Development of a Method for Quantitative Assessment of Brain Activity Using Infrared Images of the Head

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***Abstrac*—The discovery of the phenomenon of the brain emitting electromagnetic waves, primarily infrared rays, opens up new prospects for easy, contactless, rapid, inexpensive research examination of the brain function. In some cases, the descriptive characteristics of brain infrared images become insufficient to capture the dynamics of structural and functional changes occurring in the brain. There is a need for a quantitative characteristic of the brain infrared dynamic image. The development of such a method was the goal of this study. A 60-second non-contact infrared video recording of five sides of the head was made on 150 healthy people of different ages and both sexes. Five equally spaced static frames were cut from the video recording of the parietal surface of the head, in every 5 seconds. The total area of active (“hot”) fields (A) in cm2 in each frame was measured, the average weighted temperature of active fields in each image (T℃) was determined, the speed of movement of active fields (v) and changes in the number of active fields (n) were measured. An integrated assessment of the specified parameters was carried out using the formula we derived: E(parietal) = A/T/v/n/, where E(parietal) is the energy that was produced in the brain for 30 seconds to complete a specific task, or for a person in relative rest. The parameters (v) and (n) were expressed through the dimensionless coefficients (Kv) and (Kn). Then the equation for determining brain energy took the form: E(parietal)=A*T*(Kv*Kn). Measurement of brain activity in six men aged 32-85 years, with different educational backgrounds, revealed wide individual variation in brain activity. In the older age group, consisting of three professors with an average age of 77 years, the E(parietal) index was 1.4 times higher than the average index for the relatively younger three men (average age 46 years) with a lower educational background.**

***Keyword*—Brainpower measuring, brain infrared radiation, image analysis, mathematical modeling.**

I. Introduction

At present, we are witnessing the non-stop development of artificial intelligence, which is increasingly displacing human intelligence from various spheres of life. In order not to lose this endless battle, human intelligence must also continuously develop. The bearer of human intelligence is the human brain and the latter must develop structurally and functionally.

The phenomenon of development in general, and of the brain particularly, is a dynamic process and in order to identify the dynamics of development, a quantitative assessment of both the functional state and the structural reorganization of the brain, at different stages of its development and improvement is necessary.

In order to see, to document, and prove the existence of development, it is necessary first to visualize the intellectual activity of the brain and then to measure quantitatively the intensity of that intellectual activity.

Modern advanced technologies now allow us to visualize not only the most delicate parts and structures of the brain but also to make visible the functional activity of many of these structures.

Such cutting-edge technologies are presented, for example, by direct corticography, PET-CT Scan, functional MRI, f(NIR), and by a method of visualizing brain activity using infrared photography and infrared video recording that we are developing (Fig. 1).

Brain activity, and primarily intellectual activity, is based on biochemical, cytochemical, electrophysiological, and hemodynamic processes, which are also accompanied by the emission of various electromagnetic waves from the head, primarily infrared rays, which can be visualized today.

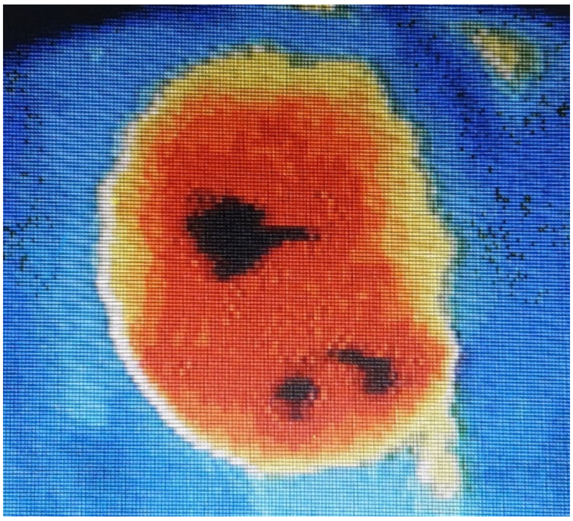

Figure 1. Infrared pattern (photo) of the parietal part of the head of a man aged 58. Dark fields correspond to active areas of the brain.

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Our developments [2] - [6] in this method have posed a problem: how to measure the characteristics of the brain's IR radiation and what about these characteristics can tell us.

Objective: The aim of this research is to develop a method for integrative quantitative assessment of brain activity using the pattern of infrared radiation of cerebral cortex and other gray substrates, which are the main morphological carriers of human intelligence.

II. The Methods And Objects Used

Today it is known that the living brain emits infrared rays of a certain wavelength (0,78 and-1,4 micrometers) during its work. Here we find it appropriate to note, that recently was stated, that the brain emits also very weak visible light waves [1]. (It must be noted, that about 30 years ago this fact was also revealed in Yerevan Institute of Physics, Armenia). We assume, that the brain must also emit longer wavelength electromagnetic rays, longer than infrared rays, which have not yet been recorded today, but in the future, we hope they will also be visualized. A number of phenomena, for example the phenomenon of telepathy could be explained by such relatively long ways (rays of gray zone), which today still cause rejection, or are considered as if they are fantasies.

We used for most cases an infrared camera mounted on a CAT-968M Pro mobile phone, with the help of which we conducted a survey of about 150 people, obtaining more than 1200 photographs and videos of people's heads, faces, and hands.

The main object of the study was the human head. In the initial phase of the study, we took photographs and then videotaped them. Comparative analysis of static and dynamic images has clearly shown that video images definitely contain much richer information than photographs, and even contain characteristics that could not be present or fixed in photographs.

We took both photos and video recordings from at least five parts of the head: the top, from the right temporal, left temporal, frontal and occipital regions. We recorded each segment for at least 30 seconds or 1 minute.

In this initial phase of the study, the subjects were in a state of mental and physical rest, sitting in a chair, looking at a flat pastel-colored wall in front of them.

The main characteristics of static infrared brain imaging are: a) the presence of a bright fields, b) the location of the bright fields, c) the size of the bright fields area, d) the intensity of the bright fields illumination.

In comparison, the video recording of brain activity contains more parameters: 1) the presence of light fields; 2) the topology, localization of light fields; 3) the area of light fields; and. along with this, it is found that: 4) some light fields have a stable topography: they are mainly in the temporal regions, and in the occipital region of the head. 5) Some light fields have a very dynamic variability character. 6) Light fields are fastly moving. Such areas are mainly projected on the parietal part of the head. 7) Light fields on the top of the head are very dynamic, they constantly changing both the place and the size of the bright areas, and, possibly they also change the spectrum of infrared waves. All of the seven indicated characteristics are signs of brain activity and in order to characterize brain activity in general with one indicator, these seven signs must be taken into account in combination, in a single integration, that is, an integrative systemic assessment must be made.

Before continuing, it would be appropriate to note two points here. First, human intelligence is the highest form of human brain function, which goes through the following stages: metabolic and electrical activity cluster of neurons - activation of interneuronal connections through synapses, and in the result - thought process. It can also be said that the metabolic processes in the brain in the form of biochemical, electrical changes and infrared radiation are to a certain extent physical equivalents of the phenomenon of human intelligence.

We want to make another comparison, which has already served us once, when we were developing a method for measuring the volume of brainpower under a microscope in a tissue thin section taken from the brain. This is that comparison. To simplify it quite a bit, the brain can be compared to a computer. The following two characteristics are important for both: how much information they can store in themselves, how quickly this information is processed, how quickly they can exchange this information, and how many new connections they can create. This is similar to the phenomena of hard disk capacity in computers, the speed of RAM, and the abundance of new programs and machine teaching.

III. Results

Almost every day we hear that another artificial intelligence tool has been created, which is even better and smarter. In this regard, a similar phenomenon also exists in the human brain. The power of the brain can be more accurately measured by how many cortical centers or fields are active over a certain period of time (not at a given moment in time), how high the activity (the temperature) of those areas is, how high the rate of changes (movements) of the fields are.

An integrative indicator for quantitative assessment of brain function can be the amount-volume of energy expended by the brain in a unit of time, or in a distinct time - [E(parietal)watt/sec] for a certain action, or as in our preliminary conditions: in a sitting position, without essential physical, psychological, and intellectual exertion.

[$E_{(parietal)}$watt/sec] - should be directly proportional to the area of active fields – (A).

[$E_{(parietal)}$watt/sec] - should be directly proportional to the average value of illumination or energy intensity – (L) (in lumen) or (T) (in Celsius grade).

[$E_{(parietal)}$watt/sec] - should be directly proportional to the speed of movement of the active fields – (v).

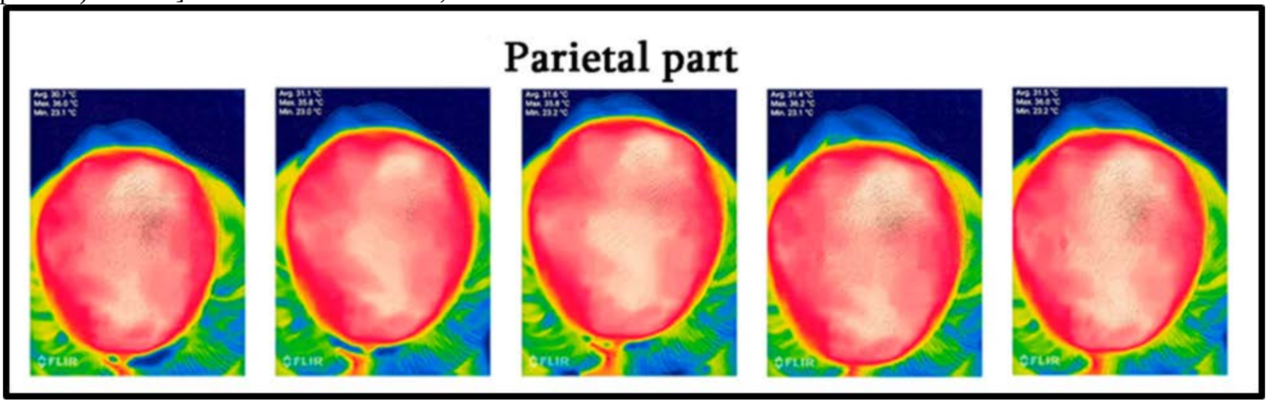

Fig. 2. Infrared images of parietal part of the head of a man aged 74. Snapshots are “cut” from head videos after every 5 seconds: on 5-th, 10-th, 15-th, 20-th and 25-th seconds. White fields correspond to active areas of the brain.

[$E_{(parietal)}$watt/sec] - should be directly proportional to the average number of active fields –(n).

From a 30-60 second video recording, we cut 5 frames at 5, 10, 15, 20, 25 seconds (figure 2) and get the averages of the images for (A) and (T), for (v) and (n).

On this beginning stage of investigation, we will determine the brain activity for cortex of only parietal surface of the brain, using data from the top of the head. In the future, it will be necessary to separately determine the activity of the stable radiation fields of the brain (hippocampi, cerebellum, hypothalamus and/or subcortical centers), and finally try to determine and give the degree of activity of the entire brain [E(total)], by jointly assessing data of all dynamic and all static fields.

To a certain extent, in the process of the model preparation we were helped by an analogy with the Stefan-Boltzmann law [7] and with the problem of determining the water regime of a river. We were modeling the amount of water moved by the river in 30 seconds. It depends on the width of the river, the depth of the river, and the speed of the water current. River flow rate is the volume of water passing through a certain section of the riverbed per unit of time. Water flow rate is usually measured in cubic meters per second (m^3/s). It is an important hydrological indicator characterizing the water content of the river and its water regime.

V=(L.h.v.t)m3, for 30 seconds, (1) or
V=(l.h.v)m3/tsec, for one second. (2)

Respectively, the mathematical equation for calculation of E(parietal), gets the following view:

$[E_{(parietal)}=f(A,T,v,n)]$, (3)

where units of measuring of (A) is cm2, for (T)-Celsius grade. There are problems for integration of parameters (n) and (v) in the equation. For a temporary solution of these problems these parameters could be presented in the equation in form of non-dimensional coefficients (Kv) and (Kn). These coefficients are calculated using the following fractions:

Kv=v(distinct person)/v (mean); (4)

where v(mean) is the statistical average determined from data of 10 healthy men, and,

Kn= n(distinct person)/n (average), (5)

where n(average) is the weighted statistical average determined from data of 10 healthy men, using the following formula:

$n(average)=(n_1*t_1+n_2*t_2+n_3*t_3+\ldots+n_i*t_i)/(t_1+t_2+t_3+\ldots+t_i)$. (6).

The equation receives the following view:

$[E_{(parietal)=}A*T*(Kv*Kn)]$, (7) or

$[E_{(parietal)}= (Kv*Kn)*A*T]$. (8)

For the calculation of specific energy capacity of the brain the modified formula (9) may be used:

$E_{(parietal)sp}=\{[A*T*(Kv*Kn)]/(A*t)\}$. (9)

Using this empirical mathematical equation (7), we measured the level of brain activity in 6 bald men whose common characteristic was the absence of scalp hair (age-related hair loss or shaving).

From obtained data follows that brain activity is mostly positively correlated with the intellectual level of a person. For example, in three professors whose average age was 77 years, the level of brain activity was in average 880 conventional units, in the time, when three other comparatively young men (mean age 46 years), with relatively lower educational level have in average 300 units less brain activity.

The presented formula is, to a certain extent, both a priori and empirical. Empirical, since the formula is based on known facts and experimental data and allows to obtain an approximate result, and in typical situations to get data close to the exact one. In order to obtain an accurate mathematical dependence of the general indicator of brain activity on the above seven parameters, it is necessary to conduct a sufficient number of experiments, it is necessary to have a sufficient number of observation cases for which the absolute, integrative indicator of brain power will most likely need a mental equivalent, for example IQ, or a speed of solving some intellectual problems.

IV. Conclusion

The derived equation, although mathematically not advanced, allows one to obtain an approximate result in specific situations. This result is close to the exact result and the equation solves two problems. It allows one to measure the brain power quantitatively, and on the other hand, it will serve as a prototype - a foundation for deriving a mathematically more accurate and more justified equation in the future. The method developed in this work is not purely a priori or purely empirical. It can probably be called the method of analogy, or the method developed through analogization.

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