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**Discreteness and Continuity of Information in Consciousness  
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This article addresses the question of how information is organized in the human mind, particularly the fundamental possibility of extracting any kind of structural units from the array of information perceived and processed, and the potential for identifying the smallest, “elementary,” unit of information applicable to consciousness. The process of perception is regarded as a process in which information received from receptors is sequentially generalized, compared with previously acquired experience, and converted to ma- terial for forming higher-level abstract concept. The process of “understanding” concepts is considered as a process opposite to the process forming them, i.e., a process during which the mind’s encounter with a previously assimilated concept reactivates the multitude of images and associations which previously served as the material for its formation. The question of identifying key characteristics and most significant associative connections in the array of information is addressed with respect to the normal mind and the pathology of schizophrenia spectrum disorders.

**Keywords:** perception, categorization, semantic memory, salience, schizophrenia.

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**1. Introduction.** The main task facing neurophysiol- ogy is to understand how physiological processes occur- ring in the brain relate to our subjective reality. The main contemporary methods of studying brain activity are EEG, MEG, and fMRI. Individual experiments generally analyze some quite complex cognitive process using these methods, i.e., consider the question of how measures such as EEG parameters change when subjects perform some task or oth- er. The quite complex cognitive process is related to quite complex changes seen in the EEG or fMRI, often described with the word “pattern.” Study of the patterns of one or an- other cognitive process leads to so-called “brain reading” [3]. It has become possible to use EEG patterns to recognize how a cognitive process occurs in the brain at a given time point. Nonetheless, the physiological sense of the patterns observed and the concrete mechanisms supporting solution of various cognitive tasks remain unclear.

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In this regard, consideration of cognitive activity from the point of view of the most elementary “cognitive acts” – simple operations performed by our brains with information to support a multitude of intellectual activity – is interesting and valuable.

The conceptof information and the information pro- cess has quite long been used to describe relationships be- tween the mental and the physiological. Subjective reality (mind) and objective reality (physiology) are two manifes- tations or aspects of the information process. Thus, consid- eration of operations performed by the brain using informa- tion is valuable in solving problems in psychophysiology. However, before considering these operations, we should clarify and specify the concept of information in neurophys- iological and mental terms.

In computer technology, information is a measurable quantity and is measured in bits. One bit is either “0” or “1” in digital code, i.e., conduction or not conduction of an electrical signal. As applied to the human brain and con- sciousness, identification of such an “elementary unit” of information involves a number of difficulties. Primarily, it is problematic to identify an “elementary unit” of informa- tion for our subjective reality. The search for such an “el-

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ementary unit” raises the question of the extent to which information contained in and arising within our mind can in general terms be divided into fragments.

On the one hand, it is obvious that we extract separate concepts, images, and categories of concepts, as well as sep- arate features of objects and concepts – in this sense, infor- mation in our minds has a definite discreteness. On the other hand, attempts to define any even simple concept (a boot, food, ball, etc.) generates the need to involve a multitude of concepts and, ultimately, the whole of the individual’s accumulated experience. We define a boot as “footwear” and “something made of leather” and link it with the con- cepts of “walking,” “legs,” and “clothing.” These concepts in turn can be defined only via other concepts. Thus, each concept “pulls along” a chain of associations linking it with the whole cognitive experience. In this sense, information in our minds is indivisible and exists as integral cognitive experience, where all concepts are associatively linked and actually indivisible from each other.

How can the ability to operate with individual concepts and the impossibility of understanding them without involv- ing the whole gamut of cognitive experience be reconciled?

To answer this question, we will consider two process- es – the process of formation of concepts during the percep- tion of reality and the process of revealing the essence of concepts when they are presented and utilized in context, which for the purposes of this article we shall term “under- standing” of concepts.

**2. The Formation of Concepts.** Concepts are the re- sults of generalization of information coming from the senso- ry organs throughout life. We will therefore start by consid- ering their formation from the process of perception. We will consider this process using the visual analyzer as an example.

*Perception.* Concepts have meaning, while the infor- mation arriving at receptors in and of itself is meaningless. It becomes meaningful when is it compared with existing human experience. This is the point at which a person be- comes aware of this information and determines a relation- ship with it, i.e., the meaning of this information for the per- son. This process of awareness of information is described in information synthesis theory [2]. The sense of this theory is that any new information arriving in the brain is com- pared with information stored in memory and the subjective feeling arising from something seen or heard is the result of this comparison or, in other words, “synthesis” of the new information with existing experience.

Clearly, in order to compare something with something else, or “synthesize” them, there is a need to divide the in- formation stream arriving at the receptors into some kind of fragments. Fragments of the information stream can be relat- ed to fragments of information stored in memory. Thus, there is a need to discretize the information stream and separate information perceived by a person into its constituent parts.

*Discretization of information on perception of a visual scene.* This discretization process actually occurs, and starts

before information arrives in the cortex, at the level of the retina. The basis for this is the difference in the physical characteristics of the elements of a visual scene. A visual scene observed by a human initially contains spots of dif- ferent colors, different illumination, and different shapes. Contrast and increases in these differences are the basis of processing of visual information in the retina, lateral genic- ulate body, and primary visual cortex [4]. This is support- ed by the presence of cells selectively responding to illu- mination at the center and periphery, as well as the lateral inhibition mechanism. This leads to contrasting of images in terms of color, which creates the grounds for extracting object boundaries, i.e., dissection of the entire visual scene into its component parts. The primary visual cortex carries out not only further contrasting of images in terms of color, but also recognizes the spatial orientation of visual objects relative to the vertical and horizontal axes [73, 78].

*“Comparison” with memory.* The initial visual scene perception process is well described in the literature. It consists of a retinotopic projection of an image in the pri- mary visual cortex with contrasting of color spots. The subsequent “fate” of the visual information is less clearly described in the current literature. Most investigators in this area address the selective activity of one or another cortical area on recognition of various geometric shapes and specif- ic visual objects [55, 71]. The process of recognition of hu- man faces in the fusiform gyrus has been particularly well described [80].

The word “recognition” itself, used in describing these information processes, immediately implies comparison of the new information with existing information. A person sees a new previously unseen face but recognizes it as a face, i.e., an already familiar object. The information synthesis pro- cess described above operates. Discretization of information does not yet occur; conversely, it is not individual color spots which are recognized and compared with memory data but combinations of spots (for example, faces). This raises the question of how and by what principle color spots are com- bined into typical objects which are recognized and used to transmit to memory the information required for recognition – the initial image of a face, for example. An answer to this question is provided by prototype theory.

*The Rosch prototype theory. Connectionism.* Recogni- tion of the most diverse objects becomes possible thanks to the existence of their prototypes – generalized images used for perception – in memory. Rosch took the view that proto- type formation begins from the moment at which perception starts and continues throughout life. This process is based on assimilation by humans’ neural networks of defined sta- tistical patterns. In the real world, color spots are presented to a person not chaotically, but in characteristic combina- tions with each other. Thus, one of the earliest objects in reality that a child learns to recognize is a face, specifically its mother’s face. This becomes possible because of repeat- ed presentations of the characteristic combination of col-

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or spots (eye, nose, mouth). These characteristic repeated combinations of features become prototypes [67].

Prototypes in turn also form stable combinations with each other which are also “remembered” and become proto- types at a higher level of generalization. Thus, a “face” is generally presented to a person along with arms, legs, and other attributes of the human body. “Remembering” this characteristic combination of features, the child forms the prototype “human,” which will later be supplemented by all the new characteristic features (not necessarily in the visual modality). With the onset of speech and the ability to relate them with words, these become concepts.

This principle of training neural networks to extract frequently encountered combinations of features is well packaged in the concept of connectionism. This is an ap- proach to the study of cognitive processes built on modeling of cognitive processes using artificial neural networks. The very process of learning by neural networks (artificial or human) to extract characteristic or frequently encountered combinations of features is termed statistical learning. The principles of statistical learning have now been applied to modeling many processes in human thought. In particular, they have been shown to be able to learn to extract words from human speech [17] and to classify images of animals and furniture [63].

We note that from the connectionism viewpoint, mem- ory, in which prototypes for comparison and recognition are “stored,” is not some abstract separate place in the cortex but a property of the neural networks involved in perception and trained to extract specific combinations of features from a large information stream. Recognition of these combina- tions leads to activation of higher-level neural networks rec- ognizing characteristic “combinations of combinations” at lower-lying levels. A hierarchical system arises, tuned to extracting even deeper patterns from the information con- stantly arriving from receptors. We will discuss this system in more detail.

*Information transformations in the formation of con- cepts. Inclusive characteristics.* Formation of concepts or recognition of visual objects using initial sensory informa- tion involves two transformations:

1. A significant volume of information on the physical characteristics of the object is lost. The “table” or “human face” prototype does not contain information on the specific parameters of any one or another particular example. Recognition of the object requires only a quite small set of key characteristics. A face can be recognized even from a diagram. This obvious fact has a concrete neurophysiologi- cal basis. Neurons involved in recognizing faces have been shown to be sensitive to the distances between different parts of the face such as the eyes, mouth, brows, and hair [80]. This distances and characteristic proportions operate as key features allowing the face to be recognized as a face.

2. Loss of initial sensory information is “compensated for” by the concept acquiring a semantic load. Recognition

of one or another object opens up access to an enormous multitude of its properties which the person has acquired during the whole of life. Recognition of a face or percep- tion as a specific familiar person immediately actualizes a significant volume of information characterizing the role of this person in the life of the person now hearing the name or recognizing the face.

This reduction in the volume of information when “its quality is improved” can be illustrated from the point of view of the inclusive characteristic proposed by Sergin [6]. According to this hypothesis, the first layer of neurons involved in the act of perception and the first layer of neu- rons in the occipital cortex retinotopically reflect the image falling on the retina. The second layer of neurons involved in the act of perception has a wider receptive field than the first and reflects not the image itself, but specific patterns of activation of the first layer. These specific activation pat- terns are also inclusive characteristics. The inclusive charac- teristic arises because of partial reduction in the volume of information (information on each pixel in the image) and ex- traction of key features (for example, an area of a single col- or). Subsequent layers of neurons have even wider receptive fields. They analyze combinations of inclusive characteris- tics from lower-lying layers, extracting their key elements and forming the inclusive characteristic for the next higher neuron layer. This forms a hierarchy of inclusive character- istics whose morphological basis is a hierarchy of neuron layers with ever wider receptive fields. In the information sense, formation of the hierarchy of inclusive characteristics immediately provides for a reduction in the volume of per- ceptual information by means of extraction of its meaningful fragments (ultimately, recognition of faces, objects, etc.).

The concept of an inclusive characteristic largely pro- vides for solution of problem of discreteness, continuity, and “elementary units” of information formulated in the title of this article, in least in relation to the process of perception.

The initial perception of a visual scene occurs discrete- ly as soon as it is carried out by discrete elements, i.e., reti- nal cells and primary visual cortex neurons. However, each subsequent level of visual information processing implies generalization of information from the preceding level in the form of an inclusive characteristic. We note that the in- clusive characteristic is not divided into any component el- ements. Thus, recognizing a human face, we recognize the typical combination of elements rather than the elements themselves and not simply their sum. In this sense, we can say that there is an inclusive characteristic for each level of perception of an elementary unit of information, which in turn is the result of generalization of the inclusive character- istics of the preceding level but in no case are they included as constituent parts. The question of defining an elementary unit of information must therefore be answered separately for each specific level of perception.

*Abstract concepts.* Prototype theory provides a good description of the formation of elementary concepts on the

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basis of generalization of immediate sensory experience. As a child develops, it starts to assimilate ever more abstract concepts which are not directly linked with perceptual ex- perience and are derived from a system of concrete con- cepts. There are several theories as to how our mind forms abstract concepts.

Barsalou regarded the formation of abstract concepts as a process of modeling internal states [11]. According to this theory, abstract concepts arise as a result of generaliza- tion of concrete concepts and their linking with humans’ in- ner subjective feelings and experiences. Lakoff and Johnson addressed the formation of abstract concepts in terms of metaphor, i.e., by alienating the properties from the object [41]. Emotional states and other fragments of cognitive ex- perience are described using a kind of thought by analogy. Abstract concepts and perceptually inaccessible processes are described by analogy with concrete processes available to direct perception. This point of view finds some reflection in language. We can provide numerous examples of words arising from concrete concepts but associated with abstract concepts. These include, for example, words formed from the characteristics of space – “increase” (for example, in prices), “humiliation” [Translator’s note: The Russian word for *humiliation* is derived from the root meaning *decrease*], “correctness,” [Translator’s note: the Russian word for *cor- rectness* is derived from the roots meaning *rightness*] “left” (in the meanings *falsification*, *substandard*). Glenberg and Kaschak regarded formation of abstract concepts in terms of the development of motor skills and mastery by complex algorithms for actions [27]. Support for this theory comes from the fact that a person’s understanding of words des- ignating abstract concepts involves activation of the motor cortex [28].

The common idea behind all these approaches is a kind of “grounding” of abstract concepts in concrete concepts available to direct perception [62]. The brain generalizes in- formation available directly to perception and identifies its key features, which are universal for a series of concrete objects. This information can in turn serve as material for further generalization with extraction of ever more abstract and universal properties.

We again come up against the now familiar, from the example of perception of visual information, sequential generalization of information with decreases in the volume of data, but increases in the “quality” of the information due to the generation of a semantic component. We can say that the processes of information generalization and extraction of key characteristics does not end with recognition of con- crete images or formation of prototypes. Throughout life, these images themselves serve as material for subsequent generalization. During life, a person hoards and generalizes information on the external and internal world, forming con- cepts of ever higher levels of generalization and abstraction.

The concept of an inclusive characteristic is fully de- scribed in existing ideas of the formation of abstract con-

cepts and can be transferred from the area of direct percep- tion to the area of further multilevel generalization of the initial perceptual information.

The question of the discreteness or continuity of in- formation in the domain of abstract thought can also be ad- dressed from the point of view of inclusive characteristics. It becomes obvious that any concept, no matter how broad its meaning, cannot be dissected into component parts. This is easy to see when, for example, trying to “explain” a con- cept or look up its meaning in a dictionary. Such an “expla- nation” can never be exhaustive and can never convey the whole weight of subjective feelings and associations which the concept elicits in a particular individual person. At the same time, these associations cannot be regarded as con- stituent elements of a concept. A concept is an “elementary unit of information” for a given level of generalization. The associations and images whose generalization formed the concept are also elementary units of information, though for a different levels of generalization.

*The role of the hippocampus in forming concepts.* The general concept of the formation of simple prototypes (ta- ble, chair) and highly abstract concepts such as, for example, “cause” and “effect,” is the detection of repeating combina- tions of features in an initially meaningless sensory stream. Thus, it is logical to suggest that there is a mechanism en- suring constant fusion of different remembered episodes (even when significantly separated in time) with detection of patterns within them. This role is now mostly assigned to the hippocampus and its many connections with the cortex [32, 37, 38, 48, 53, 68]. The view is that the hippocampus supports fast memorization of individual episodes (episod- ic memory) by means of changes to functional connections within the hippocampus and by means of the connections of the hippocampus with the cortex, while small changes in short cortico-cortical connections, operating by statistical learning, support the slow assimilation of patterns encoun- tered in these episodes, i.e., semantic memory. Thus, the hippocampus supports the demarcation of separate memo- ry episodes, while the cortex detects general patterns within these scattered episodes. The functional “circuits” between the hippocampus and cortex are the material substrate for this process. These theories have been confirmed by studies of patients with hippocampal lesions. These patients have been shown to have impairments to the ability to establish new semantic connections [39, 40]. An interesting fact found from detailed studies of the hippocampus and its role in gen- eralizing experience and forming general semantic concepts was its functional heterogeneity. The dorsal segments of the hippocampus were found to be involved in forming more detailed concrete representations, the anterior parts forming more abstract representations [43, 60].

**3. The Utilization of Concepts.** Thus, a concept is some particular level of generalization of information by our brains. The utilization of concepts presumes the ability to actualize a set of associations connected with the con-

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cept. What neurophysiological mechanisms could support this phenomenological given?

Many fMRI studies of the brain have been under- taken to address this question using a variety of concepts. “Utilization” consists of perception of concepts by hearing, display, and reading. The data obtained in these studies can be summarized in terms of the following points:

1. Thoughts about some object activate the same areas of the brain which are activated by perception of that object [16, 46, 75].

2. The more modality-specific a given concept is, the stronger this pattern [47]. An analogous pattern is seen for concepts associated with actions, i.e., the motor cortex. Activation patterns arising on use of the verbs “pick up,” “kick,” and “kiss” include those areas of the motor cortex associated with the corresponding parts of the body (arms, legs, lips, respectively) [61].

3. The more diverse the context of utilization of a giv- en concept in language, the more polysemantic it is, the wider the pattern of activation seen on its use [65, 52].

4. The activation pattern arising on utilization of a con- cept depends on the individual personal conditions in which it forms. Presentation of pictures of instruments and the names of these instruments to right-handers produced acti- vation in the left hemisphere and vice versa. Areas activat- ed on presentation of images of animals did not depend on hand dominance [33]. An analogous relationship between activation patterns and hand dominance in reading the verbs “write” and “throw” was demonstrated [77]. Presentation of images of musical instruments to professional musicians ac- tivated areas of the auditory associative cortex [30]. Reading sentences describing actions during hockey games induced activation of the premotor areas of the cortex in professional hockey players [13]. A link has been demonstrated between activation patterns on utilization of concepts and the modal- ities in which a given person prefers to receive information (for example, visually or by hearing) [35, 36].

5. The activation pattern arising on utilization of a con- cept depends on the immediate context of its utilization. For example, depending on the context a lemon can be charac- terized as “yellow,” “round,” or “bitter.” fMRI studies have shown that the activation pattern on operating with a partic- ular concept depends on how its properties actualize the context. This is particularly clear on utilization of concepts whose properties (like those of a lemon) can be described well in different modalities [31, 51, 59, 72, 66, 74, 76].

The general conclusion from these experimental data is the view that utilization of a concept leads to activation of the same neurons which were initially involved in its for- mation during ontogeny [8, 11, 20]. A concept serves as a kind of label providing rapid access to a large array of nec- essary information [44]. During ontogeny, constant changes in the meanings of concepts occur as a concept is utilized in different contexts, with constant relearning by the neural networks representing the concept. This brings together the

concept and the context in which it arose and exists, actually making them inseparable [10, 22, 23].

We can consider the occurrence of specific activation patterns on utilization of a particular concept as a process opposite to the process producing concepts. Formation of concepts involves a process of sequential generalization of sensory characteristics “compressing” a large volume of sensory information into a concept carrying meaning. Utilization of the concept produces a kind of revealing in reverse order of the sensory characteristics that generated it, a “recollection” of the initial sensory or sensorimotor ex- perience. This “remembering” corresponds to activation of the corresponding areas of the cortex, initially associated with the perceptions seen in the experiments. A concept in compressed form contains the “history” of its formation – a sequence of inclusive characteristics whose neuronal sub- strate is reactivated on utilization of the concept.

This process at the phenomenological level can be clas- sified with features such as presentation and understanding. On pronouncing a word, for example, “red square,” we al- most involuntarily visualize the object, i.e., we actualize our pre-existing perceptual experience serving as material for formation of the concept. Realizing that the word “under- standing” itself has multiple meanings and is used in differ- ent senses in contemporary literature, we nonetheless take the view that the process of revealing the inclusive charac- teristics when a concept is utilized can also be called un- derstanding. Any word, even an unfamiliar one, when pro- nounced gives rise to a set of associations referring us to the context in which we learned it. We cannot know that what a synchrophasotron is, but we have a vague “understand- ing” that it is something in physics and perhaps the physics of elementary particles. These associations, actualizing our previous experience of interactions with the concept, will also be our understanding of it, albeit at a purely superficial level. As we receive new information associated with the concept, the context of its utilization expands (the corre- sponding pattern of neural network activation also expands) and our understanding of the concept becomes deeper and more complete.

**4. Generalization and “Understanding” in Health and Disease. Selection of Significant Characteristics.** Thus, any new information perceived by a person generates excitation in neural networks which can be described in terms of two processes:

1. A generalization process (for example, sequential generalization of visual information from a visual image to recognition of the concrete image). This process can be de- scribed as propagation of excitation “upward” though the sensory networks with sequential definition of inclusive characteristics at ever higher levels.

2. A process of discovery of the contents of the image or concept (understanding). Tis process is accompanied by the generation of activation patterns in the cortex similar to those arising on perception. These can be triggered not by the

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image, but, for example, by pronunciation of a word. That is, a process in some sense opposite to generalization – infor- mation is propagated “downward” through the sensory path- ways actualizing previously accumulated perceptual data.

Definition of key characteristics is important for both of these processes. Recognition of a face does not require the whole array of sensory data; the presence of its key parts and characteristic proportions is sufficient. Understanding of a concept also has no need for actualization of all its possi- ble properties assimilated during life. Correct understanding and utilization of a concept in the required context occurs be- cause of some of its most important properties or character- istics. Thus, information used for understanding concepts or extracted from initial sensory data is of unequal significance.

It is incorrect to speak of the significance of informa- tion without consideration of its context. What is significant and important in one context may be irrelevant in another. This is why the activation patterns seen when a person uti- lizes a single concept are different depending on context.

In most cases, the context is our everyday life and the most significant properties of concepts are those linking the concept with the functions of the object which it designates. That is, for example, for concepts such as “spoon,” “cup,” and “fork” the most significant are associations with their purpose in eating food (and not with their shape, material, or color). Clearly, these are the connections most frequently used by a person and are thus “reinforced” when cortical neural networks learn. In the situation of a specific context (for example, the task of selecting round objects), other properties of the objects will be utilized and, thus, other as- sociations designating their concepts.

Lack of a link between a concept and the ongoing con- text would generate the situation in which its utilization would give rise to actualization of an almost infinite volume of data accumulated by the person throughout life, actual- ization of the most diverse memories and low-significance episodes, however connected with the concept. This in turn would lead to a decrease in the productivity of the associa- tive process and, ultimately, the whole thought process, or random “pulling out” from an enormous dataset of associa- tions, where perceptions which are correct from the sensory point of view would lead to a distorted understanding of the integral reality.

*Schizophrenia.* Such a situation occurs in schizophre- nia. Studies of thought processes in patients with this disor- der have shown that the leading thought impairment, which largely determines the whole multifarious clinical features of the disease, is impairment to the patient’s ability to dis- criminate significant and low-significance associations and significant and low-significance features of objects and con- cepts [1, 5].

The Russian school of pathological diagnosis has cre- ated extensive experimental methodologies providing good illustrations of this key feature of patients. Thus, for exam- ple, one such method consists of comparing concepts. The

patient is given the task of answering the question of what is common to two concepts and what is the difference between them. The researcher names pairs of concepts, gradually progressing from easily compared concepts (for example, island and peninsula; river and lake) to less easily compared concepts (for example, boat and spoon) and to essentially non-comparable concepts (for example, boot and pencil; hedgehog and milk). The task of seeking common features between a pencil and a boot can be fully solved by healthy people both by increasing the level of generalization (both are objects of human life) and by actualization of low-sig- nificance (latent) features – “both leave a trace.” However, for the healthy person this actualization requires a quite sig- nificant and focused cognitive effort (perhaps with consid- eration of all the possible features of a pencil and a boot). The concepts are therefore “noncomparable” and automati- cally elicit very different associations (boot – shoes; pencil – a medium for writing or drawing). A different situation obtains in schizophrenia patients. They have been shown to actualize the latent features of objects and concepts signifi- cantly more frequently and, this being the important point, much more easily than healthy people. The ease with which patients compare concepts which are not particularly com- parable and perform other experimental tasks, giving orig- inal and formally correct responses, is particularly discor- dant with the incompetence typical of patients in perform- ing many everyday tasks. The cause of this incompetence is the same – patients constantly come up against information redundancy due to their inability to rigidly subordinate their own associative process to the requirement of the context of the situation.

This phenomenological observation has a number of parallels with data from instrumented and biochemical in- vestigations. We note from the earliest studies of event-re- lated potentials (ERP) in schizophrenia patients [7] that anomalies were found in the late ERP waves, whose phys- iological role consists directly of assessment of the biolog- ical significance of a stimulus. Interesting results were also obtained by comparison of data on the biological role of dopamine [14, 24, 25], its imbalance in schizophrenia, and clinical illness. Comparison of these data allowed Kapur to formulate aberrant salience theory [34]. Salience is intrinsic significance as well as the ability of the brain to assign the significance of a piece of information and to evaluate the significance of information in a context. Following Soviet psychologists, Kapur, now from the standpoint of neu- rotransmitter research, holds that the leading impairment in schizophrenia is patients’ inability to correctly (that is, context-dependently) evaluate the significance of a piece of information and correctly assess the significance of various associations generated by some word or event.

*The salience network.* Growing interest in the theme of salience and assessment of the significance of stimuli and information in the wider sense prompted fMRI researchers to discuss the functional salience network. Anatomically,

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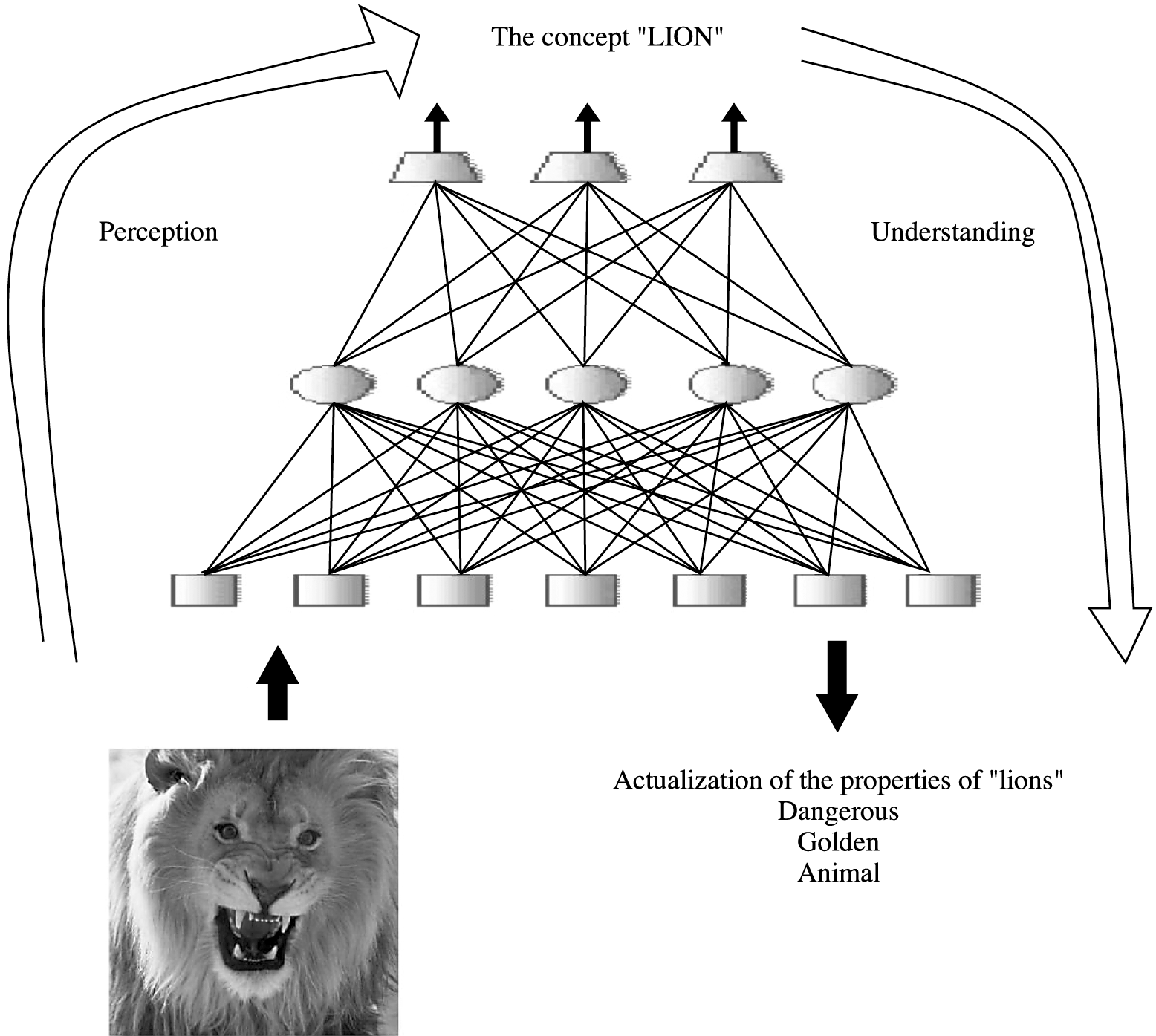


Fig. 1. “Perception and understanding.” In the process of perception, semantically neutral information on the physical characteristics of a stimulus is generalized and compared with previously accumulated experience, which leads to semantic recognition of the object (in this case a lion). At the same time, the key properties of this class of object (lions), particularly their potential danger, are actualized, which determines the subsequent behavior of the individual in relation to the object.

this includes the orbital frontoinsular cortex and the dorsal part of the anterior insular cortex in tight functional con- nection with subcortical limbic structures [69]. Many stud- ies have shown these to undergo activation in response to stimuli with high biological significance [12, 15, 19, 21, 58, 70]. Most neural nodes in the salience network are sub- cortical structures associated with the emotions, the regula- tion of homeostasis, and the “satisfaction center” [49, 54]. The salience network is in close functional interaction with the central executive network and the because basal resting network. Encountering significant stimuli, it activates the central executive network and deactivates the basal rest- ing network, thus pulling the brain out of the resting state to undertake particular actions in response to significant stimuli [50]. Clearly, when scientists refer to this salience network, the point is more its role in the identification and processing of stimuli of high biological significance than its role in identifying the main and secondary elements in a given context. It remains to be seen whether the primary and secondary tasks have the same physiological mecha- nism, associated with the same brain structure. There are

quite extensive data on pathology of the salience network in schizophrenia [9, 26, 29, 42, 56, 57, 79]. These data provide indirect evidence that the salience network as described is related to the set of the most significant associations.

The search for brain structures actively involved in as- sessing the significance of information and the linked pro- cesses of selecting criteria for categorization is not restrict- ed to studies of the salience network in health and disease. Interesting data were obtained using inhibitory electrical stimulation of various areas. Inhibitory electrical stimula- tion of the left prefrontal cortex was shown to lead to dif- ficulty in classifying objects using defined features (for ex- ample, as “round” or “red”), while the ability to classify on the basis of a set of complex properties (for example, “a de- vice for storing liquid”) does not disappear) [18, 45]. These data, along with data on the salience network, also point to the predominant involvement of the frontal cortex in as- sessing the significance of information depending on the context of the task. It is interesting that the more elementary categorization criterion (color or shape) is more vulnerable to inhibition than the more complex (use). This is evidently

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related to the fact that the more elementary and more mo- dality-specific categorization criteria are more stringently linted with defined material substrates mediating the initial perception of shape and color. More complex categorization criteria are the products of prolonged training of neural net- works throughout life, which implies understanding of the meaning and role of an object and, apparently, are mediated via larger neural networks not associated with any particular brain structures and therefore invulnerable to direct inhibi- tory actions.

**4. Conclusions**

data. It is this specific identification of the main element in the information stream that allows fast and effective upward translation of information in the generalization process and downward translation in the understanding process, involv- ing a limited set of the most important associations for these processes. This identification of the main element is largely mediated by dopamine. Schizophrenia provides an exam- ple of impairment to this fundamental feature of perception and thought. The effectiveness of generalization and under- standing processes in these patients decreases because of the involvement of a much larger quantity of data. At the same time, patients suffering from schizophrenia often dis- play good ability to solve nonstandard creative tasks pre- cisely because task solution involves large volumes of data.

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1. The information discreteness-continuity paradox in perception and thought can be resolved by considering dif-  
ferent levels of generalization of information, organized hi- erarchically: from the simple retinotopic reflection of the physical characteristics of the stimulus to a concept at a  
higher level of abstraction. Each such level has its own ele- mentary and indivisible unit of information, which in turn is  
the inclusive characteristic (as per Sergin), the result of gen- eralization of information at the lower-lying level. It cannot  
be separated either in terms of function (at the level of pat-  
terns of cortical activation) or phenomenologically into lower-level information characteristics (a person perceives  
a face, visual object, or a concept as some whole which can-  
not be divided into parts). 5.

2. Any new information perceived by a person gen-  
erates arousal of a neural network which can be described  
in terms of two processes: a generalization process, with “upward” propagation of arousal via the sensory networks  
with subsequent definition of the inclusive characteristic at  
a higher level, and a process of understanding. This process  
is accompanied by the occurrence of activation patterns in  
the cortex similar to those arising on perception and which  
can be regarded as a process which is the reverse of gener- alization – in the functional sense, information propagates 9. “downwards” via the sensory pathways. These processes evidently operate practically simultaneously – we recognize  
an object, understand its categorial assignment, and at the  
same time “recall” the concrete properties of objects of the  
same type, knowledge of which we accumulate throughout 11. life. Thus, having seen a fierce lion, on the one hand we recognize it (we generalize information) and on the other  
we understand associations generated within us by the im-  
age of this animal (for example, that lions ae dangerous)  
– see Fig. 1. We note that in and of itself a specific lion is informative only in that it shows us its belonging to lions.  
From direct observation we cannot obtain any more infor-  
mation than this. Other information (about lions as a class  
of objects) is actualized only by appropriate recognition of  
the image and its categorial assignment. However, this in- formation on lions, like information on the class of objects,  
is important for our protection.

3. The effectiveness of both processes (generalization and understanding) is determined by the identification of key characteristics in the volume of perceptual data or memory

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