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The Biophysical Adjustment in the Human Organism

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Abstract

Homeostasis is one of the biophysics' major concepts. The term „homeostasis" has been introduced by Cannon in 1929, meaning auto adjustment in order to maintain a certain level of morphological, biophysical and biochemical parameters, as well as the reestablishment of the disturbed equilibrium by returning to the initial state or an equivalent one. Hence, homeostasis was defined as an organism's ability to maintain the equilibrium states of the whole based on the coordinated biophysical processes. The biophysical models offer a „language" of quantitative and qualitative processing of experimental data, being compatible and adequate to the laws of biology. The organism is a psychobiological system ensemble situated in a dynamic equilibrium permanently controlled through the adjustment loops. The reverse bond makes possible characterization with a mathematical modelling. This equation describes ten types of reverse connection. At the end we introduce in a synoptic table with essential parameters of the different types of regulation.

Keywords: *Biophysical adjustment; Feedback; Psychic-; Neuronal-; Hormonal-; Humoral-regulation*

Introduction

It is only a banality that health is of value but once stereotyped it's worth sometimes reconsider again and appraise its role, its significance. The health inasmuch as valuable has to be appreciated, protected, enriched and not to be wasted. If we follow the first half of the sentence, then a long, well-balanced life can be expected, in the second case, on the other hand, the outcome is illness or an end ahead of time. Health is well known determined by hereditary properties (20%), the way of life (40%), the environment (25%) and health care (15%). If we want to manage the health then we don't have to underestimate the role of these four determinant factors. In order to see clearly we have do define some concepts like cure (medical treatment), the preven¬tion of illness and health development.

The dynamic equilibrium

The dynamic equilibrium state can be thought of mathematically as a sinusoidal oscillation at a certain time (t), characterized by the amplitude (A), angular velocity (ω), period (T), frequency (ν) and phase (φ) of intensity:

$x = A \cdot \sin(\omega t + \varphi)$.

If a biopsychological system responds specifically to an external stimulus, it means that the value of some of its parameters changes and then returns to its original state of homeostasis when the response is complete. Parameters characterized by static equilibrium and is involved in the response return their values over time to their original value such that its envelope is an exponential (ascending or descending) curve. The parameter that is characterized by a state of dynamic equilibrium and is involved in the response returns to its

original value with attenuated harmonic oscillation after its completion. The duration of the return is different for each parameter, and the normal state of homeostasis is determined by the parameter with the slowest finish. [1]

Hence, homeostasis is the ability to maintain the structure and functions of the living organism within optimal limits, on the basis of the adaptive requirements imposed by the surrounding environment. This implies complex control and anticipation mechanisms through which the organism and its constitutive systems auto adjustments the equilibrium level for the given situation, dynamic equilibrium between the disturbing and compensating factors. Homeostasis is a dynamic process of permanent adaptation, each of its sequences representing a new equilibrium which, in the following sequence, will be at a different level, in accordance with the requirement, between the permissive limits of the systems reactivity. [2]

Types of modelling

With modelling we usually understand the reproduction of the behaviour of a system on an analogue one especially built on the basis of certain rules. Usually, the system is modelled either on a physical one, either on a mathematical one. The mathematic model has the advantage of comfort and economy. The mathematic dealing mode also eases significantly the discovery of the analogies between the various systems.

Generally, for the study mode of the biophysical systems, two methods are foreseen: the phenomenological methods and static methods. The phenomenological method studies the phenomena regarding a few fundamental principles that result from various experiences, leaving aside the discreet internal structure of the matter.

The statistic method studies the phenomena starting from the discreet internal structure of the matter. For the study of the systems with an enormous number of particles the probability calculation is used. Hence, the measurable macroscopic properties appear like average statistic values of the properties of the individual elements.

The modelling method in biophysics consists of the creation of certain devices (models), with which processes analogue with those happening in living organism are studied. The biophysical model though abstract reasoning leads to models of the phenomena which by simplifying and isolating some aspects of the phenomena discover laws and relationships which describe with a certain approximation the behaviour or functioning of bodies or biological ensembles. [3]

Types of inversed connections

Within the reverse connection, we can distinguish two fundamental forms of this mechanism: negative inverse connection and the positive one. According to the classical definition we name negative reverse connection the mechanism through which, after the comparison of the value of the exit signal with the desired value, the adjustment initializes a reverse process in relationship with the deviation direction. Hence, if the value of the exit signal is higher than the desired value, then the negative reverse value will adopt a counter-decision in the system which will lead to the decrease of the signal value at the following exit. If the exit signal has a lower value than the expected one, than it will adopt a counter-decision through which it achieves an increase of the exit signal. We will give a concrete example from biophysics: the thermal homeostasis in humans. If the body temperature decreases under the environment influences, than the activation of the body's catabolic processes starts, achieving an increased release of thermal energy in order to re-establish the peripheral temperature.

A contrary process takes place in case the temperature of the environment is high and the organism tries to reduce the temperature on the body's surface through sweat. In the living systems the negative inverse connection is considered the basic mechanism of achieving the homeostasis of the internal homeostasis.

The feed-back or negative inverse connection functions "constantly" and its main role is, to maintain certain functional parameters of the body to a relatively constant value. This is about a relative stability, since the adjustment involves oscillations around an abstract medium value with a tendency to minimize the deviation in respect of this mean value. [4]

Let's denote with o(t) the exit output and the mean value of the characteristic parameter on the system is o*(t); after the adjustment, the values of the outputs obtained shall be denoted with

$o(t_1), o(t_2)\ o(t_3), \ldots, o(t_n) = o^*(t)$;

if $t1 < t2 < t3 < \ldots < tn$.

We talk about a negative inverse value, if the following two conditions are satisfied:

$|o^*(t) - o(t_1)| > |o^*(t) - o(t_2)| > |o^*(t) - o(t_3)| > \ldots > |o^*(t) - o(t_n)|$

$$\frac{d\left|o(t_i) - o^*(t)\right|}{dt} \leq 0.$$

In the living organisms, all the mechanisms for maintaining a constant composition and internal environment function on the basis of on negative feedback.

We call "reverse positive connection", the phenomenon in which the value of the exit system differs from the desired value and the adopted decision will stress this difference. Hence, the reverse positive connection produces an increase of the value of the exit signal if it were higher, respectively a decrease of the exit value if it were lower than the desired value. The reverse connection functions "on trend" finally leading to the destruction of the system, if it is not limited or controlled. Contrary to older opinions, the positive retroaction circuits are numerous in the living systems and have an important role in the auto adjustment of the various functions of the organism. Generally, their activity is limited, either through the intervention on nonlinearities, or through the influence of inverse negative reactions.

The positive reverse connection creates instability leading either to the explosive auto destruction of the system or to its blockage. However, in numerous cases, the extreme states in which the system must react are avoided as a consequence of two circumstances which limit the effects of the positive reverse connection:

- The apparition at a certain point of a reverse negative connection which stabilizes the system in a new state of equilibrium;
- The transformation of the system in another system, different from the quality point of view, in which the reverse positive connection looses significance.

The positive reverse connection is the connection which introduces an amplification of the effect caused by the entry signals. Maintaining the denotations above, we speak about a reverse positive connection, if it fulfils the following two conditions:

$$|o^*(t) - o(t_1)| < |o^*(t) - o(t_2)| < |o^*(t) - o(t_3)| < \ldots < |o^*(t) - o(tn)|$$

$$\frac{d\left|o(t_i) - o^*(t)\right|}{dt} \geq 0.$$

The existence of the so-called Vincze-effect also points to the specificity of the human organism due to which, the repetitive response of the body to the same stimulus varies. First, as a result of the same multiple perturbation, the perturbation threshold is reduced. Due to the existence of secondary centers, the latency time is shortened, and therefore, the response is faster. But at the same time, we see that not only direct perturbation generates the answer, but the transmission of the responses given to perturbations are also perceptible, thus the multiple repetition of a specific perturbation induces the response of another subsystem as a non-specific stimulus. In our view, the exis-tence of the Vincze-effect is closely related to the interne tics and conversion of the interaction between the types of regulations. For example, psychological and neural regulation can only exist in the case of humans.

Reverse connection quantification

The study of the biological systems, as well as of the non living systems they are part of, made possible the discovery of extremely efficient adjustment and auto adjustment principles. The mechanisms which function according to the principle of the reverse connection are very spread in the living systems. For the regulation of each element of the systems, there is at least one, if not several reverse connections, which seek to correct their inherent variations. Normally, only the living systems which were capable if not to foresee, at least to correct the inevitable disturbances that the various entropic factors produced could survive.

Normally, only the living systems which were capable if not to foresee, at least to correct the inevitable disturbances that the various entropic factors produced could survive. Within the living systems, the purpose of the ordered activities is achieved by the application of the reverse connection principle. This is why it is extremely important to classify the notion of reverse connection.

Through reverse connection (feed-back) the understanding of the phenomenon through which the output signals are directed back into the system, where they overlay the input signals and so they determine a higher level of adaptation of the response to the aimed purpose. [1]

Hence, the reverse connection is the phenomenon through which the centre is informed on the mode and extent to which the effector organ executed the command which was transmitted to it, the following command being elaborated according to the degree of achieving the previous connection.

This general characterization of the reverse bond makes possible the mathematical modelling of this process:

$y = D_0 + C0.e^{-at} . [A_0.\sin(nt + \varphi) + B_0.\cos(mt + \psi)]$

Where: y – response; t – time; φ,ψ – lag; A_0, B_0, C_0, D_0, a – real parameters; m, n – parameters which depend on the latency time.

This mathematical formula of the reverse connection was transposed on a computer and through the variation of the parameters the stimulation of the reverse bond process was achieved.

Both in the definition of the negative reverse connection and in the definition of the positive one, we used an essential stochastic element, namely the state of a system from a given moment has a determining effect on the state in the following moment, that is the output signal at a given moment, which lies at the basis of the decision exerts the effect on the output signal in the following moment.

For each type of reverse connection (Table I) we give the characteristic parameters are included in a synoptic table II.

No.	Types of reserve connections
1.	Type I descending negative reverse bond
2.	Type I ascending negative reverse bond
3.	Type I descending positive reverse bond
4.	Type 1 ascending positive reverse bond
5.	Type II negative reverse connection
6.	Type II negative reverse bond with a π delay
7.	Type II negative descending reverse connection
8.	Type II negative ascending reverse connection
9.	Type II positive descending reverse connection
10.	Type II positive ascending reverse connection

Table I: *The reserve connections.*

Types	Constants								
	n	M	φ	Ψ	A_0	B_0	C_0	D_0	a
1.	kπ	(2k+1)π/2	π/2	0	1			>0	>1
2.	kπ	(2k+1)π/2	π/2	0	1		<0 $\lvert C_0\rvert<\lvert D_0\rvert$	>0	>1
3.	kπ	(2k+1)π/2	π/2	0	1		>0	0	>1
4.	kπ	(2k+1)π/2	π/2	0	1		>0	0	<–1
5.			0	0			$\lvert C_0\rvert<\lvert D_0\rvert$	>0	>1
6.			π/2	π		>0 $\lvert B0\rvert>\lvert A_0\rvert$	$\lvert C_0\rvert<\lvert D_0\rvert$	>0	>1
7.			0	π/2			1	>1	>1
8			0	π/2			–1	>1	>1
9							>0	0	>1
10.							>0	0	<–1

Table II: *Constants characteristics of the types of reserve connections.*

Parameters	Humoural reg.	Hormonal reg.	Nervous reg.	Psychological reg.
Apparition in phylogenesis	Unicellular	Metazoa	Hydrozoa	Human
Information channel	None	Indirectly through blood	Neuron	Superordinal groups of neuron
Adjustment centre	None	Yes	Yes	Mnemical repository
Latency time	None	10^2–10^3 s	10^{-2} s	10–10^5 s
Action period	10^3–10^4 s	10^3–10^5 s	10^2–10^3 s	10^3–10^7 s
Circuit type	Open	Closed	Closed	Closed
Inertia	Average	High	Small	Little
Sensivity	Variable	Low	High	Big
Answer accuracy	Diffuse	Diffuse	Exact	Unequal

Number of controlled states	Low	Median	High	Individual
No. para.which are modified under the exciter action	One	A few	High	Variable
Subordination level	Inferior	Mean	Superior	Highest degree
Substances or states which transmit the information	Passive substances	Hormones	Electric potential Chemical mediators	First and second signalizing system
Reception system	Specific receptor, effecter cells	Hormonal receptors	Intero-, extero- proprioreceptors, free nervous termination	Cognitive organization
Adjustment form	Direct	Indirect	Indirect	Indirect
Conscious adjust.	Impossible	Impossible	Possible	Consciously
Time of exhausting the capacity of the repetitive answer	Short	Mean	Long	Variable

Table III: *Parameters of the types of regulation.*

Types of regulation within living systems

In higher-level living organisms the following forms of regulation are known: biological, nervous, hormonal, and humoral regulation. In the case of humans, psychic regulation also appears due to the existence of psychic activity. Human congenital types of regulation are, in part, the nervous, the hormonal and the immune regulation. During a person's ontogenetic evolution, its psychic regulation changes, new types of nerve connections are formed due to conditional reflexes and immune regulation can also be acquired regulation. Living organisms carry out humoral regulation in accordance with the laws adopted from inanimate.

Psychic regulation

Psychic regulation only characterizes the human organism. This regulation varies greatly during ontogenetic evo-lution, because personality becomes fully developed only by adulthood. The perturbation of the human organism may be hereditary or acquired. Depending on the level on which psychic regulation becomes successful, the human body is forced to use this form of regulation for a longer or shorter period of time. The shorter or longer path depends on the absence or creation of organic changes as the result of psychosomatic perturbation. It should be emphasized that the body's return to the original homeostasis always means that due to the existence of biological hysteresis, the body preserves the type of perturbation in the repository of psychic memory. If the same perturbation affects the organism again, the intensity of its effect increases, thus the psychosomatic change is most likely followed by organic change as well. [5]

We argue that the different types of regulations also have a control center psychic regulation, which occurs in the case of humans as the highest regulation, has a control center in these groupings of nerve cells, which is called mnemonic repository. In the case of humans, a special form of regulation appears, that is psychic regulation, the center of which is the mnemonic repository consisting of spatial superordinate neurons.

Biological regulation

The human organism is composed of a number of subsystems: cells, tissues, organs, organ systems, apparatuses and, above all, the living human consisting of one system. If our bodies are subject to external or internal stimuli, these affect one of the subsystems. The task of this subsystem is to initiate a response in the context of classical regulatory processes. The human body as a whole often overrides this response based on its inherited experiences and the ones gained during its ontogenesis. This means that the organism as a whole has a state of consciousness by which it chooses the nature of the response. This is what we call biological regulation.

Nervous regulation

The fundamental functioning mechanism of the nervous system is the reflex, which represents the response reaction of the nervous centres to the stimulation of a receptor area. The reflex arc is made of five components: the receptor, the afferent pathway, the nervous centres, the efferent pathway and the effector. The reflexes are somatic, vegetative, unconditional and conditional. The somatic reflex is the one whose stimulus is received by the exteroceptors or proprioceptors and whose answer is performed by the somatic effector,

namely the voluntarily controlled striated muscles. The vegetative reflexes are those whose stimuli are received by the interceptors or visceroceptors and whose answer is performed by the vegetative effectors, namely the smooth muscles of the internal organs and the various types of glands. [6]

The central nervous system includes the organs placed in the cranium: cerebrum, the cerebellum and the brain stem (the ensemble forms of these three organs is called encephalon) as well as the bone marrow.

The brain is formed of two symmetrical parts – the cerebral hemispheres. They are united in an area called the corpus callosum, which transmits the information from one hemisphere to the other. Moreover, the two hemispheres are covered by a thin layer of grey matter, a tissue formed mostly of neurons, made of 3–6 cellular layers.

In the cerebral cortex there are the cortical localizations: some thesis, visual, hearing, taste, olfactory and vestibular. There are some special centres of the human activity: language, writing and reading centres. The mathematical centre, which coordinates the calculus, has not been found yet.

In the human organism have a control system which he calls the "hypothetical secondary brain". In the everyday regulation of the human body the functioning of these "hypothetical secondary brains" is suppressed by the regulation of the whole organism, but with tremendous probability, space-microscopy will prove the validity of this hypothesis in the near future. [7]

Hormonal regulation

The endocrine glands are organs the cells of which produce hormones with different effects. These glands release their hormones regulating their vital function directly into the intercellular space and thus into the bloodstream. Hormones can thus produce their effects on organs distant from the gland. These substances, by reaching the bloodstream, produce their effects in the whole organism.

Hormonal regulation is much slower than nervous regu¬lation and is much less targeted, however, the continuous functioning of metabolism is unimaginable without it. Hormonal regulation is controlled by nervous regulation. This cooperation is made possible by the hypothalamic-pituitary axis. [8]

Humoral regulation

In our opinion, this is the oldest type of regulation of living organisms because it has been inherited from inanimate systems. Humoral regulation is created when two or more components are present at the same time in a liquid or gaseous state multi-component system. In this case, the forces applied to physical concentrations, emerging between the different components, as well as the underlying mechanisms are in control; in the living systems, however, the semi-permeable membranes have an active role, as well as the receptors specific of ligands.

We presented the characteristics of different form of the regulation (psychic-, nervous-, hormonal-, and humoral-regulation) in the synoptic table (Table III.). [9]

Living organisms have special regulatory mechanisms to maintain the living condition. [10] Such special regulatory mecha¬nisms include psychological, biological, neurological, and hormonal regulation. According to our hypothesis, all of these have an independent control center. Of course, humoral regulation, well-known from inanimate systems, is naturally added to this, and the laws of physics apply to living systems as well.

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