

**ASPECTS REGARDING THE NEUROBIOLOGY
OF PSYCHO-AFFECTIVE FUNCTIONS**

ASPEKTI KOJI SE TIČU NEUROBIOLOGIJE PSIHIČKO-AFEKTIVNIH FUNKCIJA

Alin Ciobica^{1,3}, Raducu Popescu², Ion Haulica^{2,3}, Walther Bild^{2,3}¹»Alexandru Ioan Cuza« University, Iasi, Romania²»Gr. T. Popa« University of Medicine and Pharmacy, Iasi, Romania³Center of Biochemical Research of the Romanian Academy, Iasi Branch

Summary: In this mini-review we were interested in analyzing the main achievements concerning the neurobiological substrate of the human psycho-affective functions. The cortico-subcortical areas implicated in the elaboration and the control of the sensorial and psycho-affective reactions of the human brain are described, as well as the neurobiological basis of the psychic and affective manifestations, with focus on the new achievements in understanding the genetic, morpho-chemical and electromagnetic bases of the psycho-affective and behavioral manifestations, both normal and pathological. It is known that emotional states like anxiety, fear or anger generate complex psycho-affective reactions that are controlled by the limbic system, which is called the emotional brain. This is connected with the polyneuronal circuits of the Papez loop, the hypothalamic-pituitary complex and the reticular formation of the brainstem. Some imagistic aspects concerning the implication of the amygdala and the cingulate gyrus in laughing and crying are mentioned, as well as the cerebral areas implicated in romantic and maternal love. Also, some electromagnetic manifestations of the brain are presented, introducing the concept of »electromagnetic plasma«, as a possible component of the human brain activity.

Keywords: psycho-affective functions, behavior, cortico-subcortical areas, emotional brain

Kratak sadržaj: Naš interes u ovom mini pregledu bio je da analiziramo glavna dostignuća vezana za neurobiološki supstrat humanih psihičko-afektivnih funkcija. Opisana su kortiko-supkortikalna područja uključena u elaboraciju i kontrolu senzornih i psihičko-afektivnih reakcija u ljudskom mozgu, kao i neurobiološka osnova psihičkih i afektivnih manifestacija, uz poseban osvrt na nova dostignuća u razumevanju genetskih, morfo-hemijskih i elektromagnetskih osnova psihičko-afektivnih i bihevioralnih manifestacija, kako normalnih, tako i patoloških. Poznato je da emocionalna stanja poput anksioznosti, straha ili besa stvaraju složene psihičko-afektivne reakcije koje kontroliše limbicki sistem, koji se još naziva emocionalnim mozgom. Ovo je povezano s polineuronalnim kolima Papezovog kruga, kompleksom hipotalamus-hipofiza i retikularnom formacijom moždanog stabla. Navedeni su neki aspekti slikovne dijagnostike koji se tiču učešća amigdale i *gyrus cingulatus*-a u smejanju i plakanju, kao i cerebralnih područja koja imaju ulogu u romantičnoj i majčinskoj ljubavi. Takođe su predstavljene neke elektromagnetske manifestacije mozga, uz uvođenje koncepta »elektromagnetske plazme«, kao moguće komponente aktivnosti ljudskog mozga.

Ključne reči: psihičko-afektivne funkcije, ponašanje, kortiko-supkortikalna područja, emocionalni mozak

Address for correspondence:

Walther Bild
»Gr. T. Popa« University of Medicine and Pharmacy
Str Universitatii 16
700115 Iasi, Romania
Tel. +40744524762; Fax +40.232.301.873,
e-mail: wbild@rdslink.ro; waltherbild@gmail.com

Introduction and a little bit of history

The growing interest concerning the neurobiological bases of the various psychic manifestations has recorded important progresses in the past few decades, thanks to the introduction of modern research techniques. Although there are plenty of

analytical data, there are still many questions regarding the scientific substrate of many neuropsychic manifestations, both normal and pathological. Compared with its psychological part, which has a rich and different interpretation, the biological component is still unknown. Another problem is the lack of adequate methods for decoding the secrets of the brain and the progress of knowledge concerning the biological substrate of the psycho-affective manifestations.

These aspects are the result of the rationalist ideas which were dominated from Aristotle to Descartes by various theosophical concepts, dualistic or monotheistic.

Using the Hippocrates's theory, according to which the human body is a complex of humours, Galenus performed in the second century the very first dissection on animals and laid the foundations of anatomical conceptions regarding the material substratum of the vital process, which were dominant for 15 centuries in biology and medicine.

The experimental fundamentals regarding the materiality of the neuropsychic activity appeared in the 17th century, with the studies of Thomas Willis (1664) from Oxford concerning the cerebral circulation of various animals, a short time after his master W. Harvey (1628) had discovered the role of the heart pumping the blood into the whole body, including the brain. He noticed the relations between the circulation and the activity of the central nervous tissue and was the first to signalize the role of the blood circulation, controlling the normal functions of the brain. By analogy with the liver and kidney, the brain was considered as a »secretive organ of thoughts«.

Later on, many researchers, using more and more advanced techniques, brought new clinical and experimental evidence concerning the relation between various forms of nervous activity and the structure, biochemistry and functional state of the cerebral nervous tissue. Therefore, the bases of neuroanatomical, electrophysiological, behavioral and imagistic researches have been established, with a great impact on the understanding of the cortical-subcortical localization and the mechanism of superior nervous functions, both normal and pathological.

Morphological aspects

In terms of structure, the Central Nervous System (CNS) is made up of billions of neurons and trillions of interneuronal synapses and over 50 chemical substances act at its level with the function of neurotransmitters and synaptic modulators. At the same time, the existence of a ten times bigger number of glial cells has been noticed, which have functions of support, defense and nutrition in the cerebral network. Also, the morpho-chemical integrity of the

triplet neuron-neuroglia-caterpillars is crucial in the various forms of central nervous activity.

The classical micro- and macroscopic neuro-anatomical research, completed by modern imagistic techniques such as computer tomography electron emission and functional magnetic nuclear resonance, showed the localization of various cortico-subcortical areas which play roles of integration, regulation and control of the motor, sensitive-sensorial and psycho-affective functions of the human body, describing a real geographic map of the human brain.

The morpho-functional relations between specific cortical areas and the subcortico-bulbo-medullary structures are bidirectional – afferent and efferent. According to the holistic theory, these relations permit the vertical and horizontal integration of the polyn neuronal cortico-subcortical structures which generate cognitive, ideal and affective manifestations of special complexity.

Different aspects of the neurobiological basis of psycho-affective functions

Regarding the neurobiological basis of the psycho-affective manifestations, the opinions from the large field of neuroscience research still differ. According to Gerard Edelman, holder of the Nobel Prize (1972) and director of a Neuroscience Institute from USA, the brain functions are based on complex polyn neuronal circuits, which are cybernetically activated by the information that comes from the external environmental factors and internal humoral factors. According to his vision, the brain is a biological computer formed by a complex group of polyn neuronal aggregates, disposed as integrate modules which play the role of an interface and assure the capacity to decode, analyze, explore and elaborate reactions and differentiate solutions, depending on the received information (1).

Another Nobel Prize holder, Christian de Duve (2), who specialized in cellular biology, when speaking about brain functions, said that the cognitive, affective and behavioral mental processes have a genetic substrate and they are formed in different ways, especially at the cortical level. In this way, the human being has been equipped since birth with a preformed nucleus of impulses and moral predisposition, which is located in the prefrontal cortex and inferior parietal lobe. Afterwards, this nucleus can be modulated by familial, educational and environmental factors (3).

On the other hand, Erwin Schrödinger, who also received the Nobel Prize in the field of physics, extends the quantum theory of energetic leaps to a biological phenomenon and also proposes a material explanation for the neuropsychic manifestations. In his monography called »What Is Life?« (1944) he says

that »Life – as an island of order in the huge ocean of entropic disorder« is both matter and spirit. Referring to the content of these affirmations, Schrödinger considers the spirit or the soul as an energetic manifestation of the psychic, moral and intellectual features which defines individual personality. For Schrödinger the conscience is a mental state dependent on the relation brain-psyche, which generates fundamental forms of superior nervous activity, at a given time (4).

Topographical aspects and main neurotransmitters

Starting with the introduction of non-invasive neuroimaging techniques, as new research tools for the morpho-functional substrate of the various forms of brain activity, new experimental proofs emerged, sustaining the implication of some nervous structures in the various neuropsychic manifestations, both normal and pathological.

But their efforts in order to identify and to localize the psycho-affective processes, depending on the dominant hemisphere, established that the emotional reactions are mostly associated with the activation of structures from the temporal lobe and prefrontal cortex of the right hemisphere. Meanwhile, in the left hemisphere, the analytical processes are predominant and they assure the performance in creativity, artistic inclinations and intelligence (5).

Concerning the psychic problems induced by emotions and anxiety, it is known that their neurobiological substrate is based on organo-vegetative, endocrine, psycho-affective and expressive reactions of different types, intensities and duration, starting with the face expression and skin color and finishing with possible aggressive vocal and behavioral reactions.

The so-called emotional brain is part of the cortico-subcortical areas of the limbic system and it is activated in case of unpredictable events, such as fear, anger and other motivational and adaptative situations. The basic elements of the limbic system implicated in the psycho-emotional and the behavioral manifestations are represented especially by the amygdala, which is located in the mesotemporal lobe and is connected through a large network of neurons with the hippocampus, the anterior thalamus and the associative prefrontal cortex.

Also, the premotor cortex together with the hypothalamus, the septum, the insular and the anterior cingulate cortex activates the limbic system and has an important role in triggering the aggressive or emotional reactions. It has been demonstrated, through electroencephalographic methods, that predominant activation of the left prefrontal cortex is associated with positive emotional reactions, whereas the activation of the right associative cortex is predominant in negative emotions. The prefrontal cortex

lesions alter the capacity of concentration, without affecting cognitive functions and speaking. As it is known, prefrontal lobotomy was practiced in some psychiatric disorders and it has been reported to have some positive effects.

Acute and chronic stress alter the normal equilibrium between the two prefrontal areas, leading to multiple neuro-endocrino-metabolic imbalances. The structures implicated are components of the Papez loop (anterior thalamic nucleus, hypothalamic mammillary bodies and cingulate gyrus) and they are interconnected with some polynuclear circuits of the limbic system. The stimulation or the lesion of these nervous structures modifies the emotional and behavioral reactivity. For example, electric stimulation of the amygdala or hippocampus induces anxiety, anger and aggressive manifestations, while their lesion is followed by the taming of animals. Also, stimulation of the dorso-medial and anterior nuclei of the thalamus leads to major affective and behavioral changes. Recently, the activation of neuronal circuits implicated in the emotional reactions induced by positive stress (eustress) and negative stress (distress) has been determined (6). Using the functional RMN technique, Sander et al. (7) established the participation of the amygdala, anterior cingulate gyrus and auditory cortex in the generation of laughing and crying.

Lauc and Flögel (8), studying the neuroendocrine reactions to stress, recently discovered a serum glycoprotein called stressin, which they assume to be a molecular marker in stress alterations.

Also, Morilak et al. (9) discovered that chronic stress alters the genetic substrate of the enzymes that inactivate norepinephrine and serotonin.

Very interesting data have been presented regarding the association between different nervous areas and the psychical and emotional features of maternal and romantic love. In both cases the neuronal circuits are mainly dopaminergic, leading to the activation of the tegmental area, insular cortex and cingulate cortex and the inhibition of the amygdala and caudate nucleus (10). Also, the circuits of pain include the activation of the endorphin opioid system located in the dorso-lateral prefrontal cortex, the left nucleus accumbens and insular and cingulate right cortex (11).

Suprarenal and gonadal hormones have an important modulator role. The stimulation of the limbic-hypothalamus-pituitary-adrenal axis, which produces CRH, ACTH, cortisol and epinephrine, induces anxiety and depression, while stimulation of the limbic-hypothalamic-pituitary-gonadal axis, which activates the secretion of estrogen and testosterone hormones, stimulates the dominant manifestation of sex and personality. The predominance of one class of these steroid hormones has an important role in modulating several psycho-affective and behavioral mani-

festations, which results from different neuropsychic alterations. While cortisol is a biochemical marker of emotion, anxiety and depression, testosterone is correlated with the psycho-affective reactions of good mood.

The most important chemical mediators of synaptic transmission between neurons that are usually involved in psycho-affective and emotional reactions are serotonin, adrenaline, noradrenaline and dopamine. They also use opioids, neuropeptides, neurotrophins and neurokinins (substance P) as chemical modulators.

There is also growing interest concerning GABA (as an anxiety inhibitor) and substance P (as a neuro-modulator of serotonin and adrenergic nervous pathways involved in emotional state, anxiety and depression). Recently, new experimental proofs emerged in favor of a possible gashouses transmission that could be realized by nitric oxide, carbon monoxide and hydrogen sulfide (12). There is still no conclusion about the role of these mediators in the psycho-affective manifestations.

Although the research progressed from the cerebral level to the cellular and molecular level, the intimate mechanisms involved in these functions are not yet fully understood. The recent models of the human brain, created by electronists, are in full progress, but still they do not reach the functional performance of the central nervous system tissue.

Recent research about the relations between neuronal circuits from the brain and those from modern computers draws attention to the possible implication of photonic radiations (with high frequencies -1-4 billions cycles per second) belonging to nuclear DNA, in the interdependence between the brain, con-

science and spirit (13). In keeping with this idea, Mc Fadden (14) recently elaborated a theory concerning the magnetic field of the conscience. According to his vision, the electromagnetic phenomena, generated by microwaves that are emitted by the nucleic acids from cortico-subcortico neurons, represent the »electromagnetic plasma«, as an energetic matrix indispensable to the integration, processing and execution of specific neurochemical reactions for the various forms of nervous activity. Additionally, modern clinical and experimental studies are trying to define the implication of neuronal electromagnetic fields in the neurochemical process of integration, processing and elaboration of the various neuropsychic manifestations, both normal and pathological (15).

Conclusion

From the briefly presented data about the materiality of the neuropsychic manifestations we can conclude that we are still in the position of a brave alpinist watching the mountain peak hidden in clouds, and comforting himself with the idea that the journey is more rewarding than staying in one place.

Acknowledgments. Ciobica Alin is supported by a POSDRU grant /89/1.5/S/49944, Alexandru Ioan Cuza University, Iasi. This paper is dedicated to the memory of Acad. Prof. Ion Haulica (1924–2010), who had the idea of performing this work a few years ago, but never got the chance to finish it.

Conflict of interest statement

The authors stated that there are no conflicts of interest regarding the publication of this article.

References

1. Edelman GM. Neural Darwinism: The Theory Of Neuronal Group Selection. Oxford, Oxford University Press 1989.
2. De Duve C. Life evolving: Molecules, Mind and Meaning. Oxford, Univ. Press, 2002: 108 pp.
3. Moll J, De Oliveira-Souza R, Zahn R. The neural basis of moral cognition: sentiments, concepts, and values. *Ann N Y Acad Sci* 2008; 1124: 161–80.
4. Schrödinger E. What Is Life? The Physical Aspect of the Living Cell, 1944.
5. Snyder SH. Seeking god in the brain—efforts to localize higher brain functions. *N Engl J Med* 2008 3; 358: 6–7.
6. Bajčetić M, Brajović M, Korkut-Tešić R. Diagnostic and therapeutic significance of the oxidative stress parameters. *Journal of Medical Biochemistry* 2010; 29: 196–203.
7. Sander D, Grafman J, Zalla T. The Human Amygdala: an Evolved System for Relevance Detection. *Reviews in the Neurosciences* 2003; 14: 303–16.
8. Lauc G, Flögel M. Glycobiology of stress. *Encyclopedia of Stress* 2007; 2: 222–227 pp.
9. Morilak DA, Bondi CO, Lapiz-Bluhm MD. Effects of chronic stress, monoamines and antidepressant drugs on cognitive function in prefrontal cortex. 'Abstract'. *European Neuropsychopharmacology* 2008; S20.05: S185.
10. Ortigue S, Bianchi-Demicheli F, Hamilton AF, Grafton ST. The neural basis of love as a subliminal prime: an event-related functional magnetic resonance imaging study. *J Cogn Neurosci* 2007; 19: 1218–30.

11. Zubieta JK, Yolanda R, Bueller J, Xu Y, Kilbourn M, Jewett D, et al. Regional Mu Opioid Receptor Regulation of Sensory and Affective Dimensions of Pain. *Science* 2001; 293: 311–15.
12. Snyder SH, Ferris CD. Novel neurotransmitters and their neuropsychiatric relevance. *Am J Psychiatry* 2000; 157: 1738–51.
13. Vind CD. Brain-Soul-Consciousness: a synthesis of ideas (in progress), <http://www.west.net/simon/brain-soul-consciousness.html>.
14. Mc Fadden. The conscious electromagnetic field theory 2002, <http://www.surrey.ac.uk/qe/cemi.html>.
15. Scaruffi P. The nature of consciousness – second part. *J Neurosci* 2008; 8: 13–23.

Received: October 12, 2011

Accepted: November 29, 2011