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Postulates of the cognitive theory of thinking and their consequences

V. A. Antonets

National Research Lobachevsky State University of Nizhny Novgorod, Russia
Federal Research Center Institute of Applied Physics,
Russian Academy of Sciences, Nizhny Novgorod, Russia
E-mail: antonetsva@gmail.com
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Abstract. *Purpose* of the work is to create a theoretical model of the thinking process, considered as a set of operations for the formation of cognitive generalizations of the level of categories (concepts). *Method* for creating a theoretical model is based on the approach used in natural sciences. It involves the selection of a small number of reliable facts, which are accepted as true on the basis of their evidence. On the basis of these facts, established in various scientific disciplines, the axioms of the proposed theory are formulated. Further, from the accepted axioms, they are logically deduced in the form of consequences: a) already known results that could be obtained in various fields of science, including those differing in the content of research, and therefore previously perceived as not related to each other; b) predictions of new connections and patterns in the study area. *Results* of the work are that it was possible to propose a version of the postulate dynamic theory of thinking, in which the main variables are the number of concepts formed, lost, realized and unconscious by the subject. The introduced postulates and variables made it possible to consider two types of models at the moment. Balanced integrodifferential models that describe the accumulation of the volume of conscious and unconscious concepts, as well as combinatorial models that describe the interactions of concepts. *Conclusion.* The proposed version of the dynamic thinking model made it possible to construct reasonable theoretical descriptions of the process of spontaneous language acquisition by bilingual children in a bilingual environment and a person's ability to compare semantically heterogeneous objects with each other. The logical scheme of the approach and the concepts used in it made it possible to connect some facts known in psychology and in an explicitly compact formulation of the difference in the structure of scientific and artistic generalizations of the picture of the world.

Keywords: theory of thought, categories, plurality of consciousnesses.

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Introduction and problem statement

The purpose of the work was to propose, by analogy with the natural sciences, a theoretical model of thinking based on the logical analysis of a small number of selected reliable facts from different fields of science. On the basis of these facts, statements used in the theory as axioms are formulated. Such a theory should have two properties that theories in the natural sciences usually have.

First, its logical consequence should be an explanation of the connection between known facts that previously seemed independent. That is, from the point of view of this theory, a certain set of disparate facts turns out to be only the manifestation or implementation of fundamental

laws in specific conditions.

For example, the theory of gravity explains the orbits of planets, and the fall of objects to the Earth, and not the fall of the Moon and artificial satellites on it, and the tides of the oceans and seas, and the heterogeneous distribution of matter in the visible part of the Universe.

Consequently, explanations of some already known properties of thinking should be obtained logically from the introduced postulates.

Secondly, the logical consequence of the theory should be the prediction of properties and relationships between the studied objects and processes, and even the prediction of the existence of yet unidentified objects and their properties. Such a prediction makes it possible to plan new studies, the results of which may be both consistent with the model, and limiting the scope of its application or even refuting it.

The formal model of thinking proposed by the author affects exclusively cognitive processes. It does not include any description of its neural mechanisms, nor descriptions of the psychophysiological processes that support it, nor the evolutionary mechanisms of its formation. It also does not consider any meaningful aspects of cognitive activity.

The model considers cognitive processes exclusively as a set of operations, consciously or unconsciously carried out by the subject as an acceptor, carrier, user and creator over conscious or unconscious knowledge. At the same time, knowledge is understood as a set of concepts formed during the accumulation of life experience and training. Since the cognitive differences between humans and higher primates are not of a qualitative nature [1], the author consciously uses the term "subject"and not "human"as long as possible.

The model assumes that at each moment of time the conscious and unconscious knowledge of the subject includes:

- a finite number of images of specific objects that can be represented by modalities that a person may not have [2];
- a finite number of generalized categories or concepts to which the subject refers these specific objects;
- a finite number of symbolic representations of concepts in a communication system.

Symbolic representations of concepts (language) can be sound (acoustic communication and articulate oral speech), visual (gestures, pictures, signs, letters, words), tactile (Braille, etc., etc.).

The postulates of the theory should be formulated in such a way as to ensure the introduction of formal variables (quantities) and to define mathematical operations on them that would allow describing some processes of cognitive activity and logically deducing consequences.

Each of the entered formal variables needs a name. To do this, you will have to choose well-known words of the language, which in the historical process of formation and use of this language are already loaded with some meanings. Therefore, there may be disputes of a terminological nature, which are common for many fields of science, and not in substance.

In the meantime, in an unsettled situation, the terms *generalization, concept, category and concept will be considered identical by the author*. In meaning, they do not necessarily have to coincide with other scientific entities, historically previously designated by the same words.

1. Methodological notes

1.1. Changing the accepted methodology of thinking research. Traditionally, philosophers and psychologists are engaged in the study of thinking. Philosophers have formulated various modern problem statements [3–5].

Psychologists have extracted and introduced into scientific circulation the vast majority

of empirical data in the field of thinking research. They have carefully worked out the issues of setting up a psychological experiment, including ethical aspects [6]. They also own the main part of definitions and developed concepts that are quite successfully used in various types of practice. They even developed methods of psychological manipulation (control) [7], creating the impression of possession of prediction methods.

It is difficult for a representative of other sciences to master this voluminous scientific section of psychological science and get involved in solving the problem of thinking, which in psychology is designated as the most difficult problem of modern science in general. However, there are three encouraging considerations.

Firstly, not all of this volume of previous knowledge may be required, since its composition obviously contains facts and connections identical from the point of view of the future theory.

Secondly, some definitions and concepts of the psychological science of thinking, introduced by psychologists for one and a half to two centuries of their professional scientific activity after marking the boundary with philosophy, may turn out to be symptomatic, that is, not general, not essential for theory. Some may turn out to be completely wrong. Therefore, when constructing a theory, one should not necessarily adhere to these definitions and concepts, but modify them, fill them with other content, or even reject them. At least, this is the methodological experience of physics in relation to such fundamental concepts as hydrogen, ether, etc.

Thirdly, there may not be enough knowledge from other sciences in this arsenal to solve the problem. That is, within the framework of canonical psychology, which has little formal knowledge generalization methods, the problem may turn out to be unsolvable. Therefore, many experts recognize the need for an interdisciplinary approach in such cases [8].

1.2. About terminology and interpretation. The author uses the term "thinking"conditionally only to designate the field of modeling. Clarification of the content of the term will occur as the approach develops and applies to specific tasks. This situation is known, for example, in physics. When creating quantum mechanics, it took more than 25 years to develop a probabilistic representation of the wave function, the equations for which have already been formulated [9–12].

The same can be attributed to the use of the term "consciousness". Nevertheless, thanks to the formulated approach [13] and the use of an explicitly allocated observable ("number of categories"used by the subject in the process of thinking), it is possible to introduce quantitative variables that characterize thinking as a certain set of operations on a set of categories (concepts).

1.3. the methodology of caricature. The first step that will have to be taken is to try to modify the methodological approach so that it accommodates postulates based on facts, logical consequences of accepted postulates, as well as hypotheses that allow experimental verification.

At the same time, the author will adhere to the recommendation [14] and consider not too complex models. They, like caricatures, will not give details, but will give a vision. The famous physicist Ya. I. Frenkel, the author of the theory of the expanding Universe, owns the words: «Theoretical physicist... he is like a cartoonist who must reproduce the original not in all details, like a photographic apparatus, but simplify and schematize it...» [15].

Therefore, we will take this general position: the thinking machine is not too complex, but it is difficult to see it because of the many modes and variety of content of its work, which are manifestations of the psyche.

For example, it is difficult to imagine a person who does not understand how a car works. The minimum is a cart with wheels, a motor, steering and a brake. Then there are thousands of necessary and not very necessary parts that ensure the operation of this whole mechanism and adapt it to certain conditions and needs. But if you start looking at all of them, then you

certainly won't know how the car works!

In addition, in our methodology we will not contrast natural and artificial intelligence, but will focus on the presence of common features.

2. The main postulates, the motives of their choice and direct consequences

The central postulates of the proposed cognitive model of thinking are four statements formulated by the author earlier [13].

2.1. Postulate № 1 on the spontaneous formation of generalizations. *The formation of basic generalizations in the form of categories (concepts), which the subject operates in his cognitive activity, can occur spontaneously without the direct participation of consciousness and without motivation in the process of accumulating life experience and perception of objects of the surrounding world.*

The proof of this possibility was demonstrated in [16]. In the experiment, a network of 16,000 computer processors connected to the Internet processed about 10 million digital images taken on the YouTube service and independently trained itself to recognize images of cats. She modeled a generalized image of a cat without a teacher and encouragement. The head of the experiment Jeff Dean noted: "We never told the network during training: 'It's a cat." Thus, the machine actually invented for itself a generalized concept (concept, category, — *V. A.*) "cats" [17].

Three conclusions follow from this result.

Firstly, no matter what definition we give of the ability to "think the computer network [16] obviously does not possess it. It follows from this that the formation of the generalization "category"can occur spontaneously without the participation of consciousness and explicit motivation. It does not follow from what has been said that a teacher cannot participate in the formation of generalizations.

Secondly, this experiment proves that for the implementation of at least some elements of cognitive activity (in particular, generalization), a biological neural substrate is not required.

Thirdly, during the experiment, the learning network dealt not directly with images, but with their digital codes. Consequently, her ability to form concepts spontaneously and without motivation extends not only to images, but also to other modalities of fixing life experience - sounds, smells, tactile sensations, etc.

2.2. Postulate №2 on the nomination of categories. *The concept (category, concept), reflected linguistically, arises by awareness (consciousness) and assigning a name to a ready-made concept (generalization) in one or another symbolic system, and only after nominating the concept enters the circulation of conscious activity.*

In other words, dictionaries of any language can contain only conscious and nominated categories of objects, actions and signs. Otherwise, dictionaries simply could not be compiled.

In [13], this postulate was included by the author in Postulate # 1. However, the link shown in [18–20] between the development of the oral speech system in children and the development of their conceptualization systems made this statement stand out as a separate one.

2.3. Intermediate consequences and conclusions from postulates №1 and №2.

2.3.1. It follows from Postulates №1 and №2 that the cognitive processes of generalization of information obtained during the accumulation of life experience by the subject, and awareness and naming of the concept are relatively independent. Contrary to popular beliefs, generalization is primary.

More than 100 years ago, V.,M.Bekhterev actually already formulated postulates №1 and №2 in the work "What is suggestion?" [21]. He wrote: «...in addition to active perception, we perceive

much of the surrounding passively, without any participation of our "I when our attention is occupied with something, for example, when focusing on a thought, or when our attention is weakened due to one reason or another, as is observed, for example, in a state of distraction.

In both cases, the object of perception does not enter the sphere of personal consciousness, but penetrates into other areas of our mental sphere, which we can call general consciousness.

This latter is quite independent of personal consciousness, so that everything that enters the sphere of general consciousness cannot be arbitrarily introduced into the sphere of personal consciousness by us».

Not only people, but also animals are capable of generalizing the "category"type [1]. It is known that pigeons are able to sort images into containing and non-containing trees of any kind. And if we do not recognize the ability of animals to think logically, then we have to admit that the spontaneous generalization of their life practice is the mechanism for the formation of categories. And there is no reason to think otherwise about man, chimpanzees, bonobos and gorillas. However, in relation to these species, their ability not only to generalize, but also to nominate generalizations has been proven.

What has been said allows us to move to such an approximation that the subjects of cognitive activity use both conscious nominated concepts and unconscious ones for its implementation in different proportions. At the same time, the species Homo sapience has the highest ability to realize and nominate. Higher monkeys have a lower one. It is even smaller in evolutionarily lower species. Of course, even within the Homo sapience population, the ability to recognize and nominate has a different level [18] with all the consequences that follow from this. The author hopes that this statement will not be considered racist.

2.3.2. In [13], the set of areas of the *functional* space of cognitive activity of the brain, where generalizations (concepts) are formed and stored, was defined by the author as a cognitive loft. It follows from postulates №1 and №2 that a certain number of unconscious generalizations can be stored in the cognitive loft of the subject, which can be used by the subject during active actions and when making decisions.

This stock looks like an unconscious life experience. If such a reserve is capable of creating a network of computers, then it is obvious that not only humans have it, but also animals. About a person, we know that he can be aware of at least part of his life experience. We don't know this for sure about animals. This stock is a good candidate to be the "working body"of *The system 1* D. Kahneman, providing rapid (intuitive) decision-making [22].

2.3.3. Regardless of the way the unconscious generalization gets into the cognitive loft of the subject (accumulation of one's life experience or injection from the interlocutor), when realized, these generalizations have an equivalent novelty for the subject of cognitive activity and he perceives them as made by himself. V. M. Bekhterev understood this: «...the products of the general consciousness can, under certain conditions, enter the sphere of personal consciousness, and the source of their initial origin is not always even recognized by the personal consciousness» [21].

In everyday and professional (including scientific) life, this often manifests itself as disputes about priority.

2.3.4. In the process of verbal communication, images of specific objects can be displayed/transmitted only in the form of a logical intersection of the nominated generalized categories. As a result, speech has limited accuracy in describing images of specific objects. Even technical terms, the use of which is based on an agreement (convention) between professionals, although narrowing the class of designated objects, never designate a unique object.

2.3.5. Cognitive loft of people with different socio-cultural and historical experiences can have both similar and different types of generalizations. A small volume of similar concepts and a large volume of different concepts may be the reasons for the emergence of communication

barriers between representatives of different strata of society, countries and cultures.

As an example, here is a quote from [23]: «...our visual experience does not arise from direct contact with reality, but is formed by a system of indirect conclusions. ...a person living in the 'carpenter's world that is, in a culture where things are mostly created with a saw and an axe, gets used to interpreting sharp and obtuse angles perceived by our retina as derivatives of rectangular objects (this, among other things, is based on the convention of pictorial perspective). A person who grew up in a culture where ...rectangular objects are much smaller, perceives the world differently and, in particular, does not understand the conventions of visual perspective...».

This property of generalizations is the reason for the emergence of translational communication barriers that manifest themselves in a variety of social activities from the interaction of representatives of various strata of society to the intercultural interaction of countries and civilizations. The proposed context makes it possible to see more clearly the severity of the communication problem and indicates that its solution in each specific case should begin with the exchange of value representations. [24].

2.4. Postulate №3 on the iterative mechanism of category formation. *Further iterations of generalizations from already formed generalizations (concepts) and the flow of new information are possible in the cognitive loft. Both conscious and unconscious generalizations can participate in repeated generalization.*

This postulate means that the flow generalized to the level of concepts consists of information coming not only from the outside world, but also from the pool of concepts stored in the cognitive attic. When creating abstract theories that represent a high level of generalization, this pool is most important.

The system mentioned in [16]was not concerned with generalizing images, as a person does, but with generalizing codes. So, a generalization of the "category"type is also code.

In humans and animals, already at the first step, external and internal receptors convert physico-chemical effects into streams of electrical and chemical signals, which then undergo several processing iterations.

Since the generalization "category"is a code and in this sense the result of generalization does not differ from the results of the primary processing of the external sensory stream, repeated iterations of generalization are possible for generalizations.

Therefore, the author further uses the idea that generalizations arise in two ways. Firstly, due to the generalization of conscious or unconscious information received by an individual from the outside during the accumulation of life experience and / or training. Secondly, due to further iterative operations on the formed primary generalizations, which generates new concepts of a higher level.

In the broad sense of the word, life experience can be considered a set of spontaneously obtained generalizations (life experience in the narrow sense of the word) and learning outcomes. One of the fundamental differences between the accumulation of life experience and learning is that learning requires strong motivation.

2.5. Intermediate consequences and conclusions from postulates №1, №2 and №3.

2.5.1. Work on the re-generalization of concepts stored in the cognitive attic, as well as in the case of primary generalization, can occur spontaneously. However, consciousness somehow stimulates iterations of generalization, simulating the tension coming from the real external world. It also selects the "successful and unsuccessful"results of iterative generalizations. This will be considered an unconditional sign of the "ability to think".

2.5.2. Repeated iterations of natural generalizations from different fields of activity can lead to the emergence of virtual plausible generalizations (chimeras), that is, to the manifestation of imagination, which ensures the creative process of the development of the technogenic, social and artistic worlds.

The first archaeologically recorded artistic chimeras are about 40 thousand years old, when, probably, the brain of Homo sapience became capable of "repeated iterations"and imagination [25].

This is how the mechanism of the appearance of chimeras was described in the psychology course of the Voronezh Orthodox Theological Seminary (!) in the middle of the 19th century (!). «...Although the creativity of fantasy, as a free transformation of ideas, does not hesitate to strictly follow the law of truth, however, by showing off ideas taken from reality, it already adjoins the real world. It only expands reality to plausibility and possibility... Fantasy can create a winged horse, but only when we already have an idea of a horse and wings...» [26]. In particular, in the virtual world, there can be complete freedom of will. In [27–29], a neural model of combining two concepts into a single one is given.

2.5.3. The creative act is performed in the virtual world and only then is realized and separated from the author as text, image, etc.

2.5.4. There are so many connections between neurons that the virtual world of imagination may turn out to be more than a part of the real natural, social and man-made world reflected by the subject.

2.5.5. In the cognitive loft, the generalization of information flows from internal sensors can occur, that is, the formation of proprioceptive (motor) and vegetative generalizations that have all the properties of generalizations of the external flow. In particular, the suitability for participation in secondary iterative generalizations linking the physical and mental states of an individual.

If we recognize that proprioceptive images exist, then sport is one of the forms of the ability to think, although training allows you to form standard movements in various individual sports and standard combinations in individual and collective confrontations.

2.6. Postulate №4 on the multiplicity of consciousness systems. *A person has at least two relatively independent systems of consciousness.*

The arguments and motives in favor of this postulate are as follows.

We are not only aware of the world around us and ourselves, but also realize that we know how to do it. This is more than passing Gallup's "mirror test"for self-awareness [30], used to assess the self-awareness of animals.

No matter how we define consciousness, its mechanism is based on the same substrate as the mechanism for the formation of generalizations of the "category"type - on the use of a neural network. Therefore, the mechanism of consciousness itself is a code and works with codes. Only in this way is one consciousness able to realize the presence of another.

Since the neural network is unusually large, the presence of a volume in it to accommodate an additional mechanism of consciousness should not seem impossible.

2.7. Consequences of the postulates № 1, № 2, № 3 and № 4.

2.7.1. If there is awareness of the existence of consciousness, then there is a structure reflecting consciousness. Since consciousness and its reflecting structure can be realized only on the basis of the same substrate and its similar organization, they should be approximately equal. So we are not dealing with a situation of "consciousness — reflecting structure but with a situation of "consciousness — consciousness that is, the existence of at least two approximately equal consciousnesses.

2.7.2. Generally speaking, there can be more than two consciousnesses. Apparently, there is a dynamic process of interaction of consciousnesses, in different situations leading to the predominance of one or the other.

2.7.3. Generally speaking, each of the consciousnesses may prefer different samples of generalizations stored and formed in the cognitive attic. This can lead to a change in human behavior when the prevailing consciousness changes. Priming of the behavioral order may be associated with the impact on the competitive dynamics of consciousness.

2.7.4. The dynamic state, characterized by the absence of the predominance of one of the consciousnesses over the other, leads to pathological bifurcation.

2.7.5. The situation "consciousness — consciousness"makes possible an internal dialogue, similar to the dialogue between two people, when "the soul speaks to the soul, and not to the ears" [31].

3. Introduction of formal variables

We can distinguish three numerical characteristics for each subject of cognitive activity at any given time.

The first is the number of concepts C^{M} formed during the accumulation of life experience and training. The part of C^{M} that relates to life experience is formed without motivation. Training, of course, requires considerable motivation, which many subjects may lack.

The second is the number of actual concepts (generalizations) contained in memory, C^{A}, formed as a result of life experience. It is the difference between the number of formed (made) C^{M} and forgotten (lost, lost) concepts C^{L}, which are subsets of C^{M}, by virtue of their origin

$$C^{\mathrm{A}} = C^{\mathrm{M}} - C^{\mathrm{L}}.$$

Note: part of the concepts from C^{A} may be conscious (C^{A+}), part — is not (C^{A-}). The set of C^{A} contains all the concepts that the subject consciously and/or unconsciously operates with at each moment of time when perceiving the surrounding and inner worlds, as well as when making decisions about personal actions and intersubject transactions.

The third is the number of different symbolic representations of concepts C^{S}, which can be sound (acoustic communication and articulate oral speech), visual (gestures, pictures, signs, letters, words), tactile (Braille, etc., etc.) and are represented by other modalities that a person may not have.

Next, we will assume that Homo sapience is the champion in terms of C^{S}, in evolutionarily low animals C^{S} is vanishingly small, and in higher monkeys — in the gap between man and them.

Let's focus on the person in more detail. In a dictionary of any purpose, you can see that the words given in it usually do not denote a specific object from the flow of external information, but serve to designate (nominate) several categories of objects from C^{M} and, respectively, C^{A} and C^{L}. Therefore, the inequality is valid:

$$C^{\mathrm{S}} < C^{\mathrm{A}}.$$

Each word from C^{S} from the dictionary corresponds to a subset of the nominated concepts from C^{A}. Each meaningful statement is a logically and grammatically ordered subset of C^{A}, which corresponds to a combination of intersections and unions of subsets of C^{S}. Since $C^{\mathrm{S}} < C^{\mathrm{A}}$, their mapping to each other is not one-to-one. This leads to semantic ambiguity and, as a consequence,

to mutual understanding of the subjects. In oral speech, due to several iterations of communication, this ambiguity can sometimes be overcome. The result of reading a written speech is always the reader's interpretation. It is very difficult to make an unambiguously understood text.

In agreement with [13] , the location of the sets C^{A} and C^{S} is the cognitive loft.

4. Examples of application of the proposed approach

4.1. A model of speech development in a bilingual environment. In accordance with [18–20], it is assumed that language acquisition represents the related processes of the child's acquisition of concepts about the surrounding world (concepts) and their nomination (naming) in the mastered concepts. This process takes place in a competitive bilingual environment, where the most important parameters are motivation and time spent in a particular environment [32, 33].

$$\tau_{1S_1}\frac{dS_1}{dt} = -\frac{\tau_{1S_1}}{\tau_{2S_1}}S_1 + F_0\left[-T_1 + \gamma_{11}S_1 - \gamma_{12}S_2\right],$$

$$\tau_{2S_2}\frac{dS_2}{dt} = -\frac{\tau_{1S_2}}{\tau_{2S_2}}S_2 + F_0\left[-T_2 + \gamma_{21}S_1 - \gamma_{22}S_2\right].$$

Here τ_{1S_1} and τ_{1S_2} are characteristic times of spontaneous learning of new elements of the first (S_1) and the second (S_2) languages (usually — days, weeks), and τ_{2S_1} and τ_{2S_2} — characteristic times of destruction of the fraction of elements of the languages S_1 and S_2 or their transfer from active working memory to passive «storage» (usually — months, years); F_0 — nonlinear functions, are stepwise character with threshold values T_1 and T_2 for languages S_1 and S_2, respectively; γ_{ij} — coefficients of influence of language S_j on activation of language acquisition S_i. The analysis of the equations allowed us to find the conditions and modes of dominance of one of the languages and the establishment of true bilingualism [32, 33].

4.2. A model for matching semantically dissimilar objects in exchange transactions. In the works [24, 34] it is assumed that the concept of any object is a logical intersection (product) of concepts that are significant for it, not always conscious properties of the object. The model also assumes that an object cannot have some absolute abstract value, but can only have value in relation to another object. That is, we are talking either about an exchange transaction, or about the possibility of the loss of an object that generates this or that damage. We will assume that when evaluating, the subject consciously or unconsciously takes into account only a finite number of characteristics of the object. It is known [35] that a person has the ability to quantify the subjective significance of any of the features of a particular object. Then each of the i objects being compared S_i can be described by the significance vector of its properties (features) $\mathbf{w}_i = (w_{i1}, w_{i2}, ...w_{im})$. The vector can be normalized so that $\|\mathbf{w}_i\| = 1$.

Then, in accordance with the opinion of the subject, which can be both intuitive and based on measurement or reasoning, for each i th object, a vector of the expression of the properties of the object that are significant to it is formed $\mathbf{v}_i = (v_{i1}, v_{i2}, ...v_{im})$. It cannot be normalized, since the subjectively assessed severity of the object's characteristics may be higher or lower than the requirements or expectations. As a result, an integral estimate q_i of the subjective value of the i object under consideration can be formed, expressed by the scalar product: $q_i = (\mathbf{w}_i, \mathbf{v}_i)$.

This makes it possible to compare heterogeneous semantic objects with each other, for example, goods in a store. Since q_i does not depend on the nominations of significant characteristics of the objects being compared, not only tangible, but also intangible objects can be exchanged. For example, it can be a paid transfer of rights, compensation for material and moral damage, a

bribe, etc.

Given that the evaluation of q_i is subjective, a mutually beneficial transaction between subjects A and B is possible only if two inequalities are observed simultaneously: $q_{AA} < q_{AB}$ and $q_{BB} < q_{BA}$. Here q_{AA} and q_{BB} are subjective integral estimates by the participants of the transaction of "their"objects, and q_{AB} and q_{BA} are "strangers". In [24,34], the problem of basket exchange transactions, each of which contains many objects, is considered.

Conclusion

1. The introduction of the observable — "the number of categories (concepts)"used by the subject in the process of thinking allows us to describe thinking as a set of operations on a set of categories. This means that in accordance with the canons of experimental psychology [6], the empirical question of the dynamics of generalizations at the "category (concept)"level is compared to the non-empirical question of the work of thinking.
2. This allowed us to get not only obvious, but also quite unexpected conclusions that will help formulate new tasks and new interpretations of known facts. In particular, the logical scheme of the approach and the idea of the observed "category (concept)"used in it made it possible to formulate explicitly compactly:
   - the idea of conscious and unconscious "categories (concepts)";
   - the difference between the structure of scientific and artistic generalizations of the world picture;
   - hypothesis about the multiplicity of consciousnesses.
3. The proposed approach allowed us to describe in quantitative variables:
   - the process of spontaneous language acquisition by bilinguals in a bilingual environment as the dynamics of a set of "categories";
   - is a mechanism for matching semantically dissimilar objects.

References

1. Zorina ZA, Smirnova AA. What the «Talking» Monkeys Told About: Are Higher Animals Capable of Operating With Symbols? Moscow: Yazyki Slavyanskoy Kul'tury (Studia naturalia); 2006. 424 p. (in Russian).
2. Nagel T. What is it like to be a bat? The Philosophical Review. 1974;83(4):435–450. DOI: 10.2307/2183914.
3. Husserl E. Méditations Cartésiennes. Introduction á la phénoménologie. Paris: Armand Collin; 1931. 136 p. (in French).
4. Chalmers DJ. The Conscious Mind: In Search of a Fundamental Theory. Oxford: Oxford University Press; 1996. 432 p.
5. Chalmers DJ. Facing up to the problem of consciousness. Journal of Consciousness Studies. 1995;2(3):200–219.
6. Goodwin KA, Goodwin CJ. Research in Psychology: Methods and Design. 8th Edition. Hoboken, NJ: John Wiley & Sons Inc.; 2016. 480 p.
7. Thaler RH, Sunstein CR. Nudge: Improving Decisions about Health, Wealth, and Happiness. New Haven, Connecticut: Yale University Press; 2008. 312 p.
8. Thagard P. Being interdisciplinary: Trading zones in cognitive science. In: Derry SJ, Schunn CD, Gernsbacher MA, editors. Interdisciplinary Collaboration: An Emerging Cognitive Science. Mahwah, NJ: Erlbaum; 2005. P. 317–339.

9. Born M. Statistical interpretation of quantum mechanics. Science. 1955;122(3172):675–679.
10. Heisenberg W. Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen. Zeitschrift für Physik. 1925;33(1):879–893 (in German). DOI: 10.1007/BF01328377.
11. Schrödinger E. Quantisierung als Eigenwertproblem (Erste Mitteilung). Annalen der Physik. 1926;384(4):361–376 (in German). DOI: 10.1002/andp.19263840404.
12. Born M. Quantenmechanik der Stoßvorgänge. Zeitschrift für Physik. 1926;38(11–12):803–827 (in German). DOI: 10.1007/BF01397184.
13. Antonets VA. The postulates of the theory of thinking and their consequences. Part 1. In: Proceedings of the VI All-Russian Conference «Nonlinear Dynamics in Cognitive Research — 2019». Nizhny Novgorod, 23–27 September 2019. Nizhny Novgorod: Institute of Applied Physics RAS; 2019. P. 34–37 (in Russian).
14. Neimark YI. Mathematical Modeling as Science and Art. 2nd edition. Nizhny Novgorod: Nizhny Novgorod University Publishing; 2010. 420 p. (in Russian).
15. Filippov AT. Many-Sided Soliton. Ser. Library «Quantum». Vol. 48. Moscow: Nauka; 1986. 222 p. (in Russian).
16. Le QV, Ranzato MA, Monga R, Devin M, Chen K, Corrado GS, Dean J, Ng AY. Building high-level features using large scale unsupervised learning. In: Proceedings of the 29th International Conference on Machine Learning. 26 June–1 July 2012, Edinburgh, Scotland, UK. Madison, WI, United States: Omnipress; 2012. P. 507–514.
17. Markoff J. How many computers to identify a cat? 16,000 [Electronic resource]. The New York Times. June 25, 2012. Available from: https://www.nytimes.com/2012/06/26/technology/in-a-big-network-of-computers-evidence-of-machine-learning.html.
18. Wolf M. Proust and the Squid: The Story and Science of the Reading Brain. New York: Harper Perennial; 2008. 336 p.
19. Ostler N. Empires of the Word: A Language History of the World. New York: Harper Collins; 2005. 640 p.
20. Pease DM, Gleason JB, Pan BA. Learning the meaning of words: Semantic development and beyond. In: Gleason JB, editor. The Development of Language. 3rd ed. New York: Macmillan; 1993. P. 115–149.
21. Bekhterev VM. What is suggestion? In: Bulletin of Psychology, Criminal Anthropology and Hypnotism. No. 1. Saint Petersburg; 1904. 144 p. (in Russian).
22. Kahneman D. Maps of bounded rationality: Psychology for behavioral economics. The American Economic Review. 2003;93(5):1449–1475.
23. Herskovits MJ. Man and his Works: The Science of Cultural Anthropology. New York: Alfred A. Knopf Inc.; 1948. 678 p.
24. Antonets VA, Levchuk IV. Subjective evaluation of semantically unlike objects during exchange transactions. Izvestiya VUZ. Applied Nonlinear Dynamics. 2011;19(6):75–82 (in Russian). DOI: 10.18500/0869-6632-2011-19-6-75-82.
25. Harari YN. Sapiens. A Brief History of Humankind. London: Harvill Secker; 2015. 443 p.
26. Nikitin IS. Seminarist Diary. Moscow: Sovetskaya Rossiya; 1976. 160 p. (in Russian).
27. Tsukerman VD, Kharybina ZS, Kulakov SV. A mathematical model of hippocampal spatial encoding. II. Neurodynamic correlates of mental trajectories and decision-making problem. Mathematical Biology and Bioinformatics. 2014;9(1):216–256 (in Russian). DOI: 10.17537/2014.9.216.
28. Tsukerman VD, Kulakov SV. A temporal ratio model of the episodic memory organization in the ECI-networks. Contemporary Engineering Sciences. 2015;8(19):865–876. DOI: 10.12988/ces.2015.57215.
29. Tsukerman VD. What does the neurodynamics of the brain hide? (Modern data and model). In: Proceedings of the VI All-Russian Conference «Nonlinear Dynamics in Cognitive

Research — 2019». Nizhny Novgorod, 23–27 September 2019. Nizhny Novgorod: Institute of Applied Physics RAS; 2019. P. 222–225 (in Russian).
30. Gallup Jr GG. Chimpanzees: Self-Recognition. Science. 1970;167(3914):86–87. DOI: 10.1126/science.167.3914.86.
31. Casanova G. Mémoires de J. Casanova de Seingalt, écrits par lui-même. Tome Premier. Garnier Frères; 1880. 532 p. (in French).
32. Alexandrova NS, Antonets VA, Nuidel IV, Shemagina OV, Yakhno VG. Modeling the modes of spontaneous learning of several languages of communication. In: Proceedings of the VI All-Russian Conference «Nonlinear Dynamics in Cognitive Research – 2019». Nizhny Novgorod, 23–27 September 2019. Nizhny Novgorod: Institute of Applied Physics RAS; 2019. P. 27–30 (in Russian).
33. Alexandrova NS, Antonets VA, Kuzenkov OA, Nuidel IV, Shemagina OV, Yakhno VG. Bilingualism as an unstable state. In: Velichkovsky BM, Balaban PM, Ushakov VL, editors. Advances in Cognitive Research, Artificial Intelligence and Neuroinformatics. Intercognsci 2020. Vol. 1358 of Advances in Intelligent Systems and Computing. Cham: Springer; 2021. P. 359–367. DOI: 10.1007/978-3-030-71637-0_41.
34. Antonets VA. Simulation of intuitive evaluation of unlike semantic objects. In: XXI International Scientific and Technical Conference «Neuroinformatics-2019»: Part 1. Moscow, 07–11 October 2019. Moscow: Moscow Institute of Physics and Technology Publishing; 2019. P. 141–149 (in Russian).
35. Osgood CE, Suci GJ, Tannenbaum PH. The Measurement of Meaning. Urbana: University of Illinois Press; 1957. 342 p.