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The Informational exchange of the biological systems and its practical implications

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Abstract: Biological organism is an open system communicating with environment by exchange of energy and information. Biological systems structure, order and organize energy and information transforming it from chaotic to ordered state. We discuss the notion of entropy and information applied to the description of biological systems and present equation describing the exchange of information with the environment and corresponding changes of the entropy. Developed ideas allowed to create a software for GDV Bio-Well complex and use it for the quantitive definition of different states of human physical and emotional condition. Entropy parameter calculated by the Bio-Well software was found to be very efficient in evaluation of the human condition. Many years of using Bio-Well worldwide demonstrated high practical value of this notion.

Keywords: Information, entropy, biology, image processing

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1. Introduction

We are accustomed to the fact that biological organisms exist at the expense of energy consumption. Air, water, nutrients and microelements are all necessary components of biological life. Processes of metabolism and energy production of the organism under conditions of mental and physical activity is investigated by physiologists in detail [1]. It has been demonstrated that metabolic rates depend on sex, age, activity, and to a first approximation might be characterized by work production, emitted heat and energy, stored in the form of depositing nutrients and structural transformation.

At the same time not less important components of a biological system's existence are informational signals. The sensory organs are usually subdivided into three main groups:

- ⇨ extroceptors, stimulated by the environmental information;
- ⇨ proprioceptors, receiving information of body position and movements; and
- ⇨ interoceptors, receiving information from the inner organs.

One of the main notions of psychophysics is the notion of sensory threshold. It is defined as a minimum stimulus capable of causing certain response. Every threshold depends on the range of parameters, for example, hearing threshold depend on the sound frequency, eyesight threshold – on the time of adaptation. Another notion is so named "Hardly visible difference". This is the quantity, in which one threshold should differ from the other, so that their difference is perceived by a human. In 1834 E. Weber demonstrated that a minimum discernible change of intensity of stimulation dJ makes up a constant part of its initial intensity J. This law is expressed by equitation:

$$dJ / J = \text{const} \quad (1)$$

The given rule is implemented in a wide range for many sensory modalities, being a useful measure of relative sensitivity of sensory systems. It is impossible mathematically compare the sensitivity of eye to the light power with the sensitivity of ear to the level of sound pressure. However, non-dimensional Weber coefficient for these modalities can be compared with one another.

2. Informational exchanges of the organism

In recent decades, the high effectiveness of treatment methods based on influencing an organism by weak, subthreshold factors, has been demonstrated. These methods include electromagnetic signals of weak intensity; light, including laser radiation; aeroions in small quantities; as well as homeopathy and structured water. Clinically demonstrated effectiveness of such weak signals influence enables us to study a relatively new class of psychophysical interactions, which can be denoted as informational. Important to understand that not all the informational signals would be meaningful for the organism, so we can talk about informational-significant signals which stimulate the informational reactions. We can define several principles that govern these informational reactions R:

1. Wr >> Ws : Energy of reaction is many times higher that the energy of stimulus. Effects are developed at the expense of free energy of the organism.
2. R = f (L) : Reaction depends on the area of stimulus application. Experimental facts particularly indicate the importance of notion of reflexogenious zones and biological active points.
3. R = f (ν) : Reaction depends on the frequency of stimulus.
4. R ≠ f (Ws) : Reaction does not proportional to the energy of a stimulus, in homeopathy lower concentrations may have the strongest effect.
5. R ≠ f (t) : Reaction does not depend on the time of influence, i.e. it starts developing at the moment of influence and continues developing when the influence has already ended.

In this way, we can say that external signals can be initiators of specific reactions, flowing at the expense of free energy of organism itself. This is the basis of modern vibrational, wave, or informational medicine, medicine of low intensity. The factors used in these methods influence the organism not through the energy that they contribute, but owing to regulatory influence on electron-ion processes.

It is known that the quantity of information is determined through the change of the subject's state entropy [2]. Let us define the notion of information quantum and on the assumption of constancy of source's entropy ε it may be expressed as follows:

$$dI = \gamma d\varepsilon \quad (2)$$

where dε - unit measure of entropy of the receiver's state, and γ is informational coefficient. The main characteristics resulting from this formula are as follows:

1. Information quantum differs from zero in the case of the receiver's state change under the influence of a received signal.
2. Information quantum does not depend on the nature of the signal transferring information, or on the nature of the information carrier.

Let us take an integral from the both parts of the equitation (2) on the time interval from t1 to t2:

$$\int dI = IR \int dt = \gamma \int d\varepsilon \quad (3)$$

$$\Rightarrow \quad IR\,(t2 - t1) = \gamma \int d\varepsilon \quad (4)$$

$$IR = \gamma\,/(t2 - t1) \int d\varepsilon \quad (5)$$

The value IR may be called a parameter of informational response. This value estimates the change occurring with the given subject in a definite time interval under the influence of the informational signal. Expression (5) diverts the emphasis from the source and carrier of the reaction to the subject perceiving information, and provides a practical method for estimating this reaction.

3. Practical implementation of the notion of entropy to the image processing

The glow from different types of objects in high intensity electromagnetic fields was detected over 200 years ago, and since then has attracted the attention of researchers [3]. But it was only with the creation of software-hardware gas visualization discharge (GDV) systems in 1995 that research into these glows gained scientific status. Since then, the physical mechanisms which make up glow have been studied in detail [4], the serial production of the devices has been established, a system of programmes for applications in medicine, biology and research into materials has been created [5]. It has been shown that the characteristics of the glow of a person's cutaneous covering depend primarily on the activity of the autonomous nervous system, taking into account the system of adaptation levels [6]. The modern GDV equipment – the Bio-Well system has found its applications in medicine, sport, material testing, and environmental studies [7-14]. Thousands of professionals benefit from using Bio-Well system worldwide.

The principle of the technology is based on the stimulation by high-voltage electromagnetic impulses the electron-photon emission from the subject, that generates sliding gaseous discharge along the surface of the electrode. The glow of the discharge is captured by sensitive optical cameras and processes in the computer by a specialized software in the form of images. The image of a glow from a metal cylinder, which is being used for the calibration of the device, represents a figure with radial distribution of density (fig.1), which is characterized by a certain diagram of density distribution. To attribute this image to the particular technology, it was given the name "Bio-gram". This picture may be presented as function $F(\alpha)$ where α is an angle within the interval [0, 360o]. Bio-grams of a human finger, used for the analysis, function has more stochastic presentation (fig.2) which allows for the analyses of a physical and psycho-emotional condition of a person using non-linear algorithms [6, 10]. In these cases function $F(\alpha)$ is quasichaotic that suggests the idea to consider function $F(\alpha)$ as random variable, and calculate associate statistical parameters. Let us introduce the integral function:

$$Q = \int F(\alpha)\, d\alpha \qquad [0, 2\pi] \quad (6)$$

And pass from function $F(\alpha)$ to the normalized function $f(\alpha)$:

$$f(\alpha) = F(\alpha)/Q \quad (7)$$

Denote maximal and minimal values of function f(α) by fmax and fmin respectively. Function P(f) represent the density distribution of function f(α) on the interval [fmin , fmax]. Let us introduce the normalized distribution p(f) by the formula:

$$P(f) = P(f) / \int P(f)\, df, [fmin , fmax] \quad (8)$$

Obviously, function p(f) satisfies the normalization condition

$$\int p(f)\, df = 1, [fmin , fmax] \quad (9)$$

Now we are in position to introduce standard statistical characteristics: the mean value, dispersion and higher moments. The entropy definition using this concept is:

$$\varepsilon bio = - \int p(f) \ln \{p(f)\} df, [fmin , fmax] \quad (10)$$

From here using equation (5) we can calculate informational response of the biological subject.

The notions of Bio-grams entropy and informational response have practical application: it allows to introduce a natural classification of Bio-grams by "degree of misbalance". Namely, the highly inhomogeneous BIO-grams (which, accordance to experimental data in turn correspond to some physical or emotional problems) the random variable F(α) has high degree of uncertainty, which lead to relatively high value of Bio-gram entropy. The developed principles were realized in a program implemented in the complex of Bio-Well programs [5]. The testing has shown a high importance of notion of entropy for the description of Bio-grams. Moreover, the results obtained afford all the grounds to assume the notion of Bio-grams entropy is directly related to the notion of negative entropy of biological subjects introduced by E. Schrodinger [15]. Namely, the values of entropy turn out to vary depending on age and state of human in exactly the same way as it would expect.

As an example, we present the entropy parameter calculated in Bio-Well programs, for the images of Figure 1 and 2.

Figure 1 $\varepsilon_{bio} = 1.80$

Figure 2a $\varepsilon_{bio} = 2.22$

Figure 2b $\varepsilon_{bio} = 3.14$

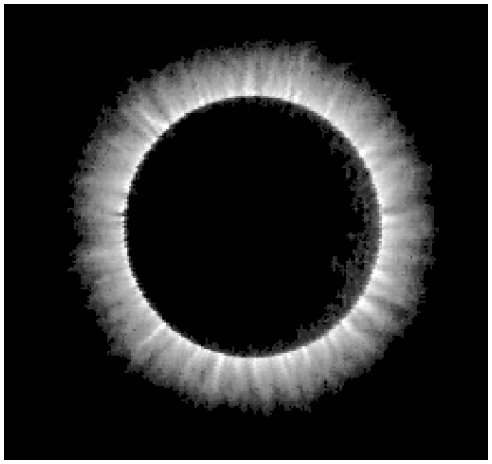
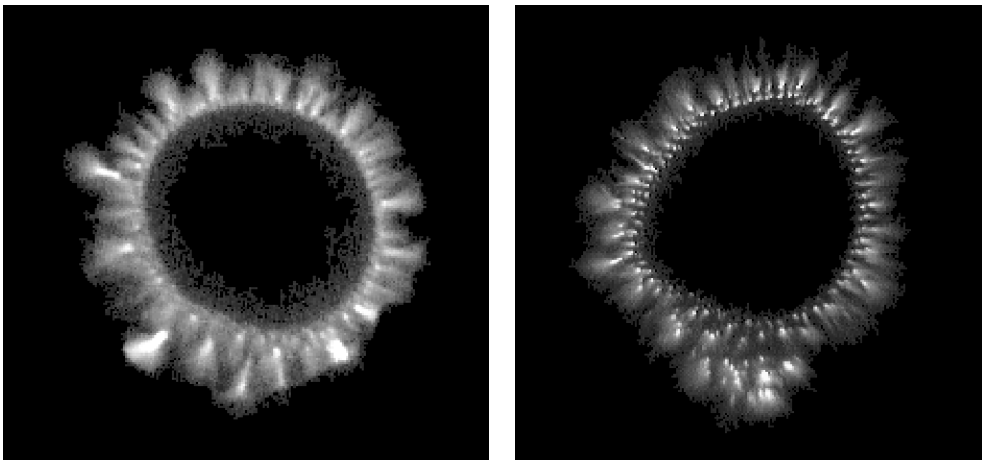


Figure 1. Bio-image of the metal cylinder.



(a) (b)

Figure 2. Bio-images of human finger.

4. Conclusions

Biological organism is an open system communicating with environment by exchange of energy and information. Biological systems structure, order and organize energy and information transforming it from chaotic to ordered state. The notion of entropy and information applied to the description of human state allows us to give an extra quantitive definition to different states of human physical and emotional condition. External influence, both energetic and informational may shift an organism's balance from equilibrium (homeostasis), and this shift may be described in the terms of changes of entropy. Bio-Well software allows to calculate entropy parameter which was found to be very efficient in evaluation of the human condition. Many years of using Bio-Well worldwide demonstrated high practical value of this notion.

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