ISSN 1019-3316, Herald of the Russian Academy of Sciences, 2013, Vol. 83, No. 1, pp. 59–69. © Pleiades Publishing, Ltd., 2013.
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Point of View

States of consciousness—subjective reality—form the direct experience of any person. As is known, we have consciousness thanks to the functioning of the human brain. Yet how do material processes transfer to ideal forms in which our subjective reality exists? How did this human ability appear? Despite long interest in this problem, science is still unable to give a satisfactory description and explanation of this phenomenon. Such an attempt is made in the article below.

DOI: 10.1134/S101933161301005X

Subjective Reality and the Brain: An Essay on a Theoretical Solution to the Problem

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The presence of subjective reality, i.e., states that an individual feels and that prove that an individual exists, is a specific and integral quality inherent in human beings. This quality is designated in the literature by different terms that are close in meaning: *mental, introspective, phenomenal, subjective experience, qualia*, etc. In recent decades, the term *subjective reality* (SR) has been used quite widely to describe the specifics of con-
1 sciousness. This trend seems promising also in the tideway of the consciousness–brain problem, since, when this problem is called the subjective reality–brain problem, its main content is emphasized. In this article, the above notions will be used as equivalent.

The SR notion covers individual phenomena and their types (sensations, perceptions, feelings, thoughts,
2 intentions, wishes, conations, etc.), as well as a holistic formation united by our *ego* with all its reflexive and
3 areflexic dimensions. This holistic formation represents a historically evolving continuum interrupted from time to time by deep sleep or cases of fainting. Subjective reality is always a certain content given to an individual as the current present or *now*, which can belong to the past and to the future.

The specificity of SR phenomena that differentiates them from objects examined by classical natural science is that we cannot ascribe physical properties to them. Hence, there is a claim to being of a special ontological status, the definition of which has always been a problem for scientists, especially for those who
4 study the relationship between psychical phenomena and activities of the human brain. The point is that SR phenomena are described by the notions of intentionality, purpose, sense, value, and will, while physical phenomena and brain processes are described by the notions of mass, energy, and spatial characteristics, and these notional complexes have no direct logical relations. We need a certain notional link to unite various descriptions into a single conceptual system capable of a theoretically justified explanation for the correlation of SR phenomena with brain processes. However, it is still unclear how to find this link and thus overcome this explanation gap.

There is also another problem: subjective reality in itself is an internal and individually subjective experience inherent only in a given individual (expressed in first-person reports). How do we transfer from this individually subjective experience to intersubjective 5
and generally valid (third-person) statements and to the justification of true knowledge?

These questions have been raised many times and have been solved differently from different positions, but, in the light of the current urgent problems, they continue to be open. This situation becomes especially acute in fields of neuroscience that are meant to study psychic activity and conscious phenomena and that do not admit reductive solutions (concepts that try to reduce SR phenomena to physical processes and speech or behavioral acts).

The consciousness–brain problem should be differentiated from a psychophysical problem that 6
expresses generally the relationship between the spiritual and the physical (corporal). Philosophy does not study the brain. Neuroscience and numerous related disciplines deal with it. However, consciousness is a primordial subject of philosophy. Therefore, the problem that interests us certainly includes the philosophical background, to say nothing of the necessary thorough epistemological and methodological analysis when stating and solving its main questions.

Science has extensive resources to study consciousness; it has accumulated a vast experience that needs conceptualization (we mean data on psychology, psychiatry, linguistics, informatics, social humanities, and cognitive disciplines, and many other fields of science, especially those of interdisciplinary nature, such as psychophysiology, psychopharmocology, psychoge-

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7 netics, and psycholinguistics). Simultaneously, the
8 role of scientific knowledge that is called metatheoretical (metascientific and general scientific) has been increasing in recent decades. It is represented by the ideas of functionalism and structuralism, system and information approaches, and several other theories that have a wide sphere of application. Conceptual tools of this level can be used in practically all scientific disciplines, performing an integrating function in interdisciplinary studies. Therefore, they are of primary importance for the development of the consciousness–brain problem, which is an interdisciplinary (I would even say, transdisciplinary) scientific challenge. Its theoretical solution should, on the one hand, rest on an empirical basis, and, on the other, it is capable of initiating new trends and methods and, consequently, new results in brain and psychic studies.

This solution primarily requires theoretically justified answers to two main questions.

Question 1. How can we explain the relationship between SR phenomena and brain processes if the former should not be ascribed physical properties and the latter necessarily have them?

Question 2. If SR phenomena should not be ascribed physical properties, how can we explain their ability to cause effects on corporal processes?

In addition to these main questions, there are several others that are usually stumbling blocks for natural scientists. Let us consider the following of them.

Question 3. How can we explain the phenomena of voluntary actions and free will and how can we combine them with the deterministic nature of brain processes?

Question 4. How can we explain the origin of SR itself in the process of evolution? At first sight, it seems unnecessary for efficient functioning of an organism.

Question 5. Why is information about an active agent not just represented but felt as subjective reality?

Note that the last three questions are of a private nature in the sense that their clarification depends on the resolution of the first two.

ATTEMPTED THEORETICAL SOLUTION TO THE PROBLEM

The theory that I propose and that will allow us to answer the above questions rests on the current knowledge of biological evolution and (biological and social, including technical) self-organization processes, as well as the information approach.[1] It is organized relatively clearly and simply, thus being convenient for criticism. We acknowledge three initial premises, the first two of which are principles with no empirical refutations, and the third one is an intuitively acceptable agreement.

• *Information is necessarily incorporated in its physical medium (does not exist outside and apart from it).*

• *Information is invariant in relation to the physical properties of its medium* (for short, the invariance principle); i.e., the same information for a given self-organizing system (organism, human being, or community) can be implemented and transferred by media that are different in their physical properties; in other words, information can be coded differently. For example, information about rain being expected tomorrow can be transmitted in different languages, orally, in writing, in Morse code, etc.; in all these cases, the media of the same information differ in mass, energy, spatiotemporal, and other physical characteristics.

• *An SR phenomenon* (for example, my sensory image of visually perceived object *A, experienced in a given time interval) can be considered information* (about this object). Note that information admits not only a synthetic but also a semantic (content–notional) and a pragmatic (purposeful, effective, program-controlled) description, which meets the requirements of the description of SR phenomena.

If these three initial premises are accepted, the desired explanatory effects are logically derived from them.

Since an SR phenomenon is information about A (we designate it as $\underline{A}$), it must have a certain medium (we designate it as $\underline{X}$). According to neuroscientific data, this medium represents a certain brain neurodynamic system. Thus, the phenomenon of subjective reality is necessarily related to a corresponding brain process, like information with its medium. Although neurodynamic system $\underline{X}$ necessarily consists of physical components, its functional specifics cannot be explained on the basis of physical properties and regularities (because, as is known, the description of functional relations is logically independent of the description of physical relations). This is also shown by the character of the necessary relation between $\underline{A}$ and $\underline{X}$.

The relation between $\underline{A}$ and $\underline{X}$ is not causative; this is a special type of functional relation: $\underline{A}$ and $\underline{X}$ are simultaneous and single-causative phenomena; they are in a relation of mutual single-valued correspondence; $\underline{X}$ is a coded implementation of $\underline{A}$, or an $\underline{A}$ code. This relation may be called *code dependency*. It is formed in the phylogenesis and ontogenesis of a self-organizing system, and its nature is that of a historical innovation and in this sense is casual (this information has acquired this particular code implementation in a given self-organizing system, but, in principle, it could also have another implementation). However, having arisen in a certain form, it becomes a functional element of the self-organization process. This relation is

[1] Note that the notion of information has a generally accepted definition, and I use it in the sense in which it is used practically by all sciences, namely, as the content of a message or the content of a signal (N. Wiener's definitions). Therefore, there is no need to go into its various interpretations here; they are presented in [1].

real, preserving its functional role either in a one-time action or in a certain interval (for example, a conditioned reflex relation), often during the whole life of an individual, and even during the whole history of a species, and during the whole period of existence of living systems on the earth in the case of the basic DNA code. Yet even the origin of a genetic code was not necessary and also was of a casual nature. As F. Crick, the codiscoverer of the genetic code, indicated, it could have practically *any* structure, because its details depend on which particular amino acid and which particular adaptor correspond to each other. Most likely, the existing option of this mutual correspondence was determined at a very early stage of evolution, and, possibly, the choice in its favor was accidental [2]. This is even more characteristic of the origin of the code structure of language (the existence of many different languages testifies to this). The accidental nature of the formation of a code dependency does not contradict the principle of the necessary relation between information and its medium but demonstrates the principle of invariance in action. In addition, evolution inevitably selects code forms that are the most economical by their physical characteristics.

A complex system that consists of self-organizing elements and subsystems has a multistep hierarchy of code dependencies, which reflect its history (both phylogenetically and ontogenetically). This hierarchy represents the main levels and nodes of organization of a given system and, consequently, the main contours of the control structure. Experience in the study of such systems indicates very complex relations of centralization and autonomy in their holistic functioning. Despite the fact that these relations are still not well studied, it is safe to say that this is a sort of a fusion of a hierarchical centralization of code dependencies and a high-degree autonomy of certain levels of organization, which includes not only cooperative but also competitive relations. Thus, self-organization is a multidimensional dynamic structure of code dependencies (consequently, information processes), and, therefore, the study of the nature of code dependency as an element of self-organization is especially urgent.

The relation between SR and a neurodynamic system as its medium, like any code dependency, differs qualitatively from a physical relation and expresses the specifics of information processes. Therefore, a thorough study of this relation, as well as of the structural and functional organization of the corresponding system, means *decoding the brain code* of this SR phenomenon.

However, what is a decoding operation if information is necessarily implemented in a certain medium, and the latter is always one code implementation or another? This operation may be only the *translation of one code into another*: incomprehensible for a given self-organizing system into comprehensible. Therefore, we should distinguish two code types:

• *Natural*: Information implemented in them is directly understandable to the self-organizing system to which it is addressed; that is, it can be used directly for control without preliminary decoding operations, and without studying the signal structure, or without a special analysis of the medium of this information. In other words, a natural code carries information in a form open for understanding.

• *Alien*: Information implemented in them is not directly understandable and cannot be perceived and used by a self-organizing system without the preliminary operation of translating an alien code into a natural one.

It is important to note that cryptology, as well as contemporary science after it, does not use the term *code* to designate objects that we call natural codes (owing to their transparency). However, the approach that I propose and the concept of decoding the brain codes of SR phenomena [3, 4] rest on a wider theoretical foundation compared to that in classical cryptology, which uses a narrow interpretation of the notion of a code. The development and justification of this question are given in my work [5, pp. 214–273].

A way to translate an alien code into a natural one is either preprogrammed initially into the structure of 9
a self-organizing system, or formed by it due to its acquired experience and as a result of accidental findings, or it remains unknown and should be found. Examples of such a search can be given by cryptology, linguistics, ethnography, and other sciences that face such tasks (see, for example, [6]).

Both natural and alien codes can be *internal* and *external* for a given self-organizing system (an organism, its subsystems, a person, or a community). Apparently, alien codes are mainly external. However, at the personal level, they also appear in autocommunication processes, where internal alien codes manifest themselves as incomprehensible and often negative feelings and symptoms, which originate from the unconscious and somatic sphere; this is also true of various cases of psychopathology.

Note a seemingly paradoxical situation: an $\underline{X}$-type code is an internal natural code for me in the sense that it directly opens to me the information contained in it (the is an A image), and it is decoded in my brain seemingly automatically. At the same time, it is an external alien code for me in the sense that I do not know anything about its location in my brain or its composition and functional structure; moreover, I do not feel at all what happens in my brain when I feel image A. In other words, SR phenomena give me information in its pure form, shutting out information about its medium. Implementing cognitive processes, we seek information of interest to us, which is given to us as a natural code. In many cases, we are unaware of the setup of natural codes, but this does not prevent us from translating alien codes into natural ones at the SR level. Such translation, developed in phylogenesis

or ontogenesis, is implemented automatically by unconscious mechanisms of the psyche.

Such code transformations that we constantly perform are so immanent in our practical and communicative acts that we simply do not notice them—this is the air of our social functions. However, to understand the specific dependence of $\underline{A}$ on $\underline{X}$, we have to know the composition of the latter and to decode its code structure like we have to do when learning a previously unknown language. Let us note here the idea of *autocerebroscope*, according to which I myself can observe and study the relation between my psychic and brain processes. In the modern conditions, it may have a certain experimental perspective. Even in this case, despite my feeling $\underline{A}$ in its pure form, I would have to obtain $\underline{A}$ (its content) in a way that is also accessible for an outside observer. Thus, $\underline{X}$, being an alien code for me and for all of us, must become a special object of research in order to decode it and bring to light the $\underline{A}$ information contained in it independently, that is, by extracting signals from my brain and translating $\underline{X}$ into a suitable natural code (as a text, image, digital recording, etc., understandable to me). This, in turn, can ensure the understanding of the results of the $\underline{X}$ code decoding by other researchers and other people, that is, its *intersubjective* status. Thus, it is possible to speak about the possibility of generating a *new type of communication*, which must become a subject of serious consideration already at present.

If the brain codes of SR phenomena are thoroughly decoded, this will disturb the fundamental principle of social self-organization—the relative autonomy or "closedness" of the personal subjective world. What consequences await us if this world is opened in spite of the will of its sovereign, if some become open and others, closed, etc.? Another interesting question is what will happen with our society and its political, economic, and other institutions if people suddenly become open (which means, for example, that no one will be able to deceive anyone)?

During the study of the $\underline{A} - \underline{X}$ dependence, two problems arise.

The *direct* one is when it is necessary to translate an alien code into a natural one and to find out the information contained in it. Note that, in the case of $\underline{X}$ objects, difficulties arise in retrieving and describing them, to say nothing of finding ways to decode them and implement the decoding process. (An impressive example of this may be the exceptionally complex creative process of decoding the genetic code described by Crick [2].)

The *reciprocal* problem is related to decoding a natural code if information is given and it is necessary to define its medium and study its functional structure. Due to the invariance principle, the reciprocal problem is more complex than the direct one, since this information can have different media (although their variety is limited by the brain properties, such as the specifics of the brain substrate, brain elements, synaptic relations, and morphological structures). Here we should add that any translation of information into another language entails some losses of the initial content (an issue of special analysis).

In the real process of studying code dependencies, the direct and reciprocal problems are interrelated. Nevertheless, the reciprocal problem, or the movement from $\underline{A}$ to unknown neurodynamic correlations that, to a certain degree, should correspond to $\underline{X}$, dominates the decoding of the neurodynamic code of psychic phenomena. Modern neuroscience sets and studies correlations with various methods (electroencephalography, electromyography, positron emission, and functional magnetic resonance tomography). At the same time, the correlates identified are related only indirectly to $\underline{X}$, which is an extremely complex multidimensional circular neurodynamic network system, and the building of adequate models of a code dependency requires special analysis and interpretation using mathematical and other tools.

Over the past five years, important results have been obtained in decoding the brain codes of visual perceptions not only for static and comparatively simple black-and-white visual images [7] but also for moving color images—a movie fragment perceived by a test subject (corresponding images felt by the testee were displayed on a computer screen as the result of the analysis and synthesis of elements of their brain correlates obtained mainly with the method of functional magnetic resonance tomography (FMRT)) [8]. This area of neuroscience, which is developing very rapidly, is called *brain reading*, but we can offer a more correct name, *neurocryptology*. Its objective is to decode the brain codes of various SR phenomena (not only visual but also auditory and tactile perceptions, emotions, voluntary actions, and even thinking) [9], and it acquires strategic importance for the creation of principally new brain–machine interfaces and for the development of cognitive technologies.[2] However, it is impossible to improve the efficiency of this area without a fundamental phenomenological development of the *objects of code decoding*—SR phenomena. The

[2] I would like to say (although this is not quite correct on my part) that the theoretical and methodological program of decoding the brain codes of psychic phenomena was rolled out on a grand scale using the information approach in my book published more than 40 years ago [10]. I should stress the importance of neurophysiological research in this area by N.P. Bekhtereva, with whom I collaborated closely at that time. This research was discontinued or at least seriously disrupted after the publication of the slashing review article by N.P. Dubinin in the journal *Communist*, an organ of the Central Committee of the Communist Party of the Soviet Union, who wrote the following about the decoding of brain codes: "here is a pretense to make recommendations from scientific and ideological positions that are absolutely alien to us," "it is an open revision of the Marxist–Leninist understanding of consciousness" [12, p. 73].

current studies do not give them clear definitions,
13 reducing the efficiency of deliverables in this area.

The formation of an object for decoding requires the correct *discretization* of the SR continuum as the *current present* and breaking it down into elements and fragments. It is desirable that discretization reach the level of quantification of SR phenomena. This operation may be implemented for comparatively simple phenomena (sensations, perceptions, and some emotional states). It implies the minimization of a given SR phenomenon by content and time. For example, in a tachistoscopic experiment, I perceive a white square against a black background in a dark room in a minimal time. This may be called a quantum of visual perception. Let us assume that information $\underline{A}$ is such an SR quantum. Then its medium $\underline{X}$, the unknown code structure, must be limited to the same time interval. A multitude of my perception quanta makes it possible to form a *personal invariant* of perception $\underline{A}$ and, thus, set a corresponding personal invariant $\underline{X}$. *Interpersonal invariants* $\underline{A}$ and $\underline{X}$ can be formed in the same way if various individuals take part in the experiment for this purpose. We need clear and strictly defined invariants of this type to observe the principle of experimental repeatability. This refers not only to the invariants of various SR phenomena but also to the invariant of any SR phenomenon, that is, to the invariant description of a felt state in general and, consequently, to the description of specific properties of brain activity and specific information processes that set the presence of SR in all of us in a given interval (unlike information processes in the brain, which, according to D. Chalmers, take place in the dark).

We have sufficient grounds to think that code neurodynamic systems like $\underline{X}$, which are the media of certain SR phenomena, although they include a wide spread of elements and properties, nevertheless, have common characteristics that allow us to identify and decode the code of given information (a given SR phenomenon). The followers of the opposite point of view usually refer to the fact that an observer deals with single, original, and inimitable phenomena. Yet the human being always overcomes this abyss of diversity one way or another, creating proper invariants! The necessary conditions of any scientific research are the formation of such invariants, which fix the unity in diversity, and their use for the purposes of scientific explanation. It is safe to say that this is a common place for a scientist. However, like many simple truths, it harbors many theoretical difficulties, which affect especially strongly the formation of clear invariants of SR phenomena that are offered as objects for decoding their brain codes. These difficulties are amplified by the absence of a taxonomy of SR phenomena, drawbacks in their classification, and extremely feeble attempts to put their diversity in theoretical order.

I developed a way to form personal and interpersonal invariants of a visual pattern and the corresponding neurodynamic media in [10, pp. 284–300]. As for the formation of an interpersonal invariant of any SR phenomenon, analysis allows us to conclude that any individual SR phenomenon that can be recorded (even a quantum of sensation or perception) and whose neurodynamic correlate is attempted to be identified proceeds against the state of wakefulness experienced by the individual, that is, against the general SR state. This circumstance, unfortunately, is very often ignored. Here we need to understand the extremely complex and multidimensional value–notional and action–will structure of subjective reality and its self-organization, whose core is our *Ego*. Therefore, any SR phenomenon taken separately even as its personal invariant always bears the properties of this structure to a certain degree and cannot be conceived without accounting for them.

Coding and decoding processes primarily indicate the necessary participation of memory in them and the circular structure of the experienced content of a given SR phenomenon in a given interval of the current present. These aspects of decoding are of fundamental importance and the subject of special studies [13–16]. No less important are the phenomenological properties of the object being decoded, which are predetermined by the multidimensional dynamic structure of subjective reality. Thus, any SR phenomenon reflects not only a certain external content but itself as well. This manifests its irremovable appurtenance to its *Ego*, a quality that psychiatry calls the *sense of belonging* and which is violated only in pathological cases, leading to depersonalization phenomena, well described by psychiatrists, and usually related derealization phenomena. The unity of "extrareflection" and self-reflection allows us to assume that the basic dynamic SR structure is bimodal; i.e., its main relations, which determine the dynamic integrity of subjective reality, represent a unity of the opposite modalities of Ego and non-Ego, which is implemented by their mutual supposition and alternating reference [17, pp. 83–116; 18]. Such bimodality, which includes a mechanism of alternating mirrorlike reference, should also be inherent in the neurodynamic organization of the code structure of any SR phenomenon. Although we are at distant approaches to an understanding of its arrangement, there is no doubt that this particular feature of any conscious act allows us to explain the phenomenon of "reflecting a reflection," which is inherent in any SR phenomenon.

In addition to two integral parameters (memory and the basic SR structure), we should distinguish another six parameters describing SR phenomena. They may be called analytical because each of them designates one "dimension" in the multidimensional dynamic SR structure. Taken together, they create the basic charac-

teristics of a model that can reflect the major properties of the code neurodynamic organization.

Let us consider each separately.

The *temporary* parameter fixes an isolated SR phenomenon in a certain time interval. The corresponding neurodynamic code also functions in the same interval, which limits the zone for its search and identification.

The *content* parameter (or, better, the parameter of contents) means that any SR phenomenon is a reflection and a meaning of *something* and that it fixes the necessary presence of contents in each interval of the current present regardless of the adequacy or inadequacy of these contents and of the fact whether it acts as a nonrecurring experience or a personal/interpersonal invariant. This parameter points to the functional mechanism of the neurodynamic organization, which codes the contents of this SR phenomenon, and aims at its experimental search. This is probably the greatest difficulty in the problems of decoding. Although simple content types of SR phenomena are reproduced on a computer display by FMRT, we should understand that the observable tomogram, being a correlate of the experienced phenomenon, nevertheless, expresses its actual code neurodynamic organization very indirectly. Therefore, such studies may be called only the first step in solving the problem of decoding the brain codes of SR phenomena.

The *formal* parameter means that any content of an SR phenomenon takes a certain form and belongs to a corresponding class, genus, or species; that is, it is *categorized* one way or another. When we speak about visual perception or perception in general, we mean a certain form of existence of sensory images, which organizes their colossal diversity. Despite the absence of a scientific taxonomy of SR phenomena, in most cases, we use successfully formal discretizations, developed and sanctioned by psychology on the basis of generalizations of everyday experiences and natural languages (sensation, visual perception, perception in general, conception, notion, etc.). The formal parameter aims at identifying functional neurodynamic mechanisms that implement the operations of categorization, classification, generalization, and identification.

The *true/false* parameter characterizes any SR phenomenon in terms of its adequate reflection of a corresponding object. It can be true or false, ambiguous or indefinite, but in all cases our basic mindset on truth and rightness remains. Any interval of the current present includes sanction: to accept or not to accept the given contents. This mechanism is far from perfect and often selects false and absurd concepts as true and correct. However, all true ideas and theories originated and started off in the minds of individuals; they were first sanctioned by the individual; and only with time were they acknowledged at the level of interpersonal and suprapersonal relations. The presence of a personal sanction in the structure of SR phenomena allows us to assume that the same functional mechanism exists in the neurodynamic code organization of a SR phenomenon under study and to outline ways of its special study.

The *value* parameter characterizes the importance of the contents of a felt SR phenomenon for a person and the person's attitude to it. The value dimension has its specifics that cannot be reduced to the true or other SR parameters. It is well known that false concepts may be of an exceptional value for a person and true concepts, of a very low and even negative value. The structure of personal value-based relations includes three types: hierarchical (clear division into higher and lower values, subordination of the lower to the higher, and unambiguous choice); peer (numerous value-based intentions that are on the same and mostly low level, easily interchangeable, and their choice is either very difficult or, reversely, very simple), and competitive (two incompatible value-based intentions that require choice; if no choice, a poignant state of ambivalence arises, which, however, can be ousted successfully). A value-based intention that dominates in a given time interval determined the choice, the decision, and the action. The value parameter denotes a similar specific functional mechanism in the code brain organization of SR phenomena that motivates various nisus and sanctions (cognitive, emotional, painful, etc.).

The *pragmatist* (intentional–willful) parameter characterizes any SR phenomenon in terms of its activity and points to factors such as a projection to the future, foresight, the definition of objectives and purposefulness, the expression of will, and action. This parameter expresses an *activity vector* as a special quality that cannot be replaced with any of the above parameters despite a close relation with them, especially with the value parameter. It is important to view activity in its self-development as a process of permanent formation of innovations, including significant changes in its direction and ways of implementation, which ensures the possibility of developing more perfect forms of activity. This parameter aims at study of specific functional mechanisms in brain activity, which maintain activity states and implement them in various activities, as well as processes of neurodynamic self-organization, which serves as a necessary factor of the functioning of the neurodynamic code media of SR phenomena.

Thus, the briefly described parameters for the description of SR phenomena point to similar functional mechanisms of the brain neurodynamic organization, which should serve as the subject and goal of neuroscientific studies when solving the problems of brain decoding. Registering the main dynamic dimensions of the multidimensional SR structure, they can be used for building more sophisticated computer

models of code representations of SR phenomena in the brain and, thus, for understanding the dynamic self-organizing structure that functionally predetermines the existence of consciousness.

On the basis of the principle of information invariance in relation to the physical properties of its medium and, consequently, the principle of system
17 isofunctionalism, substantiated by A. Turing and meaning that one and the same function or complex of functions can be reproduced on substrates different in their physical (chemical) properties, we may make a conclusion about the theoretical conceivability of SR reproduction on other media. It is possible to create elements (different from neural ones in their physicochemical and morphological properties) and a dynamic self-organizing system built from them that will be able to reproduce information processes, that is, supply the control center of this system with information in pure form, provide for the ability to operated it, and thus constitute reflexive and bimodal mechanisms of information processing, characteristic of our *Ego*. The convergent development of nano-, bio-, information, and cognitive technologies is moving increasingly in this direction, creating new components and ways of self-organization, opening up prospects for the formation of artificial intelligence and for the transformation of human nature. In recent years, these problems, which are of strategic and fundamental importance for the future of the earth's civilization, have become a topic of serious discussion by prominent scientists and philosophers. Numerous conferences, symposia, and discussions have been dedicated to them. An important event was the recent Global Future 2045 International Congress, held in Moscow and attended by representatives of science from various countries of the world.

CAUSAL EFFECT OF PHENOMENA OF SUBJECTIVE REALITY ON CORPORAL PROCESSES

An SR phenomenon as information based on the existing code dependency is the cause of external or internal corporal changes and personal complex actions and predetermines their result. In addition, information is sort of "isolated" in the continuum of physical interactions (as long as the code structure of a given self-organizing system is preserved). When I say to a person, "Come up to me!," and the person fulfills this action, it is generated and determined not by the physical properties of the words that I pronounced but by the information expressed in them, its semantic and pragmatic characteristics. The physical properties of the information medium in themselves do not explain the resulting effect, although they necessarily participate in the act of determination. This is proved by the fact that I can generate the same effect by other words and, in general, by signals very different in their physical properties. Here we have a special type of causality, *information* causality. Its specifics, compared to physical causality, is determined by the invariance principle. A type of information causality is psychic causality. The notion of psychic causality also covers unconsciously produced actions. However, despite the very close relation between the conscious and the unconscious levels of the psyche, we are first of all interested in actions taken consciously, initiated by existing SR phenomena. Therefore, in this case, it is better to use the notion of *mental* causality as a subtype of information causality (under the condition that the scope of the notion "mental" is limited to SR phenomena).

It is important to stress that the notion of information causality does not contradict the notion of physical causality, which fully preserves its meaning even if it does not pretend to the role of a universal tool of explanation of all phenomena of reality, for instance, an explanation of the causes of an economic crisis or the causes of a self-sacrificing act. As for psychic causality, it gives a scientifically justified answer to the classical question of the effect of the mental on the physical. Yet here the reciprocal question arises: the effect of the physical on the mental. Even if we disregard cases in which strong mechanical, temperature, radiation, etc., effects destroy brain code structures and biological organization, physical causes may serve to explain the significant properties of the mental, when we are speaking about direct sensory reflections (sensations, etc.); or such effects on code structures that lead to mutations; or electromagnetic, chemical, and other effects on the brain. However, in all these examples, physical causes are often mediated by information processes and, consequently, information causes. Thus, the notion of information causality broadens significantly the theoretical tools of scientific explanation and becomes necessary if self-organizing systems (biological, social, and technical in a number of relations) become the subject of research. Theoretical and empirical justifications of information causality differ significantly from the principles of describing and explaining physical causality.

Together with the capability to have information "in pure form," we were given the capability to operate it in a very wide range. This expresses the activity of subjective reality. It includes voluntary actions that can be taken not only purely mentally but also communicatively and practically. Analysis of the structure of a voluntary action points to a significant role in it of the areflexic level and registers, which ensure stable reac- 3
tions and human behavior. However, the initiator and regulator of this action is always a certain SR phenomenon. Therefore, a voluntary action is graphic evidence of mental causality. Let us take an example. I want to turn on a desk lamp and do so by bushing a button. In this case, the mental cause in the form of my desire rep-

resents an action program and launches a chain of code transformations, well worked out in phylogenesis and ontogenesis (serial and parallel switching on of code programs of arm movements and other associated corporal changes, as well as code programs of energy support for the whole complex of actions that achieve the result). An SR phenomenon with a higher value ranking can have a more powerful causal effect on corporal
18 processes. Well known are somatic effects of a "supervaluable idea" and many similar manifestations of the extraordinary power of psychic causality and mental control. We may refer to the experience of the Great Patriotic War, many striking examples of fortitude and will, allowing outstanding feats for the love of the Motherland, duty, honor, and justice.

Mental causality means not only mental effects on the corporal but also mental effects on the mental. The fact that one thought can affect and cause another is our omnipresent psychic experience. Despite difficulties in the discretization of SR phenomena, comparatively simple cases allow us to imagine associative transfer from one of them to another as a cause–effect relation. For example, visual image $\underline{A}$ causes in me in the next moment visual image $\underline{B}$. Such mental causality or the "mechanism" of posteriority of $\underline{B}$ from $\underline{A}$ is not fundamentally different from processes where an SR phenomenon causes a certain corporal change. Different are only the contours of code transformations or those subsystems of the brain where they happen and the character of effector changes (their presence or absence in external organs).

Information $\underline{A}$ is encapsulated in neurodynamic system $\underline{X}$, and $\underline{B}$, correspondingly, is in neurodynamic system $\underline{Y}$. The transformation of $\underline{A}$ to $\underline{B}$ is the transformation of $\underline{X}$ to $\underline{Y}$. If I can do it of my own volition, this means that I can operate and control these brain neurodynamic systems. Controlling the phenomena of one's own subjective reality and one's own thoughts is control of the corresponding brain code structures. Everyone of us of one's own volition constantly controls various classes of the neurodynamic systems of one's own brain, although one does not feel this and does not even suspect, as a rule, of such ability of one's *Ego*.

Yet what is our *Ego* in terms of neuroscience? According to recent research, the *Ego* is represented in the brain as a special structural–functional subsystem,
19 which is called the *Ego system* of the brain (or Selfhood). It includes genetic and biographical levels of stable properties of an individual and comprises the highest personal level of brain self-organization and control, which forms, in turn, the conscious–unconscious contour of psychic processes [19, 20]. This is the level where code transformations take place that represent our *Ego* and information in pure form (i.e., as SR) and ensure the *Ego*'s activity as voluntary actions and the *Ego*'s ability for self-organization, sup-
20 port of its identity, and implementation of mindsets and target vectors. The Ego system embodies personal features of an individual and the ability to express one's will. To this end, a question arises about the freedom of will and its compatibility with the determination of brain processes.

Note that those who reject the freedom of will cross out themselves as personalities and divest themselves of any responsibility for their actions, including the statement that there is no freedom of will. Everyone of us is sure that, in many cases, one can, at one's discretion and will, choose and operate these or those concepts, thoughts, intentional vectors, etc., although SR comprises classes of phenomena that are overpoweringly imposed on us from outside or from within and resist or partially yield to control, often with great difficulty (pain, emotions, etc.). Nevertheless, our *Ego* can control itself and its SR phenomena in a very broad range and, moreover, expand it.

If the ability to control voluntarily one's concepts and thoughts is the ability to control their brain code media, this means the ability to control the energy supply of these operations, including the corresponding biochemical processes; to change action programs and, consequently, change their neurodynamic structures; and to expand the contours of psychic regulation (including the creation of accesses to vegetative functions, as yogis can do when, for example, they voluntarily change their heart rhythm). This approach allows a deeper probe into the phenomena of "thought strain" and "will strain" and ways of intensifying the creative process and of creating new resources of psychic self-regulation, not only functional but also ethical. In other words, we are capable of constantly expanding the range of abilities to control our brain neurodynamics (with all its desirable and maybe undesired implications).

Yet the human ability to control one's brain neurodynamics voluntarily means that the Ego system of the brain is a self-organizing and self-controlling system. Consequently, a freedom-of-will act (in terms of the choice made, as well as in terms of generating an internal effort to achieve a goal, including energy support for the action) is an act of self-determination. This means that the notion of determination must be taken in the sense of not only external but also internal determination, set by programs of the self-organizing Ego system and the brain in general. This eliminates the thesis of incompatibility of the notions of the freedom of will and determinism of brain processes. These issues are of fundamental importance for brain decoding, because the latter also represents self-organizing systems, i.e., functional elements of the Ego system of the brain.

In the context of the problems of psychic causality and the freedom of will, we often find a sacramental question that symbolizes an explanatory deadlock: how can the mental (an SR phenomenon) affect the brain if the brain generates it? In terms of the informa-

tion approach, the answer is simple. The mental, by all means, affects the brain in the sense that the activated code neurodynamic system, which carries information in "pure form" (the mental) to a person, is capable of affecting other code structures of the brain, including those that implement information processes
21 at the prepsychic level and thus affect various levels of brain activity, including blood circulation processes and biochemical and electric changes in individual neurons and synaptic networks. This happens sometimes in an especially strong and pronounced form, for example, if a happy thought comes unexpectedly. This
18 is an inspiration and a supervaluable mental state, which is accompanied by an emotional surge and boisterous productive activity (mental or practical). Initiated at the level of the Ego system, it produces functional changes in other brain subsystems and finally causes strong reactions in a number of internal organs and in the whole system. Any mental state of an individual is a product of a specific brain activity at the level of its Ego system, and, when it occurs, the functioning of practically all brain subsystems changes significantly (compared to states when the SR state is absent, i.e., during deep sleep or temporary loss of consciousness).

CAUSES OF SUBJECTIVE REALITY

We are left with one issue, probably the most complex: the origin of subjective reality. It may be formulated in the following way: "What is subjective reality designed for?" or "Why did it originate during biological evolution?" I will try to answer this question briefly from the position of the information and evolutionary approaches, relying on my earlier work [21].

The process of the origin of metazoans put forward a cardinal task whose solution predetermined their survival: to create a new type of control and maintenance of integrity. After all, the elements of such a self-organizing system are cells that also represent self-organizing systems with their quite rigid programs, run and polished by evolution over hundreds of millions of
22 years. In a multicellular organism, such programs had to be agreed with a general organismic program and vice versa. This demanded an optimal measure of centralization and autonomy of control contours, a measure capable of ensuring the preservation and strengthening of the integrity of a complex living system in its incessant interactions with the external environment. We mean a measure of control centralization that does not violate the fundamental programs of individual cells and such a measure of autonomy of their function that does not hinder but contributes to their consensual participation in the implementation of programs that are fundamental for an integral organism. Together with control centralization, it demanded the efficiency of its operation and a high speed of information transfer. This measure of centralization and high efficiency was reached due to the emergence of psychic control in those metazoans that moved actively and stayed in constantly changing conditions. Therefore, the psyche does not develop in organisms with minimal motor activity and fixed to one place, for example, plants.

Evolution demonstrates a very close relation between motor and psychic functions. Hence, there is an obvious causal ability of the mental (information) to perform external actions directly and instantaneously and to control the organs of movement. By contrast, control of internal organs and processes appears to be automatic at the unconscious and prepsychic levels. At the same time, there is constant 21
"trimming" of different parameters of local and integral changes (energy-based and informational) in the internal environment of an organism for its efficient actions in the external environment.

Psychic control is related to the process of specialization of cells and the origin of a nervous system, which has the functions of programming and implementing actions based on analysis and integration of information that comes from the external and internal environments. The products of this integration are initially expressed as sensations–emotions and, only at the subsequent stages, as more complex SR forms (perceptions, ideas, concepts, thinking operations, etc.). Consequently, the operative mechanisms of SR also become more complex. The animal psyche has an SR quality that, at higher levels of evolution, acquires a rather complex structure in animals, including the hierarchical centering of SR phenomena, or a certain "selfhood," which is an evolutionary precondition for 19
the human Ego system. Therefore, we may say that SR represents a specific level of information processes at the level of the human brain's Ego system.

In order to shape information as subjective reality, it is necessary to perform its two-stage code conversion at the Ego system's level: information that stays "in the dark" is represented at the first stage, and a natural code of a higher order is formed at the second stage, thus creating an information phenomenon about information; i.e., information is opened up and made relevant for a personality. The SR states of wakefulness, attention, circumspection, constant readiness for immediate actions, search for necessary means of subsistence, probing the environment for potential dangers, and dispatching vital functions initiate a new stirring activity of a living system. Subjective reality, which is created by the subsystem of natural codes of the second order within the Ego system, is *virtual reality* or the initial basic form that, during anthropogene- 23
sis, during the emergence of language, and during social development, acquires new forms of external objectivation. Information processing in such a code structure, i.e., at the virtual level, is operationally efficient, and it can be performed independently from

external effector functions, which turn on only after an action program has been formed and sanctioned.

The development of the psyche initiated growth in the roundaboutness and multidimensionality of information-about-information production. The range of virtual operations expands, making the generalization of experience more efficient; developing the ability of "delayed actions" and virtual trial actions, the ability of forecasting, and the ability of building models of a probable future; creating an ever-higher level of stirring activity; and multiplying its degrees of freedom. In humans, unlike in animals, information processes acquire new essential features thanks to the emergence and development of language. This primarily concerns an additional and very productive level of coding and decoding, created by the language system, which qualitatively improves the analytical and synthetic abilities of information operation and develops metarepresentation and reflection abilities.

Why is information about an active agent not just represented but felt as SR? This occurs because feelings in the form of subjective reality combine the functions of reflection and control, thus being a way of representing and actualizing information for Selfhood, an easy quick, and, primarily, arbitrary way that allows us to operate information that unveils in its pure form (i.e., at the level of virtual reality). The question of how or by which mechanisms information processes in the brain create subjective reality lies within the competence of modern neuroscience. Studies show that a condition for the emergence of a subjective feeling is a circular process and information synthesis in certain brain structures (works by A.M. Ivanitskii, V.Ya. Sergin, M. Arbib and G. Rizzolatti, G. Edelman, A. Humphrey, etc.). Subjective feelings in the form of sensations arise during comparison and synthesis on the neurons of the projection cortex of two types of information: sensory (about the physical parameters of a stimulus) and data (retrieved from the memory) about the significance of the signal. Information synthesis is assured by the mechanism of impulse return to initial projection locations after a response from brain structures that are responsible for the memory and motivation. A feeling is an act of "information synthesis" within the above cycle [22]; it occurs as the result of a high-frequency cyclic process of identification [23, 24].

Thus, any SR phenomenon carries simultaneously information about a certain object and information about this information (at least, as a feeling that it belongs to me or to my *Ego*). As for the elimination of the reflection of the brain medium of information, it is inherent in any psychic activity. The ability to reflect neither originated nor developed during evolution because of the invariance principle. Since the same information can be carried and transferred by media that differ in their properties, the medium's ability to reflect did not matter for the adequate behavior and survival of an organism. These required only the information itself and the ability to use it for the purposes of control. So, these functions developed during evolution and anthropogenesis. Humans, as they practiced all their social and life activities, had no need either for information about the brain medium of the information that they operated. However, the situation has changed recently. After decoding the genetic code, the decoding of brain codes of psychic phenomena (primarily SR phenomena) was put on the agenda, and this problem is being developed successfully, as was mentioned above. There are grounds to believe that objectives related to this problem are caused by societal needs and that successes in meeting them mark the beginning of a new stage of human development and social self-organization.

Even elementary analysis shows that the ability of a self-organizing system to display an information medium and to control this medium broadens immensely the sphere of its cognitive and transforming activities and, most importantly, the abilities of self-transformation. In this context, we may speak about new opportunities to transform those genetically predetermined properties of human nature and consciousness that serve as the initial cause of the ever-deepening environmental crisis and other global problems of human civilization, primarily, the irrepressible individual consumer intention and aggressiveness to other humans (and thus to oneself). If these properties are not changed, an anthropological disaster will await us. It is understood that there are other theoretically conceivable options of overcoming the current crisis of our civilization and rising to a new stage of development, but they all depend on civilizational self-transformations that imply change in the consciousness of a social individual. The latter appears to depend one way or another on the results of the elaboration of the consciousness–brain problem.

ACKNOWLEDGMENTS

This work was supported by the Russian Foundation for Basic Research, project no. 11-06-00133a.

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SPELL: 1. tideway, 2. conations, 3. areflexic, 4. psychical, 5. intersubjective, 6. psychophysical, 7. psycholinguistics, 8. metatheoretical, 9. preprogrammed, 10. autocerebroscope, 11. closedness, 12. testee, 13. deliverables, 14. mindset, 15. suprapersonal, 16. nisus, 17. isofunctionalism, 18. supervaluable, 19. Selfhood, 20. mindsets, 21. prepsychic, 22. multicellular, 23. anthropogenesis, 24. roundaboutness, 25. metarepresentation