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The main results of the mechanisms' study of the of mental self-regulation based on the method of assessing the basal emotions' matrix

Vsevolod V. Volov[1]

[1]Samara Institute of Fundamental and Applied Research, Samara, Russian Federation

vsevolov79@mail.ru

Abstract

Introduction. The article presents an overview of the author's original works devoted to identifying the regulatory mechanisms of the emotional sphere using an innovative approach. The problem of self-organization of mental activity, connected with the determination of the system's state and the assessment of its stability, is discussed. **Methods**. The research program included the author's model of qualitative assessment of mimic response patterns. To quantitatively assess the state of the system by the tension of the facial muscles, an analytical apparatus was developed based on the matrix method, as well as stability criteria and other indicators for assessing the state of the emotional regulation system. **Results**. The main results were obtained on subjects with epilepsy. During diagnostic tests using the myographic measurement of facial muscle tone during the experience and perception of basic emotions, signs of their blocking were revealed. A comparative analysis of individual clinical groups made it possible to determine the significance of various limitations of emotions that manifest themselves at the level of reverse afferentation of the emotional regulation system. **Discussion**. Comparative analysis of the data of qualitative and quantitative analysis made it possible to reveal patterns of regulatory mechanisms associated with distorted afferentation of basic emotions.

Keywords

matrix of basal emotions, psycho-emotional state, mimic patterns, epilepsy, psycho-emotional stability, excessive stability, block, distorted afferentation

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Introduction

The problem of self-organization of mental activity remains relevant in psychology. The structure of the internal mechanisms of both lower and higher mental processes is determined by their ability to reflect and the systemic structure. At the same time, only volitional methods of self-regulation in behavior and activity have been studied in practice. An exception, perhaps, are the discoveries of psychoanalysis, which shed light on unconscious processes. However, they do not reveal regulatory patterns either.

These are descriptive models that reveal a protective adaptation to stress by psychologically limiting painful experiences and memories, with a distortion in the assessment of the event and its perception. The ability of the mental process to self-regulate can only be revealed within the framework of the system.

The consideration of thinking, memory and speech as psychological systems by Russian scientists, which became revolutionary and surpassed the level of scientific thought of contemporaries, made it possible to make a significant breakthrough not only in psychology, but also in the brain sciences. Thus, the application of this methodology to the study of the brain mechanisms of HMF led to an understanding of the principles of the brain, its ability to self-organize in various disorders and injuries, to restore lost functions and, as a result, to create a new science – neuropsychology (Luria, Vygotsky).

As you know, system analysis has become a signature of domestic psychology, the foundations of which were laid even before the advent of cybernetics and synergetics, and even more so similar trends in foreign psychology and humanitarian research, ahead of their time. On its foundation, a new approach to the problem of state and stability is developed in the works of V.A. Ganzen, E.P. Genkovsky, V.N. Ilyina and others. However, so far it offers only a qualitative analysis, without the possibility of calculating dynamic indicators.

Unlike psychology, where the personal approach prevails (Dolgova, Golyeva, 2014), in psychophysiology, a practical solution to the issue of stability research is outlined. So the optimal state of the system is determined by the range of permissible fluctuations of its main parameters without signs of transformation or oppression in order to effectively achieve the desired result. Such a modern approach is offered by Anokhin's theory of functional systems (FS). This can be fully attributed to the HMF and emotional states, reflecting the level and status of the mental organization as a whole.

However, for the time being, the clinical focus prevails, which determines the practical expediency in assessing resistance. There are rare exceptions, for example, the tapping test (Tsukanov, 2000), which determines stable and unstable psycho-emotional states (PES) associated with an increase in neuropsychic stress and fatigue, as well as own time (an individual unit of time). Of interest is the "Vibraimage" method, which makes it possible to remotely diagnose basic emotions and emotional state by microvibrations (Minkin, 2007). On the basis of somatovegetative manifestations in physiology, the emotional state is traditionally assessed at a quantitative level by instrumental diagnostic methods, but only indirectly.

Domestic psychologists were laid the methodological prerequisites for the study of the stability of emotions, primarily A.F. Lazursky. Ideas about the stability of the emotional sphere were proposed by K.K. Platonov and L.M. Schwartz, on sustainability in ensuring activities while overcoming overexcitation – developed by V.A. Plakhtienko, Yu. M. Bludov and others (Dolgova, 2014).

The modern theory of fixed forms of behavior offers a methodology for studying stability in micro-intervals of time (Zalevsky, 2007). At the same time, the principles of self-organization are embedded in the theory of the basal system of emotional self-regulation, identified in the study of autism (Lebedinsky, 2010). The concepts of mental stress and emotional maladjustment were also introduced, but the methods for studying the self-regulation of emotions necessary for a systematic analysis have not yet been created.

Sustainability often comes down to stress resistance (Shevchenko, Makarova, 2013; Yuzhakov, Avdeeva, Nguyen, 2015; Kislyakov, Meyerson, Egorova, 2020). A similar trend can be traced in foreign literature: consideration of stability as an integral property of the emotional sphere – the level of neuroticism, "affective stability" (Guilford, 1959; Cattell, Eber, Tatsuoka, 1970). This approach is observed in foreign works and now (Darvishzadeh, Bozorgi, 2016; Kosonogov, De Zorzi, Honoré, Martínez-Velázquez, Nandrino, Martinez-Selva, Sequeira, 2017; Al-Salkhi, 2019; Mao, Yang, Bonaiuto, Ma, Harmat, 2020). It is also necessary to mention the works of Russian scientists linking the state with emotional stability (Zilberman, 1974; D'chenko, Ponamorenko, 1990; Prokhorov, 2005; Ragozinskaya, Solovieva, Nikolaev, 2009).

In psychology, as well as in psychophysiology, there are no methods for measuring stability, because no methodology has been developed for its study as a dynamic characteristic of the system's state. Methods are limited to tests, questionnaires with scales of subjective assessment, etc. But the main problem is that in the search for identifying mechanisms for achieving sustainability, its carriers are not singled out. So far, no analytical apparatus has been created that makes it possible to identify criteria-based assessments of the state of the system, including stability.

An innovative approach based on the matrix method is devoted to this problem. Below is an overview of the results highlighted in past works and the methodology for studying the emotional regulation system (ERS).

Methods

The methodology for the study of mental self-regulation was based on the theory of functional systems (Anokhin, 1980), the theory of systemogenesis (Barabanshchikov, 2000), the principles of the system-dynamic organization of the HMF (Luria, 2007), and the theory of differential emotions (Izard, 2012).

The rationale for this approach in the works of the classics was based on the connection of basic emotions with the processes of homeostasis, the instinctive sphere, which was noted by Darwin, Kretschmer, Sondi, Deryabin, Obukhovsky, Kempinski (Ilyin, 2013). This is also confirmed by their phylogenetic relationship with brain structures responsible for vital needs, as noted by Luria, Anokhin, Simonov, Plutchik (Ilyin, 2013). That is why the critical deviation in the balance of basic emotions, observed in a wide range of disorders, leads to the development of depression, dysphoria and phobias, inevitably leading to a loss of mental stability.

In turn, according to the principle of reciprocal relationships, bringing PES to balance by the methods of psychotherapy or pharmacology levels these deviations. In this regard, the possibility of assessing the stability of PES opens the way to the study of the mechanisms of mental self-regulation.

Results

Organization of the study

At the preliminary stage, myographic maps for diagnosing patterns of basic emotions were developed, based on the Facial Movement Coding System (FACS) by P. Ekman, expert assessments by G. Schwartz, E.D. Khomskoy, M.N. Rusalova (Volov, 2016). Electromyography was performed on the leads: 1) m. corrugator supercilli, 2) m. epicranius, 3) m. orbicularis oculi, 4) m. zigomaticus major, 5) m. masseter, 6) m. orbicularis oris. After measuring muscle tone in a calm state, tests were carried out when expressing emotions and when it was perceived from a photograph with microexpression (Ekman's test). Registration of contraction of mimic muscles was carried out according to the maximum amplitude in 3 leads. The nature of each reaction (weakening, strengthening of tone or its invariance) determines the type of pattern. The technique was standardized for each emotion (fear, anger, joy, sadness – 1, 4, 5; disgust, surprise – 1, 3, 6 and 2, 4, 6).

According to the plan, the impulse of the resulting afferent and efferent synthesis of the SER is reproduced in the samples. We consider facial expressions as a manifestation of the SER effector (Volov, Zalevsky, 2020). The expression on the face during the experience of emotion reflects a signal for a change in PES (test 1). In the FS theory, this corresponds to the link of efferent excitation. The expression that arises during the perception of an emotion reproduces a signal about the change that has occurred (test 2), which indicates the achievement of the result of the RD action. In Anokhin's theory, this is a link of reverse

afferentation: due to the effect of emotional resonance, the work of this mechanism is displayed. It has been experimentally established that reactions in samples in terms of frequency-amplitude characteristics cause involuntary phenomena.

A technique for decoding mimic patterns

Initially, any reactions that did not correspond to the standard were considered as a failure of the FS: the deployment of basic emotions as the basis for the formation of the state does not occur or is not completed. However, repeated uniform violations of the pattern draw attention to their true meaning. Recurring blood sugar "errors" when there is no response or an uncharacteristic response is observed on delivery or three deviations (tension instead of weakening of the tone, or vice versa), indicate a non-random type of response, an altered mode of functioning of the SER effector. These forms include the b-pattern.

Separately, an antagonistic pattern (c) was identified: there is a paradoxical reaction in all three leads – the opposite to the expected change in tone. It was by this form of reaction that the block of emotion was determined, because. The subjects unambiguously noted difficulties in expression (determined in the first test – c1), experience (c2), and often in determining emotions. As a result, three types of pattern were identified: a – reference, b – disturbed (incomplete), c – antagonistic.

When decoding myographic data, reactions of mirror reproduction of the emotion pattern were revealed in both samples, not only of the reference type, but also with a modified profile. This phenomenon is called the "chiral effect" (CE). With its help, signs of a block were revealed and the non-random nature of the disturbed pattern in a number of cases was confirmed once again. Later it was found that it manifests itself under conditions associated with the limitation of emotions, such as affect, neurosis, affective disorder, paroxysmal states, etc. This occurs due to a distortion in the work of the FS feedback link that determines the balance of PES.

Reproduction of the reference pattern (a) in both samples (k1), regardless of the intensity of the frequency-amplitude characteristics, is a standard manifestation of facial feedback (FRF). Mirror repeating deviations of the pattern indicate a change in the operation of this mechanism, leading to blocking of emotion. First of all, this concerns c-reactions. Accordingly, if such a pattern is determined in both samples, the emotion is completely blocked (k3). The same effect is observed during CE on b-type emotion (k2). Part of the EC with a changed profile is of the asymmetric type (b-type reactions* (k4), in which the disturbed pattern was reproduced in a paired sample inversely). This group includes profiles of the type "a-c", "c-a". The value of each block shape will be determined later, based on the matrix method.

Separately, the effect of imposing a pattern of one emotion on another (cir) should be mentioned. An extreme version of this form of blocking is fixation – a total imposition on several emotions at once.

It turned out that the emotion of fear is more often fixed. With the help of the chiral

principle, the types of reactions and forms of limitation of basic emotions at the level of efferent excitation or reverse afferentation were established, leading to a restructuring of the FS that forms the state (Table 1). Later, this made it possible to identify signs of MBE asymmetry associated with its stability (Volov, 2020).

Table 1
Model of qualitative diagnostics of basic emotions. Reaction types

reference	disturbed	antagonistic	asymmetric	overlay
(a-a) - k1	(a-b), (b-a), (b-b) - k2	(c-b), (b-c), (c-c) - k3	(a-c), (c-a) - k4 (b-b)* - k4	(cir-1) (cir-2)

All reaction profiles of k3, k4, cir-1-2 types are associated with the limitation of basic emotions (Volov, 2021). The direct block (on the efferent link - expression of emotion) is determined in sample 1, the isolation of affect or partial restriction (on the afferent link – experience) is detected on sample 2. Mimic reactions that give signals for change and for a change in PES reflect this process. The above-described typology of RLS restriction became the basis of a model for the qualitative diagnosis of mimic patterns of basic emotions, including the chiral principle, the decoding technique, and the blocking rating scale.

Approbation of the technique was carried out in a study of patients with epilepsy and healthy subjects. Based on the U-criterion, differences in the presence of mimic patterns of different types in the groups were revealed. It was found that the reference patterns for all basic emotions in the control group were more common than in the main group, although there were also violations (but much less frequently). Antagonistic reactions to fear, verifiable as an emotion block (c), were often found in both groups.

In the main group, non-standard reactions are observed more often for all emotions. Similar occurs in the control group, but only for incorrectly defined emotions and less often. It turned out that in the main group, not only more errors, but also false recognition is observed – the perception of one emotion for another. Differences were established for sadness in b- and c-type reactions (p=0.056) and for c-type anger (0.57). Patients better define anger. In a group of healthy anger subjects, an incomplete pattern occurs (b). In patients with a high c-reaction intensity was often elicited by fear. These differences were found in both samples.

With the help of frequency analysis (cr. McNamara), significant differences in EC were established. It turned out that in patients with epilepsy, b-type ECs occur regularly, for all emotions (p=0.405), regardless of recognition (much less often in the control group, p=0.205). And vice versa, a-type EC is more common in the group of healthy individuals for all emotions (in the main group less often, p=0.0258). In terms of anger, the main group of patients had more b-, c-, and k4-type ECs (p=0.0229). Most often, the overlay effect is associated with the emotions of fear, sadness and anger.

At the next stage, deviations in the patterns of basic emotions in the samples, some of which were identified as their blocking, were compared with clinical manifestations. Connections of blocking emotions with equivalents, paroxysmal and post-paroxysmal phenomena were determined. The role of the emotional sphere in the course of epilepsy is difficult to overestimate, because affects can provoke a seizure, be part of a seizure, its equivalent, and even a factor in the antiepileptic system. A special place in terms of the influence on PES and the course of epilepsy is occupied by a special form of distortion of the emotion pattern – superposition.

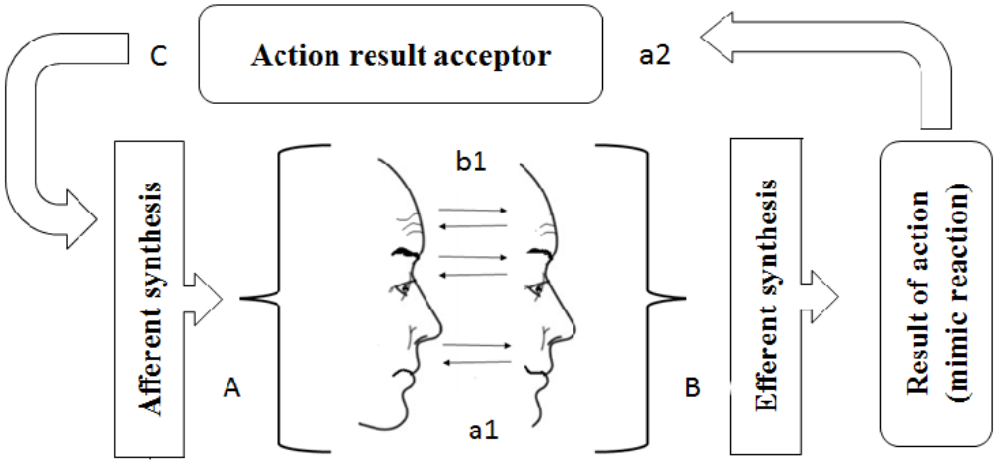
Additional studies have shown that a block to anger, including those with superimposed effects (when a sadness pattern appeared instead of the anger pattern) is of great clinical importance and manifests itself in the symptoms of the disease, such as dysphoria, dysthymia, and depression. Particular regularities were also established. For example, asymmetric block was more often observed in subjects with rare partial paroxysms. In the same group, a block to an emotion of the "isolation" type (a-c) is more often noted. The blocks revealed in the study found the corresponding clinical expression, and were later confirmed by psychodiagnostic data and in self-reports.

Experimental model

The mimic apparatus is considered in the work as a FS effector. The mimic pattern, as a kind of RD code, carries information about the specified changes, simultaneously reporting on the work of the effector, which has its own RD acceptor. The FS that implements mimic movement is included in the SER that determines the state. Both systems share a common feedback mechanism.

Representing it as an information node, we get the opportunity to track the work of the FS by the effector when the RD is reached. It turned out that blocking emotions is possible, both at the level of the flow of impulses for change, and about change. Both signals may not correspond to physiological manifestations and sensations, at the same time being reflected in the FS. As a result, not matching the given result in the form of a reference pattern, the signals lead to a restructuring of the PS or to a change in the RD acceptor. This is a fundamentally new approach to understanding the foundations of SER self-organization, which develops the concepts of Anokhin's theory. This process is modeled in the experiment and recorded using electromyography. The FS blocks are highlighted in the diagram (Fig. 1).

Figure 1
Conditional diagnostic scheme of the SIR information node



***Note**: A – efferent excitation; B – efferent voltage; C – decision-making; b – impulse to change; a1 – signal of change, a2 – reverse afferentation*

The figure shows how mimic movements in the effector, being converted into signals, encode state parameters. Being a subordinate link, the effector, having a common feedback mechanism (a1), reflects the work of the SER. At this level, it is possible to adjust the program for achieving the RD. In case of RD mismatch, in accordance with the FS theory, a decision is made to continue the action or restructuring of the FS, which implements the deployment of the basic emotion, reported through the back afferentation channel (a2). This approach makes it possible to diagnose signs of distorted afferentation. At the next stage, an analytical apparatus was used to quantify TEC.

The analytical method for quantifying the PES, including the static stability of the MBE, was developed on the basis of the matrix method (Gantmacher, 2010). The principle of symmetry and the principle of superposition are applied for the criterion assessment of stability. In the development of the MBE Z_{ij}, a dyadic analysis of paired affects (orthogonal), selected on the basis of psychological polarity, was used. In our previous works, we have described in detail the method of estimating PES, including the mathematical part, which we will present below (Volov, 2015, 2016). In general, the MBE matrix element has the following form:

$$Z_{ij} = Y_j + X_i, where\ i = 1 \div 3, j = 1 \div 3, \quad (1)$$

where the elements of the matrix are determined by the addition of emotions (Table 2).

Table 2
Basic Emotion Matrix

Emotions	X_1 (anger)	X_2 (joy)	X_3 (surprise)
Y_1 (fear)	Z_{11}	Z_{12}	Z_{13}
Y_2 (sadness)	Z_{21}	Z_{22}	Z_{23}
Y_3 (disgust)	Z_{31}	Z_{32}	Z_{33}

The main indicators of the MBE are the norm of the matrix $||M_{ij}||$ and tension (L). The trace of the matrix is determined by summing the readings of paired emotions:

$$L = Z_{11} + Z_2 + Z_3 = (Y_1 + X_1) + (Y_2 + X_2) + (Y_3 + X_3) \quad (2)$$

All MBEs are canonical, and their elements are positively defined. This means that the norm of the matrix has the following form:

$$\text{K-norm} \quad \left\| M_{ij} \right\| = \sqrt{\sum_{i=1}^{3} \sum_{j=1}^{3} z_{ij}^2} \quad \text{(mW)} \quad (3)$$

will be greater than any of the MBE elements

$$\left\| M_{ij} \right\| \geq z_{ij} \quad (4)$$

All matrices are canonical and degenerate (r=2). This fact indicates the connection of paired emotions. The criterion of deviation from MBE symmetry is determined by the average value of deviations of paired non-polar emotions of the matrix (Z_{ij}, Z_{ji}).

This dimensionless criterion determines the stability of the MBE:

$$\bar{\varepsilon} = \sum_{i=1}^{3} \sum_{j=1}^{3} \left| z_{ij} - z_{ji} \right| \Big/ z_{ij(ji)}^{\max} \Big/ 3, \quad i \neq j \quad (5)$$

where is the maximum value of the off-diagonal MBE term.

The criterion is a dimensionless quantity, and the dimensional quantity associated with it, the criterion $\bar{\varepsilon}$ *L, determines the share of the TEC feedback energy that goes to the off-diagonal imbalance of the MBE (Volov, Volov, 2015).

The MBE criterion has also been developed, which determines the degree of deviation of paired polar emotions MBE $\{Z_{ij}\}$ from their average values equal to L/3. This criterion has the following form:

$$\Delta\bar{L} = \Delta L / L, \text{ where } \Delta L = \sum_{i=1}^{3} \left| L/3 - z_{ij} \right| \quad (6)$$

The next criterion is an indicator of the energy efficiency of the PES feedback is defined as follows:

$$I = 1 - \left[\frac{\Delta E + \Delta L}{\|M_{ij}\|} \right] \cdot \varphi, \quad \Delta E = \bar{\varepsilon} \cdot z_{ij(j)} / 3 \quad i \neq j, \phi = \begin{cases} 1, \text{ if } abs(\|M_{ij}\| - L)/\|M_{ij}\| \leq \varepsilon_1; \\ \beta, \text{ if } abs(\|M_{ij}\| - L)/\|M_{ij}\| \rangle \varepsilon_1 \end{cases}; \quad (7)$$

$$\text{where } \beta = 0.7; \ \varepsilon_1 = 0{,}05.$$

The energy of the OLS is only a part of the energy of the PES. When the intensity is close to the value of the norm, the energy of the imbalance is drawn from the energy of the RL (φ=1). Otherwise, part of the energy going to the imbalance is transformed from the total energy (φ=0.7).

Approbation of the method

A comparative analysis according to the criteria of the matrix method revealed significant differences between healthy individuals and patients with epilepsy. Below is a comparison of the MBE characteristics of the two groups (Table 3).

Table 3

Energy indicators of MBE

EMG values(healthy)		EMG values(healthy		Differences (%)
L	ε	L	ε	εL
47	0.18	86	0.245	26.5%
EMG values (sick)		EMG values (sick)		Differences %
L	ε	L	ε	εL
46	0.18	86	0.31	42%

It follows from the table that the higher the level of tension, the higher the level of imbalance, which is equivalent to an increase in the degree of asymmetry of the MBE. A trend was revealed: subjects with epilepsy are distinguished from healthy individuals by a significant increase in this parameter.

The main results were obtained in studies of the emotional sphere of subjects with different forms and course of epilepsy (Volov, 2016). The data of subjects with rare generalized seizures (1), with frequent generalized seizures (2), with equivalents (3) and in remission (4) were compared. Significant differences were revealed (Table 3).

In past studies, it was determined that MBE indicators differ in patients depending on the frequency and form of paroxysm. When comparing these groups with generalized seizures, the following was determined. Group 2 is characterized by lower energy efficiency (I), high voltage (L), high imbalance costs (εL), as well as high entropy values (H1=0.613, H2=0.66). This trend shows the best state of the ER group with rare generalized seizures.

Each of the mentioned MBE parameters can be correlated with the state of the emotional sphere and the ability to self-regulate. The intensity of the MBE to a lesser extent requires justification, because physically reflects the quality of the state of the SER. But the imbalance indicators are associated with the stability parameter - the most complex and important object for modern research of the system and assessing the level of its self-organization.

It was a surprise that, according to these indicators, group 1 compares favorably with groups 3 and 4. The revealed trend was justified in the Ivanov-Smolensky theory, in which a convulsive seizure is considered as a factor in discharging paroxysmal tension. The latter contributes to the normalization of the state of the emotional sphere and mental activity. As you know, the reverse mechanism also works: a change in the emotional state, for example, due to antidepressants, normalizes brain activity, leveling paroxysmal activity.

At the same time, the indicators on the energy efficiency index (I) are significantly better in groups without generalized paroxysms (3, 4). So, despite some advantages, the model of self-regulation of the emotional system in the presence of generalized paroxysms, albeit rare ones, is ultimately inferior to these forms. The data of groups 3 and 4 are similar in their indicators.

Noteworthy is only the difference in the stress factor, which is significantly higher in group 4 in subjects in remission. This fact is presumably due to the fact that, unlike group 4, group 3 has epileptic equivalents in its clinic, and, therefore, ways to discharge paroxysmal tension. Thus, the correspondence of the PES profile according to the characteristics of MBE to the clinical forms of the disease was established.

At the next stage of the study, a comparison was made based on the factor of the presence of a block according to the energy indicators of the MBE. A comparative analysis of a group of patients with epilepsy with a sign of block (in sample 1) and with isolation of basic emotions (in sample 2) was carried out. Differences in the level of entropy and imbalance are established. In group 2 they are lower (H_2=0.63, H_1=0.639; ε_2=0.187, ε_1=0.228). In terms of I, group 2 also surpasses group 1, which indicates a greater efficiency of the isolation mechanism. Presumably, the block and isolation solve the problem of achieving stability in different ways. A higher MBE voltage in group 2 is not accompanied

by high imbalance indicators: the formation of a c-block in the second sample occurs under such conditions arises as a factor in leveling the imbalance.

The revealed trend demonstrates the advantages of emotion isolation over the block in some cases. This mechanism is more often observed in the group with rare generalized seizures. In this case, isolation, on the one hand, limits the experience of emotion directly (by blocking the feedback signal), on the other hand, indirectly by eliminating the mechanism of emotional resonance that can trigger the state (Simonov, 1981). Thus, stability of the MBE is achieved. This assumption is confirmed by the fact of large values of imbalance indicators in the specified group in the presence of a block or its absence in both samples.

It was found that the group of the same clinical form with a block favorably differs in MBE characteristics from the group without it. At the same time, the condition and prognosis for the former are more favorable. This was noted in the group with frequent generalized seizures with c-reactions in two tests on the emotion of anger. Also, on the basis of statistical analysis, correlations were established between MBE indicators and signs of emotion limitation. So, in the main group, tension correlates with the factor of blocking emotions of fear (r=-0.47) and disgust (r=0.57), as well as with the index of anger identification (r=-0.48). The last dependence is especially interesting, because it is stated above that it is the emotion of anger that is determined by patients better. Outbursts of anger, attacks of dysphoria are known to be characteristic of patients with epilepsy. The similarity to paroxysm makes this emotion dangerous in terms of provoking a seizure, so its definition becomes an important task of self-regulation. The effect of lowering the MBE tension in the presence of a block on fear is largely determined by the great clinical significance of this emotion and involvement in almost all paroxysmal phenomena and symptoms that occur in epilepsy. The imbalance index correlates with the aversion block (r=0.51). This connection is not accidental: this is largely due to the low ability to displace.

In the group of healthy subjects, MBE tension correlates with the indicator of identification of sadness (r=-0.47) and surprise (r=0.67). Surprise as an emotion related to the orienting reflex triggers cognitive processes. The decrease in the ability to determine sadness, accompanied by an increase in MBE tension, is explained by the mechanism of the displacement of protection from painful experiences accompanied by sadness.

In the next cycle of work, gender differences are identified. In the group of women with epilepsy, a tendency was revealed: a block to fear is observed when its tension (according to the MBE index) is exceeded compared to sadness. Both emotions are observed in the clinic of the disease, but are not orthogonal. Despite this, a dependence was revealed due to the unity of the matrix of basic emotions that determines the energy balance, the expression of which is the balance of PES.

This dependence is not accidental. Fear often provokes an attack, signals about in the structure of precursors. Sadness often manifests itself in the interparoxysmal period in the form of depression. Accordingly, blocking the emotion of fear becomes necessary

to achieve balance in the MBE. When the tension of anger (orthogonal emotion) predominated over fear, the same tendency was noted, reflecting the mechanism of stability of the MBE. In the group of men with epilepsy, with the prevalence of fear, all forms of the block are noted. However, as in the control group, no patterns were found.

It is necessary to separately note the asymmetric block and the overlay effect. Most often, this block was detected in the group with rare partial paroxysms with similar indicators. When the resulting afferent and efferent synthesis are in antiphase, the excess stability of the PES is compensated (Volov, 2016).

A specific distortion of the emotion pattern indicates the presence of the so-called. a stable pathological condition (in the terminology of N.P. Bekhtereva), in which a temporary balance is achieved by limiting the RLS. The variety of forms of the block reflects the variability of the mechanisms of mental self-organization in the conditions of the paroxysmal brain, associated with the solution of the problem of achieving stability. But the question of the role of each block shape is yet to be clarified.

It is known that basic emotions can mix and inhibit each other. According to Izard, the energy of one affect can be transferred to another. As it turned out, this happens when imposing. An important assumption is the idea that overlaps gradually lead to the formation of corresponding emotional traits. Thus, the old scientific problem of an "epileptic nature" sounds in a new context (Boldyrev, 2000).

It is necessary to take into account other factors, for example, fixation, which consists in fixing a typical reaction in the form of a distorted pattern (b-type), or a chiral reaction of orthogonal emotions (type a-c, c-a). More often these are persistent stereotypes of aggressive-angry behavior and an angry-dreary mood.

Entropy method

In addition to matrix criteria, static and dynamic sustainability criteria were developed based on the entropy approach (Volov, Volov 2015). The generalized measure of stability developed in 2015-2016 was the deterministic entropy, which has the following form:

$$H = \alpha\left[1\text{-}\delta\left(M_{ij}{}^{(sym)}\text{-}M_{ij}\right)\right] + \frac{H_0 - \alpha}{\ln\left(a^{r-1}\right)}\ln\left[a^{r-1} + b\left(\frac{\bar{\varepsilon}L}{<\bar{\varepsilon}L>_{healthy}} + \frac{JL}{<JL>_{healthy}} + \frac{J\bar{\varepsilon}}{<J\bar{\varepsilon}>_{healthy}} - 3\right)\right][1\text{-}\delta(r\text{-}1 \quad (8)$$

$$\alpha = 0.3, \quad a = 1.2, \quad b = 1\cdot 10^{-3}, \quad \delta\left(M_{ij}^{sim} - M_{ij}\right) = \begin{cases} 1, & M_{ij}^{(sim)} = M_{ij} \\ 0, & M_{ij}^{(sim)} \neq M_{ij} \end{cases}, \quad \delta(r-1) = \begin{cases} 1, & r = 1 \\ 0, & r \neq 1 \end{cases}$$

where $\overline{\Delta E} = \Delta E / L$ $i \neq j$ $\Delta \overline{L} = \langle \Delta L / L \rangle_{healthy} = 0.1023;\ \langle \Delta \overline{E} \rangle_{healthy} = \langle \Delta E / L \rangle_{healthy} = 0.2047.$

In forumule (8) M_{ij}^{sim} – a symmetric matrix having the same norm as the MBE obtained as a result of the study, M_{ij}, r – matrix rank $\overline{\varepsilon} \cdot L$ – the value of the average energy imbalance of the MBE, H=0.618, the value of the "golden section" entropy , $\varepsilon L_{healthy}$, $\langle \Delta \overline{E} \rangle_{healthy}$, $\langle \Delta \overline{L} \rangle_{healthy}$ – are the averaged values of the off-diagonal imbalance, relative imbalance of off-diagonal terms and relative inhomogeneity of tension for healthy people.

There is a difference in the dependence of entropy on the MBE tension parameter in epilepsy (Volov, 2016). It was found that for healthy individuals, the increase in entropy is linear, and for sick subjects, a parabolic dependence is noted. At the same time, the level of entropy (H) in healthy people with an increase in the parameter L is significantly higher than in patients, where is the standard deviation (Fig. 2, 3).

Figure 2

Dependence of entropy on the intensity of the MBE in a group of healthy individuals

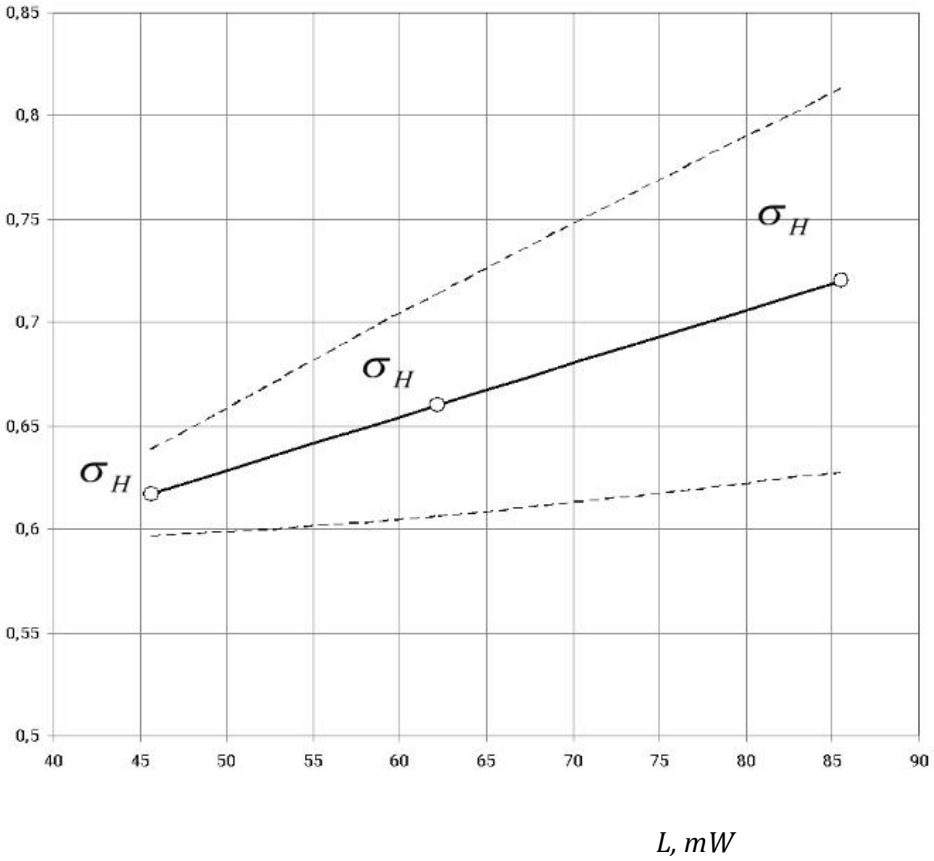
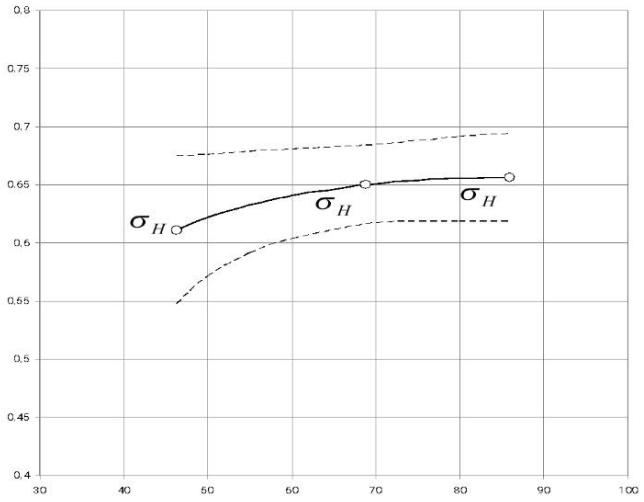


Figure 3

Dependence of entropy on MBE intensity in the group of patients with epileps



Previously, the dependence of entropy on the MBE voltage level was established (Volov, 2015). In the first sample (at L ≤60), with the same MBE parameters, the level of entropy volatility in patients with epilepsy is significantly higher (Fig. 4, 5).

Figure 4

The level of entropy volatility in the group of patients with epilepsy

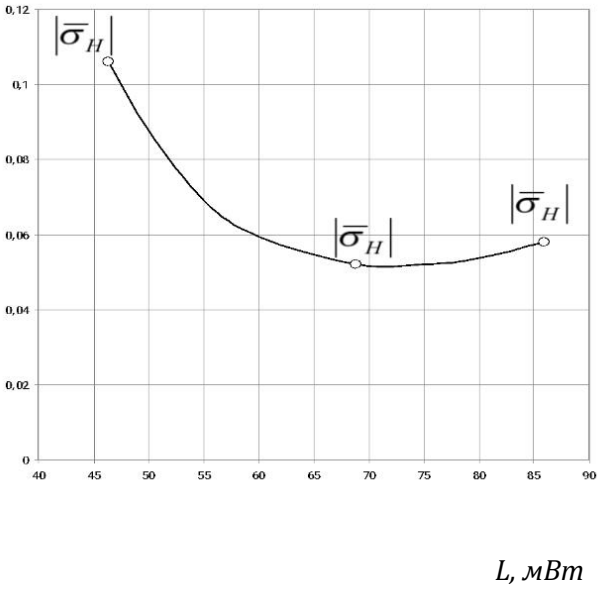
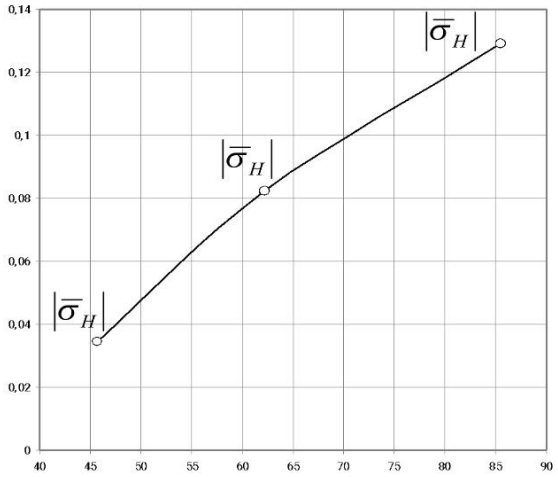


Figure 5
The level of entropy volatility in the healthy group



In the second group (L≥60), with the same values of the parameter L, the level of entropy fluctuations in healthy people is significantly higher (Volov & Volov, 2015). With an increase in stress, the level of entropy fluctuations in patients decreases, which corresponds to the effect of excessive stability (Zalevsky, 1993).

With the help of the method, a fundamental pattern was revealed: in epilepsy, with an increase in the power of the MBE, its energy imbalance increases, which means that the stability of the PES is lost. Higher voltage is combined with higher unbalance energy ratings. The figure shows that the trend depending on the tension has a convex character, which, in accordance with I. Prigogine's theorem on the minimum entropy production, can be interpreted as a stable MBE character (the L parameter here plays the role of time).

An analysis of the average values of the standard deviations of entropy shows a decrease in their values with an increase in the tension L, which additionally confirms the stability of the functioning of the ER in epilepsy.

This is a manifestation of self-organization associated with the blocking of basic emotions: the system gets rid of unnecessary degrees of freedom.

Discussion

The paper presents an innovative method by which the criteria for assessing PES are determined. The basis of the method, which opens up new perspectives in the study of the regulatory mechanisms of the functional systems of the psyche, is the matrix of basic emotions.

Established on the basis of the model of qualitative analysis, the block of emotion, identified at the level of the OLS, under such conditions arises as a factor in leveling the imbalance of the MBE. Comparative analysis made it possible to determine the effectiveness of various forms of emotional block in epilepsy as a mechanism for achieving PES stability, determined by the balance of basic emotions. For the first time, the phenomenon of distorted afferentation was experimentally established, which does not arise as a result of a perception error or pathology of sensations, but as a phenomenon of internal self-regulation of the SER, which manifests itself in the feedback link.

Based on the MBE, a formula for its entropy has been developed, which allows revealing additional information about the dynamics and statics of the psycho-emotional state. The revealed effect of volatility shows the fundamental difference between the SER between a healthy and paroxysmal brain. Thus, the study reveals individual mechanisms of self-regulation associated with limiting the feedback of the emotional response system.

Conclusion

– Mimicry is considered as an effector of the functional system of emotions, according to the manifestations of which the work of the information node is diagnosed, reflecting in the facial muscles impulses to change the state and signals about its implementation.
– In the experiment, the operation of the information node of the emotional regulation system was modeled, which was recorded using electromyography and made it possible to assess the state, as well as determine the quality of the reaction, and establish signs of distortion of the basic emotion pattern.
– The proposed approach for the study of the psycho-emotional state based on monitoring the matrix of basic emotions by facial feedback includes an analytical apparatus that allows us to make quantitative assessments of stability, tension, the level of imbalance, as well as a model for the qualitative diagnosis of mimic patterns of basic emotions.
– Based on the developed approach and innovative methods, signs of distorted afferentation at the level of the resulting afferent and efferent synthesis were revealed. These phenomena are identified as various forms of limitation of emotional response in the form of a block, isolation or overlap, some of which relate to the mechanisms of self-organization, and some to pathological signs.

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Author Details

Vsevolod Vyacheslavovich Volov – Cand. Sci (Psychology), Samara Institute of Fundamental and Applied Research, Samara, Russian Federation, doctoral student, Tomsk State University, Russian Federation; ORCID: https://orcid.org/0000-0002-1647-6754; e-mail: vsevolov79@mail.ru

Conflict of Interest Information

The author has no conflicts of interest to declare.