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## ENTROPY OF GAS-DISCHARGE IMAGE CORRELATES WITH THE ENTROPIES OF EEG, IMMUNOCYTOGRAM AND LEUKOCYTOGRAM BUT NOT HRV

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### Abstract

**Background.** In implementing the project of verification gas discharge visualization (kirlianography, biophotonics) method, we documented the significant correlation of the gas discharge image parameters with the parameters of electroencephalogram, heart rate variability (HRV), dexterity and spasticity of brush, blood pressure, as well as blood levels of adaptive hormones. As part of a project to investigate the physiological nature of entropy, we have shown that EEG entropy is related to a number of its amplitude-frequency and spectral parameters, as well as to the parameters HRV, blood leukocytogram and immunocytogram and their entropies. The **purpose** of this study is to analyze the relationships between the entropies of the listed information systems. **Material and research methods.** The object of observation were 20 volunteers: 10 women and 10 men aged 33-76 years without clinical diagnose but with dysfunction of neuro-endocrine-immune complex and metabolism. We registered twice kirlianogram by the method of GDV by the device of “GDV Chamber” (“Biotechprogress”), EEG (“NeuroCom Standard”, KhAI Medica), HRV (“CardioLab+HRV”, “KhAI-Medica”), Leukocytogram and Immunocytogram. Then we calculated the entropies of the listed information systems. **Results.** By stepwise exclusion, 5 variables were included in the canonical GDV root structure, and 6 variables were included in the root EEG structure. Overall, GDI entropy determines the SPD EEG entropy by 33%. The additional inclusion in the dependent set the parameters of HRV, LCG and ICG entropies gives a increase in determination to 48%. HRV entropy was found outside the model. **Conclusion.** We have documented the relationship

between the entropy parameters of electroencephalogram, blood leukocytogram and immunocytogram but not HRV on the one hand, and gas-discharge images on the other. However, the question of the causal nature of this relationship remains open. What is primary: electrical activity of the brain, excretion of cytokines and hormones by immunocytes, or emission of photons and free electrons by acupuncture points (circulation of vital energy)?

**Key words:** gas-discharge visualization; electroencephalogram; HRV; blood leukocytogram and immunocytogram; entropy, relationships.

## INTRODUCTION

In implementing the project of verification gas discharge visualization (kirlianography, biophotonics) method proposed by KG Korotkov [17,18], we documented the significant correlation of the gas discharge image (GDI) parameters with the parameters of electroencephalogram [4,8,9,16,19,20,30,31], HRV [4,8-10,19,20,28,29,31], dexterity and spasticity of brush [4,9,19,20,31], blood pressure [28,29], as well as blood levels of adaptive hormones [1-3,5-7,10,11]. As part of a project to investigate the physiological nature of entropy, we have shown that EEG entropy is related to a number of its amplitude-frequency and spectral parameters, as well as to the parameters HRV, blood leukocytogram and immunocytogram and their entropies [13,22-27,33].

The purpose of this study is to analyze the relationships between the entropies of the listed information systems.

## MATERIAL AND RESEARCH METHODS

The object of observation were 20 volunteers: ten women and ten men aged 33-76 years without clinical diagnose but with dysfunction of neuro-endocrine-immune complex and metabolism, characteristic for premorbid (intermediate between health and illness) state.

In the morning on an empty stomach we registered kirlianogram by the method of GDV by the device of "GDV Chamber" ("Biotechprogress", SPb, RF). The first base parameter of GDV is Area of gas discharge image (GDI) in Right, Frontal and Left projections registered both with and without polyethylene filter. The second base parameter is the Shape coefficient (ratio of square of length of external contour of GDI toward his area), which characterizes the measure of serration/fractality of external contour. The third base parameter of GDI is the Entropy [17,18]. The most recent set of parameters was selected for further analysis in this article.

Then we recorded EEG (hardware-software complex "NeuroCom Standard", KhAI Medica) monopolar in 16 loci (Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, P3, P4, T5, T6, O1, O2) by 10-20 international system, with the reference electrodes A and Ref on the tassels of ears. Among the options considered the normalized (%) spectral power density (SPD) in the standard frequency bands:  $\beta$  (35÷13 Hz),  $\alpha$  (13÷8 Hz),  $\theta$  (8÷4 Hz) and  $\delta$  (4÷0,5 Hz) in all loci, according to the instructions of the device.

Simultaneously we recorded electrocardiogram in II lead (hardware-software complex "CardioLab+HRV", "KhAI-Medica") to assess the parameters of HRV. For further analysis

(Frequency Domain Methods) were selected normalized (%) spectral power (SP) bands of HRV: high-frequency (HF, range 0,4÷0,15 Hz), low-frequency (LF, range 0,15÷0,04 Hz), very low-frequency (VLF, range 0,04÷0,015 Hz) and ultra low-frequency (ULF, range 0,015÷0,003 Hz) [15].

We calculated for HRV and each locus EEG the Entropy (h) of normalized SPD using formulas [22] based on classic CE Shannon's formula:

$$hHRV = - [SPHF \cdot \log_2 SPHF + SPLF \cdot \log_2 SPLF + SPVLF \cdot \log_2 SPVLF + SPULF \cdot \log_2 SPULF] / \log_2 4;$$

$$hEEG = - [SPD\alpha \cdot \log_2 SPD\alpha + SPD\beta \cdot \log_2 SPD\beta + SPD\theta \cdot \log_2 SPD\theta + SPD\delta \cdot \log_2 SPD\delta] / \log_2 4$$

In portion of capillary blood we counted up Leukocytogram (LCG) (Eosinophils, Stub and Segmentonuclear Neutrophils, Lymphocytes and Monocytes) and calculated its Entropy (h) using formula:

$$hLCG = - [Lym \cdot \log_2 Lym + Mon \cdot \log_2 Mon + Eos \cdot \log_2 Eos + SNN \cdot \log_2 SNN + StubN \cdot \log_2 StubN] / \log_2 5$$

For phenotyping subpopulations of lymphocytes used the methods of rosette formation with sheep erythrocytes on which adsorbed monoclonal antibodies against receptors CD3, CD4, CD8, CD22 and CD16 from company "Granum" (Kharkiv) with visualization under light microscope with immersion system [21]. Next we calculated also the Entropy of Immunocytogram (ICG) using formula:

$$hICG = - [CD4 \cdot \log_2 CD4 + CD8 \cdot \log_2 CD8 + CD22 \cdot \log_2 CD22 + CD16 \cdot \log_2 CD16] / \log_2 4$$

Every day four people were tested. A week later, all the tests were repeated. Results processed using the software package "Statistica 5.5".

## RESULTS AND DISCUSSION

According to the formula:

$$|r| \geq \frac{\exp[2t/(n-1,5)^{0,5}] - 1}{\exp[2t/(n-1,5)^{0,5}] + 1},$$

for a sample of 40 observations critical value of correlation coefficient module at  $p < 0,05$  ( $t > 2,02$ ) is 0,31, at  $p < 0,01$  ( $t > 2,70$ ) is 0,41, at  $p < 0,001$  ( $t > 3,55$ ) is 0,52.

In the first stage of the analysis a correlation matrix is created (Table 1).

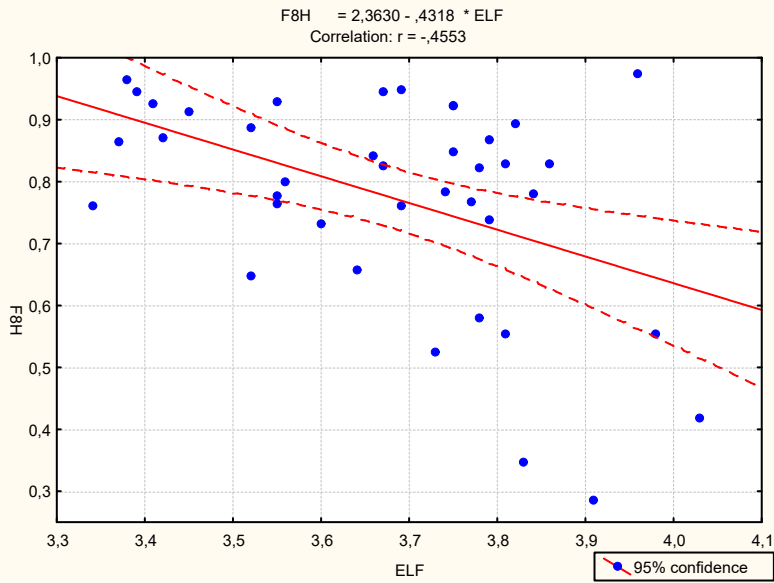
**Table 1. Correlation matrix for Entropies of gas-discharge image, spectral power density EEG loci, HRV, Leukocytogram and Immunocytogram**

Entropy	Right GDI	Right GDI (f)	Frontal GDI	Frontal GDI (f)	Left GDI	Left GDI (f)
Right GDI	1,00	,46	,71	,42	,58	,31
Right GDI (f)	,46	1,00	,50	,69	,49	,64
Frontal GDI	,71	,50	1,00	,58	,77	,36
Frontal GDI (f)	,42	,69	,58	1,00	,50	,64
Left GDI	,58	,49	,77	,50	1,00	,44
Left GDI (f)	,31	,64	,36	,64	,44	1,00
Fp2	,09	,10	,18	,16	,08	,06
F4	,08	-,07	,16	-,04	,07	-,14
F8	-,01	-,19	-,02	<b>-,24</b>	-,07	<b>-,46</b>
T4	-,22	-,08	-,06	<b>-,27</b>	-,02	-,16
C4	,03	-,07	-,06	-,04	-,17	-,19
T6	,17	-,01	,03	-,12	-,05	-,08
P4	<b>,24</b>	,20	,19	<b>,27</b>	,13	,02
O2	,21	,21	-,02	,06	,04	,11
Fp1	-,00	-,07	-,06	,11	-,15	,05
F3	,19	,14	<b>,28</b>	,19	<b>,25</b>	-,02
F7	-,03	-,03	,08	,10	-,19	-,11
T3	-,22	-,05	-,07	-,08	-,24	-,22
C3	,01	-,14	-,17	-,11	<b>-,24</b>	-,19
T5	,10	-,17	-,07	-,10	-,07	-,14
P3	,20	,12	,09	,20	,04	,05
O1	,16	,24	,13	<b>,31</b>	,17	,19
HRV	-,10	-,05	-,08	-,24	-,21	-,10
LCG	<b>,30</b>	-,08	<b>,30</b>	,18	,18	,14
ICG	-,25	-,18	-,26	-,21	-,27	<b>-,30</b>

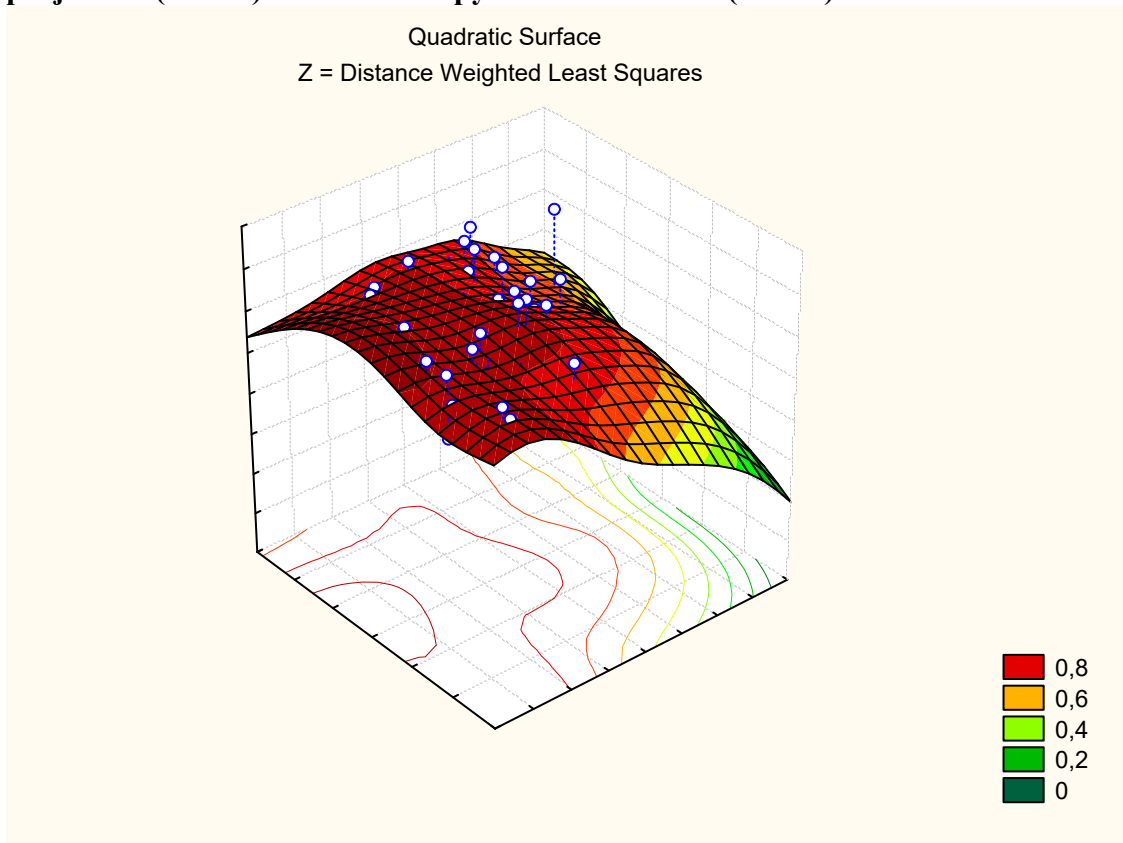
To visualize correlations we should decide concerning factor (argument) and effective (function) parameters. As stated in the previous article, in terms of mathematics it does not matter, while in terms of physiology there is the perennial problem of cause and effect. We have chosen as a factor GDV parameters [10].

As a result of the screening, the most significant relationship was found between the GDI entropy (filtered) in the **left** projection and the SPD EEG entropy in the **right** lateral frontal locus (Fig. 1). Unfortunately, intrigue about cross-linking such as the corticospinal pyramid tract has been dispelled by other facts.

The inclusion in the multiple regression model of the second, by the power of the link, variable brought about the aesthetic pleasure of the three-dimensional image (Fig. 2), but no more, judging by R.



**Fig. 1. Scatterplot of correlation between the entropy GDI (filtered) on the Left projection (X-axis) and the entropy in F8 locus EEG (Y-axis)**



$$F8h=2,22-0,472 \cdot ELF+0,081 \cdot EFf; R=0,458; R^2=0,210; F_{(2,4)}=4,9; p=0,013$$

**Fig. 2. Scatterplot of dependence of entropy in F8 locus EEG (Z-axis) on entropies GDI (filtered) on the Left (X-axis) and Frontal (Y-axis) projections**

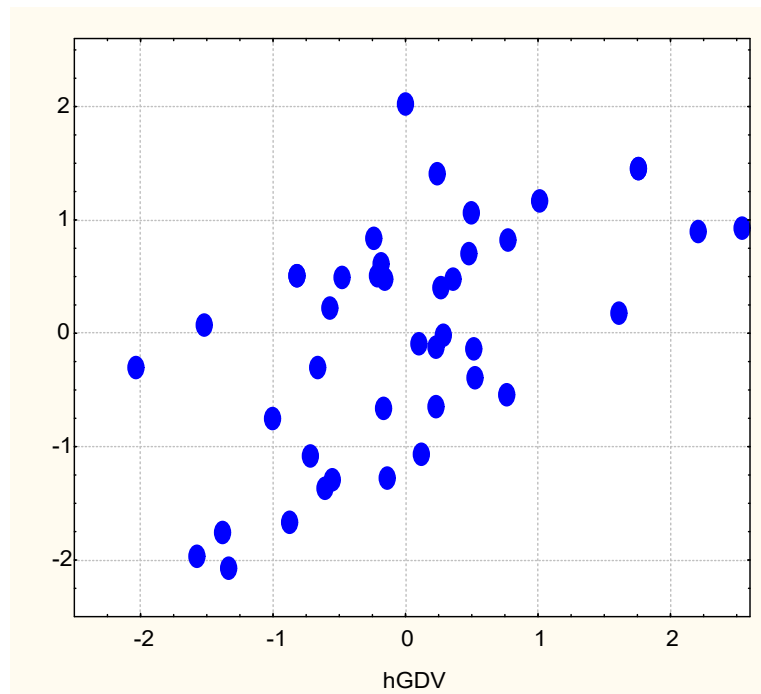
In the next step, the canonical correlation between the entropy indices of the gas-discharge image taken without a filter and with a filter in three projections, on the one hand, and SPD 16 EEG loci, on the other, was analyzed.

By stepwise exclusion, 5 variables were included in the canonical GDV root structure, and 6 variables were included in the root EEG structure (Table 2). Judging by the factor loadings, the causal root represents directly, mainly, the entropy of GDI (with filter) in the left projection, while the entropy of GDI (without filter) in the right projection reflects inversely.

On the other hand, the EEG root reflects the SPD entropy at five loci inversely and only one directly. Overall, GDI entropy determines the SPD EEG entropy by 33% (Fig. 3).

**Table 2. Factor structure of canonical correlation between Entropy of GDI (right set) and EEG (left set)**

<b>Right set</b>	R
Left GDI (f)	<b>,536</b>
Left GDI	<b>,158</b>
Right GDI	<b>-,420</b>
Frontal GDI (f)	<b>-,084</b>
Frontal GDI	<b>-,055</b>
<b>Left set</b>	R
F8H	<b>-,514</b>
P4H	<b>-,478</b>
C3H	<b>-,454</b>
F3H	<b>-,237</b>
O1H	<b>-,141</b>
T4H	<b>,360</b>



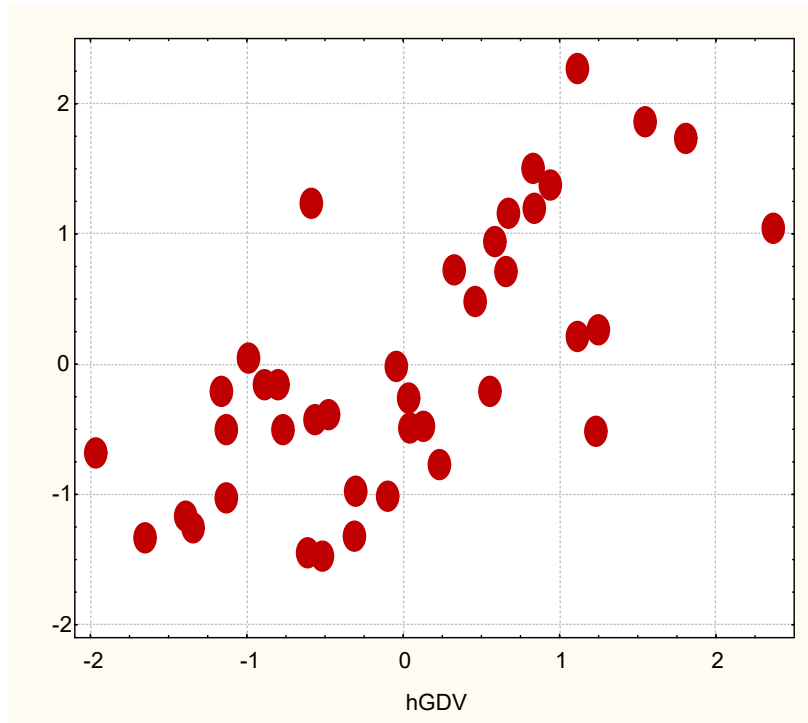
$R=0,575$ ;  $R^2=0,330$ ;  $\chi^2_{(30)}=38$ ;  $p=0,158$ ;  $\Lambda \text{ Prime}=0,341$

**Fig. 3. Scatterplot of canonical correlation between Entropy of GDI (X-line) and EEG (Y-line)**

The additional inclusion in the left set parameters of HRV, LCG and ICG entropies gives a significant increase in the canonical relationship between the roots. This changes the factor structure of the roots. Contrary to expectations, HRV entropy was found outside the model (Table 6 and Figure 4).

**Table 6. Factor structure of canonical correlation between Entropy of GDI (right set) and EEG,LCG&ICG (left set)**

<b>Right set</b>	R
Right GDI	,50
Frontal GDI	,24
Frontal GDI (f)	,24
Left GDI (f)	-,33
Right GDI (f)	-,28
Left GDI	-,03
<b>Left set</b>	R
LCGH	,477
P4H	,335
C3H	,287
F8H	,229
F3H	,183
O1H	,121
T4H	-,440
ICGH	-,006



$R=0,699$ ;  $R^2=0,489$ ;  $\chi^2_{(48)}=54$ ;  $p=0,262$ ;  $\Lambda \text{ Prime}=0,181$

**Fig. 4. Scatterplot of canonical correlation between Entropy of GDI (X-line) and EEG as well as LCG&ICG (Y-line)**

## CONCLUSION

We have documented the relationship between the entropy parameters of electroencephalogram, blood leukocytogram and immunocytograms on the one hand, and gas-discharge images on the other. However, the question of the causal nature of this relationship remains open. What is primary: electrical activity of the brain, excretion of cytokines and hormones by immunocytes, or emission of photons and free electrons by acupuncture points [17,18] (circulation of vital energy [32])?

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## ACCORDANCE TO ETHICS STANDARDS

Tests in patients are conducted in accordance with positions of Helsinki Declaration 1975, revised and complemented in 2002, and directive of National Committee on ethics of scientific researches. During realization of tests from all participants the informed consent is got and used all measures for providing of anonymity of participants.

For all authors any conflict of interests is absent.

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