Postcorrection and Mathematical Model of Life in Extended Everett's Concept

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Abstract

Extended Everett's Concept (EEC) recently developed by the author to explain the phenomenon of consciousness is considered. A mathematical model is proposed for the principal feature of consciousness assumed in EEC, namely its ability (in the state of sleep, trance or meditation, when the explicit consciousness is disabled) to obtain information from all alternative classical realities (Everett's worlds) and select the favorable realities. To represent this ability, a mathematical operation called postcorrection is introduced, which corrects the present state to guarantee certain characteristics of the future state. Evolution of living matter is thus determined by goals (first of all by the goal of survival) as well as by causes. The resulting theory, in a way symmetrical in time direction, follows from a sort of anthropic principle. Possible criteria for postcorrection and corresponding phenomena in the sphere of life are classified. Both individual and collective criteria of survival are considered as well as the criteria providing certain quality of life and those which are irrelevant to the life quality. The phenomena of free will and direct sighting of truth (e.g. scientific insight) are explained in these terms. The problem of artificial intellect and the role of brain look differently in the framework of this theory. Automats may perform intellectual operations, but not postcorrection, therefore artificial intellect but not artificial life can be created. The brain serves as an interface between body and consciousness, but the most profound level of consciousness is not a function of brain.

Key Words: Everett's interpretation of quantum mechanics; consciousness; life; anthropic principle; poscorrection

1. Introduction

From the time of creation of quantum mechanics up to now conceptual problems of this theory, or quantum paradoxes, are not solved. They are often formulated as the problem of measurement. Various interpretations of quantum mechanics are nothing else than attempts to solve this problem. The origin of the measurement problem is the fact that, contrary to classical physics, consciousness of an observer plays an important role in quantum mechanics (this difference may be formulated as the difference between classical and quantum concepts of reality). This fact made it possible for the author to suggest theory of consciousness called Extended Everett's Concept (EEC) starting from the principal points of quantum mechanics. Here we shall introduce a mathematical model for this theory and discuss some principal issues resulting from it.

The reasoning applied in EEC is following (see Sect. 2 for details):

1. Commonly accepted Copenhagen interpretation of quantum mechanics includes the reduction postulate declaring that a quantum system's state is converted, after a measurement, into one of the alternative states corresponding to the alternative measurement outputs (readouts). This postulate contradicts to linearity of quantum mechanics: the state of the measuring device and the measured system should, in linear theory, include all the alternatives as components of the superposition. In the interpretation suggested by Hew Everett
(Everett, 1957; DeWitt, 1973) the linearity was taken as a basic principle and therefore all alternatives were assumed to coexist (to be equally real). To explain, why any real observer always watches only a single alternative, it was assumed that «many classical worlds» exist, a single alternative being realized in each of these worlds. Equivalently, one may say that the observer’s consciousness separates the alternatives from each other (subjectively the observer, when watching some alternative, cannot watch the others).

2. In the Extended Everett’s Concept (EEC) proposed by the author (Mensky, 2000; 2005a; 2005b; 2007), the observer’s explicit consciousness is identified with separating alternatives. This simplifies the logical structure of the theory and yields new consequences: when the explicit consciousness is disabled (in the states similar to sleep, trance or meditation) one acquires a sort of «superconsciousness» being able to take information from all alternatives, compare them with each other and choose the favorable one. This allows one to explain the well known phenomena of free will, absolute necessity of sleep, as well as such unusual phenomena as direct sighting the truth (e.g. scientific insights) and even «control of reality» in the form of «probabilistic miracles».

According to EEC, the principal feature of consciousness (of human and, more generally, of any living being) is its ability, overcoming the separation of the alternatives, to follow each of them up to a distant time moment in the future, find out what alternatives provide survival and choose these alternatives excluding the rest. Evolution of living matter is thus determined not only by causes, but also by goals, first of all by the goals of survival and improvement of the quality of life.

In the present paper we shall introduce the mathematical formalism describing this principal feature of living matter (of its consciousness): the ability to correct its state making use of the information (about the efficient way of survival) obtained from the future. It will be assumed that the evolution of living matter includes the correction providing survival at distant time moments. This correction leaves in the sphere of life only those scenarios of evolution which are favorable for life. Unfavorable scenarios do not disappear from the (quantum) reality but are left outside the sphere of life (are absent in the picture appearing in consciousness).

This correction (selection of favorable scenarios) is represented by the special mathematical operation which is called postcorrection. It corrects the present state of the system in such a way that its future state satisfies a certain criterion.

After defining the operation of postcorrection, various criteria for postcorrection are considered as well as the corresponding aspects of the phenomenon of life. In particular, a simple mathematical model of a collective criterion of survival is proposed, and the important role played by collective criteria are briefly discussed. Stronger criteria providing not only survival but also certain levels of the quality of life are considered. It is argued that the postcorrection is possible also according to such criteria which are irrelevant to the life quality. Such phenomena as free will and direct sighting of truth may be explained by the action of postcorrection performed according to these criteria.

The paper is organized in the following way. A short sketch of EEC is given in Sect. 2. The operation of postcorrection is defined according to the criterion of survival for a single living being in Sect. 3 and for a group of living beings in Sect. 4. Classification of various criteria for postcorrection and the corresponding aspects of the phenomenon of life are discussed in Sect. 5. At last, Sect. 6 includes comments on the whole theory. In particular, deep analogy of the postcorrection (providing survival) with the anthropic principle is analyzed.

2. Extended Everett’s Concept (EEC)
The «many-worlds» interpretation of quantum mechanics proposed by Hew Everett in 1957 (Everett, 1957) assumes linearity of quantum mechanics as its starting point. The von Neumann’s reduction postulate is rejected in this interpretation, and therefore all components of the superposition which correspond to the alternative outputs of a measurement are presented in the measured system’s measuring device’s state after the measurement (the only change of the state is entanglement of the measured system with the measuring device). This suggests that the classical alternatives corresponding to various measurement outputs coexist, even though they are conventionally considered to be inconsistent.

Remark 1. The conclusion that various alternatives coexist is made in the Everett’s
concept in the course of analyzing the procedure of a quantum measurement. In EEC this conclusion was considered in a more general context. It is not important that the alternatives may appear as a result of a measurement. The only essential issue is that the state of our (quantum) world may have the form of a superposition, the components of which represent distinct classical pictures. According to Everett, all these «classical alternatives» are equally real (coexist). For making the status of these alternative pictures of the world more transparent, they are often called «Everett’s worlds» (DeWitt, 1973), the term «many-worlds interpretation» resulting from this. The same assumptions were accepted also in EEC, but in the connections with the phenomenon of consciousness as such.

Thus, coexistence of the classical alternatives is predicted by the Everett’s concept. However, real observers never encounter any evidence of this coexistence, always watching only a single alternative. In order to explain this real experience in the framework of the Everett’s concept, one has to assume that the classical alternatives are separated (disconnected) from each other in the observer’s consciousness. Thus, despite of all the alternatives being equally real, an observer, when watching in his (explicit) consciousness one of them, cannot watch at the same time the others. The alternatives coexist but are not co-observable.

The statement «the consciousness separates the alternatives» which is characteristic of the Everett’s interpretation has been replaced in the Extended Everett’s Concept (EEC) (Mensky, 2000; 2005a; 2005b; 2007) by the stronger one: «the phenomenon of (explicit) consciousness is nothing else than the separation of the alternatives». Such change of the theory simplifies its logical structure, since two unclear (may be even not definable) notions are identified with each other and therefore «explain each other». These are the notion of consciousness in psychology and the notion of «alternatives’ separation» in quantum physics.

Besides simplifying logical structure of the theory, this identification yields new very interesting conclusions. In quantum mechanics it becomes clear, in the light of this identification, why the alternatives are classical (because the classical world is «locally predictable» and therefore appropriate for habitation). In psychology it becomes clear why free will is possible and why sleep is absolutely necessary for support of life. Moreover, the strange things characteristic of consciousness, such as direct sighting (discovery) of truth and probabilistic miracles (realization, by the willpower, of events having very low probabilities) may be explained (Mensky, 2005a; 2005b; 2007).

All these conclusions result from the following argument. If the (explicit) consciousness is identified with the separation of the alternatives, then its disappearance (i.e. the transition to unconscious, for example in sleep, trance or meditation) suggests disappearance (or weakening) of this separation. The consciousness stops to watch the world’s state as separated into classical alternatives, but starts to perceive (in some sense or another) this state as a whole. The consciousness stops to watch continuous «developing» alternative scenarios (from the definite past to the ambiguous future), but views instead the reversible evolution of the quantum world i.e. actually four-dimensional image of the world in which all time moments are treated on equal footing.

In other words, when the explicit consciousness is disabled (in the regime of unconscious), the (implicit) consciousness witnesses, instead of the usual classical world, something quite different, including all classical scenarios in all time moments. Such an image of the world can serve as an enormous «data base» allowing comparing various alternative scenarios between each other. This data base may be used first of all for support of life. Indeed, usage of this data base makes possible selecting those scenarios which are favorable for life, i.e. provide survival. Addressing this data base may be performed periodically (for example, in sleep) or even permanently (since many processes in living organisms are regulated unconsciously, with no participation of the explicit consciousness).

In the next sections we shall suggest a mathematical formalism describing this function of consciousness: its ability to use the information obtained in the future for correcting the present state. To mathematically describe this function, operation of postcorrection will be introduced. This mathematical operation performs such a correction of the state of a «living system» which guarantees the required features of its future state. In the simplest case the requirement of survival is meant, but this may also be the requirement of a certain level of
quality of life or even the requirement of something that is desirable although not directly connected with the quality of life. In all cases this suggests selecting favorable (in some sense or another) scenarios.

3. Life as Postcorrection with the Criterion of Survival

Life is a phenomenon which is realized by living matter consisting of living organisms (living beings). Living matter differs from non-living matter in that its dynamics is determined not only by causes, but also by goals i.e. by the state this matter should have in the future. First of all the goal of survival (prolongation of life) is important in this context. However, more complicated goals are also requisite in case of sufficiently perfect forms of life. These can be formulated in terms of quality of life.

In the real conditions on Earth, important features of the phenomenon of life are connected with the balance between all organisms. However, the very definition of life and essential features of this phenomenon may be illustrated in case of a single living being. Let us first consider this simple situation (the case of a group of identical living beings will be considered in Sect. 4).

An organism consists of atoms interacting with each other; therefore it is in fact a physical system. According to the modern views this is a quantum system. Let us apply the term «living system» to refer this quantum system. Denote by \( \mathcal{H} \) a space of states of this system. The state of the environment will be considered to be fixed (in the simple model we are to discuss at the moment).\(^2\)

Let \( \{L, D\} \) (from the initial letters of the words 'life' and 'death') be a complete system of orthogonal projectors in the state space \( \mathcal{H} \), so that \( L + D = 1 \) and \( LD = 0 \). These projectors determine two orthogonal and complementary subspaces \( LH \) and \( DH \) in the whole space \( \mathcal{H} \). The subspace \( LH \) is interpreted as the space of the states in which the living being remains alive (its body is acting properly). The subspace \( DH \), vice versa, is interpreted as the space of the states in which processes of life are seriously violated, the living being is dead. The projector \( L \) plays the role of the criterion of survival.

If a quantum system is in the state \( |\psi(t_0)\rangle \) at a time moment \( t_0 \), then its state \( |\psi(t)\rangle = U(t,t_0) |\psi(t_0)\rangle \) at time \( t \) is determined by the action of the unitary evolution operator \( U(t,t_0) \). In case of static environment and invariable properties of the system, the evolution operator depends only on the increment of time: \( U(t,t_0) = U_{t-t_0} \). At the moment we shall assume for simplicity that this is valid, but the generalization onto the generic situation is straightforward (see Remark 3 below).

Description of evolution by a unitary operator is characteristic of non-living matter, whose dynamics is determined by causes (by the initial state and Hamiltonian). However, such a description of evolution is not enough for living matter. The dynamics of a living being is partially determined by goals, i.e. by characteristics of the future state of this living being.

In the simplest case the goal is survival. According to this goal the living being has to remain alive, i.e. the state of the living system should be in the subspace \( LH \) at a distant future moment of time. This is provided by correcting the initial condition in such a way that the evolution of this state presented by the usual unitary operator brings it into the subspace \( LH \) in the future. Such a correction may be called postcorrection. The operation of postcorrection is a correction of the present state of the living system, but it is performed according to the criterion which is applied to the future state of the system.

Let us consider the simplest example of postcorrection. For simplicity, we shall fix two time moments, «the present time» \( t = t_0 \) and «the future time» \( t = t_0 + T \).

Denote by \( U_T \) the evolution operator leading from the present time to the future time.

Let the living system's state at time \( t = t_0 \) be presented by the vector \( |\psi\rangle \in \mathcal{H} \). If only conventional (characteristic of non-living systems) dynamics act, then after time interval \( T \) the state vector should be \( U_T |\psi\rangle \). However, life as a special phenomenon is described only by those scenarios in which the conventional evolution provides survival (prolongation of life). For life prolonging during the time interval \( T \), it is sufficient to restrict the initial condition by the

\(^2\) This is a sufficiently good approximation if the change caused by the influence of the living being on its environment is not essential for its life.
requirement for it to be in the subspace
\[ U_T^{-1} L U_T \cdot \mathcal{H} \]. Indeed, any state from this
subspace will happen to belong, after the time
interval \( T \), to the subspace
\[ U_T \cdot U_T^{-1} L U_T \cdot \mathcal{H} = L U_T H = LH \], i.e. the
living system will remain alive.\(^3\)

Thus, the correction resulting in
selecting the favorable scenarios is described by
the projector \( L_T = U_T^{-1} L U_T \) which may be
called the \textit{postcorrection operator}. The living
system’s evolution, with the postcorrection
taken into account, may be described as a series
of short time intervals \( \tau \) of the usual (causal)
evolutions \( U_T \), each of them being preceded by
the postcorrection \( L_T \). This is described as the
action of the operator
\[ U_{\text{cor}}^{\text{ST}} = U_1 L_T \cdot \ldots \cdot U_{\tau} L_T \cdot U_{\tau} L_T \cdot \ldots \cdot U_1 L_T \cdot U_T \] (1)

which replaces, for the living system, the usual
evolution operator \( U^{\text{ST}} = U_1 \cdot \ldots \cdot U_{\tau} \cdot U_{\tau} \) that
had to be taken if the system were non-living.

\textbf{Remark 2.} A single period \( \tau \) of the
evolution according to the equation (1) is
represented by the operator
\[ U^{\text{cor}}_t = U_t L_T = U_T^{-1} L U_T \cdot \]

Applying operator \( L U_T \) to the whole state space \( \mathcal{H} \), we shall obtain \( L U_T H = LH \) i.e. the
subspace of states interpreted as being alive (see
footnote 2). Therefore, operator \( L U_T \) brings
any state into a state interpreted as being alive.
Operator \( U^{\text{cor}}_t \) also brings any state into an
“alive” state, \( U^{\text{cor}}_t H \subset LH \), provided that
\( U_T^{-1} LH \subset LH \). This is a requirement which
is necessary for the evolution law (1) being
correct. This requirement suggests that the usual
causal evolution (represented by a unitary
operator \( U_T^{-1} \), i.e. taking into account not only
favorable, but all scenarios) cannot return a
dead body into the state of being alive. It is of
course evident that living matter has this
property.

Selecting favorable scenarios does not
suggest violating the laws of nature as such. The
material world is described by all scenarios
obtained by the action of the unitary evolution
operators on the arbitrary initial state vectors.
This conventional presentation of the evolution
of matter is sufficient to describe how non-living
matter evolves. However, the phenomenon of
life is represented by only a part of the set of all
scenarios of evolution. «Unfavorable» (for life)
scenarios are left «outside the sphere of life».
The picture appearing in consciousness of any
observer may include only one of the favorable
scenarios.\(^4\) Subjectively this looks as if the living
being could find out what should be its state in a
distant time \( t_0 + T \) and correct the state at time
\( t_0 \) in such a way that it provides being alive at
time \( t_0 + T \).

It could be not quite clear what is meant
by the words «the unfavorable scenarios are left
outside the sphere of life». To clarify this, let us
reformulate this statement in the language
utilized in the preceding works on EEC (Mensky,
2000; 2005a; 2005b; 2007) (see also Sect. 2),
however with the help of the mathematics
introduced above.

In the preceding works the (explicit)
consciousness is identified with the separation
of the alternatives. In the transition to the
regime of unconscious («at the boundary of
(implicit) consciousness») the separation of the
alternatives disappears, and the possibility arises
for the (implicit) consciousness to compare all
alternatives between each other, select the
favorable and discard unfavorable ones. Let us
express this feature of consciousness in the
language of mathematical formulas.

Let the set of the (quasiclassical)
alternatives at the present time be defined as
the set of subspaces \( \{ H_i \} \). Denote by \( I \) the set
of favorable alternatives (i.e. those providing
survival in the time interval \( T \)), and \( \tilde{I} \) the set
of unfavorable alternatives. This suggests that
\( L_{T_i} H_i = U_T H_i \) for \( i \in I \) and \( L_{T_i} H_i = 0 \)
for \( i \in \tilde{I} \). But this precisely means that the
operator of postcorrection \( L_T = U_T^{-1} L U_T \)
conserves any «favorable alternative subspace»
and annihilates any unfavorable one,
\( L_T H_i = H_i \) for \( i \in I \) and \( L_T H_i = 0 \) for
\( i \in \tilde{I} \).

\(3\) We took into account that the whole state space \( \mathcal{H} \) is
invariant under the unitary evolution, \( U_T \mathcal{H} = \mathcal{H} \).

\(4\) This expresses the very principle of life, without details like
accidents and other casual obstacles for life. In Sect. 4 we shall
consider «programmed death» of individuals necessary for life
of a group (collective).
Therefore, «to stay in the sphere of life» means «to leave only favorable alternatives in the picture appearing in consciousness». The unfavorable alternatives (subspaces) do not disappear. They exist in the complete description of the (quantum) world (other would be the violation of the laws of nature), but they disappear from the sphere embraced by consciousness of living beings.

From this point of view the statement that the phenomenon of life is described by postcorrection performed according to the criterion of survival is in fact not a postulate but only a mathematical form of the definition of life. Any reasonable definition should differ from this only in details, but not in principle. Indeed, the essence of the phenomenon of life reduces to a strategy of survival, and the efficient survival is provided only by estimating the future state of a living system (from the point of view of its survival) and by the corresponding correction of the system’s present state.

Some remarks should be made about the evolution law (1).

**Remark 3.** In the above specified formulas we assumed that the operator of causal evolution depends only on the time interval, but does not depend of the initial time moment: \( U(t, t') = U_{t'} \). If the environment of the living being is varying with time, this assumption is invalid and one has to make use of the evolution operator \( U(t, t') \) depending on two arguments. The formula (1) should then be appropriately modified.

**Remark 4.** We assumed that evolution of the environment is specified independently of the state of the living system. This may be justified in many cases. However, this assumption has to be abandoned if the criteria for postcorrection include parameters of the environment as well as parameters of the living system itself (such situation will be considered in Sect. 5). Then \( \mathcal{H} \) has to be defined as the space of states of the compound system including the living system and its environment. The operator \( U(t, t') \) is then the evolution operator in this more wide space.

**Remark 5.** The evolution represented by the operator (1) consists of the series of operations, each of them including causal evolution preceded by postcorrection. The evolution law (1) is characterized by two time parameters: the period of correction \( \tau \) and the depth of postcorrection \( T \). It is possible that some processes in living organisms are adequately presented by such a type of evolution (for example, higher animals and humans periodically experience the state of sleep in which the state of the organism is corrected). However, continuous regime is typical for other correcting processes. In these cases an evolution law with continuous postcorrection should be applied. The simplest variant of it can be obtained as a limit of the discrete process.

**Remark 6.** We considered a transparent mathematical model of life in which the postcorrection is represented by a projector. This may be (and in fact should be) generalized. For example, criteria for postcorrection may be presented by positive operators (not projectors). This is evidently necessary for the postcorrection criteria connected not with survival, but with less critical parameters of the quality of life. Such criteria and corresponding aspects of the phenomenon of life will be considered in Sect. 5.

**Remark 7.** Up to now we considered only the simplest scheme for support of life of a single living being. This scheme requires only a single criterion of life called survival and mathematically presented by the projector \( L \). This may be enough for primitive forms of life in case of unlimited resources (first of all food). However, for realistic description of more sophisticated forms of life one has to consider more complicated criteria. Particularly, the role played by the living beings in respect to each other should be taken into account. In Sect. 4 a sort of collective criterion of survival expressed through a number of individual criteria will be considered.

**Remark 8.** A «future state» of a system has been used by Y. Aharonov, P.G. Bergmann and J.L. Lebowitz in the paper published in 1964 (Aharonov, 1964) and by Y. Aharonov with other coauthors in the subsequent works (see, for example, Aharonov, 1991, 2005) in the framework of the formalism of postselection, or the two-vector formalism. In this formalism the states of a system at both initial time and some later moment of time («final time») are fixed. In (Aharonov, 1964) the formula for the probabilities of various outputs of the measurement performed at an intermediate time (between the initial and final times), given the initial and final states, was derived. The above defined operation of postcorrection differs from the two-vector formalism (postselection) both formally and essentially.
The formal difference is that in the postcorrection 1) not a single state but a subspace (of an arbitrary dimension) is fixed in the future (at the «final time»), and 2) the initial state is not fixed, but undergoes correction. The essential difference is in the physical interpretation (sphere of application) suggested for the corresponding mathematics. The two-vector formalism was applied for analyzing events predicted by conventional quantum mechanics for usual material systems. In the paper (Aharonov, 2005) the two-vector formalism was exploited to formulate a novel interpretation of quantum mechanics, in which the various outputs of a measurement (of a usual material system) were associated with various future state vectors. In contrast with this, postcorrection describes (in the framework of EEC) not the usual material system, but a «living system», or, more precisely, the picture of the evolution of living matter (the set of favorable scenarios) appearing in consciousness.

4. Collective Criterion of Survival

It was shown in Sect. 3 how evolution of a living being providing its survival may be described mathematically in terms of the operation of postcorrection. The simplest form of this operation considered in Sect. 3 was determined by a single criterion of survival. This criterion was expressed by a projector \( L \) onto the subspace of states in which the living system remains alive. This model is sufficient for simple forms of life and unlimited resources (first of all unlimited amount of food).

Let us consider now the model of life applicable in case of restricted resources. The cardinal difference of this situation is in that only a certain number of living beings can survive. It is clear that in this case the relations between various living beings become important and should be taken into account.

One possible strategy for survival of living beings in these hard conditions is competition (fight) of them with each other. However, the collective strategy of survival is also possible in this case. Let us consider the simplest mathematical model of such a collective strategy.

Let us introduce necessary notations. Consider a group consisting of \( N \) similar living beings (living systems), enumerated by the index \( i \in \Omega \), where \( \Omega = \{1, 2, \ldots, N\} \). The living system having the number \( i \) is described by the state space \( H_i \), and projector \( L_i \) in this space as a criterion of survival of the given living being. The corresponding orthogonal projector is \( D_i \).

The sum \( L + D_i \) is a unit operator in the space \( H_j \). The operators \( L_i \) and \( L_i \) commute with each other even for \( i \neq i' \) because they act in different spaces \( H_i \) and \( H_j \). For an arbitrary subset \( I \subset \Omega \) of the set \( \Omega \) denote by \(|I|\) the number of elements in \( I \) and by \( \bar{I} = \Omega - I \) the complementary subset in \( \Omega \) (the set of the elements belonging to \( \Omega \) which are not elements of \( I \)).

In the condition of unlimited resources all living systems forming the group can exist (survive) independently of each other. Then each of them may be described by the simple model considered in Sect. 3 so that all of them can survive forever. Assume however that the resources (for example food) that can be found in the environment are restricted and their amount is sufficient for survival of only \( n \) living systems of this type. In this situation life may be regulated in such a way that the interests of the whole group are taken into account. Then a sort of a «super-organism» exists. This means that the group consisting of \( N \) living beings behaves as a single living system. What has to be taken as a criterion of survival of the whole group in this case?

The simplest form of the collective criterion of survival is following:

\[
L_{(n)} = \sum_{I \in \Omega} L_i D_i
\]  

(2)

where it is denoted

\[
L_i = \prod_{i \in I} L_i \quad \text{and} \quad D_i = \prod_{i \in \bar{I}} D_i.
\]

It is not difficult to show that this operator is a projector and the projectors \( L_{(n)} \) and \( L_{(n')} \) are orthogonal for \( n \neq n' \). The set of projectors \( \{L_{(n)} \mid n = 0, 1, 2, \ldots, N\} \) forms a complete system of orthogonal projectors.

\[5\] In case of a primitive living being, the expression «the image appearing in the consciousness» stands for the information which is exploited by this living being to manage its behavior.

\[6\] in the framework of the considered simple model
The postcorrection described by the collective operator of survival \( L_{(n)} \) guarantees that in the time interval \( T \), precisely \( n \) living systems will be alive, the rest will be dead. This means that the resources will be sufficient for those which are alive. The death of some members of the group is in this case a condition for survival of the rest.

It is seen from the structure of the operator \( L_{(n)} \) that it projects the space \( H = \prod_{i \in \Omega} H_i \) of the states of the whole group of living beings onto the subspace \( L_{(n)}H \) of the states in which \( n \) members of the group are alive and \( N - n \) dead. Each state in the subspace \( L_{(n)}H \) is a superposition of the states differing by the concrete choice of those members of the group that remain alive. Therefore, none of the group is discriminated in such a state; each of them has the same status, being alive in some terms of the superposition and dead in the others.

In this model operator \( L_{(n)} \) represents correction of the state of the whole group of \( N \) living systems. It is interesting that this correction describes not competition, or fighting, of the members of the group with each other, but rather collective regulation of their states. Such a regulation provides survival of the group with the maximal possible number of members. The state of each living system in the group is corrected at the present time moment, and thus corrected states, simply because of the natural evolution (described by the unitary operator \( U_T \)), results in the death of certain number of the members of the group. The number of those who have to die is sufficient for surviving the rest in the condition of the available resources.

Such a correction of the state may be called collective programming of death for some members of the group for the sake of life of the rest. The collective program of death does not determine which members of the group have to die (the choice varies for various alternatives). Therefore, this is actually the collective strategy of survival discriminating none.

It is well known that for almost all species of living being death is programmed. There exists a program leading to death of an organism when it achieves a certain age. This is an example of collective strategy of survival for the given species. In this case the reason for programming death is not the deficit of resources, but the task of the progress of the species as a whole.

Evidently, survival of animals is regulated by collective criteria, which are common for the whole species. This explains particularly why intraspecific competition is as a rule absent. In this respect humans radically differ. It seems that they have collective criteria for the collectives (groups) of various levels: for a nation, for a social group, for a family and so on, up to the individual criteria. This makes possible conflicts between different groups of people. In the limit this may result in fighting anyone against anyone.

In our time the exponential development of science makes high technology available for small collectives. In these conditions individual criteria of survival and even lower levels of the collective criteria of survival (i.e. individualistic consciousness) increase violence so much that the very existence of Mankind is in danger. This leads to a global crisis which may be prevented only by the transition to the universal (common for all people and even for all living beings) collective criterion of survival (i.e. to collective consciousness).

It was suggested long time ago (Teilhard de Chardin, 1959; Satprem, 1970; Grof, 1997) that transition to a sort of collective consciousness is necessary for preventing global crisis. However, it remains unclear up to now how transition of most people to the collective consciousness may be achieved in practice (the catastrophe may be prevented only if consciousness of most people is made collective). The theory of consciousness following from EEC offers grounds for optimism. According to EEC, the change of consciousness will happen automatically, the crisis will be stopped, and the catastrophe prevented.\(^7\)

5. Various Criteria for Postcorrection

In the preceding sections we considered postcorrection with the criterion of survival, the most important criterion for living beings. In fact this criterion defines life as such. The simplest

\(^7\) The transition of almost all people to the universal criterion of survival (collective consciousness) will necessarily happen in one of the alternatives (Everett’s worlds) at the moment of the highest level of the global crisis. The catastrophe will be therefore prevented in this alternative. The people who have changed properly their consciousness beforehand will witness just this alternative with high probability. Those who have not managed to change their consciousness will most probably watch the end of world.
Mensky MB., Mathematical model of life extended Everett’s concept

The set of several criteria of life characterize quality of life in more detail. Several operations of postcorrection, corresponding to various criteria, are performed in this case simultaneously and provide certain level of quality of life. It seems plausible that in case of human beings such criteria for postcorrection may exist which are connected not only with the parameters of the human organisms (bodies), but also with the parameters of their environment.

Analyzing various criteria for postcorrection is an interesting problem that may be approached from various viewpoints. Not pretending to be general and precise in details, we can suggest a rough classification of possible criteria of life as follows.

Criteria of survival
- Criterion of survival for a single creature
- Criterion of survival for a group of creatures
- Criterion of survival for the living matter as a whole

Parameters of the state of the body
- Evidence of being alive or dead (the criterion of survival)
- Criteria of various levels of the quality of life
- Parameters which are irrelevant to the life quality

Parameters of the environment (conditions for life)
- Parameters which are essential for survival
- Parameters which are essential for certain quality of life
- Parameters which are irrelevant to the life quality

Let us make some remarks concerning this (of course, oversimplified and approximate) scheme of classification.

It is clear that sophisticated structure of living systems allows them to control not only the very survival, but also a certain level of quality of life. In our mathematical model this may be described by the same scheme of postcorrection as in Sect. 3 but with projecting on a narrower space of states in which not only life carries on, but the quality of life remains sufficiently high. This suggests that in an arbitrary state from the given subspace the parameters of the state of the body are in the limits characterizing the given quality of life.

The question naturally arises why we included parameters which are irrelevant to the life quality (insignificant for the quality of life) in the list of the possible criteria for postcorrection. There is no doubt that control on such parameters is unnecessary to provide the principal internal needs of life. However, anyone knows from his own experience that at least human beings (but most probably also animals) are in command of certain parameters of their bodies which are irrelevant to the quality of life. This reveals itself in the phenomenon of free will.

Indeed, a person can, according to his will, choose one or another variant of behavior with no essential influence on the fact of survival, or even on the quality of life. For example, he may in certain limits vary the schedule of his meals, amount of food he eats and its choice (the menu). The more so, one may decide quite arbitrarily whether he wishes to open or close the window, to read a book or watch TV and so on.

In the framework of our model free will is an arbitrary choice of some parameters of the body which are irrelevant to the quality of life. Execution of the free will is postcorrection for a short time interval, performed according to the chosen parameters. The postcorrection provides then that the chosen parameters will be in the given limits in a short time.

Considering various parameters for postcorrection from somewhat different point of view, one may suggest the following (of course, also tentative) classification (see Fig. 1).

Figure 1. Various criteria for postcorrection: the state of the world $S$ is determined by the state of the body $b$ and the state of its environment $e$. The regions $L$ and $D$ correspond to survival and death. The lines going in horizontal direction separate from each other those areas which correspond to different levels of the quality of life. Any subregion on the plane
Denote by $s$ (after the word «state») the set of various parameters of life (characterizing both the body and the environment). The parameter $s$ is in fact a pair $s = (e, b)$, where $e$ (after the word «environment») stands for the conditions of life, or the state of the environment, and corresponds to the horizontal axis, while the parameter $b$ (after the word «body») refers to the state of the body of the living being (the bodies of a group of the living beings) and corresponds to the vertical axis. The parameter $s$ lies in some two-dimensional area, in which the very notion of life makes sense.$^8$ This area is divided in two parts. The parameters in the upper part of the area correspond to survival (projector $L$), while the lower part corresponds to death (projector $D$). The region of survival is partitioned into the subregions corresponding to various levels of the quality of life.

Each subregion in the upper part of the area drawn in Fig. 1 determines some criterion according to which the postcorrection may in principle be performed. Of course, in general case the criterion for postcorrection is defined as an operator in the space of states of the whole system, including both living system and its environment. The parameter $s$ lies in some two-dimensional area, in which the very notion of life makes sense.$^8$ This area is divided in two parts. The parameters in the upper part of the area correspond to survival (projector $L$), while the lower part corresponds to death (projector $D$). The region of survival is partitioned into the subregions corresponding to various levels of the quality of life.

The operations of postcorrection with various criteria describe various aspects of the phenomenon of life. This may be illustrated by the following scheme of identification.

- **Life** (the principle of life, without details) $= postcorrection$ with the criterion of survival for the living matter as a whole.
- **Survival** $= postcorrection$ with the criterion of survival relating to the body (bodies).
- **Health** $= postcorrection$ with the criterion of quality of life relating to the body.

- **Free will** $= postcorrection$ with the criterion, relating to the own body, but as a rule irrelevant to survival.$^9$
- **Control on the appearing reality (probabilistic miracle)** $= postcorrection$ with the criterion relating to an object outside the own body.

The last point concerns an unusual phenomenon, called **probabilistic miracle**. By this term we mean that a person, by the power of consciousness, makes happen such an event in the environment which has low, though nonzero, probability (we suggest that some persons can do such things). The ability to perform probabilistic miracles does not seem to be necessary, in the usual meaning of the word, for life. However, first, this phenomenon naturally enters the general scheme so that its exclusion could look artificial, and, secondly, the human experience seems to point out that the events of this type really take place.

There is one more class of unusual phenomena in the sphere of consciousness (and therefore in the sphere of life) that can be explained by postcorrection:

- **Insight** $= postcorrection$ with the criterion of truth.

This class includes foresights, insights (among them scientific insights), **direct sighting of truth** (i.e. conclusions not supported by logic or facts). The phenomena of this type can be explained in the following way.

Let a person formulate some question or pose some problem (a scientific problem is a good example). Then, in order to experience insight, he should go over to the regime of unconscious (not necessarily completely disabling his explicit consciousness but at least disconnecting it from the given problem). In this regime, sooner or later, the true solution of the problem comes out without any further effort, as an insight.$^{10}$

In fact, the true solution of the problem is selected, with the help of the postcorrection, among all thinkable «attempted solutions», most of them wrong.

The selection is performed in this case with the help of **postcorrection with the criterion of truth**. Even if the problem cannot be solved at

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$^8$ In reality each of the parameters $e$ and $b$ is multidimensional, thus we talk of the «two-dimensional» area only for the sake of an obvious image.

$^9$ The exclusions such as suicide require more detailed model accounting for the influence of the living system onto its environment.

$^{10}$ This does not mean that hard problems can be solved without any work. In order for the process to be efficient, the problem should be formulated and preliminarily worked out in much detail that requires hard work on the first stage.
the present time by conventional methods (on the basis of the known facts and logical conclusions), it may have evident solution in the future. For example, some future events may point to the correct solution. In case of a scientific problem, new experiments may be realized in future which will unambiguously point to the right solution, singling it out from all seemingly possible «attempted solutions» of the problem. Therefore, a criterion of the true solution to the given problem may exist in the future, even though it is absent in the present.

In all these cases the operation of postcorrection does correct the present state making it to be in accord with the criterion existing in the future. This yields immediate choice of the correct solution of the problem, although its correctness can be confirmed by regular methods only in the future. This is an example demonstrating that consciousness, when being in the regime of unconscious, obtains the ability to look into the future, and to make use of the obtained information in the present.

The idea may be clarified if it is reformulated in terms of the states of brain. From all states of the brain corresponding to various «attempted solutions» of the problem (wrong ideas of the solution among them) the postcorrection selects the state which corresponds to that solution which has to be confirmed in the future. This change of the state of the brain means that insight, or direct sighting of truth, occurred. Indeed, if one is confident in the foreseen solution, the same state of his brain (corresponding to this solution) will remain unchanged till the future when the criterion of truth will appear, be applied to the problem and confirm the solution.

It is important in this argument that the person undergoing insight believes in its result. But it is known from the experience that the confidence in the information obtained in the course of insight is characteristic just for those cases when the insights are later confirmed. Many examples of this are given by great scientists making their discoveries with the help of insights. Great scientists, Albert Einstein among them, confirm the fact that they always feel absolute confidence in the solution found in the insight, and the solution found in this way always turns out to be correct in the course of its verification by conventional methods. One may draw a practical conclusion from this, that the feeling of absolute confidence may serve as an evidence of the faithful guess (of course, this evidence may be securely exploited only by calm experienced scientists rather than young people inclined to excitement).

An interesting remark may be made about the criterion of truth used in the process thus described. This criterion may sometimes coincide with the «formal proof» which is found by the scientist after he had experienced instantaneous insight. It is clear that the formal proof may serve as a criterion of truth for a solution of the given problem. This criterion does not exists (not yet found) at the moment of the insight, but it arises later on, when the solution that has been guessed in the insight is later deduced by conventional methods. The whole process looks like lifting oneself by hairs. Does it really offer any advantage for solving problems? Let us show it does.

Solving any problem is easier if it is known that the solution exists (may be it is known that this problem has already been solved by someone else) and much easier if the final result (not its proof) is available. Just this situation, of the final solution known beforehand, is realized in the process of the scientific insight followed by the formal derivation of the foreseen solution. Indeed, the scientist anticipates the right solution in the course of insight, he is completely confident in this solution, and because of this it becomes much easier for him to formally derive the foreseen solution by conventional methods. It is curious that in this case the scientist foresees the certainly right answer which himself will find in some time.12

The operator of postcorrection selecting the right solution of the problem (among «the attempted solutions») may be presented in the form \( P_T = U_T^{-1}PU_T \), where \( P \) is a criterion of the correct solution. The operation of postcorrection presented by the operator \( P_T \) is efficient if the criterion \( P \) is not realizable at present, but can be realized in the time interval \( T \).

This leads us to the question about the role of brain. Many attempts to explain how functioning of brain can produce the

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11 By the way, this is not at all strange because the solution found in this way is not a product of the imagination but the genuine true observed by the mechanism of direct sighting.

12 This ability is very exciting in case of great scientists, but it is often exploited by many experienced scientists as well as people of other professions and simple people in each-day life.
phenomenon of consciousness gave in fact no result. In each of these attempts either a logical circle is included (what should be proved is implicitly assumed) or not consciousness as such is dealt with in the argument, but various operations performed in the consciousness (for example, calculations or logical conclusions).

From the point of view of EEC consciousness is not a product of brain, but a separate, independent phenomenon, closely connected with the very concept of life. What about brain, it is an instrument of consciousness rather than its origin.

The brain is used by the consciousness to control the body and obtain information about its state (and, through its perception, about the state of the environment). In other words, the brain (or rather some regions in it) is the part of the body which realizes its contact with the consciousness; it is an interface between the consciousness and the body as a whole. In particular, the brain forms the queries that should be answered. Sometimes these queries are answered by the brain itself with the help of the processes of the type of calculations and logical operations. Sometimes queries cannot be solved directly in the brain and are solved by the consciousness with the help of «direct sighting of truth» (by postcorrection).

Remark 9. A. Lossev and I. Novikov noted (Lossev, 1992) that time machines (space-times including closed time like curves), in case if they exist, may be used for solving mathematical problems with the help of the methods or technical devices which are not known at present but can be realized in future. For this aim, the problem is solved at the time when the necessary methods are created and then its solution is sent into the past with the help of the time machine. The above formulated mechanism for solving problems (of arbitrary types) with the help of postcorrection is quite analogous. The only difference is that in this process a virtual «time machine» acts which «exists» only in human consciousness.

6. Conclusion

Extended Everett's Concept (EEC) originated as an attempt to improve the interpretation of quantum mechanics proposed by Everett. Yet, it is not simply a novel interpretation, but a theory going beyond the scope of quantum mechanics. Starting from the role played by an observer’s consciousness in the conceptual problems of quantum mechanics, EEC finally suggests what consciousness is and, more generally, what are specific features of living matter.

Considering consciousness on the basis of EEC, one is led to the conclusion that the conventional (causal) laws of nature are insufficient for describing phenomenon of life. The laws of nature elaborated in physics (including quantum physics), chemistry and other natural sciences correctly describe the behavior of non-living matter. The behavior of «living matter» cannot be explained only by the action of usual laws of nature (say, quantum mechanics). Nevertheless, quantum mechanics may help in discovery of the laws governing living matter. Comprehensive analysis of quantum mechanics indicates at the principal points in which the laws acting in the sphere of life must differ from the conventional physical laws. The laws governing living matter may then be formulated at least in their most general aspects. Just this is made in EEC.

The novel features that have to be introduced in order to describe the phenomenon of life, can be formulated in various ways. Restricting himself by the most general formulation, one may say that not only causes but also goals play role in behavior of living matter. The main goal, always existing in connection with living beings, is survival, or persistence of life (this may be survival of a single living being, or of some group, for example of a herd or specie of animals, or, at last, of the living matter as a whole). Therefore, the goal of survival has to be accounted in the evolution law for living matter.

In the preceding works of the author on EEC (Mensky, 2000; 2005a; 2005b; 2007) the laws governing life were formulated on the basis of the concept of consciousness and its identification with the separation of alternative classical realities (the concept characteristic of the Everett’s interpretation). In this context the term «consciousness» embraces not only the explicit (plain) consciousness, but also regime of unconscious (unaware) in the sphere of life. Moreover, just in the regime of unconscious (or at the border between the explicit consciousness and unconscious) the feature of consciousness which is the very essence of the phenomenon of life is revealed: the ability to obtain information from all alternative realities and select those alternatives which are most favorable for life.

In the present paper we have shown that the (accepted in EEC) evolution law of a «living system» may be represented
mathematically if one introduce, besides the usual (unitary) evolution operator, an additional operation called postcorrection. This operation corrects the state of a «living system» to provide necessary features of this state in future: survival of the living system or even certain quality of its life (for example the health). Introducing postcorrection in the evolution law of the living system allows one to classify various forms of life and various aspects of the phenomenon of life, depending on what characteristics of life are provided by the postcorrection. We shortly discussed only the key points of classification of various criteria for postcorrection. The detailed elaboration of this issue is a question of future development of the theory.

The operation of postcorrection not only supplies a mathematical formulation of the principal feature of EEC, but also simplifies the logical structure of this theory. In fact, it is sufficient to postulate that the boundaries of the sphere of life are governed by postcorrection. After this, the concretization of the theory requires only the choice of the criteria, according to which the postcorrection is performed.

Interpretation of the operation of postcorrection, as describing evolution of living matter, became possible because we did not restrict ourselves by the framework of physics. Starting from the arguments originated in physics (conceptual problems of quantum mechanics) and following the ideas of EEC, we were forced to go beyond the limits of physics as such and to consider at least the principal points of theory of living matter. Then, instead of the commonly accepted suggestion that each event is completely determined by its causes, we had to agree that all important events and processes in the sphere of life are determined not only by causes but also by goals, first of all by the goal of survival. The operation of postcorrection is a mathematical formalization of this feature playing the central role in evolution of living matter.

Let us remark that theory of consciousness and life following from EEC essentially differs from the usual mechanistic approach where the phenomenon of consciousness is considered as a function of brain. From the viewpoint of theory of «quantum consciousness» resulting from EEC, brain is rather an instrument exploited by the consciousness (as a specific feature of a «living system») to control the body and obtain information about the environment with the help of the organs of perception of the body.

This, by the way, allows one to look in another way at the problem of artificial intellect. The conclusion following from EEC is that it is possible to create an automat possessing intellectual abilities (there are great achievements in this respect nowadays), but it is impossible to create a machine having consciousness as something that can to perform postcorrection, i.e. such that can be called «artificial living being». This conclusion is in accord with the argument of Roger Penrose who suggested (Penrose, 1989), with reference to Gödel's incompleteness theorem, that a non-computable aspects may exist in the phenomenon of consciousness (see also Song, 2007a, 2007b).

The postulate of postcorrection broadens quantum mechanics, including in the consideration the law of evolution of living matter. The resulting theory is in a way symmetrical in time direction. Non-living matter evolves in the causal way (the past determines the future), but in the sphere of life only those initial conditions are left which provide survival (the future determines the past). This «influence of the future on the past» is realized as the selection of favorable scenarios and mathematically described by postcorrection.

Let us make finally one more remark demonstrating how natural for living systems is the evolution law (1) including postcorrection. This law is, in its spirit, very similar to what is called anthropic principle. The anthropic principle explains «fine tuning» of the parameters of our world by the fact that in case of any other set of the parameters organic life would not be feasible and therefore no humans could exist to observe this world. The principle of life, formulated as the ability of the living system to postcorrect its state to provide its survival, suggests in fact something quite similar, even in a softer variant.

In order to explain this, we have to underline once more that the postcorrection describes selecting those scenarios which remain in the sphere of life. The rest scenarios do not disappear. They are real as well (included in the complete description of the quantum world), but they are excluded from the sphere of life, therefore are unobservable. This means that no observer can watch these «unfavorable for life» scenarios. The «sphere of life» is such an image of our world which can be observed. If just this
image (i.e. not «the whole world» but only «the sphere of life») is taken as a starting point for constructing evolution law, then the result of the construction will necessarily be the evolution including postcorrection.

Thus, postcorrection in the evolution of living matter (of the sphere of life) does not need even to be postulated. Instead, it may be derived from the (generalized) anthropic principle. Non-living matter satisfies the conventional quantum-mechanical causal evolution law. Evolution of the living matter (of the sphere of life) simply by definition should include postcorrection.

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