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Ishunov Vjacheslav

Novomoskovsk, Ukraine

Ишунов Вячеслав Васильевич

Новомосковск, Украина

BRAIN THINKING CENTERS
ЦЕНТРЫ МЫШЛЕНИЯ ГОЛОВНОГО МОЗГА

Summary. *Thinking is the process of operating with three-dimensional, polymodal images, which takes place in the center of thinking of the brain. In the course of evolution, the brain has undergone a number of significant transformations, which led to the formation of two different centers of thinking, harmoniously interacting with each other.*

Key words: *thinking center, sensation neuron, memorial thinking.*

Аннотация. *Мышление – это процесс оперирования трехмерными, полимодальными образами, происходящий в центре мышления головного мозга. В ходе эволюции головной мозг претерпел ряд существенных трансформаций, которые привели к образованию двух различных центров мышления, гармонично взаимодействуют друг с другом.*

Ключевые слова*: центр мышления, нейрон ощущения, мемориальное мышление.*

Introduction. Thinking is a psychical process based on the neurophysiological mechanisms of the brain (lat. *encephalon*). The nature of these mechanisms has not yet been fully elucidated, because the moment of transition from neural excitation to psychical phenomena is not clear. The solution of this problem will allow significant progress in the knowledge of thinking.

Analysis of studies and publications. Brain researchers have long been trying to figure out whether the activity of a collection of neurons can characterize the thought process. We are talking about the so-called "constellations" of A. A. Ukhtomsky (1875 - 1942) and "patterns", as a sequence of nerve impulses that has a certain information value.

According to the idea of I. P. Pavlov (1849 - 1936), the implementation of thinking requires the work of several brain systems, such as the first signal system and the second signal system.

N. P. Bekhtereva (1924 - 2008) began to study the recoding of information from neurophysiological to psychological since 1977.

Formulation of the problem. The section of the brain, where the transition from neuronal excitation to psychical phenomena and vice versa takes place, as well as the process of thinking directly, appears as the center of thinking in its functional features. The study of the structure of this center and its functioning in various modes will reveal the secret of thinking.

Main part. Thinking is preceded by such a phenomenon as sensation. Its physiology is based on the process of nervous excitation resulting from the influence of the external environment on the receptor cells of the sense organs. Then, from these sensations, the perception of an object of the external world is formed in the form of a three-dimensional, polymodal image. The organ responsible for the generation of images is a special part of the brain - the center of thinking. To understand the process of thinking, let us construct a primitive model capable of thinking.

Abstract center of thought

As a starting element, let's take an ordinary reflex arc. Let's cut it at the junction of the sensory and motor neurons.

Let's connect the first, sensory part to a special effector - the sensation neuron. **A sensation neuron** *is a nerve cell whose state changes under the influence of a nerve impulse, as a result, a sensation of a certain modality is gener-*

ated (color, sound, smell, taste, etc.). For example, an electromagnetic wave with a frequency of 405-480 THz, hitting the retinal receptor, is transformed into a nerve impulse, which rushes along the sensory path to the color sensation neuron. Here the second metamorphosis takes place - a nerve impulse initiates a sensation of red color in the target organ.

Let's call the new arc *the reflex arc of sensation*. A set of sensation neurons of one modality forms *a sensory field*, where the reflection of objects of the external environment takes place in the format of a mental image.

A mental image *is a three-dimensional perception of the characteristics of the reflected objects of reality in the sensory field, thanks to the synchronous operation of a huge number of parallel reflex arcs of sensation of a certain modality*.

N.B. The brain works like a thermal imager, coloring colorless electromagnetic waves in different colors. The world, in itself, is colorless, silent, odorless and tasteless! Color, sound, smell, taste, etc. - these are the internal properties of the brain, which it assigns to the reflected objects of the external environment in order to be able to perceive them in the image format.

Further. We will connect the second, motor part of the reflex arc with the voluntary motor neuron. **A neuron of voluntary motor skills** *is a nerve cell, the excitation of which causes the movement of a certain part of the body.* Let's call this construction *a motor reflex arc*.

The entire set of voluntary motor neurons form a *motor field*. The image of the command for the movement of limbs or the body in the field of motor skills is transformed into nerve impulses, which, acting on motor neurons, provide the corresponding movement of the body or limbs in space.

The department of thinking is able to manipulate mental images.

And now let's combine the sensory fields of different modalities and the field of motor skills with *the department of thinking*. As a result, we get a trivial center of thinking, where sensory information from the external environment

flows in the format of an image, where the current situation is assessed, after which a decision is made to act in the format of an image of movement.

So, we come to the definition of thinking. **Thinking** *is the process of operating with mental images, which takes place in the center of thinking.*

Note that our model is flawed - it has to solve the same problem constantly as a new one. In order to eliminate this defect, we will connect here the memory that contains the storage areas: sensory information, various movements, solving old problems.

Real centers of thought

In the course of evolution, the brain has undergone a number of significant transformations that have led to the formation of its *three* main types. In this regard, we will divide all the owners of the brain into *three* groups: non-mammals (fish, amphibians, reptiles and birds), mammals and humans.

Non-mammals brain. The brain of non-mammals is divided, as a rule, into five sections: oblong (lat. *myelencephalon*), posterior (lat. *metencephalon*), middle (lat. *mesencephalon*), intermediate (lat. *diencephalon*) and telencephalon (counting is carried out from the spinal cord).

The center of thinking, which looks like a colliculus, is located in the midbrain in its upper part and is called the tectum (lat. *tectum* – roof).

The colliculus consists of six main layers of nerve cells, with the top three layers associated with the retina. If one of the hills is removed, the animal becomes blind in one eye, while if both are removed, complete blindness occurs.

Sensory fields in the tectum are placed in layers one above the other, due to this, images of different modality are integrated, forming one polymodal image.

The motor field is located in the lower layers.

Optical and all underlying layers are ordered retinotopically, i.e. have an ordered projection relative to the retina. This structure allows the animal to es-

tablish a correspondence between the body and the environment, thereby providing spatial orientation.

All layers are permeated with neurons with radially oriented dendrites, which represent the department of thinking.

The sensory and motor fields, together with the thinking department, form the center of thinking.

As for memory, there are two types - short-term and long-term. Short memory (up to 30 minutes) is based on the inertial activity of neurons in the thinking center. Memorization for many years occurs due to the formation of new axon-dendritic connections between neurons.

In non-mammals, events associated with space are localized in the dorsolateral (Dl) zone of the telencephalon, while in mammals and humans, the homologue of this region is the hippocampus.

Motor memory (skills) is represented by the basal ganglia (lat. *nuclei basales*) located at the base of the telencephalon in all groups.

Let us especially note the interaction of the center of thinking with the vegetative systems of the body. This interaction is carried out through the visceral department. In the first group, it is located in the dorsomedial (DM) zone of the telencephalon, while in the rest, the homologue is the amygdala (lat. *corpus amygdaloideum*).

Impulses from the vegetative systems in the visceral region are transformed into images - *vegetative feelings* (thirst, hunger, cold, pain) - understandable for perception by the center of thinking.

On the other hand, when the center of thinking analyzes a specific situation, it forms an attitude towards it in the format of an image - *an individual feeling* (fear, pleasure, aggression), which becomes for the visceral department a reference point for setting the autonomic systems of the body.

To perform these two functions, the visceral region has reciprocal connections with the hypothalamic-pituitary endocrine system, the reward system (do-

pamine, serotonin), the pain system (substance P), the reticular formation (sleep and wakefulness), the blue spot (activation of muscle reactions).

In addition, the visceral department receives information from all sensory systems, which is integrated here with individual feelings and is remembered, forming an individual stereotype of perception of environmental objects (for example, a snake causes fear, a lemon provokes salivation). This is the third function of the visceral department.

The center of thinking, based on the decision made and the mood of the body, launches a motor program, which can consist of two components: emotions and purposeful action.

In view of the fact that the center of thinking works with specific information, thinking is characterized as *concrete*. In turn, concrete thinking is divided into real and subreal thinking.

Real thinking *is the operation of the center of thinking with sensory information coming from receptors in real time*.

Subreality thinking *is the operation of the center of thinking with information coming from both receptors and memory*.

Mammals brain. As for mammals, they also have a second center of thinking - new cortex of the telencephalon (lat. *neocortex*). At the same time, the primary center of thinking - the tectum - is further developed, turning from the double colliculus into the quadrigemina (lat. *corpora quadrigemina*). The anterior tubercles are associated with vision, the posterior tubercles with hearing.

In the neocortex, sensory fields are already localized in separate areas: in the occipital region there is a visual zone, in the temporal region - a zone of hearing, in the parietal region - a zone of general sensitivity.

In sensory areas, in addition to primary (projection) fields, secondary and tertiary fields are distinguished, which are a special form of long-term memory.

The main feature of the second center of thinking is that the reflection of the objects of the external world here occurs through memory. The sensory in-

formation entering the projection zone is divided into simple elements with the help of neural cortical modules. Then the neurons of sensation, representing the elements of the image, are combined with each other through the neurons of the secondary zone, due to the convergence of connections. In the secondary zones, connections of unimodal images are preserved. In the tertiary zones (parietal region), located at the junctions of the secondary zones, polymodal connections are formed. After memorization, the reverse process begins - the initiation of memory up to the simple elements of the primary zone, from which the reflected image is recreated.

Due to such a complex procedure, the reflection of the objects of the outside world occurs with a long delay – 140-180 ms (EP latency).

The motor zone of the neocortex consists of the primary and secondary motor cortex and supports complex and fine motor coordination. The primary motor cortex (precentral gyrus) is the field of motor columns. Stimulation of a single neuron activates the contraction of an entire group of muscles, which causes the movement of a certain part of the body. The secondary motor cortex (premotor cortex) is the site of motor memory where complex movements are remembered.

The role of the thinking department of the neocortex is played by the prefrontal cortex (lat. *cortex praefrontalis*) (frontal lobes) together with the anterior cingular cortex (lat. *cortex cingularis anterior*).

Thanks to the second center of thinking, a third form of thinking appears in mammals - *cortical concrete thinking*.

This type of thinking is based on the mechanism of *arbitrary attention*. The prefrontal cortex, exerting inhibitory and facilitating effects on the level of activity of the cortex through the specific nuclei of the thalamus along the direct corticothalamic pathways and on non-specific ones through the cortico-reticulothalamic connections, controls the movement of the "searchlight of attention" ("bright spot" by I.P. Pavlov) along the bark. At the same time, neurophysiolo-

gists assign the role of "attention gates" to the reticular nucleus of the thalamus, whose neurons have a selective inhibitory effect on sensory inputs. Concentrating attention in this way on significant information coming from the environment, the individual analyzes it in real time with or without traces of memory (engrams), and makes a specific decision, an actual action.

The two centers of thought work harmoniously, harmoniously complementing each other. The tectum is responsible for the panoramic perception of space and quick reaction. The neocortex works slowly, but precisely and brilliantly, carefully analyzing the object to the smallest detail.

In cases of high-speed acts, the tectum acts alone, but when the unhurried neocortex is turned on, the tectum continues to function, but in the background mode (for example, lateral (peripheral) vision, background sound perception).

Human brain. At one time (about 5 million years ago), the prefrontal cortex was able, firstly, to block the influx of sensory information into the primary cortical zones and, secondly, to activate long-term memory areas, using the thalamus in both cases.

The prefrontal cortex, on the one hand, gives the command to close the "gates of attention" for sensory signals. With an increase in the power of alpha oscillations in the thalamus, the flow of information into the primary cortex is hindered [5]. In experiments using functional magnetic resonance imaging, it was shown that the maximum increase in the alpha rhythm coincides with an increase in metabolism in the thalamus and its decrease in the visual cortex [3]. On the other hand, the prefrontal cortex selectively activates memory modules through voluntary attention. The mechanism by which voluntary attention performs synchronous selective modulation of the activity of various cortical zones is the interaction of rhythmogenic thalamocortical structures at the level of the thalamus reticular nucleus. As a result of all this, external attention is transformed into *internal attention*, directed exclusively to memory.

So one species of higher primates had a new form of thinking - memorial thinking.

Memorial thinking *is a form of thinking based on internal attention, during which, on the one hand, partial blocking of external sensory signals occurs, and on the other hand, activation of memory traces* (engrams).

This marked the formation of a new species of higher primates - *Homo* (human). Memorial thinking is a qualitatively new state, being in which a person gets an amazing opportunity - fenced off from the outside world, extract the necessary information from memory, analyze and create new concepts and ideas on its basis. When we lock ourselves in our inner world, we become free, independent of the environment. Here we are omnipotent in our fantasies: we are able to descend into the depths of the microcosm or fly to the far corners of the macrocosm, recreate events of the distant past or look into the future. Operating with ideal images, the artist creates future pictures in his head, the writer creates book heroes, the inventor creates new devices.

When memorial thinking finishes its work, new images remain in the memory that are available to concrete thinking. In this regard, a person acquires another variety of concrete thinking - intellectual thinking.

Intellectual thinking *is a form of concrete thinking, in the process of which, among other things, the result of the activity of memorial thinking is used*.

Intellectual thinking brings to life everything that a person has thought up, known, discovered, being distracted from reality. Thus, it becomes, as it were, an external continuation of memorial thinking.

Conclusion.

1. The discovery of the sensation neuron allows us to understand the transformation of absolutely *identical* nerve impulses into sensations of *different* modality (color, sound, taste, smell).

2. Memorial thinking plays the role of a *watershed* between man and the entire animal world: if a biological individual is endowed with memorial thinking, then this is a person, if not, an animal.

3. Intelligence is a form of manifestation of thinking, which refers to mental attributes. The so-called "artificial intelligence" is not an element of the psyche, therefore, has nothing to do with real intelligence and thinking.

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