pupils. Some research required re-testing of semantic space for the same subjects after few years in order to capture the dynamics of change of object position. This research had several phases: (1) Subjects were asked to produce the list of objects they encounter every day, or they often think about (abstract nouns were also included); (2) From the obtained list of few thousands “objects” hundred items were randomly selected; (3) The list of selected items was given to different subjects who were asked to evaluate each item on three distinct scales; the scales were: (a) scale of physical remoteness (cognitive dimension), (b) scale of emotional value (emotional dimension) and (c) scale of object presence in

the focus of consciousness; each scale was divided into seven grades (from 1 to 7); thus, each object was represented by a single point in a hypothetical 3-D space defined by three coordinates which referred to cognitive, emotional and conative (i.e. motivational) dimension. (4) Subjects' answers were then analyzed by statistical tests of homogeneity; the analysis indicated that the obtained points group into five categories; (5) These categories were submitted to a qualitative analysis and each category was labeled accordingly; and (6) Several dozens of subjects were subsequently interviewed in order to verify the qualitative analysis.

The obtained five categories in the space of consciousness had the following properties:

A. *Object per se*. This category represents group of objects located at the periphery of consciousness. Both emotional dimension and presence in the focus of consciousness are negligible, in spite of the fact that objects are physically close. Selection of those objects is rare - usually they stay at the margins of our attention. Vast number of objects fall in this category like, for example, people on the street, remote houses, tree on the road side etc. This category could also be treated as some kind of storage from which objects in transition are selected, of which we'll talk in the forthcoming paragraphs.

B. *Object for me*. This category includes objects whose position in consciousness implies strong emotional ties, but the object is remote (objectively and subjectively) - i.e. it is unreachable. Consciousness is often actively engaged with such an object which could be subject of longing or hatred, but it always implies strong emotions. Here we see some kind of object mystification - object is ascribed enormous effectivity. The stronger the emotion, the unrealistic expectation gets higher, as is often the case with emotions.

C. *I in the service of an object*. Objects from this category are also characterized with strong emotional ties. However, in contrast to the previous category, object is objectively close to the subject. Emotionally shaded object is now #possessed# by subject, but this is an illusion. Instead of being a master of an object, subject becomes its slave and puts himself in the position of serving the object. Take, for example, objects from the previous category that were highly estimated. Here such an object is in possession of a subject but, instead of being a source of benefit and satisfaction, its usage becomes of secondary importance, subject is too cautious about it, invests enormous efforts in its maintenance. Thus, through contact with such an object subject becomes object's slave.

D. *Object in my service*. Objects from this category, although being in close vicinity, are seldom in the focus of subject's consciousness. The object is pushed at the periphery of subject's attention, but subject is not (ravnodušan) as is the case with objects from category A. This category includes objects that are used as instruments. Object is physically close, but being an instrument it does not require attention because it is an intermediary for some other field of action where attention is focused at. Object is thus incorporated and treated as an expansion of oneself. Sometimes it becomes part of a more complex chain of automated operations that require minimum cognitive investment. Object thus remains at the perceptual periphery, with no attention being present nor deeper cognitive elaboration being required. Only in the case of malfunction of the automatic action subject brings such an object into the focus of attention. Not unlike surgical instrument or stick of a blind man that provide mediated contact with reality - this contact being at the end of an instrument, in the case of more complex instruments like, for example, language, piano or computer - action is located in the outlet of an instrument, while instrument itself gets incorporated.

E. *Object and I per se*. In this category we have an exceptional state of “separation” of both object and subject from immediate reality in some other, nonstandard space of consciousness. This separation is followed by strong emotion, but the maximum effect is realized not at emotional, but rather at conative level on the scale of focus of consciousness. This category is much more rare than the previous ones and has no “permanent status” - objects from this category are temporary classified. It is an exceptional state in which both subject and object are distinct. Subjects describe this state as “the state of exaggerated awareness of object’s existence and its uniqueness”. Such status is achieved through cognitive operation of perceiving object from a different perspective. Object is removed from its primary (standard) context and it is ascribed some other meaning (or meanings). Examples of such states are “experiences” under hypnosis or some drugs, religious ecstasy, dreams, “jamais vu” and, finally - in reception of art.

It was noted earlier that subsequent investigation conducted on the same subjects after few years show specific transition of an object from one category into another. In principle, this transition goes from category A (*Object per se*), into category B (*Object for me*), then into category C (*Me in the service of an object*), and finally into category D (*Object in my service*). Some deviation from this order was observed for category E (*Object and I per se*). Any object from any category could (temporary) become part of this category. It was observed, however, that this is true mostly for objects from category A. It should be emphasized that object transition through all categories is not obligatory - some categories could be omitted. Thus, for example, category C (*I in the service of an object*) need not precede well established instrumental position of an object that is common for category D (*Object in the service of I*). Fortunately enough, we are not enslaved by all objects. This is the privilege of a few object only, but many of us get enslaved.

Object transition through categories B, C and D has its specific psychological relevancy. This transition could be conceived as a dimension whose extremes are *reification of personality* on the one hand, and *humanization of objects* on the other hand. It should be noted that these individual-psychological measurements offer some basis for generalizations on global social and historical domains as well. The observed transitions, we assume, take place in collective consciousness as well. Take, for example, case from the remote past - our attitude towards fire. It is probable that at the beginning people were afraid of fire, cherishing it from distance, ascribing it divine and mythical value (category B, *Object for me*). Later on, when they get into possession of fire they had to maintain it, take care of it. They started to cherish it, build temples and perform rituals in order to please it (category C, *I in the service of an object*). Much later we learned to make fire and use it routinely, without emotions moving it at the periphery of our consciousness. mercy

The ideas have the same fate as well. Utopian socialists, for example, for centuries were dreaming about society of social justice (B). Finally, when the “First country of socialism” was established, with enormous amount of human suffering, all social energy was focused on its preservation and caution towards inner and outer enemies (real and hymeric). Army, police, system of control and spying was exaggerated beyond reasonable proportions, which was in painful contrast to the basic ideas of social justice. Individual, for which these ideas was supposedly tailored, was suppressed, deprived of its basic civil rights and shadowed by the importance of the idea (C). Unfortunately, such transitions are not rare. Many bright revolutions ended up as obscure dogmas.

We think that on the basis of these experimental studies in neuro-psychology it is possible to make some predictions as well. Development of new humanistic relations we see in domination of category E in social consciousness. It was noted that transition and order of object categories could be placed in dimension *reification- humanization* in our consciousness. Category D includes expansion of human self with number of instrumentalized objects (it should be noted that that this includes not only material objects, but also ideas and our own actions). The next step in further

humanization we envisage in increasing richness of category E (*Object and I per se*). In contrast to category D, here we see the abandoning of instrumentalization in its primary sense and face the creation of a new space in which concept of usage and usefulness gains new meaning like, for example, in the case of good art. Development of individual and collective consciousness would thus lead to creation of novel spiritual realms within each individual which would incorporate new objects from category E (*Object and I per se*). This will enable creation of new micro-cosmoses.

From what we exposed here, a consequent action of the same principle could be observed, the principle being observed in organization of brain function and titled Theory of dynamic brain competencies. The main rout in development of human consciousness we see in acquisition and instrumentalization of operations that genuinely expand human self on broader and broader part of our immediate surroundings.

REFERENCES

- [1] L. von Bertalanffy, *General System Theory* (Braziller, New York, 1968).
- [2] M. D. Mesarović, D. Macko, and Y. Takahara, *Theory of Hierarchical Multilevel Systems* (Academic press, New York, 1970).
- [3] A. Brodal, *Neurological Anatomy in Relation to Clinical Medicine* (Oxford University Press, New York, 1981).
- [4] M. LeGare, The use of general system theory as a metatheory for developing and evaluating theories in neuroscience, *Behavioral Science* 32, (1987), pp. 106-120.
- [5] P. Ognjenović, In support of the theory of dynamic competence's, or about the meaning of dream. *Psihologija*, 15, (1982), pp. 3-16, in Serbian.
- [6] P. Ognjenović, Meaning of sleep and of dreams in theory of dynamic competences, *Harvest* 37 (1991), pp. 43-48.
- [7] Н. П. Бехтерева, *Healty and Ill Human Brain* (Медицина, Ленинград, 1980), in Russian.
- [8] P. D. McLean, Man and his animal brains, *Modern Medicine* 32 (1964), pp. 95-106.
- [9] M. S. Gazzaniga and J. E. C. LeDoux, *The Integrated Mind* (Plenum Press, New York, 1978).
- [10] Н. А. Бернштейн, *On Generation of Motion* (Медгиз, Москва, 1947), in Russian.
- [11] H. L. Wilkinson, A. Lubin & J. J. Goodnow, Impaired performance with acute sleep loss, *Psychological Monographs* 73 (1959).
- [12] G. R. J. Hockney, Changes in attention allocation in a multicomponent task under loss of sleep. *British Journal of Psychology* 61 (1970), pp. 473-480.
- [13] F. Dinges, Are you awake? In: J. Kihlstrom, R. Bootylin & D. Schacter (eds.) *Sleep and Cognition* (American Psychological Association Press, New York, 1990).
- [14] E. J. Van Liere and J. C. Stickney, *Hypoxia* (Academic Press, Chicago, 1963)
- [15] P. Ognjenović, J. Davidović, and A. Bukvić, A parallel between same cardiovascular functions and perceptive-visual abilities in the normoxia and hypoxia conditions, *5th Cong. Yug. Psych., Proc. Book.* 2 (1995), pp. 233-238, in Serbian.
- [16] D. Foulkes, *A Grammar of Dreams* (Basic Books, New York, 1978)
- [17] D. Foulkes, *Dreaming: A Cognitive - Psychological Analysis* (Erlbaum, Hillsdale, 1985).
- [18] J. S. Antrobus, Dreaming: Cortical activation and perceptual thresholds. *Journal of Mind and Behavior* 7 (1986), pp. 193-211.
- [19] J. Montangero, Dream production mechanisms and cognition. *New Ideas in Psychology* 1 (1991).

- [20] P. Ognjenović, Languages of arts and dreams, *Psihologija* 27 (1994), pp. 221-248, in Serbian.
- [21] B. Škorc, Importance of a dream, its remembrance, and objectiveness of the dream report, *LEP Commun.* 12 (1994), pp. 1-28, in Serbian.
- [22] S. Freud, *An Outline of Psychoanalysis* (Norton, New York, 1949).
- [23] R. E. Nisbett and T. Wilson, Telling more than we can know: Verbal reports on mental processes. *Psychological Review* 8 (1977), pp. 231-259.
- [24] N. Block, On a confusion about a function of consciousness, *Behavioral and Brain Sciences* 18 (1995), pp. 227-247.
- [25] H. Haed, *Studies in neurology* (Oxford Press, London, 1920).
- [26] T. Okuma, On the psychophysiology of dreaming: a sensory image-free association hypothesis of the dream process, *Japanes Journal of Psychology and Neurology* (1992).
- [27] F. Crick and G. Mitchison, The function of REM sleep, *Nature* 304 (1983), pp. 111-114.
- [28] F. Crick and G. Mitchison, REM sleep and neural nets, *Journal of Mind and Behavior* 7 (1986), pp. 229-249.
- [29] M. Benze, Concise foundations of modern aesthetics, in U. Eko, ed., *Aesthetics and Information Theory* (Prosveta, Beograd, 1977) Serbian transl.
- [30] N. Goodman, *Languages of Art* (Hackett Publ. Co., Indianapolis, 1976).
- [31] P. Ognjenović, Consciousness as a (psychological) function, in D. Raković and D. Koruga, eds., *Consciousness: - Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1996).
- [32] P. Ognjenović, Position of an object in consciousness, *Proc. 8th Cong. Yug. Psychol*, Herceg Novi, 1984, in Serbian.
- [33] P. Ognjenović, Objects and what consciousness do with them, *Psihologija* 20 (1987), pp. 3-12, in Serbian.

TIME AND CONSCIOUSNESS: A NEUROLOGICAL APPROACH

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Abstract. The subject Time and Consciousness has universal significance not only within the framework of neuroscience as scientific discipline but also of science in general. The human being with his consciousness as his innate essence is a part of nature that is much older than himself, but man is older than the science, which studies that nature. In a more specific way, this presentation is dealing with several issues, which have to correlate neurobiological attitudes with the subject of time and consciousness. First, we wish to make an analysis of different types of times (existential time, physiological and conscious time, unconscious emergent time, situational cultural time) and the problems arise to the extension of physical time; second, to elucidate the subject roots in different disciplines relevant to their relationship to neurobiology (metaphysics, physics, evolution, culture, etc.); third, to explain possible neural basis of consciousness; fourth, to explain tightening of biological actions and human experience to time (the importance of temporal integration in brain physiology, general organization of behavior, of biological clocks) with the emphasis on integration of conscious experience to present, past and future events. Finally, we shall talk about cognitive functions and mind as common neurobiological denominator and prerequisite for both time and consciousness.

Key words: *time, consciousness, neurobiology, biological clocks.*

Contemplating, as a neurobiologist, of the subject *Time and Consciousness*, I have been faced with numerous dilemmas whose universal significance extends not only the framework of neurosciences as scientific disciplines but also science as it is in its essence. Everyone of us who deals with science is inclined to divergence, as appropriately formulated by Von Weizsäcker [1]: "that science is, if it thinks of itself as the whole truth, the greatest deceit in which the mankind has ever fallen into". Anyhow, much greater delusion of people would be if they were tempted not to believe in science. Man, generally speaking, and especially a scientist is inclined to divergence which includes implicitly that the issue he understands he considers as the whole truth. This particularly refers to contemplative means of abstraction; inner consistency of world abstraction is so great that it is very difficult to learn to what extent man herein moves in the system of delusion and deceit. However very often, it is not possible to reject a priori the system of delusion, because it sometimes consists of the elements of profound truth, which we, led by existing scientific pragmatism, completely ignore. Thus, it is always necessary to approach to every notion with respect in order to discern between the truth and the delusion.

The human being with his consciousness as his innate essence is a part of nature, which is much older than himself, but man is older than the science which studies that nature. Consequently, the goal of science is to explain natural phenomena with new insights and the

knowledge with the history of nature, and all of that has been known to happen through dynamic changes over time.

The evolution of life and mankind, since the beginning, has been submerged into a sea of time. Human beings, like fish in water, have only slowly made themselves aware of the time-sea in which they live. Archaeological data from the Cro-Magnon caves in Southern France about 37,000 years ago indicated that these men, who were the first human beings, had recorded systemic observations of the moon phases migration of game animals, the spawning of salmon and possibly even the position of the sun at different times of the year [2]. The ability of these early human beings to record and predict such events, and the possession of greatly enhanced potential for survival enabled them to plan for the first time in human history.

During the ensuing centuries, men made the instruments for measurement and classification of physical time, as an external standard for defining the "acceleration" or "retardation". The development of civilization led up to the extension of possibilities for progress and expression of new modalities of social and biological life in which the time consummation became the main goal and purpose. However, the extension is limited by specific biological and physiological functions.

Extensions can be viewed as externalized manifestations of human drives, needs and knowledge, and they also reflect our unconscious drives. For example, the phone extending the human voice, television extending both the eye and ear, computers extending the memory, microscopes extending the lens of the eyes, automobiles extending our legs, etc. But every extension usually takes the place of the process which has been extended. Most frequently, it brings about the disorders of our biological clock, moves them outside ourselves and that is the moment when the extensions are treated as though they represented the only reality. And subsequently, the tension and collision of internal clock and external physical clock occur which gives rise to numerous stress situations and discrepancies in contemporary world.

The time and consciousness have their roots in numerous disciplines relevant for comprehension of their relationships in the context of neurobiology; not going into details, I would point out metaphysics, physics, evolution and culture. *Metaphysics*, especially European metaphysics in a dialogue with certain Greek sources, emphasizes that the cognition of time presents the horizon of subsistence and that time has central significance for mathematics. *Physics*, being the fundamental discipline of natural sciences, is firmly linked to time logic, out of which the quantum logic is only one of its variants. Quantum theory as the theory of probability prognosis, seeks for the possibility of its application in psychological processes, including the consciousness, what will be the topic of other communications at this meeting. *Evolution*, both as science and philosophy presents the continuing succession of changes over time. *Culture* in the scientific premises context of transcending through time barriers of millenniums of our civilization, enables our historical comprehension of man, what includes: the unity of observation and dynamics, the unification of target rationality, pointing out the trinity (theory, moral and art) and finally the unity of truth.

Let us go back to the basic phenomena of this paper - consciousness and time. According to the *Encyclopedia of Neuroscience* [3], consciousness as a neuroscientific concept has been loosely employed to encompass several different meanings or aspects of cerebral function in humans and non-human animals. The term is often applied to the states of responsiveness to the environment - being conscious or in coma, awake or asleep, and being alert or aroused within the awakening state. These conditions can be described behaviorally by observing the human or the animal. Conscious or subjective experience or awareness is clearly accessible only introspectively to the subject having the experience. The role of neuroscience is to understand the neural basis of conscious experience. i.e. the mind-brain relationship; also, to

provide necessary conditions for an explanation of this phenomenon on the cellular level. The experiments of Moruzzi & Magoun [4], Penfield [5], Jasper [6] and others on the role of reticular formation in arousal indicate that there are areas of the brain outside the cortex that are necessary for consciousness. On the other hand, the experiments of Sperry [7] demonstrate that there are separate and specific hemispheric locations of different brain functions related to consciousness. Additionally, there is evidence that the hippocampal and limbic system [8] and striatum as well [9] can function to distinguish the novelty and read out the short term memory in a fashion that might modulate input to the conscious brain.

Perhaps the main impact of this and related works is that the consciousness is not a privilege of the entire brain, but rather the result of processes occurring in certain defined areas, for example, two cortical hemispheres, the thalamocortical relation [10], the striatum and limbic and reticular systems. The recent studies on humans, using noninvasive methods of local cerebral circulation and metabolism, effects of pharmacological agents as well as direct cortical stimulation and recording by intracranial electrophysiological methods, in awake and responsive subjects, greatly contribute to better comprehension of the matter, especially the balance and relationship between conscious and unconscious mental events [11].

In searching for objective biophysical and molecular biological parameters, one should always be critical enough, cautious and above all, all these data should be observed integrally with the whole behavioral expression, especially in differentiating the conscious and unconscious. We have previously emphasized that a certain degree of cortical activation presents a prerequisite for consciousness. Libet *et al.* [12] found that many of conscious experiences required a substantial minimal period of cortical activation and those shorter periods of such cortical activation might elicit unconscious mental operations. Subsequently, the difference between conscious and unconscious mental events could be the *duration* of appropriate neuronal activities. This provides an opportunity for unconscious modification of the content of a subjective experience during the time in which the conscious event is developing. This also represents one of the possibilities of real and probable interactions of time and consciousness.

In search for neurobiological correlates of time and consciousness, the processes of learning and memory occupy a special place, about which both affirmative and marginalizing attitudes exist. Learning connotes acquisition of information or acquisition of new skills and behaviors, whereas memory implies the retention over periods of time of acquired knowledge or previously experienced events, together with the retrieval of such knowledge or conscious remembering of such events.

The question arises - what role has consciousness in the systems responsible for learning and memory? The current knowledge concerning the problem points out the existence of numerous different forms of memory in a wide range of various situations as well as necessity to differentiate them among *several kinds of consciousness*. Both are closely related to mind - the central problem of man. It is well known that a prerequisite for the phenomena of mind is consciousness which may be described as a state that implies an ability for awareness of sensation - that is, a state in which perception may take place. Consequently, consciousness is a state of awareness in which the subject is capable of perception; the state of activity in the brain which enables it to exert any of its functions as "mind". One's own mind is a subjective experience, a personal world which can be explored, within limits, by introspection. The mind of other men can be inferred from their speech, writing and actions, while the mind of animals from their actions alone. (We shall discuss later on the mind and consciousness in the early stage of evolutionary scale.)

Consciousness is a condition *sine qua non* for mind but the components of mind may be considered as perception, memory, emotion, propositional thought and response. *Perception* is the transfer of information into its physicochemical equivalent to the appropriate part of the brain by propagation from sensory organs to the cerebral sensory cortex. The information may be described as sense data, which are a part of the perceptual world of the subject in distinction from the physical world of the perceived object. The nerve cells responsible for the act of perception are maintained in a state of readiness as a part of consciousness by neural mechanisms previously described. When the system is in a state of awareness, the percept is registered, and by complex neural connections is committed to *memory*. These sense data are stored to be retrieved at will in temporal sequences. Percepts may then be correlated with preexisting memory patterns and with the stored emotional contents of those patterns. *Emotion* may be considered as having a sustained "tonic" component and a "phasic" component, linked closely with autonomic activity. The tonic aspect of emotion sets the bias for reaction pattern, so the person is said to be of happy, amiable, irritable or gloomy disposition. The phasic aspect of emotion is a response to a perceived stimulus, and its nature depends upon the memory of events associated with a similar percept - it is a learned response. The emotional reaction influences the selection of an appropriate motor response - grasping or avoiding, accepting or rejecting, advancing or retreating. The important form of intellectual endeavor, logical or propositional thought, proceeds from a given premise to a conclusion. In this system memory may provide the premise which thereupon acts as an internal stimulus, taking the place of a perceived stimulus, to initiate a chain of events. *Propositional thought* is the basis of what we term intelligence, intellectual ability comprising aggregation of special skills, out of which each may be developed to a different degree in a single person. Then, effector or motor neurons ensure that activity, whether it is speech or movement (response), which can be initiated in a fashion appropriate to information received [13]. What I wish to stress here is the importance of systematic occurrence of conscious awareness in remembering and in other mental activities. Clinical example of an essential impairment of consciousness together with the deficits of learning and memory is amnesia. Amnesic patients can learn new skills and acquire new knowledge but they do not remember such learning and therefore are not aware of the facts they now possess. Within this general picture, some neurobiological evidence favors that conscious experience may be dissociated from the memory. Sleep research indicates that a person awakened during so-called rapid eye movement (REM) sleep, usually can report dream experience. If the person is awakened later, he cannot recall any dream. Animal experiments report that in REM sleep a subject responds to previously conditioned stimuli and learns poorly new tasks during the REM sleep. This confirms that dream experiences are clearly conscious but that the memory consolidation is so weak unless the memory process is activated by awakening. Dreaming represents a good example that conscious experience is not necessarily tied to memory. All of the above mentioned phenomena emerge from the physical-chemical brain activity and its anatomo-physiological organization, what we are not able to discuss within this limited paper.

Time is very difficult to bend to simple linear description. It is not a definite constant, but a cluster of concepts, events and rhythms covering a wide range of phenomena. Not going into details, I am pointing out that one may talk about different types of times [14]. Existential time (physical, biological), physiological and conscious time (metaphysical, sacred), unconscious emergent time (personal, synchronized) and situational cultural time (profane, micro). We shall deal, in this paper, with that time which includes neurobiological aspects.

Biological action and human experience is indivisibly tied to time. There is no action or experience without an appropriate timing and duration. Contributions from classical

neuroscience emphasized the importance of temporal integration in the physiology of brain and so called higher nervous activity [15]. The establishment of conditioned reflexes depends on close association in time of conditioned and unconditioned stimuli. The duration of time base has the importance in different expressions of adaptive learning system functions-cognitive or affective ones. During classical conditioning animals are subjected to conditioned stimulus (tone) emanating from external sources, paired with biologically significant external unconditioned stimulus (food). Both stimuli effect cognitive system (i.e. animal learned that tone paired in short period of time with food is a signal for feeding), and affective system. When animal consumed food (after a longer time period) the affective values of that food in the internal milieu appeared. The cognitive and affective processes have a great impact on consciousness, and they are qualitatively distinct and subserved by different neural systems, both essential for associate learning. In general organization of behavior, temporal order of planned and deliberate behavior depends on cerebral organization (frontal lobes) which has ready access to the store of the past and present experience, capable of representing action in the form of general schemes. The execution of the behavioral act must be followed by the reference to those schemes. Following these facts I wish to mention Ingvar's data [16] on the cerebral processes involved in integration of conscious experiences related to past, present and future events, based on clinical and cerebral blood flow studies. The neuronal substrate for the *past* - responsible for storing information of events (memories of motor-behavioral reactions, sensory percepts, sounds, cognitive structures, etc.) - constitutes the structures in postcentral cortical areas and temporal lobes. The *present* means the experience of actual events in the now-situations and in a given sensory situation. We are conscious of the fact that we see, hear and feel things in the present with the aid of our sensory inputs. The basic type of awareness of the present is mediated by the sensory inputs pertaining to the present moment. Electrical stimulation of primary sensory projection field in the cortex induces functions of now experiences represented by activated sensory modality. The *future* or "memory of the future" provides us to be aware of, to be conscious of to anticipate, to expect, to plan for, and to remember events in the future, which have not yet taken place. This function has stressed the fundamental capacity of the central nervous system - to deal with the future, to make up action plans and to program anticipatory goal-directed behavior and cognition. This capacity of the brain is especially pronounced in man and it is closely related to his language ability. Using the most advanced non-invasive techniques to measure the distribution of function in different brain structures in conscious unanesthetized human subjects at rest or performing various types of mental activity, Dr. Ingvar found that future behavior and cognition were evidently handled by the prefrontal cortex.

There is increasing evidence supporting the statement that a human being exhibits some pragmatic organization of time in his daily life, shows the capacities for elaboration of cognitive treatment of temporal information, builds conceptual constructs about time and also experiences time with various affective connotations. It is worth stressing the possibilities that the aforementioned emerges from more basic and more general forms of adjustments to time in all living organisms, known as "biological clocks" or "biological rhythms". Biological clocks have evolved as adaptations to periodic fluctuations in the environment. The role of such clocks, as innate temporal substrates, for physiological and behavioral programmers forming an adaptive match to predictable variations in the outside world, is well established [17]. Without going into details, because this question will be discussed more in other contributions of this meeting, I wish, following the main task of this paper, to emphasize the importance of the circadian periodicity's in learning behavior. Our data have shown that circadian rhythm plays an important role in the formation of conditioned reflexes. Desynchronization of the

circadian oscillator by subjecting the experimental animals to permanent darkness or permanent light produces a significant disruption of the circadian variations in learning processes and the learning process itself [18]. The discrepancies between the internal (biological) and external (physical) clocks cause a lot of stresses in our everyday life. Edward Hall [14] introduced the term - time "drags" - in the case when the body clock and the clock on the wall are out of synchrony. Time dragging is expressed as a synonym for not having a good time. Accordingly, the message that time is dragging can be used to alert individuals to find out what it is that makes them feel that way. To be aware of time dragging is important, because it is increasingly clear that our unconsciousness is where the organizing, synthesizing core of our personality is located. Many persons attempt to reduce alienation and try to bring together the conscious part of ourselves with the unconscious ones. The gap between the unconscious and the conscious is not inconsiderable. When this gap is too wide, people's lives are diminished. The strain of trying to bring the two parts together makes people less productive and less satisfied. The phenomenon of time dragging has to be more often and more thoroughly considered in the context of individual psyche, psychological status and conditions. Regulation of time does not mean control of time. The general feeling must have been that time can be adapted to, but that it cannot be controlled and therefore even "the Gods followed time as given" [19].

The question arises - what structures and what systems represent a possible common neurobiological basis of time and consciousness? The data here presented indicate that it would be cognitive brain structures and systems. Talking about the neural structure of consciousness we have pointed out that property of consciousness includes: (1) the ability to appreciate or distinguish different events; (2) the capacity to react critically to inward or outward conditions and to update information; (3) the ability to accumulate memories and to recall them associatively in temporal sequences, and (4) the capacity to distinguish self from non-self (self-awareness). On the other hand, the cognitive functions are closely related to temporal organization of behavior - both temporal regulation and rhythmic periodicity's. The main dynamic function of the brain is mediating between experience and action. In doing so, one must be able to account for updating of past storage and for temporal properties of recall. Among other things, especially important are the continuity of perception, temporal succession and detection of novelty. According to that, consciousness can be considered as a form of associative recollection with updating, based on present reentrant input. The cognitive structures occupy different brain regions and may be experimental or genetic or, more likely, the result of an interaction of both. They integrate present events with the representation and generation of past history and also create the action plans for the future (anticipation, prediction). But time cannot be treated simply as a homogeneous artificial parameter describing input-output relations. Before all, time means information for man - temporal information which persists in humans throughout their lives. Time is an independent property of the information flow, same as the other properties of information patterns such as size, color sound or spatial locations [20].

Consciousness appears gradually during the evolution of life. Only on the level of a man the human consciousness develops capable of relation towards itself, of arising critical questions about the objects and living beings in the environment; likewise, capable of searching for answers to these questions within exact scientific and philosophical solutions. Together time and consciousness, besides other dimensions have a cultural dimension as well, and all of them depend upon neurobiological basis which is again under the influence of time and consciousness.

Summarizing up the whole idea I would like to point out once again that the consideration of neurobiological basis of time and consciousness includes as an obligatory prerequisite the cognitive functions which are then in dynamic interaction with them.

The data presented in this paper serve mostly for guiding the future research rather than to be an adequate response for filling the gap of the existing knowledge.

REFERENCES

- [1] K. F. von Weizsäcker, *Der Mensch in den modernen Wissenschaften*, Hrsg K. von Michalski (Ins. für die Wssenschaften vom Menschen, Wien, 1985).
- [2] A. Marschack *The Root of Civilization* (Mc Graw Hill, 1972).
- [3] *Encyclopedia of Neuroscience*, Vol.II, G. Adelman, ed. (Birkhäuser, Boston-Basel, Stuttgart, 1987).
- [4] G. Moruzzi, and H. Magoun, *W. EEG Clin. Neurophysiol.* 1 (1948), p. 455.
- [5] W. Penfield, in *Neuroscience: Path of Discovery* F. G. Worden, J. P. Swazey and G. Adelman, eds. (MIT Press, Cambridge, MA, 1975).
- [6] H.H. Jasper, in: *Brain and Conscious Experience*, J. C. Eccles ed. (Springer Verlag, New York, 1966).
- [7] R. W. Sperry, *Psych. Rev.* 76 (1970), p. 532.
- [8] O. S. Vinogradova, in *The Hippocampus: Neurophysiology and Behavior*, Vol. II, R. L. Issacson and K. H. Probram, eds. (Plenum Press, New York, 1975).
- [9] Lj. Rakić, in *Impact of Basic Science on Medicine*, M. Priwes and M. Shappiro, eds. (Acad. Press, London, New York, 1966).
- [10] V. B. Mountcastle, in *Medical Psychology*, Vol. L, V. B. Mountcastle, ed. (C. V. Mosby Co., St. Louis, 1974).
- [11] B. Libet, *Human Neurobiology* 1 (1982), p. 235.
- [12] B. Libet, C. A. Gleason, E. W. Wright, and D. K. Pearl, *Brain* 106 (1983), p. 623.
- [13] J. W. Lance, *A Physiological Approach to Clinical Neurology* (Butterworths, London, 1970).
- [14] E. Hall, *The Dance of Life* (Anchor Press/ Doubleday, Garden City, NY, 1984).
- [15] K. S. Lashley, *Brain Mechanisms and Intelligence* (Chicago Univ. Press, Chicago, 1929).
- [16] D. H. Ingvar, *Human Neurobiology* 4 (1985), p. 127.
- [17] J. Aschoff, in: *Timing and Time Perception*, G. Gibban and L. Allan, eds., *Ann. N. Y. Acad. Sc.* 423 (1984), p. 442.
- [18] N. Kovačević, and Lj. Rakić, *Arch. Biol. Sc.* 23 (1971), p. 3.
- [19] M. Toda in: *The Study of Time*, J. T. Fraser, N. Lawrence and D. Park, eds. (New York, Springer Verlag, 1978).
- [20] J. A. Michon, in: *The Study of Time*, J. T. Fraser, F. C. Haber and G. H. Müller, eds. (Springer Verlag, Heidelberg, 1972).

HIERARCHICAL NEURAL NETWORKS AND BRAINWAVES: TOWARDS A THEORY OF CONSCIOUSNESS

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Abstract. In this paper a comparative biocybernetical analysis of the possibilities in modeling consciousness and other psychological functions (perception, memorizing, learning, emotions, language, creativity, thinking, and transpersonal interactions!), by using biocybernetical models of hierarchical neural networks and brainwaves, is given. It is pointed out that contemporary artificial neural networks are not able to model most of psychic functions, primarily owing to their nonhierarchical architecture. On the other hand, some biocybernetical models of hierarchical neural networks are very encouraging - which is not surprising having in mind that information processing in the central nervous system is achieved through hierarchically organized and interconnected neural networks. However, for modeling most of psychological functions (perception, memorizing, learning, emotions, language, thinking, and especially consciousness, creativity, and transpersonal interactions), the brainwaves combined with complex biophysical ionic neural networks are necessary. This demonstrates that such a broad modeling of psychological functions requires application of subtle biophysical hierarchical neural networks with embedded ultralowfrequency brainwave activity. The implications of these investigations on the diverse scientific fields, including radical shifts in understanding fundamentals of philosophy and religion, are also pointed out.

Key words: *hierarchical neural networks, brainwaves, ionic structures, altered and transitional states of consciousness, theoretical psychology, biophysics, relativistic & quantum physics, comparative approach.*

INTRODUCTION

The prevailing scientific paradigm considers information processing inside the central nervous system as occurring through hierarchically organized and interconnected neural networks. For instance, the visual information is firstly hierarchically processed at the level of retina (from the photoreceptory rods and cones, to the ganglion cells), to be then hierarchically proceeded within the levels of primary, secondary, and tertiary sensory and interpretatory cortical regions (all of them being additionally constituted of hierarchies of several neural networks) [1]. Interconnections within neural networks and between the neighboring neural networks in this hierarchy are achieved by synapses (one neuron having approximately 40000 synaptic connections with neighbors), which can be excitatory or inhibitory. During the learning process, apart from the brain's hierarchy of neural networks, a significant role in

global distribution and memorizing (over the whole cortex) of hierarchically processed information is played by brainwaves [2].

Along with the development of experimental techniques enabling physiological investigation of interactions of hierarchically interconnected neighboring levels of biological neural networks, significant contribution in establishing the neural network paradigm was given by theoretical breakthroughs in this field during the past decade [3].

The contemporary sequential (von Neumann's) computers have a clock $\sim 10^{-9}$ s, while an average generation time of the neuron action potential is $\sim 10^{-3}$ s. Although this activation rate of the semiconducting processing elements is $\sim 10^6$ times higher, the brain is superior in some complex tasks, such as the image processing and recognition, orientation and movement in the space of changeable characteristics, speech recognition, etc. The reason for great possibilities of the brain lies in the parallel information processing.

Besides, as the number of neurons within the brain and the number of their interconnections are constant, knowledge is distributed within synapses, and new information is added by adjusting the strengths between neurons. Also, some parts of information do not occupy some local positions, but are distributed across the brain regions. Thus a damage of a neuron, or even a group of neurons, does not deteriorate performances of the system, while in most of sequential computers a damage of a part of processing unit causes either an interruption of the whole system or irreversible loss of the information.

In contrast to sequential computers, in which a central processor unit controls all internal activities and has an access to the memory, the brain control is achieved locally. Behavior of every neuron in the brain depends only on its previous knowledge and the input environment, so it can be said that the output of any neuron is a function of locally available information.

Neural networks, to emulate brain function, have many good properties: parallel functioning, relatively quick realization of complicated tasks, distributed information, weak sensitivity on local damages, as well as learning abilities, i.e. adaptation upon changes in environment, and improvement based on experience.

These good properties of neural networks have inspired many scientists to propose them as a solution for most problems: with sufficiently big network and adequate training, the networks could accomplish an arbitrary task, without knowing a detailed mathematical algorithm of the problem. Currently, such expectations are far from realization. To date the real solution is in finding corresponding network topology and training rules for every particular task [3].

One of the first and most significant concepts in the field of neural networks is the Hebb's biological learning law [4], according to which the more frequently activated synapses are strengthening, while those ones less frequently activated are weakening. In neurocomputing this rule is now known as a Hebb's learning rule.^a

^a For a neural network architecture called the linear associator [3], consisting of the input layer (having n neurons) and the output layer (having m neurons), in which every output neuron is interconnected with all input neurons, with some weights or adaptive coefficients w_{ij} ($i = 1, 2, \dots, m$; $j = 1, 2, \dots, n$) - mathematical representation of the Hebb learning law can be written in the matrix form

$$W = y_1 x_1^T + y_2 x_2^T + \dots + y_L x_L^T, \quad (L \leq n) \quad (1)$$

where the weight matrix obtained this form after L training pairs of input and output vectors: $(x_1, y_1), (x_2, y_2), \dots, (x_L, y_L)$.

The vectors y_k i x_k are matrices columns with components y_{ki} ($i = 1, 2, \dots, m$) and x_{kj} ($j = 1, 2, \dots, n$), while x_k^T are matrices rows obtained by transposing matrices columns x_k . Eq.(1) is called the outer product sum formula for the weight matrix W , implying that during successive learning with the vector pairs (x_k, y_k) the incremental changes to W is of the

In general, apart from the input layer (which only distributes input data to the following layer), the neural network can have several hidden layers, which precede the input layer. In this respect, holds Kolmogorov's mapping neural network existence theorem: Any continuous function $f(x^{(n)}) = y^{(m)}$ can be exactly implemented by a three-layer neural network having n neurons in the first (input) layer, $2n+1$ neurons in the middle (hidden) layer and m neurons in the last (output) layer.

That means that any mapping $x^{(n)} \xrightarrow{f} y^{(m)}$ does not require more than one hidden layer, although for practical reasons in the case of a large n , instead of one hidden layer with $2n+1$ the neurons, the two or more hidden layers with much less neurons is being used! Depending on the number of layers and learning rules (with or without supervisor), there are several types of practically used neural networks [3,6]. The past practical experiences with training of artificial neural networks imply the necessity for learning not to last too long, and not to have too many hidden neurons within the network, as this gives rise to overtraining of the network and tendency to memorize the input/output vector pairs only, without generalization (learning) - with no capability to recognize some new input vector for which not being previously trained.

However, the brain consists of $\sim 10^{10}$ neurons but simultaneously it is very flexible, which clearly implies its somewhat different organization in respect to artificial neural networks. Really, although the artificial neural networks appeared as a concept of duplication of biological neural networks, many of the commercial networks do not have any essential similarity with the biological ones - which are organized as hierarchical neural networks!

HIERARCHICAL NEURAL NETWORKS VERSUS BRAINWAVES: PROSPECTS FOR THEORETICAL PSYCHOLOGY

Most of the artificial neural networks have a maximum of interconnections between functionally *nonspecialized* neurons of the neighboring layers, where every neuron of one layer is connected to all neurons of the neighboring layers (so called *massive parallelism*). However, in hierarchical neural networks interconnections between neurons of neighboring layers are much more sparse and localized.

The advantage of a *hierarchical neural network* structure is that the functionally *specialized* neurons of each layer process only a limited amount of information from the previous layer.

form $y_k x_k^T$, which is the outer (direct) product of the vectors y_k and x_k . If the vectors (x_1, x_2, \dots, x_L) are orthonormal ($x_i^T x_j = \delta_{ij}$, where δ_{ij} is the Kronecker delta: $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$) - then

$$y_k = W x_k, \quad (k = 1, 2, \dots, L) \quad (2)$$

or in other words, the linear associator network will then perform the desired input/output transformation. It is obvious that there must be $L \leq n$, because of the dimensionality of the x_k vectors: the maximum possible number of orthogonal vectors in n -dimensional vector space is n . This is a consequence of the linearity of the vector space, i.e. transformations (1) and (2)!

To transcend this limitation, i.e. to enable that neural network can learn and recognize much more vectors (L) with respect to the number of input neurons (n), it is necessary to apply nonlinear transformation $y_k = W^{nl} x_k$! Contemporary neural networks, which came out the shadow of artificial intelligence after a 15-year quietness owing to Hopfield's papers [5], usually use some nonlinear transformation (S) of the linear combination (Σ_j) of input signals (x_{kj}) and weights (w_{ij}^{-1}) of neurons:

$$y_{k i}^{-1} = S \left(\sum_{j=1}^n w_{ij}^{-1} x_{k j} \right), \quad (3)$$

where index k enumerates the pairs of input/output vectors ($k = 1, 2, \dots, L$), while index i enumerates components of the output vector ($i = 1, 2, \dots, m$) in the l -th layer of neural network ($l = 1, 2, \dots$).

The total global situation is then pieced together as one ascends from one hierarchical layer to the next.

Such approach requires a spectacularly smaller number of processing elements than would be required by a network with massive parallelism of interconnections between neighboring layers! It should be pointed out that hierarchical neural networks are only appropriate in those situations where the inputs to the network have low-level, intermediate-level, and high-level structures that can be consistently related to one another, as images or sounds from outdoor scenes (random data, however, do not have such structure). That is the reason why biological neural networks are organized as hierarchical networks.

A significant contribution in modeling *biological hierarchical neural networks* was given by Grossberg and his collaborators [7], working on hierarchical architecture adapted for modeling perception of illumination of a visual field, based on the experimental neuropsychological data about the visual feature extractors; the numerical simulations have shown that such a network can recognize different psychological illusions too, related to the problem of surface illumination. By introducing excitatory and inhibitory loops for intra-columnar interactions, as well as inter-columnar feedback connectivity within columnar structure of the visual cortex, Grossberg and Somers [8] predicted electroencephalographic (EEG) γ -oscillations (~ 40 Hz) of their hierarchical network, generated in response to steady-state-inputs. A generalization of this retinocortical model by Ogmen and his collaborators [9] produced additionally EEG α -rhythm (~ 10 Hz) in response to intrinsic-noise sources (in the absence of external inputs), and flash visual evoked potentials (FVEP) of various relative magnitudes and latencies (P40, N70, P100, N130, P170) in response to flash inputs. It should be pointed out that their study makes predictions for network activities that can be translated into EEG signals, providing an important missing link between single-neuron activities and the ensemble properties of the biological neural networks!

A significant contribution in modeling biological hierarchical neural networks was given by Freeman and his collaborators [10] too. By adopting a system of feedback on different hierarchical levels of the network, the neural network which reflects the dynamics of olfaction was obtained. As a result of modeling, strange attractors with multiple "wings" were obtained: the central part of attractor can be interpreted as a basal chaotic electric activity of the olfactory system (simulating the basal brainwave EEG activity without olfactory stimulus), while the wings of attractor can be interpreted as "near-limit cycles", corresponding to quasiperiodic states of the induced brainwave EP activities upon the various olfactory stimuli, implying that EEG enables brain's quicker responses upon stimuli!

Hierarchical neural networks are also a biological basis of *learning* and *memory*, as the aforementioned types of *perception* require a previous training (learning) of the network, accompanied with memorizing of the information! In the case of olfactory system, Freeman and his collaborators have proposed the following hierarchical mechanism of learning and memory [11]. Excitatory neurons are activated, strengthening their joint synapses in accordance with Hebb's rule [4]: a nerve cell assembly (NCA) is thus created comprising perhaps 1-5% of the total in the olfactory bulb. Thereafter, excitation of any portion of the NCA by receptors sensitive to a particular odor tends to activate the whole assembly.

So, it seems that *learning* in olfactory system is related to generation of corresponding activation of a local cell assembly in the olfactory bulb, while *memorizing* and *recall* is related to the whole bulb. The very activation of only a part of the odor-specific receptors results in hierarchical activation of the local cell assembly, followed by activation of the whole olfactory bulb.

The similar is characteristics of the learning process in general [2]: while something is learned, information is hierarchically processed in primary, secondary, and tertiary brain areas, being afterwards spread by brainwaves over the whole cortex; however, when learning is achieved (so called habituation), the same visual stimulus can only be found in the visual system.

This also implies that brainwaves play a significant role in *distribution* of information across the whole cortex, and its *memorizing*. Of particular interest in this process is also extended reticular-thalamic activating system (ERTAS) [12], as a hierarchical system of neural networks which compares currently processed information with the one memorized in the cortex, giving priority and amplifying one piece of information to the conscious frequency levels of α , β , and γ brainwaves; the rest of information remain nonamplified at unconscious frequency δ and θ levels (it should be stressed that the oscillator model of Ellias and Grossberg [13] really predicts EEG rhythmicity in such a way that an increase in the input causes an increase in the frequency of oscillations, and decrease in their amplitude, offering an unified explanation of EEG waves ranging from δ to γ). This might basically be also the mechanism of "emotional coloring" of some information, and its ascending upon the ERTAS-amplification from the lower-frequency (δ, θ) unconscious form of primordial subliminal thought to the higher-frequency (α, β, γ) conscious thought! So, it seems that there are two levels of information *coding* and *memorizing* in biological neural networks [14,15]: spatio-temporal level (responsible for spatially distributed memory, through dynamic strengthening and weakening of synapses, in accordance with Hebb's rule) and ultralowfrequency level (responsible for normally conscious and unconscious states and their interactions, through the ultralowfrequency modulation of the first level).

Accordingly, a *thinking* process could be separated in at least two parts: first, the selection of one piece of information out of complete one processed by hierarchical structure of brain's neural networks, and its amplification to the conscious level, and second, the problem solving related to this piece of information. The first process is accompanied by emotional and verbal modulation of information by nondominant (normally right) and dominant (normally left) cerebral hemisphere, respectively [16]. The second process includes the prefrontal region and the associative secondary and tertiary cortical structures [17]. The significant role in this process can belong to brainwaves - through distribution of information across the whole cortex [2], and in transitional states of consciousness [15] (with anticipating creative insights), and altered states of consciousness [15,18] (with intense associative mixing of normally conscious and unconscious contents related to this problem, which can contribute to acceleration of the problem solving)!

A modeling of verbal modulation of information is an important but extremely complex task, still waiting to be fully accomplished in future hierarchical neural networks. However, it seems that basic brain mechanisms responsible for organization of natural *language* are known [19]: (a) Semantic processing (which relates indicant and symbol to the sensory input from which they derive) is carried out by systems which involve the posterior "association" areas that surround the primary sensory areas; (b) Pragmatic processing (which relates sign and symbol to their user) is carried out by ERTAS-like systems which involve the frontolimbic cortical formations of the brain; (c) Syntactic processing (the arrangement of indicants and symbols) is carried out by the motor systems of the brain to which both posterior and frontal cortical formations project. It should be then pointed out that ERTAS-like mechanism of pragmatic processing, in combination with the increase of dominant EEG frequency from δ to β brainwaves [20] during an ontogenesis, implies that the mother tongue is generally

memorized at low-frequency δ and θ levels (later being unconscious in adults), in contrast to second and even further languages in bilinguals and multilinguals which are memorized at high-frequency α , β , and γ levels (later being conscious in adults) - further on implying that second and further languages are being hardly incorporating at unconscious (automatic) levels, save only from contextual learning which enables unconscious processing of contexts. This might provide differences of the language learning in childhood and adulthood, as well as in school and in living environment!

A particularly significant role of brainwaves is involved in modeling the *states of consciousness* - and especially the altered states of consciousness [15,18], as elaborated further on.

TOWARDS A THEORY OF CONSCIOUSNESS

The key problem of any future theory of consciousness is how to incorporate altered states of consciousness (REM sleep, meditation, hypnosis, psychedelic drug influence, some psychopathological states, and near-death experiences) within a new paradigm. It should be pointed out that purely *biochemical* mechanisms of the ERTAS are not accelerated up to several orders of magnitude, as the subjective time sense is dilated in altered states of consciousness [21-23] - in respect to the normal awake state.

The only mechanism that can account for the extremely dilated subjective time base in altered states of consciousness is the relativistic *biophysical* one, if only the "subjective" observer can be associated with an EM field of the ultralowfrequency (ULF) brainwaves which can move through the brain with relativistic velocities, as it was extensively elaborated in our biophysical model of altered states of consciousness [14,15]. However, it is necessary that complete information (both conscious and unconscious) be permanently coded from neural network to brainwaves, as a spatio-temporal pattern resulting from changes of the synaptic interconnections in the neural networks of the brain.^b

^b To be more specific, the ionic medium supporting propagation of the brainwave ULF ionic currents must be inhomogeneous [14,15], to ensure that the "subjective" observer (associated with the EM component of reference ULF brainwaves), moving through the part of medium of greater ϵ_r , could register time-dilated information from faster EM component of brainwaves moving through the neighboring part of medium of lower ϵ_r . Then, at every moment the "subjective" observer is associated with the EM component of brainwaves in the dialectically "denser" medium, and the whole such system behaves like some "center of consciousness". The informational content of such "subjective" observer is continuously replaced by a new incoming EM component of brainwaves. So, we have permanently some "stream of consciousness". More precisely, for inflowing information (in the form of ULF brainwave ionic currents, coded in spatiotemporal patterns from the brain neural networks) to be recognized by the structured ionic medium, that medium itself must have a form of some kind of "optical" neural network - thus the "subjective" observer being associated with the EM component of brainwaves in dielectrical "condensations" (of greater ϵ_r), behaving like "distributed centers of consciousness", this presumably being the basis of yogic chakras [14]; in that context, it seems that other esoteric notions [24,25] such as subtle body (manomaya, lingasarira, manovijnana, ka, psyche, astral body, psychic body ...) and mental body (vijnanamaya, suksmasarira, manas, ba, thymos, mind, noetic body ...) are biophysically inevitably associated with a partly displaced (from the body) ionic acupuncture system, and an EM component of ULF ionic currents embedded within it, respectively; along the same line the qi (prana, pneuma, ether, "bioenergy", ...) can be biophysically associated with ions, implying also physiological significance of the ions in air, out of them the positive ions having an exciting influence (yang) and the negative ones an inhibiting influence (yin) [26]. It should be also added that ionic acupuncture currents, and accompanied EM fields, have both ultralowfrequency (ULF) and microwave (MW) components, i.e. the MW component is modulated by the ULF component: in support to the ULF nature of ionic currents in acupuncture channels, one can cite the resonance ULF (~ 4 Hz) stimulation of the acupuncture analgesia endorfin mechanism [27]; on the other hand, the evidence for the MW component of ionic acupuncture currents is provided by resonant MW (~ 50 -80 GHz) therapy, efficient even in very serious diseases [28]. According to former Soviet inventors of the resonant MW therapy, Sit'ko and his collaborators, acupuncture system is

It should be also pointed out that it might not be quite accidental that consciousness is related to the EM field of ULF brainwave ionic currents, as the intensity of irradiated ULF EM field is extremely low (intensity I of the field of frequency f , irradiated from a dipole source of linear dimensions d , has a dependence $I \sim f^4 d^2$ [32]), giving rise to consciousness localized around the body.

The model perfectly fits with the narrowed-down limits of conscious capacity in normal awake state (when brainwaves are predominantly located in the brain tissue with relative dielectric permittivity $\epsilon_r \gg 1$), and very extended limits in altered states of consciousness (characterized by low-dielectric $\epsilon_r \approx 1$ states, when the relative velocity between the "objective" laboratory reference frame and the "subjective" one is highly relativistic, $v = c_0 \sqrt{\epsilon_r} \approx c_0$, where c_0 is a velocity of EM waves in vacuum) - due to biophysical relativistic mechanism of *dilations of the subjective time base*.^c

a dynamic structure, differentiated at the locations of maximums of three-dimensional standing waves, formed as a result of the reflection of coherent microwave (~ 100 GHz [29]) Fröhlich excitations of molecular subunits in the cell membranes and proteins - supported also by other investigations which have demonstrated that differentiation of the intercell "gap junctions" (of higher density at acupuncture points and meridians) is slightly sensitive to voltage [30]; in that context the explanation for efficiency of this method should be sought: some disorders in the organism give rise to deformation in the structure of electrical field of the organism in MW region, which influences some changes in spatial structure of the acupuncture system, and consequently its resonant frequency, resulting in some disease; during the therapy, applying the MW sound at corresponding acupuncture point the excited acupuncture system of the patient is relaxing to the previous healthy condition, while reaching its normal frequency response upon the wide spectrum MW source - and following to physiological mechanisms of the acupuncture regulation [31] organism biochemically overcomes the disease. Then, the biophysical process of holistic healing might be generally related to appropriate artificial or biotherapeutic corrections of the disordered ionic distributions and concentrations within the acupuncture system of the healee, either by transfers of ions or EM information patterns in MW and ULF domains - responsible for normal functioning of acupuncture system and overall health.

^c By attaching the "objective" reference frame to the brain (i.e. laboratory) which moves relatively to the "subjective" reference frame with velocity $v = v = c_0 / \sqrt{\epsilon_r}$ (where c_0 denotes the propagation velocity of the EM field in vacuum, and ϵ_r the ULF relative dielectric permittivity of the denser ionic structure where brainwaves propagate), the relativistic relation between the time intervals [33], from the viewpoint of the inertial "subjective" observer ($v = c_0 / \sqrt{\epsilon_r} = \text{const}$), is [15]

$$\Delta t_{\text{subj}} = \frac{\Delta t_{\text{o}}^{\text{obj}}}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t_{\text{o}}^{\text{obj}}}{\sqrt{1 - \frac{\epsilon_r'}{\epsilon_r}}} \Bigg|_{\frac{\epsilon_r}{\epsilon_r'} \approx 1} \gg \Delta t_{\text{o}}^{\text{obj}} \quad (4)$$

where $c = c_0 / \sqrt{\epsilon_r'}$ denotes the propagation velocity of the incoming EM field inside the neighboring part of ionic structure with lower dielectric permittivity ($\epsilon_r' < \epsilon_r$). This could account for the striking dilations of the subjective time base (Δt_{subj}) in comparison with the objective time measured by the laboratory clock ($\Delta t_{\text{o}}^{\text{obj}}$), in altered states of consciousness, if $\epsilon_r / \epsilon_r' \approx 1$. This condition can be achieved only in a low-dielectric weakly ionized gaseous structured medium (with $\epsilon_r \approx \epsilon_r' \approx 1$), as the brain is a highly nonhomogeneous structure where ϵ_r could range from $\epsilon_r \geq 2$ (characteristic of biopolymers) across $\epsilon_r \approx 81$ (characteristic of free tissue water to $\epsilon_r \sim 10^5$ (characteristic of cell membranes, with striking polarization of the volume ion density within the porous cell wall, strongly depending on metabolic cell processes [31])).

This relativistic mechanism also enables the *dream-like* mixing of the normally conscious and unconscious contents in altered states [15,18], due to the relativistic Doppler mapping of EM component of the "objective" ULF brainwaves power spectrum on the zero-degenerate frequency ^d "subjective" one.^e This could be the biophysical *mechanism of dreams*, which particularly implies their psychological significance: in dreams one has continuous access and more efficient "subjective" integration of normally conscious and unconscious contents, giving rise to integration and growth of human personality (otherwise divided into conscious and unconscious associative "ego" states), which results in alleviation of emotional conflicts [15,18]. Then *meditation*, as a prolonged altered state of consciousness, enables more efficient "subjective" integration of human personality, but it is inevitably accompanied by a decay of ultradian rhythm, governing alterations of normal and altered states of consciousness (of periodicity $\sim 1.5 - 2$ hours, in both waking and sleeping [38]). However, if a person bears strong internal psychic conflicts i.e. "ego states", the result of such a prolonged meditation will be integration of human personality around foregoing several "ego-states", with undesirable result of multiply divided (instead of well integrated) personality; competent teachers of meditation are fully aware of these perils, and do not recommend its accelerated practice to psychically weak persons (for whom the main priority being a *reprogramming* of psychic conflicts [39]).

Biophysical nature of the *low-dielectric* ($\epsilon_r' \approx \epsilon_r \approx 1$) structure has also been analyzed: this structure could be related to partly displaceable (from the body) unhomogeneous ionic acupuncture system, which can conduct ULF brainwave currents $\sim 10^{-7}$ A, inside the conductive channels of the initial ionic concentration $\sim 10^{15}$ cm⁻³, with a tendency of

^d This does not diminish the rate of "subjective" information processing, as this process is not serial but parallel (both in spatiotemporal and frequency domains), being enhanced on "subjective" level by greatly enlarged temporal resolution due to extremely dilated "subjective" time base in altered states of consciousness.

^e The relativistic relation between the frequencies [35] measured in the two reference frames, moving away from one another ($\alpha = \pi$), is [15]

$$f_{\text{subj}} = f_{\text{obj}} \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 - \frac{v}{c} \cos \alpha} \bigg|_{\alpha = \pi} = f_{\text{obj}} \frac{\sqrt{1 - \frac{\epsilon_r'}{\epsilon_r}}}{1 + \sqrt{\frac{\epsilon_r'}{\epsilon_r}}} \bigg|_{\frac{\epsilon_r}{\epsilon_r'} \approx 1} \ll f_{\text{obj}} \quad (5)$$

which describes the striking relativistic Doppler shift of the excited "objective" brainwave frequency ($f_{\text{obj}}^{\text{obj}}$) down to the vanishing "subjectively" observed brainwave frequency ($f_{\text{subj}}^{\text{subj}} \approx 0$ Hz) in low dielectric ($\epsilon_r \approx \epsilon_r' \approx 1$) altered states. This can account for the mixing of conscious and unconscious contents in the altered states of consciousness, as five main frequency bands of both the spontaneous (EEG) and evoked (EP) brainwave activities, $f_{\text{oy}}^{\text{obj}}$ (30-50 Hz), $f_{\text{ob}}^{\text{obj}}$ (13-30 Hz), $f_{\text{oa}}^{\text{obj}}$ (8-13 Hz), $f_{\text{oo}}^{\text{obj}}$ (3,5-8 Hz), and $f_{\text{os}}^{\text{obj}}$ (0,5-3,5 Hz), the first three of them predominantly corresponding to normally conscious states [36] and the last two corresponding to normally unconscious states [37], for $\epsilon_r / \epsilon_r' \approx 1$ start merging from the viewpoint of the "subjective" reference frame: $f_{\gamma}^{\text{subj}} \approx f_{\beta}^{\text{subj}} \approx f_{\alpha}^{\text{subj}} \approx f_{\theta}^{\text{subj}} \approx f_{\delta}^{\text{subj}} \approx 0$ Hz. Although the "objective" brainwave power spectra in such states do not differ significantly from the spectrum of the alert state, the essential difference appears in the "subjective" brainwave power spectra; for the sake of comparison, in the alert state the brainwaves are predominantly located in the brain tissue (with $\epsilon \gg 1$), when a differentiated "subjective" spectrum exists: $f_i^{\text{subj}} = f_{\text{oi}}^{\text{obj}} \sqrt{1 - \epsilon_r' / \epsilon_r} / \left(1 + \sqrt{\epsilon_r' / \epsilon_r}\right)$, $i = \gamma, \beta, \alpha, \theta, \delta$.

deterioration during a period of ~ 1 hour [14,15]. As a consequence of the deterioration process, the displaced part of the ionic acupuncture system can be finally "emitted" together with the informational content of the embedded ULF EM waves [14,40]. Even the conditions for ULF EM field localization are not fulfilled at the end of deterioration process, as then ULF brainwave currents can flow through the surrounding weakly ionized ($\sim 10^4 \text{ cm}^{-3}$) atmosphere,^f which significantly enlarges linear dimensions of the dipole source and therefore the intensity of irradiated ULF EM field. Even *long-range interactions* of this type are energetically supported by existence of extremely low attenuation at ULF frequencies due to "Schumann resonances" of the earth-ionosphere cavity, well matched with EEG-spectrum [42]. The above mechanism has probably been of adaptational significance for animal species, in highly efficient global spreading of surviving-important novel information [43]. Inside the human population, it seems that the Maharishi effect is providing evidence [44] for the above possibility - which can be biophysical basis of Jung's *collective unconscious* [45]. In that context, it could be said that ionosphere represents a dynamic collective memory of all biological species, which is continuously being refreshed by biological units with periodicity and phase of their ultradian rhythms, having continuous backward influence on the living world globally. Such global information processing on the ionospheric level is enabled by inhomogeneities in its ionic structure due to local variations of the Earth's magnetic field, implying that ionosphere behaves as a giant "optical" neural network, with ionic channels of greater conductivity in respect to local environment.

It should be noted that some peculiar *spatial* relativistic effects in altered states of consciousness (when $\epsilon_r \approx 1$) are predicted by the model [15]: the weakly ionized gaseous neural network, with embedded ULF brainwave currents, enables that even long "objective" distances can be "subjectively" recognized *contracted*, implying that such displaced ionic neural network can optically perceive an environment *extrasensory*, as reported by reanimated patients. Even most peculiar *spatio-temporal transpersonal interactions* are predicted in *transitional states* of interchange of normal and altered states of consciousness (when brainwaves traverse from high-dielectric ($\epsilon_r \gg 1$) to low-dielectric ($\epsilon_r \approx 1$) state or vice versa, the relative velocity $v = c_0 \sqrt{\epsilon_r}$ of "subjective" reference frame being therefore subjected to abrupt change in short transitional period $\tau \sim 0,1$ s, with "subjective frame" acceleration $\sim c_0/\tau \sim 10^9 \text{ m/s}^2$) - due to the relativistic generation of so-called wormholes in highly noninertial "subjective" reference frame - fully equivalent, according to Einstein's Principle of equivalence, to extremely strong gravitational fields where generation of wormholes (or Einstein-Rosen space-time bridges, whose entrance and exit could be in very distant space-time points) is theoretically predicted [46]. It should be pointed out that apart from the EM field, the displaced part of ionic acupuncture system (in the form of ionic neural network, having the "optical" sensory function), must also be tunneled in previously "mentally addressed" distant

^f Further deterioration of the points of displaced part of the ionic acupuncture system makes the whole ionic system homogeneous, and "proper time" ("subjective" time) for photons in dielectrically homogeneous medium is identically zero [33], thus preventing any "stream of consciousness" (in contrast to situation for nonhomogeneous low-dielectric medium, when "subjective" time is highly dilated; cf. footnote c) - bringing the ultimate transpersonal state of thought-free consciousness (nirvana, samadhi, satori, enlightenment [24]). Objectively, the whole ionic system is completely open for information exchange in ULF domain, bringing a sense of oneness with the surrounding world, and subjectively, this is the state of empty consciousness, although the brain neural network can be still very active. This state lasts very shortly in nontrained persons, but can be presumably prolonged in yoga-like trained persons. The lost part of the ions (of the initial concentration $\sim 10^{15} \text{ cm}^{-3}$) is insignificant in comparison with that which exists in the body ($\sim 10^{20} \text{ cm}^{-3}$ [41]), and can even be regenerated during the breathing process in ~ 1 h.

exit in space-time^g - reminiscences on passing through some tunnel being actually reported by many patients reanimated from clinical death [23]!

This could be a biophysical mechanism of the so-called *astral projections* of consciousness, they presumably being the basis of most psychic phenomena [48] - being actually described by rare practitioners as not subjected to spatio-temporal limitations [25,49,50] - providing also explanation for their transitional nature and poor reproducibility: they last only $\sim 0,1$ s, and spontaneous conditions for them are achieved only every 1.5 - 2 hours, with periodicity of ultradian rhythms which govern the interchange of normal and altered states of consciousness [38]. However, it should be noted that the non-low-dielectric barriers in interaction with the low-dielectric barriers can induce transitional states (not limited by ultradian rhythms!), thus barriers helping in overcoming themselves in such induced transitional states - quite opposite to normal experience in usual mechanical interactions – enabling even their deliberate control and prolongation [25,49]! The aforementioned mentioned transitional states are presumably also the basis of *religious experiences*: in particular, it seems that efficiency of *prayer* in self-healing of interior psychological conflicts (caused by some previous interpersonal fights) might be the consequence of similar biophysical transpersonal interactions of the persons in conflict in transitional states of the praying person, accompanied by *mutual reprogramming* of interior conflicts (as a germ of the future interpersonal fights, as well as of potential psychosomatic and psychological disorders); that might provide an explanation for extraordinary efficiency of prayer accomplished shortly before sleeping (which is recommended by all religious traditions), with direct mental addressing on the person in conflict, or energetically more efficient indirect mental addressing via ionically abundant disembodied archetype structures [38].

The predicted transitional states of consciousness could also be the biophysical basis of *anticipation*^h in intuition, precognition and deep creative insights - which could be easily put

^g To support this, one can cite the technique adopted by "psychics" when they want to exert some distant influence: they always intensely visualize the person or place, as mental targets! On the other hand, this could be deeply connected with the role of consciousness in quantum theory of measurement, where consciousness with its act of observation affects the final collapse of the initial wave function into one of possible probabilistic eigenstates - which implies that the collapse could be related to generation of a local Einstein-Rosen bridge in highly noninertial processes of interactions of microparticles with measuring apparatuses [15], equivalent to strong gravitational effects of crucial importance for this process [47], cf. footnote i).

^h According to the computer experiments with random number generators [51], only nonactualized possible futures can be anticipated (more accurately for a priori greater probabilities of their realization), in accordance with quantummechanical viewpoint. In that context, what is actually anticipated in transitional states of "individual consciousness" might be the evolved state of "collective consciousness" $\Phi(t)$ in some future moment t [15] (to which "individual consciousness" φ_k has access, being the constitutional part of "collective consciousness", $\Phi(t) \sim \prod_k \varphi_k(t)$),

which is quantummechanically described by deterministic unitary evolution governed by Schrodinger equation (or Dirac equation in relativistic case). However, the anticipated state $\Phi(t)$ could be redefined by changing initial state $\varphi_k(t_0)$ of "individual consciousness", thus leaving room for free will and the possibility for influence on the future:

then, by changing initial state of "collective consciousness" Φ one can influence probabilities $|a_i|^2$ of realization of corresponding states Φ_i , i.e. possible objective states Ψ_i , as the composite state of "objective" system and "collective" observer is a superposition of all possible composite states, $\Psi\Phi = \sum_i a_i \Psi_i \Phi_i$ (cf. also the footnote i); this is

particularly true if the state $\Phi \sim \prod_k \varphi_k$ is very sensitive to small changes of initial conditions, which is the case for the

brain and corresponding state φ_k of "individual consciousness", described by deterministic chaos [52]. In this respect, it is quite possible that strong preferences in individual or collective futures exist, governed by karmic interpersonal

under control by "mental addressing" on a chosen problem, shortly before a waking-sleep transitional state! On awaking, the brain would then amplify the dream concerning the solution of the problem addressed, giving to it the priority in respect to other processed information during the sleep phase. The information obtained in this way is usually mixed through associative coupling with other conscious and unconscious pieces of information during the following REM-sleep periods - having therefore some symbolic form, which has to be decoded through introspective analysis of the dream. Naturally, to solve some scientific, technical or artistic problem in this way, it is necessary for the person to be expert in the field, in order to articulate the solution obtained in corresponding scientific, technical or artistic "language".

Finally, if the EM field of ULF ionic currents represents sophisticated internal display (related to consciousness) of neural network information processing, it seems that consciousness is not privilege of humans - but can be also a characteristic of higher animals. Even more, if microtubular cytoskeletal structures have neural network-like electrical activities on subcellular level, it seems that consciousness can be descended down to the cellular and even subcellular level [55]. Naturally, the conscious content displayed in such EM internal displays depends on the complexity of corresponding neural network information processing at different levels, from subcellular to brain ones. Furthermore, as the EM field is only one out of four manifestations (electromagnetic, gravitational, weak and strong nuclear forces) of the unified physical field [56], it can be tentatively generalized that the unified field itself may be internal conscious display for various physical processes at different structural levels, from macroscopic cosmic to microscopic subnuclear ones [44]. As a consequence, one could conjecture that Nature itself has consciousness at different structural levels, both animate and inanimate, as it is widely claimed in esoteric traditional knowledge. In that context, all local consciousness might be interconnected (through previously described interactions in altered and, especially, in transitional states of consciousness) making a giant cosmic informational network with collective consciousness, implying the crucial significance of *morals*, both on the level of thoughts and feelings [15]!

Although such nonlocal pantheistic idea of consciousness is rather bizarre, it can naturally help in resolving the fundamental problem of the *wave function reduction* in the quantum theory of measurement, where in an act of measurement (including finally the very act of conscious observation of the act of measurement) the macroscopic measuring apparatus (including consciousness as a "subjective" observer) makes reduction of the initial wave function into one of the possible eigenfunctions of the system.ⁱ

loads, as it is claimed in Eastern tradition [53]; along the same line, it might also be possible that spiritual cleansing (by prayer or some other esoteric technique [39]) is an efficient mechanism for changing initial state of several interrelated "individual consciousness", and hence "collective consciousness", thus changing anticipated preferences for both individual and collective futures [25,54].

ⁱ The problem of the wave function reduction (collapse) in an act of measurement is "orthodoxly" interpreted in quantum theory of measurement as the discontinues change induced by the observation of a quantity with eigenstates Ψ_1, Ψ_2, \dots , in which the initial wave function $\Psi = \sum_i a_i \Psi_i$ will be changed to the state Ψ_j with probability $|a_j|^2$. The

collapse of the wave function and the assignment of statistical probabilities do not follow from the Schrodinger equation - they are consequences of an external a priori metaphysics, which is allowed to intervene at this point and suspend the Schrodinger equation, or rather replace the boundary conditions on its solution by those of the collapsed state function. The problem of quantum theory of measurement has not been consistently resolved to date, and has been the subject of many serious theoretical efforts, from the very beginning of Quantum mechanics [57]. In one of the most recent approaches, Penrose [47] proposes gravitationally induced wave function reduction: actually, gravitational field of the state of observing apparatus Φ , with all possible observable outputs Φ_i , must be also involved in the

CONCLUSION

In Table 1 a comparative presentation of the possibilities in modeling consciousness and other psychological functions (memorizing, learning, emotions, language, creativity, thinking, and transpersonal interactions!), by using biocybernetical models of hierarchical neural networks and brainwaves, is given. It is obvious that such a broad modeling of psychological functions requires application of subtle biophysical hierarchical neural networks with embedded ultralowfrequency brainwave activity, thus incorporating good properties of both the neural networks and the brainwaves models.

Especially illuminating are investigations of altered and transitional states of consciousness, which seems to be a key for understanding the very nature of consciousness, which might have significant implications for many scientific fields:

(a) in *medicine* it might give rise to enlightening of many secrets of the brain functioning, as well as of the role of the acupuncture system in holistic health and reprogramming of internal conflicts;

(b) in *psychology* one might understand mechanisms and roles of altered states of consciousness in a growth of personality, control of creativity, as well as transpersonal phenomena usually accompanying these states;

(c) in *biology* it might appear that limits of interactions between individuals are more provisional than widely believed, which would be of significance not only for adaptive mechanisms on the level of whole biological species, but even for deeper understanding of the very significance of morals in human population;

(d) in *physics* an understanding of the phenomenon of consciousness might give rise to deeper understanding of fundamental problems of the observer's role in quantum mechanical act of measurement, which would demonstrate that consciousness, space, time, and matter are more deeply interwoven than widely believed;

(e) in *engineering* an understanding and controlling of transpersonal interactions should significantly change the field of *communications*, with many traditional spatio-temporal barriers radically surpassed, and in *computer sciences* an understanding of the nature of

superposition of quantum eigenstates ($\Psi\Phi = \sum_i a_i \Psi_i \Phi_i$) - this implying different space-time geometries

superimposed; however, when the geometries become sufficiently different (on the Planck-Wheeler scale $\sim 10^{-35}$ m), thus implying ill-defined standard superposition of the matter eigenfunctions in strictly separate spaces - Nature must choose between one of them and actually effects wave function reduction. Moreover, as microparticles are continuously subjected to fantastic accelerations ($\sim v^2/r \sim 10^{23}$ m/s² for electrons bounded in atoms, and $\sim 10^{29}$ m/s² for protons and neutrons bounded in nucleus,...), which can be met also in extremely strong gravitational fields - according to the Principle of equivalence one should expect [15] continuous opening and closing of local Einstein-Rosen bridges, addresses of their exits being related (probabilistically) to one of the possible eigenstates of corresponding microparticles. This process might yet be the mechanism for some sort of the wave function reduction, implying why so important the mental addressing is in transitional states of consciousness, related to "astral projections", described above! It also reveals that Quantum mechanics and the General theory of relativity seem to be deeply interconnected on microparticle level, showing that microparticles are continuously vanishing and reemerging (subjected obviously to corresponding conservation laws) in measurement-like interactions, throwing a new light on wave-particle dualism and other quantummechanical phenomena. In that framework, the role of consciousness in quantum theory of measurement turns out to be extremely important: for instance, in gravitationally induced wave function reduction, the very mechanism for this process could be continuous opening and closing of local microparticles' Einstein-Rosen bridges, addresses of their exits being related (probabilistically) to one of the possible eigenstates Ψ_i of corresponding microparticles - and everything being related to corresponding probabilistic addressing Φ_i of "collective consciousness" [15]. On the other hand, this nonlocality of "collective consciousness" provides an additional evidence that Quantum mechanics is nonlocal theory - otherwise demonstrated by recent tests of Bell's inequalities [58] and the Einstein-Podolsky-Rosen paradox [59], which suggest that even very distant parts of quantummechanical system (which cannot exchange light signals) can be physically correlated in the act of measurement.

consciousness might give rise to computers with artificial consciousness, functioning on deeper relativistic and quantum principles;

(f) finally, a deeper understanding of the very nature of consciousness and transpersonal phenomena might radically shift our scientific understanding of some ultimate philosophical and *religious* questions, like spiritual and practical significance of imperative moral behavior of every individual - with prospects for a new/old humanism, without meaningless and painful interpersonal, interethnic, and interreligious conflicts.

Table 1 A comparative presentation of the possibilities in modeling psychological functions by using biocybernetical models of hierarchical neural networks and brainwaves.

FUNCTION	HIERARCHICAL NEURAL NETWORKS	BRAINWAVES
CONSCIOUSNESS	- hierarchical extended reticular-thalamic activating system (amplitude and frequency modulation)	- biophysical nature of consciousness; - normal and altered states (REM sleep, meditation...)
PERCEPTION	- hierarchical structure (image, olfaction, speech)	- EM "neural networks/ brainwaves" coding; - altered and transitional states of consciousness (ionic neural network as a "sensor")
MEMORIZING	- spatial synaptic activation (short-term and long-term memory)	- frequency memorizing for various unconscious and conscious levels; - spatial memorizing of EM field within ionic network
LEARNING	- nonlinear neural networks (generalization)	- information distribution (prior habituation)
EMOTIONS	- hierarchical extended reticular-thalamic activating system (amplitude and frequency modulation) modulated by minor (right) hemisphere	- conflicts reprogramming (through integration of unconscious and conscious contents in altered states; through mutual transpersonal cleansing of acupuncture systems of conflicted persons in transitional states of consciousness)
LANGUAGE	- hierarchical primary sensory and associative secondary areas (semantics), frontolimbic formations (pragmatics), and motor systems (syntactics) mainly modulated by dominant (left) hemisphere	- lower-frequency (unconscious) mother tongue and contextual second language learning, and higher-frequency (conscious) school second language learning
CREATIVITY		- anticipating transitional states of consciousness ("astral projections"); - intense associative coupling of conscious and unconscious contents in altered states of consciousness (REM-sleep, meditation, hypnosis...)
THINKING	- emotional and language modulation of information; - information processing in associative secondary and tertiary cortical regions, and in prefrontal cortex	- creative aspects of thinking in transitional and altered states of consciousness; - thought ascending upon the ERTAS-amplification from the lower-frequency (δ , θ) unconscious form to the higher-frequency (α , β , γ) conscious form
TRANSPERSONAL INTERACTIONS		- short-range interactions by EM induction (hypnosis) and/or ionic transfer (healer/healee); - long-range global ULF EM interaction at the end of altered states (Jung's collective unconscious); - long-range directional ULF EM mentally address-oriented spatio-temporal tunneling of the displaced ionic neural network with embedded ULF EM field, in quick transitional states ("astral projections" through wormholes: transpersonal psychic and religious phenomena, "spiritual" healing)

REFERENCES

- [1] M.Livingstone, Art, illusion and the visual system, *Sci. Amer.*, Jan. 1988, pp. 68-75.
- [2] E.R.John, Switchboard vs. statistical theories of learning and memory, *Science* 177 (1972), pp. 850-864; E.R.John, T.Yang, A.B.Brill, R.Young, and K.Ono, Double-labeled metabolic maps of memory, *Science* 233 (1986), pp. 1167-1175.
- [3] R.Hecht-Nielsen, *Neurocomputing* (Addison-Wesley, New York, 1990).
- [4] D.Hebb, *The Organization of Behavior* (Addison-Wesley, New York, 1990).
- [5] J.J.Hopfield, Neural networks and physical systems with emergent collective computational abilities, *Proc. Natl. Acad. Sci.* 79 (1982), pp. 2554-2558; J.J.Hopfield, Neurons with graded response have collective computational properties like those of two-state neurons, *ibid.* 81 (1984), pp. 3088-3092.
- [6] D.Hammerstrom, Working with neural networks, *Spectrum*, July 1993, pp. 46-53.
- [7] S.Grossberg, E.Mingolla, and D.Todorović, A neural network architecture for preattentive vision, *IEEE Trans. Biomed. Engin.* 36 (1989), pp. 65-84, and references therein.
- [8] S.Grossberg and D.Somers, Synchronized oscillations during cooperative feature linking in a cortical model of visual perception, *Neural Networks* 4 (1991), pp. 453-466, and references therein.
- [9] S.Azizi, H.Öğmen, and B.H.Jansen, A unified analysis of alpha rhythm, fast synchronized oscillations, and flash visual evoked potentials, *Neural Networks* 9 (1996), pp. 223-242, and references therein.
- [10] Y.Yao and W.J.Freeman, Model of biological pattern recognition with spatially chaotic dynamics, *Neural Networks* 3 (1990), pp. 153-170.
- [11] C.A.Skarda and W.Freeman, EEG research of neural dynamics: Implications for models of learning and memory, in J.Delacour and J.C.S.Levy, eds., *Systems with Learning and Memory Abilities* (North-Holland, Amsterdam, 1988).
- [12] B.J.Baars, *A Cognitive Theory of Consciousness* (Cambridge Univ., Cambridge, MA, 1988); K.R.Poper and J.C.Eccles, *The Self and Its Brain* (Springer, Berlin, 1977), Chs. E2,8.
- [13] S.A.Ellias and S.Grossberg, Pattern formation, contrast control, and oscillations in the short term memory of shunting on-center off-surround networks, *Biological Cybernetics* 20 (1975), pp. 69-98.
- [14] D.Raković, Neural networks, brainwaves, and ionic structures: Acupuncture vs. altered states of consciousness, *Acup. & Electro-Therap. Res., Int. J.* 16 (1991), pp. 88-99.
- [15] D.Raković, Brainwaves, neural networks, and ionic structures: Biophysical model for altered states of consciousness, in D.Raković and D.Koruga, eds., *Consciousness: Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1995), pp. 291-316; D.Raković, *Fundamentals of Biophysics* (Grosknjiga, Belgrade, 1994,1995), Chs. 5,6, in Serbian; D.Raković, Prospects for conscious brain-like computers: Biophysical arguments, *Informatica* 21 (1997), No.3: *Special Issue on Consciousness as Informational Phenomenalism*, in press; D.Raković, Consciousness and quantum collapse: Biophysics versus relativity, *The Noetic J.* 1 (1997), No.1, in press.
- [16] T.H.Budzynski, Clinical applications of non-drug-induced states, in B.B.Wolman and M.Ullman, eds., *Handbook of States of Consciousness* (Van Nostrand Reinhold, New York, 1986).
- [17] A.R.Luria, *Fundamentals of Neuropsychology* (Moscow State University, Moscow, 1973), in Russian.

- [18] D.Raković, Neural networks versus brainwaves: A model for dream-like states of consciousness, *Proc. 14th Ann. Int. Conf. IEEE/EMBS* (1992), pp. 2651-2652.
- [19] K.H.Pribram, *Languages of the Brain* (Brooks/Cole, Monterey, CA, 1977), 2nd ed.
- [20] I.Petersen, U.Selldwn, and O.Eeg-Olofsson, The evolution of the EEG in normal children and adolescents from 1 to 21 years, in A.Remond, ed., *Handbook of EEG and Clinical Neurophysiology*, Vol.7, Part B: *Influence on the EEG of Certain Physiological States and Other Parameters* (Elsevier, Amsterdam, 1974).
- [21] In C.Tart, ed., *Altered States of Consciousness* (Academic, New York, 1972).
- [22] K.Jaspers, *Allgemeine Psychopathologie* (Springer, Berlin, 1953).
- [23] R.A.Moody, jr., *Life after Life* (Bantam, New York, 1975).
- [24] K.Wilber, *The Atman Project* (Quest, Wheaton (IL), 1980), and references therein; cf. also P.Vujičin, States of consciousness in esoteric practice, in D. Raković and Dj. Koruga, eds., *Consciousness: Scientific Challenge of 21st Century* (ECPD, Belgrade, 1995), pp. 89-136.
- [25] K.C.Markides, *Fire in the Heart. Healers, Sages and Mystics* (Paragon House, New York, 1990).
- [26] A.P.Krueger, Preliminary consideration of the biological significance of air ions, *Scientia* 104 (1969), pp. 1-17.
- [27] B.Pomeranz, Acupuncture research related to pain, drug addiction and nerve regeneration, in B.Pomeranz and G.Stux, eds., *Scientific Bases of Acupuncture* (Springer, Berlin, 1989), pp. 35-52.
- [28] In *Miscellany of Methodological Recommendations and Regulations in Microwave Resonance Therapy* (MRT), S.P.Sit'ko, ed. (Vidguk, Kiev, 1992), in Russian; In *Methodological Instructions for Physicians in Using Microwave Resonance Therapy*, V.D.Zhukovskiy, ed. (GPK, Moscow, 1996), in Russian; Z.Jovanović-Ignjatić and D.Raković, Microwave resonant therapy: Novel opportunities in medical treatment, In *Proc. Microwave Resonance Therapy*, V.D.Zhukovskiy, ed. (GPK, Moscow, 1997), in press.
- [29] H.Fröhlich, Long-range coherence and energy storage in biological systems, *Int. J. Quantum Chem.* 2 (1968), pp. 641-649.
- [30] E.R.Kandel, J.H.Schwartz, and T.M.Jessell, eds., *Principles of Neural Science* (Elsevier, New York, 1991), Ch.9.
- [31] Y.Omura, *Acupuncture Medicine* (Japan Publ. Inc., Tokyo, 1982).
- [32] L.D.Landau and E.M.Lifschics, *Field Theory* (Nauka, Moscow, 1973), Ch. 9, in Russian.
- [33] *Ref. 32*, Ch. 1.
- [34] W.R.Adey, Tissue interactions with nonionizing electromagnetic fields, *Physiol. Rev.* 61 (1981), pp. 435-514, and references therein.
- [35] *Ref. 32*, Ch. 6.
- [36] E.Basar, *EEG Brain Dynamics* (Elsevier, Amsterdam, 1980), Ch. 2.
- [37] D.Foulkes, Theories of dream formation and recent studies of sleep consciousness. *Psychol. Bull.* 62 (1964), pp. 236-247.
- [38] R.Broughton, Human consciousness and sleep/waking rhythms, in B.B.Wolman and M.Ullman, eds., *Handbook of States of Consciousness* (Van Nostrand Reinhold, New York, 1986).
- [39] D.Raković, Towards a new/old humanism: Transitional states of consciousness as a clue?, this *Symp. Proc.*
- [40] D.Raković, Neural networks versus brainwaves: Biophysical model for ELF interactions, *Proc. 14th Ann. Int. Conf. IEEE/EMBS* (1982), pp. 2750-2751.

- [41] S.Alberts, D.Bray, J.Lewin, M.Raff, K.Roberts, and J.D.Watson, *Molecular Biology of the Cell* (Garland, New York, 1983), Ch. 6.
- [42] H.L.König, ELF and VLF signal properties: Physical characteristics, in M.A.Persinger, ed., *ELF & VLF Electromagnetic Effects* (Plenum, New York, 1974).
- [43] R.Sheldrake, *A New Science of Life* (Paladin Grafton, London, 1987).
- [44] J.S.Hagelin, Is consciousness the unified field? A field theorist's perspective, *Modern Sci. & Vedic Sci.* 1 (1987), pp. 29-88, and references therein.
- [45] C.G.Jung, *Man and His Symbols* (Dell Publ. Co., New York, 1972).
- [46] K.S.Thorne, *Black Holes and Time Warps: Einstein's Outrageous Legacy* (Picador, London, 1994), Ch. 14, and references therein.
- [47] R.Penrose, *Shadows of the Mind, A Search for the Missing Science of Consciousness* (Oxford Univ. Press, Oxford, 1994), Part II, and references therein.
- [48] R.G.Jahn, The persistent paradox of psychic phenomena: An engineering perspective, *Proc. IEEE* 70 (1982), pp. 136-170.
- [49] R.Monroe, *Journeys Out of the Body* (Doubleday & Co., Garden City, NY, 1971).
- [50] V.P.Kaznacheev and A.V.Trofimov, *Cosmic Consciousness of Humanity, Problems of New Cosmogony* (Elendis-Progress, Tomsk, Russia, 1992).
- [51] D.I.Radin, Effects of a priori probability on PSI perception: Does precognition predict actual or probable futures, *J. Parapsych.* 52 (1988), pp. 187-212.
- [52] A.Babloyantz, Chaotic dynamics in brain activity, in E.Basar, ed., *Dynamics of Sensory and Cognitive Processing by the Brain* (Springer, Berlin, 1988), pp. 196-202.
- [53] W.Evans Wentz, *The Tibetan Book of the Dead* (Oxford Univ., London, 1968).
- [54] Swami Rama, *Living with the Himalayan Masters* (Himalayan Int. Inst. Yoga Sci. & Phil., Honesdale, PA, 1978).
- [55] S.R.Hameroff, *Ultimate Computing. Biomolecular Consciousness and Nano-technology* (North-Holland, Amsterdam, 1987).
- [56] J.H.Schwarz, Superstrings, *Physics Today*, Nov. 1987, pp. 33-40.
- [57] J.A.Wheeler and W.H.Zurek, eds., *Quantum Theory and Measurement* (Princeton Univ., Princeton, NJ, 1983).
- [58] A.Aspect, J.Dalibard, and G.Roger, Experimental test of Bell's inequalities using time-varying analyzers, *Phys. Rev. Lett.* 49 (1982), pp. 1804-1807; see, also, in P.Lahti and P.Mittelstaedt, eds., *Symposium on the Foundations of Modern Physics 1985* (World Scientific, Singapore, 1985).
- [59] A.Einstein, B.Podolsky, and N.Rosen, Can quantum-mechanical description of physical reality be considered complete?, *Phys. Rev.* 47 (1935), pp. 777-780.

CONSCIOUSNESS AND ITS ROLE IN UNIVERSAL EVOLUTION

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Abstract. In this paper, the role of consciousness is analysed in light of universal evolution (UV). There is also an attempt to explain UV (comprising inorganic, organic and subjective evolution) with the help of a single hypothesis; this, in turn, correlates survival aspects (s-aspects) of consciousness with the process of evolution. The non-survival aspects (ns-aspects) open new dimensions and are discussed separately. It is proposed that consciousness and the 'ability to know itself' is an innate property of particles as quantum mechanics has revealed many other properties like hypercharge, charm, colour etc. This eliminates the "hard problem" of consciousness. This proposition is judged in light of the informations presently available in neuroscience, analog neural nets (ANN) and quantum mechanics.

Key words: *consciousness & universal evolution, survival aspects, no-survival aspects, consciousness & innate properties of particles, "hard problem".*

1 INTRODUCTION

Initially let us assume that, consciousness is a tool developed in the process of evolution to assist survival; it does not have more importance than the development of long neck, slender leg, club-like tail or visual organ.

As an illustration, the example of visual image may be used here. It is known that the electromagnetic wave of wavelength 5890 AU 'appears' as yellow; the latter is a mental property (m-property) for which there is a physio-chemical reason (p-property).

Similarly the entire consciousness with cognition may be the m-property for which there is a p-property (not yet fully known, may be the two conformations of the dimers of microtubules which are thought to be the seat of consciousness (Penrose, 1995)). There is only one-is-one correlation between 'yellowness' and 5890 AU, but the two are otherwise unbridgeable.

There is little study on the 'evolution of colour'. A prey will like to see the tiger (predator) in bright yellow colour with black stripes on it on the background of green field for maximum visibility; this enhances its survival potential. Other species, for whom the tiger is not a predator, may not need the same colour-contrast, and they may see in different shades. That is, the colour we see, does not give 'true shade' of the world. It may be interesting to study from the point of view of evolution 'why blood appears red, soil grey and grass green'.

The same thing may be true for consciousness. Imagine a huge bulding, in an ever-dark forest where light is not known, with infinite number of rooms each enclosing one species. Suddenly one day, spark ignities the deposited sulphar on the floor of a room and dim yellowish light appears (like consciousness). The inhabitant, already possessing visual organ, will find in surprize that he can do all his works much better and with improved clarity. He will

also see walls floor furnitures in yellow colour and he will describe the universe as yellow which is not necessarily true.

Consciousness forces us to see the world in a particular way enabling us calculation and analysis for our survival, but may not give true picture of the universe.

Possibly consciousness was there from the beginning of the evolution in very dim form. If a huge aquatic animal, driven by the predator, can have a faint mental-picture of the last attack like that in delirium, it enhances its survival potential considerably.

Though survival is the pivot of evolutionary process, it is assumed here that, the latter has other dimensions as well. Survival aspect (s-aspect) of consciousness may distort world-picture to enhance survival; it is likely that nonsurvival aspects (ns-aspects) will be relatively free from this artifact. This ns-aspect is discussed at the end of the article.

Consciousness, as we know it in the *homo sapiens*, is an intense form compared to what it was in that aquatic animal described above. This higher intensity has both advantages and disadvantages. The advantages are in better calculation, analysis and decision-making; the disadvantage is that the animal can not easily go to the restful state (sleep) because some physiological subsystems may remain excited. It is, therefore, required to 'switch-on' or 'switch-off' the consciousness whenever necessary. It is likely that this 'on-off' mechanism (or modulation control mechanism) appeared at the latter stage of evolution and presently an intense effort is there to identify this 'seat of consciousness'.

In search of this seat of consciousness, Penrose (1995) scans most of the presently available anaesthetics : nitrous oxide (N_2O), ether ($CH_3CH_2OCH_2CH_3$), chloroform ($CHCl_3$), halothane ($CF_3CHClBr$), isofluorane ($CHF_2OCHClCF_3$) and the chemically inert gas xenon. In absence of any chemical relationship amongst these, he concludes that chemistry may not be responsible for the loss of consciousness. He focusses on the two conformations of dimers (made of alpha- and beta-tubulin each being composed of about 450 amino acids) on the microtubules and suggests that van der Waals force may be responsible for switching between these two conformations. Initially this was suggested by Hameroff and Watt (1983).

Before elaborating the survival aspects of consciousness, it is necessary to elaborate the concept of universal evolution.

2 UNIVERSAL EVOLUTION

The entire process of evolution is presented here in the following way:

$$Inorg E \rightarrow Org E \rightarrow Subj E \leftarrow Spiri E$$

where *Inorg E* is inorganic evolution, *Org E* - organic evolution, *Subj E* - subjective evolution, and *Spiri E* - spiritual evolution (also note the direction of arrows).

The guiding hypothesis of the evolution is proposed as (Ray, 1988):

Each and every element of the universe or its combinations want to simultaneously occupy maximum space and maximum time, directly or indirectly.

It is a known statement from prior knowledge of expanding universe which is an expansion in space. Schopenhauer's 'will to live through reproduction' is an example of the tendency to occupy maximum time by perpetuating one's own entity (Durant, 1961). The hypothesis only emphasizes the fact that both the tendencies are simultaneously active, i.e., if there is a tendency to occupy maximum possible space there should also be a tendency to occupy maximum possible time.

For the convenience of explanation, the entire spectrum of evolution is divided into four parts, namely, (i) inorganic, (ii) organic, (iii) subjective, and (iv) spiritual.

3 INORGANIC EVOLUTION

Inverse square law of force (gravitational or electrostatic), properties of elementary particles, periodic table and growth of elements are salient features in inorganic evolution. This stage is continued up to the origin of life on earth.

Inverse square law of force

This is one of the most important physical law of nature. It is obeyed by celestial bodies as well as by charged particles. This law is expressed as $F = f(r, n) = -k/r^n$, where r is the distance between the two bodies M (say, fixed) and m (rotating), and the constant k depends on the masses or charges along with some other physical constant. It is not known why mother Nature chose $n=2$, and not $n=1.9$ or $n=2.1$; ultimately 2 cannot be a blessed number in the celestial sky.

In view of the hypothesis, expressed above, some insight may be obtained. Assume a simple system of two bodies, one rotating around the other, in a circular orbit on a plane. It is known that the centrifugal force is balanced by the gravitational (or electrostatic) force and the system remains stable. A two-body system like this is identified by two parameters, the total energy W and the angular momentum J . Sometimes these two are mentioned as initial conditions (Rosenberg, 1972), because conservation of energy and angular momentum are two fundamentally important physical phenomena.

It is also known that the circular orbit will be stable if n is less than 3 (Synge and Griffith, 1959).

The two-body system is likely to be disturbed by all other bodies far and near; the destabilizing force is also guided by the same equation. Let us now assume that mother Nature is trying to fix the value of n which will result minimum change in initial condition W , i.e., $dW/dn=0$ (note that J is not necessarily a function of n , in the case of circular orbit $J=mvr$ where v is the peripheral velocity). This will help the two-body system to exist for longest possible time, i.e., it will occupy maximum time. However, one more condition is to be satisfied; the system must occupy maximum space. This may be accomplished by forcing the value of n which will allow maximum radius r . It is interesting to note that both the conditions are satisfied by $n=2$ only (Ray, 1988).

Periodic Table and Growth of Elements

Atoms grow in size from smaller to bigger by the addition of electrons one after another and this is guided by Schrodinger equation. Growth indicates expansion in space. Also the atom will exist for longest possible time within an environment of disturbing force if the electron has maximum binding energy. It is known that the consideration of binding energy is more important than the quantum state suggested by Schrodinger equation. Potassium ($Z=19$) may be taken as an example. Here the position of the 19th electron is $n=3$, $l=2$, as suggested by Schrodinger equation. The binding energy corresponding to this position is 2.46 eV. In actual case 19th electron occupies the quantum state $n=4$, $l=0$, where the binding energy is 4.34 eV and the atom has more probability to exist for longest possible time. The same thing happens for calcium, rubidium and yttrium ($Z=20$, 37 and 39, respectively). Atoms try to grow in size and at the same time try to survive for longest possible time like tiny organisms.

The basic tendency of nature towards stability (succumbing to the state of minimum total energy for maximum survival) may be questioned. In absence of the observers like *homo sapiens* and all other intelligent species, this tendency remains; why it is preferred over disintegration?

Organisms occupy a 'territory' of their own. In that territory it has a preferred position where the probability to find it is maximum. At other points the probability decreases. The gradually decreasing probability to find a particle up to infinite space (it is also true for time domain) is a similar manifestation as suggested by de Broglie's hypothesis and Heisenberg's uncertainty relation.

4 ORGANIC EVOLUTION

It is difficult to place a sharp dividing line separating living and non-living things when one considers a series of structures of gradually increasing complexity such as hydrogen, water, benzene, egg, albumin, insulin, vaccine, virus and bacteria. *Life* may be indented by two unique phenomena - *growth and reproduction*. These two characteristics may be observed in the simplest possible case - the life of a unicellular organism. The tiny organism absorbs the nutrient blocks from the surrounding medium, increases its size up to a certain limit and is then divided into two. Growth is swelling in space and it is the manifestation of the tendency to occupy more space. Reproduction, in its basic form, is another unique device of nature by which the organism perpetuates its existence in time.

'Life thus appears, as a particular, complicated form of motion of matter arising as a new property at a definite stage in the general development of matter' (Oparin, 1957a).... 'The whole series (of chemical reactions) is directed towards a single goal, towards the uninterrupted self-preservation and self-reproduction of the living system as a whole in accordance with the conditions of the surrounding medium' (Oparin, 1957b).

Cope's law (1885) suggested that there is a persistent and widespread tendency for body-size in animals, invertebrates and vertebrates, to increase during their phylogeny (Newell, 1949). Edward Drinker Cope (1840-1897) was a renowned naturalist but his law was not a success because it did not take into account the probability to survive in time. In many cases gigantism became the cause of extinction, but animals of optimum size survived.

Many animals also occupy a 'territory' of their own which is the indirect expansion in space. This tendency is seen among animals almost from the primitive stage of life. The territorial behaviour of molluscs like limpets and various kinds of snails, arthropods like burying beetles, digging wasp, spiders, bees and ants, crustaceans like fiddler crab, uca and prawn, various fishes and birds, toads, lizards and tortoises are all well studied and recorded (Thorpe, 1958). Relatively recent studies on domestic cat (Leyhausen, 1964), lemurs, gibbons, howler monkeys (Carpenter, 1965), colobus monkeys (Marlar, 1969), and Indian baboons and chimpanzees have given more information's about the nature of territories.

Various attempts have been made to find out the reasons of occupying territories. It has been suggested as food zones, but there are examples of territories where no food is available (the territory of herring gull). Safe reproduction has been suggestion as another reason but there are many examples of non-reproductive territories (Hush, 1952).

It seems that, food-zone or safe reproduction is the use of occupied territories, but the reason to occupy is instinctive.

5 SUBJECTIVE EVOLUTION

For the indirect expansion of entity in space and time, instincts and primary emotions appeared in the first stage of subjective evolution. These instincts may be divided into following three parts.

Instincts for Maintaining Entity

Many of these are physiological - hunger, thirst, suckling, temperature regulation of the body, activity-sleep cycle, collection and disposal of waste products, pain-avoidance, respiration, combat and escape, gregarious and acquisitive instincts etc.

Instincts for Expansion in Time

Mating and parental instincts.

Instinct for Expansion in Space

Self assertion.

But instincts are mechanical and in new circumstances it can not change the set course of reaction. The freedom of doing so without much trial and error can be taken as the dawn of intelligence with which the second stage of subjective evolution was started. It was found that chimpanzees fashioned short sticks from twigs which they then thrust into ant or termite holes, withdrew and leaked of a meal. If these animals are assumed to have sufficient intelligence to understand that the diameter of the twig should be less than the diameter of the hole, it did not require much intelligence for the Australopithecus to understand that pointed edge of a pebble is more helpful than the flat edge, particularly when the fingers to grip and the binocular vision were all ready. The second stage probably appeared from the age of flint and chipped stone tools.

‘Social motives’ appeared after these.

6 SPIRITUAL EVOLUTION

The tendency to occupy more space and time inevitably leads to the clash among individuals, communities, nations. The resulting sorrows and sufferings, stress and mortifications were widespread. An escape from it was found immediately by contraction of self and entity in space and time. This was the beginning of asceticism. This universal search for salvation was prevalent in India, among obscure Greek cults and among the Jewish communities of Judea and Alexandria. This phase of the history of mankind throughout the first and second century BC has been described by Wells (1965) as: "Amidst the prevailing slavery, cruelty, fear, anxiety, waste, display and hectic self-indulgence, went this epidemic of self-disgust and mental insecurity, this agonized search for peace even at the price of renunciation and voluntary sufferings".

Aphorisms of Patanjali provide a similar method. It has eight parts or steps in succession. The first two steps - *yama* and *niyama* - require non-killing, truthfulness, non-stealing, continence, non-receiving, internal and external purification, contentment, mortification, study and worship.

Since sex and reproduction are the mechanism for the continuity of one's own entity in time, continence is essentially required to stop it (this simple situation has recently been complicated due to the introduction of contraceptives!). Most of the religions can not prove it

but prescribe continence as essential for the spiritual progress. The other requirements of yama and niyama prepare the subject to control its indirect expansion in space.

The physiological and psychological states of *homo sapiens* do not easily want to accept this opposite trend of gradual process of contraction in space-time. Hence, long training of the mind is needed through the stages of *dharana* and *dhyana*. The ultimate objective is to occupy zero space and zero time, that is, to transcend space-time. Hence, *samadhi* has been described as a *psychologically simulated* condition of occupying zero space and zero time (Ray, 1988). Even if somebody may achieve this state for short time, the ‘feelings’ cannot be translated in terms of the other experiences woven in space-time continuum.

7 THE ROLE OF CONSCIOUSNESS

In this entire process of universal evolution, ‘do the particles know’ that they are trying to occupy maximum space-time, how much they have occupied and what mechanisms are to be developed to improve the position? It is assumed here that ‘it knows’ and the tendency to occupy maximum space-time is not a blind mechanical one. It is for this reason that it can devise unique mechanism at specific stages as it was from non-living to living. Once this stage was mysterious enough and many thought that Bergson’s *elan vital* was necessary; but now-a-days rationality seems to be complete without this.

Many may surprise initially with this introduction of new property of particles, but the other properties like strangeness, hypercharge, charm, flavor, color etc are no less surprising and are more abstract than the simple one introduced.

Do matrices of particles possess consciousness? If so, why a stone of the size of human head is not equally conscious as the latter (or it is?)? It is known that the magnitude of consciousness also depends on the ‘structure (biochemical?) formed’, because even the human being is not equally conscious during sleep and awake state. How this modulation of magnitude occurs in the ‘structure formed’? It is specifically this parameter which is lacking. This may be elaborated by an example: in complete absence of quantum mechanics, a scientist equipped with Newtonian dynamics will exclaim, ‘particles are not always detected at the desired positions, they seem to possess *free will*, how this may be resolved’? However, the de Broglie’s waves associated with particles largely de-mystify the *free will*.

If all particles possess the ‘ability to know itself’, the ‘hard problem’ of consciousness vanishes; what is left is the problem of modulation. This is likely to be related with some parameter (another *psi-like* property), and its intensification by Bose-Einstein condensate is not unlikely. On the other hand, neural nets may also possess mental properties.

Analog Neural Nets (ANNs) and Its Psychic Properties

Human cortex contains about 10^{10} to 10^{12} neurons each possessing about 10^4 synapses. The upper layer (gray matter) is the cell bodies where as the lower layer (white matter) contains the ‘wirings’ between neurons. ‘What one knows, are in these wirings’; that is, whenever something new is learned, it is stored in the form of new wirings or arborization amongst the neurons. This much information is known with a certain degree of certainty because the arborization is seen to increase as the new-born baby grows and learns new tricks. In ANN, the wirings are represented by weights (say resistors) and neurons by summing amplifiers (Samp). Since the wirings have not been traced exactly from beginning to end, almost wild imagination is used in ANN. Weights have been considered from output of any SAMP to input of any, from output to any intermediate layer, through different types of summing and/or multiplying feedbacks etc. These have given rise to large number of ANNs (eg Hopfield, Hamming,

Carpenter/Grossberg, Kohonen's self-organising feature map, Boltzmann machine, fuzzy nets etc) which may considerably differ from biological structures. Surprisingly, even in these simple configurations, some of the mental properties are retained. A few examples are given below.

Hopfield Net: Say this net is trained with exemplars of 8x8 matrix pixel-bits forming digits (Lippmann, 1987). After training, distorted exemplars (ideal exemplar corrupt with noise) may be given as input. In the output, all distortions are straightened ie, all wrong pixel-bits are pulled to the correct positions. But this has limitation. With more distortion at the input, the net can straighten the error for less number of exemplars. This is a common property of human mind. Students, particularly, are familiar with this (they try to cram too many things before examination and cannot straighten simple twist in conventional questions).

Adaptive Resonance Theory 2: In short this is called ART2 and was introduced by Carpenter and Grossberg (1990). This net claims to have a property called 'Search-Direct Access Tradeoff'. If an input pattern is too familiar, the search for matching with the stored exemplars in the memory is automatically disengaged and identification takes place immediately. Let us take the case of a person soldering resistors in electronic circuit boards. All resistors have code of color rings (ten colors in total, suggesting ten digits). Three successive rings of color brown, black and red will mean 1 followed by 0 followed by 10^2 , that is, 1000 ohms. After long practice, one really does not decipher the values like this, but arrives at the correct value just with a glance at the color rings.

It is interesting that the authors tried to incorporate this innate property of the mind into ANN. However, the network and the equation provided is just problem-specific and not a general one.

Role of symmetry and Kohonen's map: In this self-organising feature map, the variation of a parameter of a system follows proportional topographic variation on Kohonen's surface (Lippmann, 1987). Indeed there are many examples in nature where proportional variation of a parameter obeys proportional topographic variation in the system also. Auditory system may be taken as an example, where the frequency variation (linear) of sound is represented along the length (log scale) of cochlea. In some recent example (Shamma, 1993), it is shown that cortical cells in the primary auditory cortex A1 exhibit a systematic change in the *symmetry* of the tuning curves on the iso-frequency plane. The author has also shown the arrangement of excitatory and inhibitory neurons responsible for the *symmetry*. Indeed symmetry has deeper implication in consciousness, particularly in aesthetics (sculpture, painting, musical rhythm etc). Creation of *symmetry* in natural system, which is the product of random chance mutation, is rather unusual. It is likely that the property of *symmetry* will be retained in the Kohonen's surface also.

8 NON-SURVIVAL ASPECTS OF CONSCIOUSNESS

The non-survival aspect of consciousness is mainly the domain of aesthetics out of which musicogenic epilepsy is probably more thoroughly studied. In these phenomena, definite symptoms appear on EEG (electroencephalogram) when a subject is 'swept away' by the aesthetic appeal of music. The level of consciousness is changed and the corresponding physiological states may be interpreted with some recent signal processing techniques using EEG, ECG, respiration and heart rate as data.

Musicogenic epilepsy was first reported by Critchley (1937). Subsequently in the sixties, Servit *et al* (1962) reviewed twenty cases where seizures were triggered by music; many of the reports indicated that the induced seizures were located in the temporal lobe and probably arose

from foci in the auditory cortex. It is also interesting to note that musicogenic epilepsy, in some cases, has been found related to something devotional. Poskanzer *et al* (1962) reported that only a discrete frequency band of church bell caused musicogenic epilepsy and Marsden and Reynolds (1982) mentioned a patient whose grandmal seizures were initially provoked by certain types of classical orchestral and church music, and who could be induced to have a fit by Beethoven's Fifth Symphony.

The present author's work with musicogenic epilepsy was started with music-lovers, known for their depth and understanding of Indian classical music; but even the repeated efforts did not show any spike in the EEGs (the reasons and limitations were not studied). Classical music was then replaced by devotional songs and only devotees were selected. It was anticipated that the aesthetic appeal along with the *stress* of devotion might help the subjects to reach epoch. Details of these experiments may be seen in Ray and Kaplan (1993, 1994).

Analysis techniques used were Hidden Markov Model, fractal dimension, and HRV (heart rate variability). The outcome of the analysis suggested reduction in fractal dimension (Ray, 1995a, 1995b), less crosscorrelation in EEG and sympathetic burst on autonomic system (Ray, 1997).

According to the philosophy of *Upanishads*, gradual liberation from the space-time domain marks the beginning of journey towards *ultimate reality* (*samadhi* has been shown to be a state of psychologically simulated condition of occupying zero space and zero time). It is also frequently mentioned that, the state of *samadhi* has considerable similarity with the state of deep aesthetic appreciation. This has been practiced in India, as a part of its culture, throughout the centuries by many individuals and the physiological changes are recorded in many texts. It is interesting to note that, many of the symptoms recorded are also suggested by the experiments described above. Interested readers may go through the references (Ray, 1995b, 1997) because it will not be appropriate to describe it here (it will transgress the boundary line of Science!).

9 WISDOM FROM UPANISHADS

The view presented here does not differ much from the 'Astonishing Hypothesis' (Crick, 1994) except the introduction of a few new properties of particles. Indeed this has been repeated many times earlier in the history of science. Whenever a certain behaviour of particles defied explanation, it always invited new property with new definition. When it was found that some particles attract each other, some repel, it was solved by attributing the concept of charge. In strong force interaction involving heavy baryons and mesons, all combinations of particles were not allowed; this invited the new property strangeness along with a new law of conservation of strangeness (how strange to common sense!). Why multicolored quarks do not occur in nature individually, because all naturally occurring particles are colorless (readers may kindly note that these colors are not the same as we see in rainbows! these are quantum properties).

The 'ultimate reality' (*Brahman*) is said to have three 'attributes'. "The Upanisads say that Brahman is Existence, Knowledge and Bliss; but these are not attributes. Brahman can not be said to exist. Brahman is Existence itself. Brahman is not wise or happy, but absolute Knowledge, absolute Joy" (Prabhavananda and Isherwood, 1985). According to this view, 'ultimate reality' also does not possess consciousness as 'primary attribute'. But it possesses 'absolute knowledge'. If the universe is the manifestation of *Brahman*, then each and every particle possesses absolute knowledge. Does knowledge pre-suppose consciousness ?

REFERENCES

- [1] Carpenter C. R. (1965), The Howlers of Barro Colorado Islands, *Primate Behaviour*, p. 250.
- [2] Carpenter G. A. and Grossberg S. (1990), In *An Introduction to Neural and Electronic Networks*, Zornetzer S. F., Davis J. L. and Lau Clifford eds., Academic Press Inc, pp. 465-466.
- [3] Crick F. H. C. (1994), *The Astonishing Hypothesis - The Scientific Search for the Soul*, Simon and Schuster, London.
- [4] Critchley M. (1937), Musicogenic Epilepsy, *Brain* 60, p. 13.
- [5] Durrant W. (1961), The Story of Philosophy, *Washington Square Press, Inc*, p. 312.
- [6] Hameroff S. R. and Watt R. C. (1983), Do anesthetics act by altering electron mobility? *Anesth. Analg.* 62, pp. 936-940.
- [7] Hush (1952) and Breder (1951), mentioned by Thorpe W. H. (1958), *Methuen and Co. Ltd*, p. 268.
- [8] Leyhausen P. (1964), The Communal Organization of Solitary Mammals, *Symposium of Zoological Society, London*, Vol. 14, p. 249.
- [9] Lippmann R. P. (1987), An Introduction to Computing With Neural Nets, *IEEE ASSP Magazine*, April, pp. 4-21.
- [10] Marlar P (1969), Colobus Guereza, Territoriality and Group Composition, *Science* 163, p. 93.
- [11] Marsden C. D. and Reynolds E H (1982), In *A Textbook of Epilepsy*, Laidlaw J and Richens A eds., Churchill Livingstone, New York, p. 108.
- [12] Newell N. D. (1949), *Evolution*, Vol.3, p. 103.
- [13] Oparin A. I. (1957), The Origin of Life On Earth, *Oliver and Boyd*, Edinburgh, see Introduction.
- [14] Oparin A. I. (1957), *ibid*, p. 350.
- [15] Penrose R. (1995), *Shadows of the Mind*, Vintage, pp. 357-371.
- [16] Poskanzar D.C., Brown A.E., and Miller A. E. (1962), Musicogenic Epilepsy Caused only by a Discrete Frequency Band of Church Bells, *Brain*. 85, p. 77.
- [17] Prabhavananda Swamy and Isherwood Christopher (1985), *Bhagavad-Gita*, Sri Ramakrishna Math, Mylapore, Madras, p. 271.
- [18] Ray G. C. (1988), Higher states of Rajayoga and its possible correlation with process of evolution, *Journal of the Inst. Engineers (IDP)*, Vol.68, June, pp. 1-6.
- [19] Ray G. C. and Kaplan A. Y. (1993), Identification of States of Consciousness from Transcendencies in EEG, *13th International Congress of EEG and Clinical Neurophysiology*, Vancouver, B. C., August 30 - September 5.
- [20] Ray G. C. and Kaplan A. Y. (1994), Transcendent signal and its signature on electroencephalogram, *Journal of the Institution of Engineers*, (India), Vol. 74, March, pp. 22-31.
- [21] Ray G. C. (1995), Study of Biological Rhythms During Musicogenic Epilepsy, *17th Annual Conf. on IEEE Engineering in Medicine & Biology*, Sept. 20-23, Montréal, Canada.
- [22] Ray G. C. (1995), r-Parameter: A New Measure of Level of Consciousness, *Journal of the Inst. of Engineers* (India), Vol. 76, September, pp. 7-12.
- [23] Ray G. C. (1997), Likely Sympathetic Burst on Autonomic System Just on Landing Ultimate Reality, *Journal of the Inst. of Engineers* (India), April 1997 (in press).

- [24] Rosenberg R. M. (1972), On Newton's Law of Gravitation, *Am. Journal of Physics* 40/7, July, p. 975.
- [25] Shamma S. A., Fleshman J. W., Wiser P. W., and Versnel H. (1993), Organization of Response Areas in Ferret Primary Auditory Cortex, *J. Neurophysiol* 69, pp. 367-383, February.
- [26] Servit Z., Macher J., Stercova A., Dudas D., Kristof M., and Cervenкова. V. (1962), Reflex Influences in the light of Clinical Statistics, *Epilepsia* 3, p. 315.
- [27] Synge J. L. and Griffith B. A. (1959), *Principles of Mechanics*, McGraw Hill, New York, p. 159.
- [28] Thorpe W. H. (1958), *Learning and Instincts of Animals*, Methuen and Co. Ltd.
- [29] Wells H. G. (1965), *A Short History of the World*, Penguin Books, p. 142.

QUANTUM PHYSICS OF THE ALIVE: MEDICAL ASPECTS

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Abstract. It was shown how through the integration of the West knowledge and Oriental experience new approach to the problem of the living matter had been forming. In the scope of this approach we are seeking the way to the creation of the Theoretical Biology and Medicine. The confidence in it is coming from successful treatment of many thousands "incurable" patients with the methods of Quantum Medicine.

Key words: *physics of the alive, animate and inanimate nature, coherence, laser of mm-range nonlocal self-consistent potential, channel, west and oriental medicine, gene, macroscopic quantum mechanics entirety, time, reversibility, integrable system, BAP.*

There is a great gap between approaches to the problem of human health restoring (and to the nature of the alive in general) in the West and in the Oriental Cultures. The West science and specifically medicine is based on the "atomistic paradigm". It means that only results received in microscopical investigations are allowed to accept as representative ones, and conversely - the results of macroscopic investigations are regarded at best as preliminary step before beginning of the thorough microscopical study.

At the same time in the traditions of the East (Oriental) Science (including medicine, and moreover, medicine in the first line) the Holism takes an essential place, providing look on the Man as on a cosmical entity. In the framework of such approach Oriental medicine is compelled to use inobservable, immeasurable (to the last time) and, mainly, alien for European mentality categories. And therefore despite of the remarkable successes of Oriental (and in the first place, Chinese) medicine (but may be just due to it) European science looks on it as on a mysticism.

As a result of the "atomistic paradigm" we have medicinal therapy, which also could be named "chemical therapy", because in its scope curing action is realized through short-range chemical influence on the succession of chemical reactions in the sub-cell structures of living system. It is understandable since biochemical cycles and chains of reactions are spacely located and could be at least in principle under experimental control. Therefore by to-day we are able not only to describe processes proceeding on the cell and sub-cell levels of the alive but in some cases to achieve comprehension of the functions, being realized by an organism on these levels. As example of the last we could recollect the deciphering of the mechanism of chromosome heredity in the successive chain from nucleotides to amino acids and farther to proteins (Watson, Crick, and others) and storing of metabolism energy, as a charge on the cell membranes what fulfils through proton transport (Mitchell).

But at the same time it remains unclear how synchronization of the processes going in million and million cells of body is realized, how the differentiation of cells and tissues is realized or how gene information on the level of entire body is realized. These inquiries come us may be to the most significant problem of whole science: What is the difference between dead and alive matter? And we would prefer to receive answer not on the qualitative, descriptive level of Oriental Philosophy and not on the semi-tautology definition such as: "Life is the way of existing of protein

stuff" (Engels). We should like to have a quantitative definition of the distinction between dead and alive matter. Moreover the term "quantity" ought to satisfy the claiming and criteria of modern scientific standards.

First of all I should like to emphasize that the "chemical force" is one of the modifications of electromagnetic force, which realizes itself in a contact interaction of reagents. It means that this force is a short-range component of principally electromagnetic interaction. In the conditions of solid state, long-range components of electromagnetic interaction are eliminated due to screen-effect and therefore, microscopical approach is justified in these areas of traditional Physics. But proceeding to the animate nature we notice the lacking of such approach.

Indeed, analysis of the bulk of experimental results through a prism of the last achievements of science (such as synergetic, theory of dissipative structures, and so on) has convinced us that remaining in the framework of short-rang force of the chemical nature it is not possible to explain in principle the origin and existence for relatively long time of the macroscopic forms of living organisms. In other words being in scope of tradition paradigm we in principle cannot come to understanding of the gist of distinguishing animate nature from inanimate one. I think that H. Frohlich was the first [1] who attracted our attention to this problem and, moreover, he foresighted that the exit from this situation lay on a way of consideration of "Biological Coherence" [2], which provided possibility of creation of the effective long-rang interaction.

Filling of the notion of Biological Coherence with the constructive contents began in 1982 when the displaying of the characteristical eigenfrequencies of the human body was manifested [3]. We have shown the possibility of restoring of the state of the patients by means of influence of low-intensity but sharp-tuning on frequency electromagnetic radiation of mm-range on sick men through their Biology Active Points (BAP). It is important to emphasize that the BAPs coincide with the Points of Acupuncture well known in the Ancient Chinese Medicine. The studying initiated by discovery of the above mentioned phenomenon has shown that we had touched the property immanent only to the Alive.

The conclusive experimental results [4] and first of all the huge clinical experience gained in cases of successful treatment in different countries of many thousands patients suffered from diseases which listed as "incurable" for ordinary therapy [5], have given mea basis for the perception of the role of coherence electromagnetic waves of organism in providing its genetical entirety and ensuring variety of differential stabilities of the Alive [6]. This recognition has enabled me to formulate the hypothesis about the place of the Alive on the Weisskopf's Quantum Ladder of Nature. This hypothesis is very and very potentially vulnerable because it has pretensions to be converted to the foundation of the Theoretical Biology and therefore it has not to contradict any good established knowledge and conclusive experimental results in the Biology as well as in West and Oriental Medicine.

The hypothesis could be shortly formulated in such a way: *Any functioning as an entire living system is simultaneously macroscopical quantum-mechanics object and laser of mm-range* [5,7]. It was shown that just this insight has given a possibility for non-contradictory explanation of all bulk of experimental data including treatment of "incurable" diseases with the accounting quanta of electromagnetic radiation ($\sim 10^{-20}$ W/Hz cm²) [4,5]. The forming of this idea has been based on the perception that the chief principles of Quantum Mechanics - identity and discreteness - and only these principles - stipulate the variety differential stability of the world on the three levels of its quantum organization, it is three steps of Weisskopf's Quantum Ladder - nuclear, atomic and molecular - and in conformity with the Corresponding three existing fundamental sciences. I guess that the variety of differential stabilities of the Alive, in other words, the existence of species and individual peculiarities of plants and animals, ought to have the same reason - they are the Quantum Mechanics Entities.

The problem of reality of quantum mechanics entirety of macroscopic objects is toughly connected with feasibility of unitary nonlocal self-consistent potential in it.

Under ordinary conditions of solid state the existence of such potential is impossible. That's why usually in macroscopic physics we deal only with "quantum effects", when extraordinary conditions are arisen, in case, for example, of superconductivity, superfluidity, inverse inhibition (laser's regime), plasma's state and so on.

What is the situation in the living matter? First of all I should like to remind about existence of the huge electrical field ($\sim 10^5$ V/cm) on the protoplasmic membranes of every living cell. Keeping in mind that physical properties of the membranes give them possibility to oscillate with the eigenfrequencies in the range of (10^{10} - 10^{11}) Hz (i.e. in mm-wave length band for vacuum) we have to conclude that all cells of every living organisms enable to be looked at as an active center, i.e. the source of electromagnetic radiation. Despite of it we usually cannot say in advance that the existence of active centers in the medium is the enough condition for converting into the regime of laser's generation. Very strong absorption in tissues in principle could prevent system from going through the threshold of nonequilibrium phase transition. And here we ought to appeal to the notions of the Oriental Medicine.

The point is that the BAPs are disposed on the surface of the human body not in the random way, but most of them lies on the special tracks named Chinese Channels (for example, [8]) better to say on the outside tracks of these Channels, because besides them there are the inside tracks of Channels going according to the Oriental Philosophy through main organs of the body. Thus twenty six Channels pierce whole organism and it would seem that the mechanism of action of the Acupuncture could be easily understood. But unfortunately that was not right, because there are no morphological peculiarities connected with the tracks of the Channels, while the traditions of the Western medicine demand visualization as obligatory condition of reality.

Rudenko Effect [9] (the detecting of the Channels' tracks with the aid of weak magnetic fields compared in intensity with the Earth one) has displayed the narrowness of this point of view and demonstrated the electromagnetic nature of the Chinese Channels. This fact as well as the stability of location of Chinese Channels trajectories and the gauge invariability of their length and fragments of the length between principal anatomical peculiarities of the body [8] have given me a possibility to look at these Channels as the projections on three-dimension space of the phase trajectories of the steady coherent waves of medium (limit-cycles).

In the scope of such approach the existence of the Chinese Channels alone is enough for proving the existence of the non-local self consistent electromagnetic potential of the whole body and consequently for proving the existence of the effective long-range forces (interactions) providing the quantum-mechanics entirety of the organism beyond threshold of non-equilibrium phase transition.

Indeed, the limit-cycles would be regarded as a displaying on the phase plane the stable solution of the simplest non-linear differential equation used in Synergetics [7],

$$\dot{q} = -k_1 q - k_2 q^3 \quad (k_1 < 0, k_2 > 0)$$

with the one-dimension Landau-Haken potential:

$$V(q) = \frac{k_1 q^2}{2} + \frac{k_2 q^4}{4}.$$

As it is known [10] this potential after transition to two-dimension picture could be presented as a bottle bottom like system with the steady moving of "a probe" along a chute on the circle trajectory imitated electromagnetic limit cycle.

By the way, such "synergetic form" of quantum-mechanical potential, being revealed in this situation, has permitted me to generalize this result on the tradition quantum mechanics tasks. It has also stimulated my suggestion to substitute an ordinary used forms of potential wells, which had given solutions in form of standing waves, to synergetic potentials with the solutions in form of running waves [11].

This substitution attaches physical sense to the mechanism of quantization of the energetical levels regenerating in such a way intuitive provision made by N. Bohr.

The running coherence electromagnetic waves are being formed in the nonlinear medium of human body, and are spreading inside of it according to the ordinary laws of non-linear optics for closed resonator filled with non-linear absorption medium with the active centers. The principle of minimum losses requires for these waves to fall on the surface of skin from inside under the angles, greater than the angle of total internal reflection for the medium. The analysis of the location of the Points of Acupuncture along the outside tracks of Channels has confirmed this prediction [6]. The dimensions of the cross-sections of the beams of the Channels are defined with the condition of saturation of the medium along the tracks of Channels and for the most ones the precise forming, according to our supposition, could be realized through reflection from fingers' and toes' nails [6].

The next question is the information contents of the spectrum of the electromagnetic running waves forming the Channels, in its connection with the genom and properties of entirety quantum systems. This problem is a gigantic one and now I am able only to express starting premises of its solution and some preliminary speculations.

It is well known that all somatic cells of every organism have the same genom. Just this property gives us the possibility to look on every cell as on active centre of the coherence field of an organism. To be a carrier of the gene information, the coherence electromagnetic field ought to receive this information after all from DNA. I share Webb's opinion that processes in cell are also synchronized by the inside coherence electromagnetic field. I guess that the translation of chemical information on the language of electromagnetic one and reverse could be realized through the mechanism of laser chemical pumping (Polanyi) with the participance of reciphering of information in the line; DNA - microtubules (cytoskeleton network) membranes (Koruga [12]). I also consider that the cell's membrane plays the role of great quality active filter with band of transmission in area of mm-range (due to its form and charge) and being governed through the system of membranes' canals. This permits to eliminate the high-frequency part of spectrum going out from the cells, which realizes the self-consistent communication for intercelling processes.

From the positions of above presented ideas there is no direct connection between either gene and the morphological peculiarities of an organism. The genes code the creation of protein molecules (as well known) and form the peculiarities of self-consistent potential well imposing in such a way the "selection rules", which transform quasicontinuous spectrum of energy transitions into a discrete one inherent to this organism only. In such a way the formation of the spectrum of the characteristic eigenfrequencies is going on. This spectrum defines all species' and specific for every entity morphological properties in the same way as it is on the other steps of Quantum Ladder. So, spectra of the characteristic eigenfrequencies are the universal Passports of all stable entirety, as for inanimate and animate nature.

In this connection I would like to state my opinion on the issue discussed very intensely in the books and on the pages of scientific magazines especially lately, when ideas of synergetic and theory of dissipative structures have revived interest to the problems of time and its reversibility, entropy, integrable and non-integrable systems, chaos and so on [13].

Proceeding from this short expounded conception of the Physics of the Alive I guess that:

(1) The notion "Integrable System" is equivalent to the notion "Entirety Quantum Mechanics System in the ground state".

(2) The Entirety Quantum Mechanics Systems (nuclei, atoms, molecules, living objects) in a ground state are described with the periodical wave functions type, $\Psi \sim e^{j\omega t}$. In the attempting of recognition of the nature of time's non-reversibility the imaginary unit ($j = \sqrt{-1}$) usually relates to the frequency (energy) [13] introducing in such a way the notion of complex energy that seems some artificial. I attribute j to t . It means that in ground state the Entirety Quantum Mechanics Systems have not got real time. As an example, for atom of hydrogen in the ground state we are unable to ascribe the notion of "time" (What is the age of this hydrogen atom?) despite that it exists in the world where time is going on. Only in case of external influence (transition to excited state, radioactivity) a real part of complex time is appearing: "time of life", in excited state, "period of half delay", in radioactivity.

(3) The category "time" is emerging as a gauge of the interaction between particles (in general case, the interaction between Entirety Quantum Mechanics Systems).

Time is growing with the increasing of interaction (number of particles). Uniform space conforms uniform time. In other cases we have more complex relation between time, space and matter. From here we could try to turn round to the relativity concepts of A. Einstein.

But if the Particles or Quantum Entireties put together and form new Entirety Quantum Mechanics System, real part of complex "time" vanishes and System begins to be described by the periodical wave function with the imaginary time. On the language of classical physics it means that we have come to regime of integrable system and can exclude from Hamilton operator (and hence from the total energy) potential energy, i.e. we can perform the canonical transformation and show that in new coordinates (angle - variable of action) there is no interaction of integrable system with the remaining world. The integrable system depends from only one variable - an action, so the Entirety Quantum System is described with only one wave function.

The issues of Theory of Development, in general, and Embryology, in particular, are also in the sphere of interests of Physics of the Alive. Now we are trying to understand the mechanism of the Embryo's "electromagnetic framework" formation in its self consistency with the biochemical development of a baby. It is essential to underline that the ideas of Physics of the Alive don't contradict to the existence of biochemical picture of the Development. On the contrary, these ideas are filling the lacunas in this picture. We are attempting to find the modern physical realization of mathematical ideas, connected with the problem of formcreation and morphogenetical fields [14]. I keep in mind in the first line the topological models with theory of graph's stability [15]; the approach to the phylotaxis and the geometrical construction of the different representatives of animate nature from the position of the Limited Magical Quantum Entirety - Science of Numbers with the Fibonacci numbers, Golden Mean and so on [16]; the conforming reflection and the projective geometry as possible mathematical foundation of ontogenesis [16]; the Fractals Theory with the Hausdorff dimension and its role in the grounds of 5-dimensions World to have come to the insight of the Alive [12]; the substantiation of imaginarity for two from five above mentioned coordinates to imitate through Mandelbrot's set the Diversities of Life in *any non-linear medium* [17].

Even some years ago many of the written in the last sentence would sound as mystical text, but now it is the area of the interest of the Western Science [18].

Thus I consider that the creation of the Science of the Alive which has just being begun will go on the way of integrity of the Western and Oriental Knowledge, by so the contribution of the Oriental one will be not a bit less.

The life itself makes it necessary to form a new branch of knowledge - "a healthy man clinic" which should comprise the diagnosis of risk situations and their treatment, and to use new approaches to concepts of "norm and disease". The Quantum Medicine diagnosis is being more widely used, and the first attempts are being made to computerize it. Unlike the blood and urine tests and other methods of diagnostics, the Quantum Medicine will bring doctors closer to their patients. Diagnostician and therapist will be as one person at "a healthy man clinic".

We think that all general physicians must be able to use the acupuncture and MRT methods of diagnosis. Now in the West many high medical schools have departments and faculties for family physicians training. It is evident that this training must be based on up-to-date level of knowledge on etiopathogenesis, diagnosis, prevention and treatment of diseases. At the same time it is necessary to introduce the course "The Basis of Quantum Medicine" as an obligatory one at the departments and faculties for training family physicians, considering the simplicity, availability, informativity, and especially diversity of the method.

It is difficult for a modern physician to imagine a variety and complexity of syndromic diagnoses that prevailed in Oriental eastern medicine. Considering the fact that the conception "early" in clinical sense does not always correspond to "initial" in anatomical sense it is extremely urgent to find the non-traditional forms of diagnosis of pathological processes long before their clinical manifestations. The experience gained allows to state that the asymptomatic, "scilent" diseases can be revealed using manual or instrumental acupuncture before the appearance of pain, other functional disorders and anatomical changes. It points to the fact that the disturbances of wave processes in meridians may appear long before the disease or its morpho-functional signs development, implying necessity for preventive action on this *psychosomatic* level of disorder!

All above stated is possible in prospect of medical science and practice when practically healthy people will become the object of study and a new branch of diagnostic, preventive and therapeutic knowledge will appear as "a healthy man clinic".

In conclusion we would like to say that in the nearest future just prevention will have a great success when treating diseases in men. The scientifically grounded staged reorientation of health services is necessary. Its aim will be not to return to a patient's former state but to stabilize his *psychosomatic* health.

We think that the preventive principles of the Quantum Medicine may serve as infrastructural basis of the new services in the dynamic integrative system of public health in the 21st century. In future we will not be able to prevent radically the atherosclerosis, malignant tumors and other types of non-infectious pathology but probably we can low the rates of their development.

In the course of time the fundamental idea of modern science "Physics of the Alive," in our opinion will become the theoretical basis for naturopathic methods of the human diseases prevention and therapy improvement.

We are convinced that in the nearest future quantum approaches will allow to draw near the problem of superearly diagnosis of human diseases and by means of coherent electromagnetic field stabilization raise the general nonspecific resistance of organism to the endogenous and exogenous factors.

REFERENCES

- [1] H. Fröhlich, Long range coherence and energy storage in biological systems, *Int. J. of Quantum Chem.* 2 (1968), pp. 641-649.

- [2] H. Fröhlich, Theoretical physics and biology, in H. Fröhlich, ed., *Biological Coherence and Response to External Stimuli* (Spring-Verlag, New York, 1988).
- [3] Ye.A. Andreyev, M.U. Bely, and S.P. Sitko, Manifestation of characteristic eigenfrequencies of human organism, Application for the Discovery to the Committee of Inventions and Discovery at the Council of Ministers of the USSR, No.32-OT-10609 (May, 1982), in Russian.
- [4] *Physics of the Alive*, S. Sit'ko, ed., VIDHUK ISSR 1023-2427 (Kiev, Ukraine, 1993, 1994, 1995).
- [5] S.P. Sit'ko and L.N. Mkrtchian, *Introduction to Quantum Medicine* (Pattern, Kiev, 1994), p. 126.
- [6] S.P. Sit'ko and V.V. Gizhko, Towards a quantum physics of the living state, *J. Biol. Phys.* 18 (1991), pp. 1-10.
- [7] S.P. Sit'ko, Conceptual fundamentals of physics of the alive, in *Physics of the Alive* (Kiev) 1 (1993), pp. 5-21.
- [8] *The Way to Locate Acu-points*, Gang Jiasan, ed. (Foreign Language Press, Beijing, 1982), p. 72.
- [9] S.P. Sit'ko, Ye.A. Andreyev and I.S. Dobronravova, The whole as a result of self-organization, *J. of Biol. Phys.* 16 (1988), p. 71.
- [10] H. Haken, *Synergetics, An introduction*, (Springer-Verlag Berlin, 1978), p. 355.
- [11] S.P. Sit'ko, Physical meaning of Schrödinger formalism from the standpoint of Quantum Physics of the Alive, *Dopovidi AN Ukraine* 10 (1993), pp. 98-101.
- [12] D. Koruga, Neurocomputing, in *Theoretical Aspects of Neurocomputing*, E. Pelikan, N. Novak, eds. (World Scientific 1991), pp. 19-39, D. Koruga, INFON, From Nature through Brain to Computers, 1991, pp. 47-66.
- [13] Prigogine and I. Stengers, *Time, Chaos and the Quantum*, (Progress, Moscow, 1994).
- [14] B.N. Belintsev, *Physical Fundamental of the Biological Formcreation*, (Nauka, Moscow, 1991), p. 252, in Russian
- [15] V.V. Isaeva and E.V. Presnov, *Topological Structure of the Morphological Fields*, Nauka, Moscow, 1990), p. 256, in Russian.
- [16] S.N. Petuchov, *Biomechanics, Bionics and Symmetry*, (Nauka, Moscow, 1981), p. 139, in Russian.
- [17] H.O. Peilgen and P.H. Richter, *The Beauty of Fractals* (Spring-Verlag, Berlin, 1986).
- [18] I.S. Dobronravova and S.P. Sit'ko, Physics of the Alive as a phenomenon of postnocalssical science, in *Self-organization and Science: The Experience of the Philosophical Comprehension* (ARGO, Moscow, 1994), p. 350, in Russian.