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Objective patterns in the evolving network of non-equivalent observers

Abir U. Igamberdiev *

Department of Biology, Memorial University of Newfoundland, Main Campus, St. John's, NL A1B 3X9, Canada

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Abstract

The world's objective pattern is formed through consistent histories of quantum measurements originating as different branches of the same wave function. When we come close to the limits of measurement (either by approaching the speed of light or the values of the Planck's quantum), the relational effects come into place and the objectivity of world's pattern melts down. But when we are positioned far from these limits, we live in a comfortable area of the world common to all beings and approximating the objective environment (classical spacetime). Living systems are based on reflective cycles that can interact with relative predictability. Being quantum mechanical observers having different clocks, they generate perpetually evolving fitness landscape. I discuss how the perception of the objective is formed by the generation of same limits of iteration for the processes performed by non-equivalent observers and how the uniform time appears from its counting through these objective processes.

Keywords: Consistent histories; Decoherence; Evolution; Quantum measurement; Selection rule; Semiotics

1. Quantum Measurement Theory and Theoretical Biology

Theoretical framework of biology appears to be equivalent to that of the quantum measurement. This non-trivial idea arises to Pattee (1971), Rosen (1977) and Matsuno (1985) and it was also introduced in my previous papers (Igamberdiev, 1985, 1993, 2001, 2004). In brief, it means that the "actualization" process, from the enzymatic catalysis to complex developmental phenomena is essentially equivalent to the pattern of quantum measurements. The latter represents a selection from the potential field, and its principles are basically the same in quantum mechanics and biology. Functioning of biosystems can be viewed as a realization of mapping from a potential space to the area of real values analogously to the quantum decoherence. The physical world in this vision appears as a robust part of a more complete biological world which includes also its observers. The unified field theory in frames of physics is unreachable in the same manner as the Hilbert's program in mathematics. The anthropic principle is the main example where physics realizes that it cannot substantiate itself within its own framework. The unity of the world can be restored only if we consider the structure including in itself the physical world, the theoretical construct describing it, and the observer applying this theoretical construct to the physical world. This corresponds to the semiotic triad of Peirce consisting of the object, the sign, and the interpretant.

In both theoretical biology and the quantum measurement theory, the central postulate appears to come as a *set selection rule*. It is usually assumed that in biology, Darwin was the first who introduced the principle of selection. However, what he introduced is a selection of the actual forms. The selection of potential states and routes of development was introduced much earlier and arises to Aristotle. In the first extensively developed theory of evolution (Lamarckism), the selection principle appears as an internal mechanism of actualization of possible perfect forms (gradation). The inheritance of acquired characters, according to Lamarck, takes place only within the same gradation, while the complication of structures involves a creative selection (orthogenesis).

In physics, starting from the Copenhagen interpretation of quantum mechanics, the measurement process involves a postulate of the reduction of wave function that is external to the original physical theory. An alternative, many-worlds interpretation of Everett avoids this extra-physical postulate but evolves into a picture of infinite events interfering without outcome. The modern concept of consistent histories (Zurek, 2003) takes from both approaches by introducing a relational soft decoherence

* Tel.: +1 709 737 4567; fax: +1 709 737 3018.
E-mail address: igamberdiev@mun.ca.

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instead of abrupt quantum reduction. The world is branched but it includes decoherent phenomena that appear as real actualizations of possibilities in the multi-branched universe. The border between the potential and the actual may be relative (Gunji, 1994) but it cannot be removed completely without destroying any heuristic value of the theory. Aristotle first developed the concept of potentiality to explain the physical Universe, and his metaphysics was a way to apply the Platonic approach to real embodied world. We also need at this step to develop the concept linking the potential to the actual to understand the difference between the physical and the mathematical world in their unity. This link will include observation with imposed limits of its computability (Igamberdiev, 2007).

2. The Principle of Selection

Although the many-worlds interpretation and to a certain extent the consistent histories approach avoid classical reduction of the Copenhagen-type which is external to the formalism of quantum mechanics, they cannot avoid completely the selection procedure that is still external to the quantum reality. In the Copenhagen interpretation, the selection is spontaneous and unpredictable. In the many-worlds approach, consciousness in agreement with the strong anthropic principle would select the world in which we live separating it as its own history (Mensky, 1997, 2004). In the consistent histories approach, a selection of decoherent histories may not be mediated by consciousness but it is related to consistency principles and processing of quantum information via the systems called IGUS (information gathering and processing systems), a sort of quantum mechanical Maxwell's demons (Andrade, 2000, 2004). These systems realize simple selection rules and evolve to very complex structures in conscious organisms through a long evolutionary process. They form the omnium of non-equivalent observers perpetually generating successful and failed observables.

Quantum decoherence implies that only special choices of histories have significative values so that fundamental objects are consistent sets of histories. Our experience is described by certain decohering variables forming a consistent quasi-classical picture. First assumed pure indeterministic selection is, in reality, driven by a condition of consistency: this condition represents its final cause in the Aristotelian sense. We can use the term Quantum Darwinism (Blume-Kohout and Zurek, 2006) for the selection of quantum states only in the case of complete indeterminism of outputs in a primary ideal chaotic situation. The solution survived in evolutionary process should be stable and consistent. This aspect includes nomogenetic evolutionary principles originally developed by Berg (1969[1922]) and may be derived from Lamarck's principle of orthogenesis. This kind of selection takes place in the potential field so that the Darwinian selection of actual forms is a small subset of total possible selections.

If we consider the quantum measurement in the Copenhagen interpretation, its similarity to biological processes is not evident: the measurement is attributed to the conscious observation. But even in frames of this interpretation, it appears as a measurement not of the external environment but of the system included in this environment. It generates the statement about the system (internal self-signification) non-deductible from its original state. If the mathematical statements (Gödel sentences) exist that cannot be proven there should be physical processes that cannot be predicted in a simple deterministic way. We come to the immanent creativity principle of signification associated with the quantum measurement becoming the basis for creativity in the biological evolution (Igamberdiev, 2002, 2007).

Furthermore, developments of the theory of decoherence (Blume-Kohout and Zurek, 2006) resulted in incorporation of the principles common to general biological concepts such as selection of branches according to the realization of the fittest decoherent histories that satisfy the principle of consistency. The information stored in branching states has a redundancy and is recorded in many fragments (Blume-Kohout and Zurek, 2006). It is propagated through the environment at the expense of incompatible information. Structured correlations between different branches develop in a way that the history evolves into states that are uniformly distributed. Thus the objectivity arises through the dynamics of decoherence. In order for a universe to come into being, the world must act to divide itself into one part that is observed and another part that observes. To observe is to choose one branching history from many. At lower levels of organization this selection is more casual while at the level of consciousness it becomes a determined choice.

3. Maxwell's Demon as a Selection Agent

The selection process needs a selection agent. A casual selection in the Copenhagen interpretation becomes consistent via the action of IGUS (information gathering and using system), a quantum mechanical edition of Maxwell's demon, in frames of the consistent histories approach (Andrade, 2004). By its internal selection rules, this agent chooses the world in which lives via separating the past, present and future (Hartle, 2005). Referring to St. Augustine, these three are properties of internal experience, not of the physical spacetime. The present has its self-reflective appearance in the sense of IGUS operation. Borges in *A History of Eternity* puts the question why if time is subjective it is the same for all. Objective world means the same branching history, a kind of a 'common account' following Heraclitus (fragment 2). For the internal measurement, decoherence output to be objective should be consistent with other events of the same local history. The most universal patterns of consistency are related to basic fundamental ratios, such as the golden ratio, and correspond to the emergence of the world exhibiting the anthropic principle (Igamberdiev, 2004). The anthropic principle follows from elementary IGUS systems: they can work consistently only if they satisfy certain sets of the values of fundamental constants. These sets can be selected initially in singularities and big bang phenomena (Gambini et al., 2007).

The counting process (and thus information) first appears in the closed loops of causation operated by the quantum mechanical Maxwell's demons (Lloyd, 1997). The demon that operates in a cyclic fashion erases bits after exploiting them (Scully et al., 2005). It pumps heat from hot modes to cold modes and thus does not contradict to the second law of thermodynamics as the classical demon does (Blume-Kohout and Zurek, 2006; Matsuno, 2006). Imposition of counting and computation is called measurement which by definition is *the process of introduction of mathematics into real world*. We come to a paradoxical task to analyze formally the process of introduction of formal rules. In this task, we face the problems occurring in the foundations of mathematics but the situation is even more complicated because of necessity to introduce "arbitrary" principles for limitations of computation. These principles impose a meaning for the existing physical reality and thus have a semiotic nature.

As we discussed earlier (Igamberdiev, 1986, 1999, 2001), the structure that is looped on itself implements the Gödelian sentence, which is a statement that carries its own unprovability. "This sentence carries a double meaning. Inside the formal system, it is a statement about properties of certain integers .... From outside the formal system, the sentence is seen to assert its own unprovability. These two meanings interlock in the compound Sign that is the Gödel sentence, to form a portmanteau that has forever changed our understanding of the nature of formal systems" (Kauffman, 2003).

The Maxwell's agent computes: it conducts the internal measurement generating its output in the form of the Gödelian statement. Different statements can represent alternative descriptions of the same reality, so they cannot exist simultaneously and should be separated by the time interval. The main feature of Maxwell's agent is that it has an indeterministic behavior when observed from the outside but intrinsically this reflects its internal choice. This means that any demon is unique: it is the observer that is non-equivalent to other observers in the Universe. The question is how non-equivalency is compatible to co-existence of observers in the relational world. Non-equivalent observers are "closed to efficient causation" by their own intrinsic way, have different clocks and interact generating new fitted equivalence (Rosen, 1985). Each closure assumes own "chronotope", i.e. own spacetime structure, the term originally introduced by Bakhtin (1937–1938) to define the relational spatiotemporal matrix governing linguistic acts. These structures interact and by this interaction form the spacetime pattern that relates to all observers.

Objectivity of space–time relations in Einstein's special theory of relativity is based on the assumption that all observers are similar and that their data is inter-transformable. This comes into development in the general theory of relativity where the spacetime itself (not only space–time relations) possesses certain "container" features uniform for all observers. As Rosen (1985, p. 319) mentioned, "The most unassailable principle of theoretical physics asserts that the laws of nature must be the same for all observers. By this is meant that the laws must be invariant to the position and state of motion of all observers ... but if the observers themselves are not identical; i.e., equipped with precisely the same meters, there is no reason to expect their descriptions of the universe to be the same."

In physics, the double-slit experiment tells us that the spacetime continuum survives within a nonlocal quantum body and even a single quantum can interfere with itself. This empirical fact raises a question of how the idea of decoherence comes to terms with the picture of quantum reality. The answer can be that the continuum necessarily survives only if we assume equivalency of all observers in the universe. In fact, both the special and the general theories of relativity accept this assumption and it is also pre-assumed in the quantum mechanics. If we assume that observers may be non-equivalent as Rosen (1985) did, an additional factor for decoherence comes to play and the spacetime continuum may rather melt down. The process of fitting non-equivalent observers together results in generation of the pattern that can be viewed as analog of objective spacetime having the pragmatic value.

The existence of non-equivalent observers, results in incompatibilities appearing when quantum measurements are performed and leads to a fundamental loss of unitarity. This induces a decoherence effect that is independent of any interaction with the environment and appears in addition to any usual environmental decoherence (Gambini and Pullin, 2007). The use of a relational time in quantum mechanics is a framework in which one promotes to quantum operators all variables in a system, and later chooses one of the variables to operate like a 'clock' (Gambini et al., 2004). Conditional probabilities are computed for variables of the system to take certain values when the 'clock' specifies a certain time. Since the clock is now subject to quantum fluctuations, the resulting evolution in time is not exactly unitary and pure states decohere into mixed states (Gambini and Pullin, 2007).

4. Objectivity in Consistent Histories

The Universe is a superposition of numerous different potential sets where some particular families of histories are singled out and referred to as consistent (or decoherent). A consistent set of coarse-grained histories is called maximally refined if one cannot insert another projector set (inequivalent to any that have been already incorporated) without destroying its consistency. A history from a maximally refined set is regarded as ontologically real. Finally, the selected consistent histories follow Bayesian distribution (Marlow, 2006) in a similar way as the set of meanings of a word (Nalimov, 1981).

The main prerequisite for the world's physical description is the assumption that it is the same for all observers (all have a 'common account' according to Heraclitus, fragment 2). This assumption is not trivial: it needs further consideration. There are different types of objectivity: one (ideal, Platonic) is related to the objectivity of mathematical world ("thinking is common to all", Heraclitus, fragment 113) and it is timeless, another (real, which we can define as the Democritean) is the objectivity of observed physical world and it occurs in time. These two types are ontologically different: the first proves its objectivity from its self-sufficiency and consistency, the second is based only on a common sense and it is difficult to find any other obvious reason to substantiate it. The development of physics was challenged by this particular problem, i.e. by the search of substantiation for the objective physical world. In the XX century, physics moved from the substantial to the relational understanding of spacetime. But the question remains if time is a relation and space is a relation, how the world same for all observers can emerge. We can follow here the idea that the physical (Democritean) objectivity has the similar reason as the mathematical (Platonic) objectivity and it is based on the existence of stable causal loops. The immersion of different observers into the same branching history results in continuous reproduction of these perception loops that evolve to fit within the omnium of observers.

A physically embodied reflective loop has certain parameters that make it objectively existing. These parameters include values that can be redundantly repeated in all loops if they co-exist. Robert Rosen once suggested that the only solution for the objectivity problem is to recognize that the "closed loops of causation are 'objective', i.e. they are only legitimate objects of scientific scrutiny. Systems containing loops of causation must possess nonsimulable models, i.e. models which contain impredicativities or 'self-reference' which cannot be removed, or faithfully mapped into a single coherent syntactic time-frame" (Rosen, 1993). Such loop contains an internal observer (which is the quantum mechanical Maxwell's demon).

The Platonic objective world is a continuum of pure mathematical essence before the price of action is paid for its implementation which results in the formation of physical world. All paradoxes and contradictions existing in pure mathematical reality should be separated when implemented into the physical reality, thus time flow appears separating contradictory statements and history begins. The price of action is set by the values of fundamental constants (Liberman, 1983). When their values are embedded, the branched history of quantum measurements leads, by generating consistent sets, to realizations that are compatible with observability and conscious events. This is a simple explanation of the anthropic principle claiming that the set of fundamental constants and parameters of our world is unique and exactly selected to fit the possibility of life and consciousness in the physical Universe.

The relational nature of physical objectivity implies that it has its own limits defined by the set of fundamental constants. When we come close to the limits of measurement (either by approaching the speed of light or the values of the Planck's quantum), the relational effects become significant and the objectivity of world's pattern melts down. Objective world can be formed by co-existing activities of IGUS systems. There is no 'objective' quantum reduction, but instead there is a redundant reduction based on the same fitting pattern that generates the observed objective picture. This reduction enforces classicality by imposing an effective ban on the vast majority of the Hilbert space via eliminating "Schrödinger cat states" (Zurek, 2003). These relatively objective states form the classical-like world in which we live.

The approach to objectivity developed here arises to early philosophers. In Plato's dialogue Parmenides, the origin and development of multiplicity follows from the logic imposed by the existence of the one through the self-referential logic of generation of numbers. The objective counting is presented as an emanation of this self-referential process. Paradoxically, this process is seen by the mind in reverse: the complexity of the composition is what is seen; the higher concept, the one, arises in the mind but is unseen. In the new era, the approach to see the world as a consistent history can be traced to Leibniz and his unpublished logic at his time: the existence is related to the events that are consistent with more events than other possible events. According to Leibniz, a change is less a transformation than an ordered revelation of the entity and the creation stands outside the temporal order. In this approach, the objectivity of spacetime is relational. It is also relational in Kant's theory of the transcendental ideality of space where the '*Ding an sich*' can be considered as the sum of possible histories, while the perception selects 'real' things in the 3D space (not necessarily Euclidean) via a kind of indeterministic transition. Objectivity of the spacetime comes as a fixed condition of perception generating phenomenal reality of the observed world.

In the XX century, in the philosophy of Whitehead (1929), the actual occasion really is not an enduring, substantial entity. Rather, it is a process of weaving together the "prehensions" of the actual occasions that immediately preclude this actual event. Whitehead calls it "concrescence". An actual entity is concrescence: it is a process of growing together into a unified perspective on its immediate past. Collections of actual occasions emerge and exhibit the characteristics we find associated with minds and material structures (Epperson, 2004).

5. Time Flow as a Consequence of Quantum Measurements

The problem of time is the most paradoxical part of the quantum theory. The most important here is to avoid a primitive approach that everything propagates in a background spacetime but to trace how the classical spacetime emerges from underlying quantum structures. This means that there is no background time against which the states evolve. Evolution by itself generates its time while the relations of different evolutions generate the environment (spacetime common for all beings). Talking about evolution, we cannot imagine it without a background spacetime. This background spacetime was an imminent feature of the primary substance of Spinoza's philosophy. Only few systems avoided it (the first was the Parmenidean), the most profound in the new time being the monadology of Leibniz. The main problem is that it is difficult to imagine something without the Newtonian assumption of a background spacetime 'multiplying essences without necessity' (Occam). In Leibniz's approach, monads are not in time, but time is generated through the embodiment of monads into the pre-established harmony. Thus the spacetime is not a substance but rather a conditional relation. Leibniz also distinguished between the logical/mathematical truth of reason and the physical truth of fact. Here in this paper we show that these two kinds of truth (objectivity) are profoundly related via implementation of Gödelian sentences.

To be consistent, we should assume that the branching history in quantum Universe takes place beyond time. Time appears as a consequence and not a reason of a branching history and enters with decoherence. Decoherent events exist in time arising from pre-temporal internal quantum states (IQS) (Igamberdiev, 2004). In the non-local IQS, the present time has the non-zero duration. The pre-temporality of IQS can be evaluated externally as time-reversibility before actualization (decoherent output), which brings irreversible time into the world. In the consistent histories approach, the histories appear in time because different branches merge together via the introduction of the time-of-arrival (Anastopoulos and Savvidou, 2006). Different times-of-arrival form a pattern where a kind of the uniform time can be seen. This uniform time allows tracing the history of the Universe from the Big Bang event, while the relational nature of time makes it difficult to establish its coordinates around the Planck's scales.

The uniform time in the Newtonian sense in this framework is really the time of objective patterns formed by successful observables in decoherent histories. These histories can be consistent only if the time flow will satisfy a certain condition of uniformity. The paradox of time is that it separates contradictory statements, so they do not exist simultaneously (Gunji, 1994; Gunji and Ito, 1999). So the paradox of time makes possible for other paradoxes to be present in the Universe. The basic semiotic paradox contained in the Gödelian sentence can be represented in different levels and in different ways. The existing one in Plato's dialogue "Parmenides" is a primary Gödelian sentence: it has ambiguity, which generates an infinite possibility of reflective loops formation.

The quantum measurement device imposes the limits for measurement process, but from the outside it is a part of the measurement system asserting its unprovability. The statements (outputs of this device) are separated by time intervals and represent Gödelian statements about the reality. One such statement is related to the gravitational force and its particle, the graviton. As a particle transferring gravitational interaction, it states certain properties of the gravitational force transmission in the space. From outside, gravity is a curvature of space itself, so graviton asserts its own unprovability. In gravity, transferring of interaction is equivocal to the interaction itself, so we come to the unitary time of gravitational decoherence which can be measured, e.g. via black hole evaporation rate (Gambini et al., 2007).

A relationship exists between quantum entanglement and the time evolution of composite quantum systems: the entanglement enhances the 'speed' of evolution of certain quantum states, as measured by the time needed to reach an orthogonal state. As the number of qubits increases, very little entanglement is needed to reach the quantum speed limit (Zander et al., 2007). Such structures can be analyzed in terms of "finite velocity of observation propagation" (Gunji, 1994) which depends on the degree of quantum entanglement.

6. Semiotic Interpretation of the Quantum Mechanics

Non-equivalency of observers in the quantum mechanics is not fully compatible with all its existing interpretations although it can fit better to the consistent histories approach. The Copenhagen interpretation assuming the classicality of measurement devices says nothing about the origin of this classicality: it comes as given and corresponds to the equivalency of all observers in the sense of equivalency of this classicality. The Everett interpretation does not provide superselection rules and considers all branches as equivalent. The concept of consistent histories generates certain rules for superselection but claims that they are dependent on the environment that imposes these superselection rules (Blume-Kohout and Zurek, 2006). In reality, life is somehow circumventing the decoherence effects of the environment and this is achieved via closure to efficient causation (Rosen, 1991). So the step forward is to assume that the environment is not a given fixed milieu, but it develops relationally with the process of superselections. This means that a modified interpretation of quantum mechanics, where the state vector is viewed as a sign, is needed upgrading consistent histories to a semiotic network. This interpretation will analyze decoherence as occurring in a relational chronotope as a semiotic process and substantiate significative essence of state vector reduction depending on the space–time relations.

A background for fundamentals of semiotic theory of measurement and correspondingly of the semiotic interpretation of quantum mechanics can be found in Robert Rosen's book "Fundamentals of Measurement and Representation of Natural Systems" (Rosen, 1978). His concept of the quantum measurement is based on two propositions: "The only meaningful physical events which occur in the world are represented by the evaluation of observables on states" and "Every observable can be regarded as a mapping from states to real numbers" (Rosen, 1978). In frames of these propositions, the world acquires qualities that are common to all observers. More explicitly and using physical formalism they are outlined (but not published widely) by Christiansen (1985, 1990). According to Christiansen (1990), the discreteness of the transition from the potentiality to the actuality connected with the reduction of the wave function, is well described in the Peircean semiotics as a transition between the sign categories index and symbol. An index cannot in general be represented numerically and the indexical character of quantum mechanical state vectors is, therefore, not compatible with the notion of hidden variables. A consequence of the Peircean view of state vectors as indices is that numerical properties of quantum systems are always contextual, i.e. they exist only in connection with well-defined setups of measuring devices. A property of a pair of particles may therefore be expected to depend on whether there exist common context for the measurements on the single particles, or not. Following this line of thought, it is possible to construct a classical scenario where every interaction is strictly local, but where Bell's inequalities are clearly violated. This also gives a different look to double-slit experiments generating common context for survival of spacetime continuum in the interference of quantum with itself.

The main postulate of the semiotic interpretation of quantum mechanics consists in the statement that the state vector is a sign. This means that decoherence is a process of allotting signs to the states and it is neither indeterministic state reduction as in the Copenhagen interpretation nor an indeterministic branching without outcome in the sense of Everett but it may be indeterministic in the Saussurean sense of sign arbitrariness. Following Peirce, the definition of a sign has to be free from reference to human consciousness; a self-reference process instead must be inherent in the definition of the sign. But the sign is generally not arbitrary from the view of optimality, so its shape is restricted by the limits imposed within perpetually formed contextual fitness landscape.

Representations of the Peircean semiotics can be formulated algebraically and a direct path from the Peircean logic to quantum theory exists (Beil and Ketner, 2003). In a Peirce algebra (Brink et al., 1994), sets can combine with each other as in a Boolean algebra, relations can combine with each other as in a relation algebra, and in addition we have both a set-forming operator on relations (the Peirce product of Boolean modules) and a relation-forming operator on sets (a cylindrification operation) (Hirsch, 2007). The latter operator establishes internally organizational invariance of the semiotic loop similarly to the factor in Rosen's relational biology providing closure to efficient causation (Rosen, 1991). This factor should have a unique solution for advanced biological systems but it is viewed externally as arbitrary. In nonliving systems, it is not unique and correspondingly the decoherent phenomena may occur in more unpredictable ways. The development of Peirce algebra can be a promising formal background for establishment of the basic principles of the semiotic interpretation of quantum mechanics.

7. Consistency of Histories in the Biological Evolution

The consistent set of histories forms an optimal state for a biosystem in the environment, perpetually being adjusted via interactions between mutually modifying embedded system and its environment, and potentially achieving maximum fitness. This is possible via the observability of environmental inputs as a possibility to measure them as objective patterns. Evolution moves towards incorporation of all potentially being observable and this corresponds to the process of adaptation via complication of organization of living systems.

The approaches to describe evolution of the system towards observability are based on the understanding of quantum measurement (as opposed to the classical measurement of external objects) as a measurement of the environment together with the embedded measuring system, which cannot be separated from it. The assimilated part of environment as recognized by the system can be defined as the *Umwelt* (Uexküll, 1909). Recognition of new observables during this measurement will generate a simultaneous complication of the measuring system itself and the *Umwelt*: it will correspond to the Gödelian enumeration within sets and lead to a possibility of measurement of a newly formed system plus environment (Igamberdiev, 1998, 1999). The measurement process will generate enfolded structures consistently appearing in the continuous recursive embedding process. Attraction to the most optimal states (canons) viewed as objective patterns takes place in the process. These canons will include fundamental values (constants) inherent for unfolding. Evolution passes through memorization events taking place in reflective loops, and the memory kept inside of a reflective loop is inherently 'objective' being a structure encoded in the system, which indicates a certain behavioral pattern for all elements of this system. The element of objective reality is a semiotic sign determining interrelations between observers, and relations of observers to decohered structural elements. Its objectivity consists in bearing a common meaning for different individual observers embedded in the given consistent history.

In correspondence with Leibniz and with the theory of relativity, we assume that the spacetime has a relational nature, so evolution does not occur in a background spacetime. The evolutionary process rather than occurring in time is the process creating time via a consistent set of internal measurements. The spacetime formed during the evolutionary process becomes uniform for different observers via the formation of 'shared' patterns that appear in the course of multiple observations. New forms arise in the evolutionary process as realizations corresponding to the condition of consistency. This condition selects possible histories from the potential set. It is determined by the pre-existing environment which makes possible only certain context-dependent objective pattern arising as a reduction from the potential field. A similar view was expressed by Nalimov (1985) who suggested a probabilistic model of the evolutionary process. Biological form itself is based on objective structural patterns and its formation is a direct result of consistent history underlying its development. A certain point of the evolutionary process corresponds to the set of consistent developments that can be realized as a selection in the potential field. The Darwinian selection is a classical limit of such selection occurring in the actual world, being only a small subset of a huge set of possible selections.

An uncertainty in the interaction between the biosystem and its environment is reduced via formation of a self-reflective loop (referred as a semantic closure, according to Pattee, 1995), which leads to establishment of emergent computation such as primitive recursive functions (Gunji et al., 1997; Gunji and Ito, 1999). Time in this approach separates contradictory statements allowing them to appear in a sequential order. The process of internal choice in the course of adaptation includes inducing and addressing a fixed point (stable element in the recursive structure). It can be compared to indicating an element together with a set consisting of elements, that is, to the Russel's paradox. Evolution as a formation of reflective loops during measurement is generally relevant to continuous relative resolving a paradox via passing certain levels of organization. The Gödel numbers hold significative context-dependent property inside the system. Via Gödel numbering, a system bootstraps on itself, so it is possible to observe certain point in it serving as a fixed point, i.e. a point that is mapped to itself by the function, the condition of $f(x) = x$.

The emergent time, by separating contradictory statements, leads to the formation of patterns that organize events in a certain sequential order. Dubois (1997) introduced the concept of incursive computation, in the sense that an automaton is computed at the future time $t+1$ as a function of its neighbor automata at the present and/or past time steps but also at the future time $t+1$. This concept may be useful for the systems closed to efficient causations in the sense of Rosen (1985, 1991), i.e. to anticipatory systems having stable point attractors. The development of this concept for inclusion of multiple states led to the concept of hyperincursion, which is an incursion when several values can be generated at each time step.

The series of incursive and hyperincursive actions will produce fractal patterns defined by functions of the past, the present, as well as the future states. External incursive inputs cannot be transformed to a recursion. But they can be internalized and thus transformed to recursive inputs via self-reference (as being memorized in the system as signs). Interference of inputs in fractal generation gives rise to various fractal patterns with different scaling symmetries. These patterns have fundamental symmetrical characteristics at different scales, corresponding to existence of certain canons in incursive computation. Hyperincursion means superimposition of states similar to that in quantum computation (Dubois, 1998). In incursive and hyperincursive fields (which are viewed as hypersets, i.e. sets including themselves), indecidabilities and contradictions occur (in the Gödelian sense), so the fractal machine operates in a non-algorithmic way and the formal system cannot explain all about itself (undecidability). The transformation of a non-local incursive system to a local recursive system leads to a folding of each automaton to other ones from the future time to the present time. The internal evolutionary process can be modeled as a function of the system's neighboring states appearing at time past, present, and future, with fundamental consequences for biological perfection (Igamberdiev, 2004).

The problem of the state in time $t+1$ can be solved as a consistent solution from the set of internal measurements occurring in the historically defined environment. Thus the state in time $t+1$ is not a real post-existing physical state but it is a potential state that will be generated as a consistent solution from the pre-existing and existing states and possibilities. This solution is a choice of one of those limited by the compatibility with other states, so it is both nomothetic and creative. In pure physical systems, Dubois' incursion and hyperincursion cannot guarantee the robustness of the scheme on their own because of unpredictability of final results. But in anticipatory systems closed to efficient causation, robustness is maintained within incursion and hyperincursion mechanisms, although different clocks of individual observers impose certain problems in external fitness landscape that are perpetually solved in the course of evolution, making possible fitting observers together in "objective world". As a result, the system forms its own internal causation: it is closed for external efficient causes forming complex signaling network recognizing these causes and reacting on them by avoiding or incorporating them (Barham, 1996). In reality, biological observers are equipped not by precisely the same meters. The meters recognizing external efficient causes and reacting on them are different for different observers depending, in particular, on their distance in the evolutionary line. In this respect, biology depends essentially on the proliferation of non-equivalent observers. It can indeed be regarded as nothing other than the study of populations of non-equivalent observers and their interactions.

8. Perfection and Objectivity

A newly generated structure attains the value in the changed *Umwelt.* This means that it is embedded in a whole system interacting with the environment as a part of a new established harmonization of the interaction. This is possible if a new configuration fits to a certain canon. Organism constructs itself via certain harmony principles (Lyubishchev, 1973, 1982). The problem of form is generally not only pragmatic: it needs aesthetic criteria, primary and absolute to any concrete adaptive harmony. According to Lyubishchev (1973), evolution passes through the change of canons. Evolution of canons includes the period of initial primitivism (simplicity of form, brightness and contrast of colors), the classical period with most harmony and finely balanced forms and colors, and finally the manieristic period with some unusual and unbalanced structures. Style unity is the highest level of wholeness, non-reducible either to the adaptive harmony or to the correlation between parts.

Interaction between the whole and the parts can be viewed as an intersection of the sets with different dimensions forming a contradiction in the sense of Russel's paradox (the fixed point) (Bounias and Bonaly, 1997). This intersection may represent a harmony or a disharmony, depending on how parts are observed within a whole. A harmony appears as a threshold for establishing a connection between local and global periods of iteration in recursive embedding (Mignosi et al., 1998). When viewed as a recursion (reflected from incursion), the preceding motif unit is transferred into the subsequent one by a certain fixed similarity transformation g in correspondence with the formula $S_{k+1}=g\times S_k$. The resulting domains (having certain quantitative values) are hierarchically embedded one into another and function at every level with different clock time periods (Petukhov, 1989). The limit of actualization fits optimality of the structure being actualized, thus it corresponds to the most optimal design solution.

In the internal evolutionary process, which includes formation of self-referential loops, the evolving state is determined in the simplest case by two contradictory values of the system separated by time interval, and by the value in time future acquired after addressing them. Addressing the fixed point means that two contradictory statements, taken as sequential values separated by time interval and equally probable, are composed to get the third statement. Thus, the next statement (quantitatively modeled as having correspondent value) is composed from two previous statements when they are memorized within reflective loop: $F_{n+2}=F_n+F_{n+1}$. This will lead to important evolutionary consequences: in the transformation of a non-local incursive system to a local recursive system, certain recursive limits will appear as objective fundamental canons of perfection formed via memorization within reflective loops (Igamberdiev, 2004).

In many cases of biological morphogenesis, the following configuration is realized as a limit of infinite recursion: $Q_n=\frac{F_{n+1}}{F_n}:\frac{2}{1},\frac{3}{2},\frac{5}{3},\frac{8}{5},\ldots\rightarrow\Phi=\frac{1+5^{1/2}}{2}=1.618\ldots$ (the golden section)

Other useful series appear when three neighboring elements F_n, F_{n+1}, F_{n+2} of the Fibonacci series are taken as lengths of three sequential segments (as appeared in the sequential past $(t-1)$, present (t) and future $(t+1)$ times). In this case we get the wurf $W{:}W_n=\frac{(F_n+F_{n+1})(F_{n+1}+F_{n+2})}{[F_{n+1}(F_n+F_{n+1}+F_{n+2})]}:1,\frac{3}{2},\frac{5}{4},\frac{8}{6},\frac{13}{10},\ldots\rightarrow P=\frac{\Phi^2}{2}=\rightarrow\frac{3+5^{1/2}}{4}=1.309\ldots$ (the golden wurf)

The value of golden wurf as a limit of the recursive process will have the wurf of three sequential segments with the values 1, Φ and Φ^2, i.e. it follows from the memorization of limits of recursion in the Fibonacci series (Petukhov, 1988, 1989). The golden ratio and the golden wurf constants represent fundamental values of infinite recursion when the next element is formed by the operation on the two previous sequentially appearing elements memorized within the reflective loop. They always occur in morphogenetic patters appearing as limits of infinite process of recursive embedding arising from the reflective action (internal quantum measurement).

The classical description of the evolutionary process views the latter as occurring in the external Newtonian time. The real evolutionary process forms time by itself—it appears as a tool to separate contradictory statements in the infinite embedding process. The transition to the Newtonian external objective and uniform time flow occurs when the internal incursive/hyperincursive process is transformed (via memorization in a self-reflective loop) to recursive rules. Evolution represents a contradictory process of growing complexity, which includes both fundamental principles of objective perfection of canons regarded as its nomogenetic laws, and a free creativity for their construction based on the internal choice.

9. Objective Patterns of Perception and Consciousness

We could interpret the correspondence of mental and physical events occurring simultaneously (pre-established harmony in the paradigm of Leibniz) as a correspondence of a statement and a metastatement within the reflective loop. A statement will represent a physical event, a metastatement—its sensor representation, and consciousness is a process (*cogito*) holding them both (the one and the existence) in unity. A subject self-determines possible finite models for his relation to the external world. By constructing the spacetime image, the observer self-determines the picture of the external reality by which it is self-maintained. The whole act of thinking (*cogito*) generates its primary model (the finite set of statements), which includes the existence (*ergo sum*, the metastatement within this set).

Constructing the spacetime image in perception is similar to building up a morphogenetic event. A system of coordinate axes to which we refer all external objects is that invariably refers to our body, which we carry wherever we go (Poincaré, 1916), so perception includes a realization of modeling of space curvature: organism selects the most optimal coordinate system for its orientation. This is similar to changing coordinate scales in transformation of biological forms in morphogenesis and in the evolutionary process, which is realized via cause–effect loops.

The cause–effect loop in a reflective structure can be found in perception systems of complex behavior like social insects or fishes (Kitabayashi and Gunji, 1997). The social behavior can be viewed as a special case of biological morphogenesis. The ants sometimes change trails, which is connected with some momentary burst of post-information (a cause originating from the future $t+1$ time) that can trigger the retreat of an existing recruitment trail. This post-information can be viewed as an internal decision-making, which is fundamentally uncertain and non-observable (Gunji and Kusunoki, 1997).

The model of interaction generating emergent phenomena is based on an incomplete identification consisting of an alternate procedure of constructing a map from coarse-grained data in a system without boundary. Incomplete identification connected with uncertainty in measurement process is read and interpreted as a cause for new realizations (Gunji et al., 1997). Biological systems are adapting to the environment that is changing in the course of adaptation. Morphogenetic events as any emergent phenomena arise when the forecasts (corresponding to developmental patterns or evolutionary adaptations) create the world they are attempted to forecast (i.e. to adapt), thus they form a space of co-evolving predictions where uncertainty is reduced in the process of formation of new emergent structures.

In the human reflection, objective patterns generated in conscious events are associated with certain types of reflective loops originally described by Freud (1976 [1899]) who discovered the basic Gödelian sentence for human social behavior (the Oedipus complex). This loop, being interpreted as a reflection of a subject, is a non-trivial semiotic structure, which determines the way of internalization of the external world. It can be considered as a logical pattern describing interrelations between the consciousness and the external world, which determines the fixation of somebody's image into the other as a possibility to substitute the other (Igamberdiev, 1999).

In the model of reflection developed by Lefebvre (1990), the trinitary Freudian semiotic structure of consciousness is reduced to recursive Boolean schemes. A unique system of dichotomous constructs serves as a special axis for projecting (mapping) the other person (organism or neighboring cellular automaton). In an internal process of making choice the system performs a procedure of maximization of the pragmatic status of its image of itself. The golden section appears here when the internal choice is made in reflective modeling of the self (Lefebvre, 1995), i.e. when the subject A_1 chooses a positive role with a frequency equal to the frequency of positive stimuli input to his image of himself ($\mathbf{a}_2$) and to his image's image of himself ($\mathbf{a}_3$). The subject's state $\mathbf{a}_1$ will be a composition of the contradictory statements $\mathbf{a}_2$ and $\mathbf{a}_3$. Thus the subject will correspond to a character $A_1 \equiv \mathbf{a}_1^{\mathbf{a}_2^{\mathbf{a}_3}}$. When $\mathbf{a}_1 = 1/2$ (e.g. in the case of the choice between two equal elements or equal contradictory states), it will correspond exactly to the values of $\mathbf{a}_2$ and $\mathbf{a}_3$ as Φ^{-1} (Lefebvre, 1995). The value of golden section emerges under the condition when a subject chooses a positive role with the frequency of positive stimuli input to his image of itself and to his image's image of itself.

The emergent bivalent Boolean logic of internal choice is related to the generation of classicality of the observable spacetime (Trifonov, 2008). The observer is permanently involved in a Boolean experiment, in which he may be capable of perceiving various realities in which he tends to distinguish stable collections of experiences. These experiences are represented as dynamical systems of objective world roaming their possible worlds. An observation of a dynamical system perturbs its evolution resulting occasionally in a creation of an observable property of the system with respect to its actual world (Trifonov, 2008). In this paradigm, the classicality is originally attributed to the logic of observer, which allows making a selective choice in the field of potentialities, i.e. it has a psycho-biological rather than the physical nature, and by this means the observer chooses the most adequate model of the Universe.

10. Semiosphere as the World of Quantum Measurements

We come to a conclusion that the physical spacetime is really a most robust part of semiosphere, i.e. the sphere of semiosis in which the sign processes operate within the set of all interconnected individual spacetimes (chronotopes and Umwelts). The semiosphere concept was developed by Lotman (1984). The Umwelt (German word meaning "surrounding world" or "environment") is usually translated as a "subjective universe" (Uexküll, 1909; Sebeok, 1977) and the organisms can have different Umwelts, even though they share the same environment (Kull, 1998). The term "chronotope" was invented by Bakhtin (1937–1938) and designates the relational spatiotemporal matrix governing linguistic acts. It may be used for designation of internal space–time relation in the closed for efficient causation system ("biochronotope" for living systems), while the Umwelt comes as a mode of exhibition or representation of this system to other systems in the omnium of non-equivalent observers.

Physical spacetime appears as a part of the semiotic set of interconnected Umwelts. Each functional component of an Umwelt has a meaning and so represents the organism's model of the world. An organism creates its own Umwelt when it interacts with the world and reshapes it. Consequently, the Umwelts of different organisms differ, which follows from the individuality and uniqueness of the history of every single organism. When two or more Umwelts interact, this creates a semiosphere in which organisms exhibit goal-oriented or intentional behaviors.

Finally, we can approach to a simple and non-contradictory explanation of the anthropic principle: sign creation in the semiosphere corresponds to conditions of observability of the world because signs themselves are formed based on the principle of observability. This "bootstrapping" formulation of the anthropic principle substantiates physical constants as solutions for fixed points in the branching history of quantum measurements. Solutions for the physical constants potentially can be any, but only those that are realized are consistent with the condition of observability. The objective reality of the spacetime appears as corresponding to the basic ideal principles of the physical world construction. Such approach can be traced to Florensky (1997 [1914]) who claimed that all elements of the reality are signs. He substantiated this, in his theory of imaginaries in geometry, as notions of potentiality (imaginary numbers) and of actuality (real numbers) are connected in the basic structures of mathematics (Florensky, 1991 [1922]). Now we can say that from the branching patterns of the wave function, the world is reduced in a way that is appropriate for life and consciousness. All other infinite numbers of worlds remain as potential and cannot be actualized.

The space–time relations between objects of the physical universe (introduced in quantum measurements) are governed by limits of computation. These limits are imposed as a minimum value of action, a finite velocity of observation propagation, and an objective fitness of measurement results between different branches of the wave function evolution. Objective fitness and finite velocity form certain patterns such as 3D space and fractal properties of its embeddings (Igamberdiev, 2004, 2007). The relational spacetime is a robust fitness landscape for observers; it has a semiotic value formed during measurement. The supposition that all observers are equivalent generates objective spacetime patterns of the theory of relativity. However, the equivalence of observers is an approximation and in reality the spacetime patterns imposed by them acquire relative equivalence via the fitting process. This process becomes more uniform with the appearance of living systems based on similar reflective cycles that can interact with relative predictability. Living systems, being quantum mechanical observers having different clocks, interact thus generating the perpetually evolving fitness landscape.

The presented analysis of objectivity in the physical, the biological, and the psychological world shows that objective patterns are formed in the relational universe as necessary conditions for the operation of reflective loops. These loops arising independently have common values uniting them in the branching history of actualizations. The objectivity of truth of reason in logic and mathematics in Gödelian reflective loops substantiates the objectivity of truth of fact of the physical world. Actual physical objectivity has its origin in the ideal objectivity of the ultimate logical structures of the world. These structures are actualized via unique sets of physical parameters making the world observable and intelligible.

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