DETERMINING PERSONALITY PROFILE THROUGH INFERENTIAL METHOD BY EDA NEUROSIGNALS

Corina Mihaela ZAHARIA[*], Dumitru GRIGORE[**], Magda MOLDOVAN[**]

[*]Institut of Public Order, Romania
[**]Psychometric Systems S.A.(dumitru.grigore@psychometricssystems.com)

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Abstract: *The work shows an original psychophysiological approach in establishing a psychological profile by using an inferential fractal method of access to the neocortex by stimulating the phasic stage of epidermis. The mathematical model used in analysing the functions of psychophysiological inference may show the specifics of some behavioural styles associated with psychological typologies.*

Keywords: fractal model, psychophysiological inference, neurostimulation, specificity.

1. INTRODUCTION

Human personality has been continuously investigated as a configuration of traits that reflect an individual's way of acting, feeling, thinking and adjusting to the environment. The continuous process of understanding human nature and nurture is vital for predicting an individual's way of acting in specific contexts and in different life areas such as work field, social interactions, family functioning or attitudes towards health. Psychological research is making progress in linking personality traits with specific actions and behaviors (e.g. Eysenck, 1991; Gray, 1987, 1991; Watson & Clark, 1992), looking for individual differences in brain anatomy and physiology, in bodily functions and selfregulation processes, in sensation and perception, in information processing and thinking styles, in behavior and emotion regulation, in interpersonal interaction and so on (e.g. Bandura, 2006; Block, 2002). Using biological (e.g. Nebylitsyn & Gray, 1972) and physiological data (e.g. Fowles, 1980; Carver & White, 1994; Crider, 2008), the connection between human personality traits and behavior is currently investigated through individual differences in brain functioning (Canli, 2006). A recent cybernetic model of global personality traitsis examining how specific personality traits exert control over human behavior (Van Egeren, 2009; Wiener, 1948). These traits are seen as self-regulatory controls that underlie behavior patterns rather than manifest behavior itself (Crider, 2008). It seems that human beings mentally incorporate propensities of action into personality traits (Carver, 2005; Robins et al., 1996; Schneirla, 1959). These traits encode all the actions and controls necessary for a person to achieve a goal.

Although research in the field has made significant progress in explaining how personality and individual differences impact a person's behavior and adjustment to specific contexts, measuring these aspects of personality is far more complicated. Almost every field of applied psychology requires psychological assessment tools. In order for psychologists and specialists to play their key part in improving individual and group functioning, at almost every level, they need to rigorously assess the individual, the group of people or the organization they are working with.

The development of mathematical models and advanced processing methods based on neural networks, especially those used in cognitive systems psychology 1 , or other advanced methods of real time analysis for functions with several variables, has led to the increasingly visible affirmation of the important role that engineering plays in psychological research. To highlight this reality, it is interesting to follow the implementation aspects of medicine, which provide instruments for diagnosis and 1 The cognitive system is a neuromimetic network where information flows between processing units as activation values (D.A. Norman). treatment, or development and therapy, respectively. In this regard, implementation involves the transposition of phenomenology in a method or tool, a definite appeal to engineering, because medical engineering, for example (also called bioengineering or biomedical engineering), interdisciplinary integrates professional activities of engineering with basic medical knowledge on the human body, as well as an understanding of how it works when healthy, sick or injured.

When studying the processes of perception, sensation, thinking, learning, cognition, emotion, motivation, personality, behavior, interaction between individuals and interaction with the environment, psychology will have allied disciplines such as anthropology and sociology (when studying social and environment influences on behavior), physics (in addressing vision, hearing and touch), or biology (in the study of the physiological bases of behavior).

Diagnosis in psychology is circumscribed to psychometrics as a field concerned with theory and technique of psychological measurement. Psychometrics is one of the main branches of psychological cybernetics. Being focused on measuring the results of scientific activity, it deals with the quantification of mental phenomena and intellectual capacities, using standardized and calibrated experimental methods. Therefore, it builds measurement tools and procedures, it develops and refines theoretical approaches of measurement, necessarily relying on extensive implementing activity that makes the evaluation technologies available to the psychometrician psychologist and beyond. The connection between a specific technology and the way to turn it into a testing instrument involves much more than psychology.

Just like in medicine, in psychology, implementation of a phenomenon in order to use it in a testing equipment involves the interdisciplinary integration of basic psychological knowledge regarding the human being, with professional engineering activities and an understanding of the difference between normality and pathology. This is the role of psychological engineering, concerned with studying the phenomenon, analyzing its relationship with the psychometric purpose of testing, establishing the type of model approach, establishing the relationship between the dependent and independent variables (in the case of statistical models), and creating an algorithm which will then be implemented in a specific and advanced testing equipment. Therefore, psychological engineering appeals to cybernetic modelling by formalizing a part or a whole psychological system and by developing theoretical models that treat it as a cybernetic system, thus resolving the functional relationship that involves understanding and applying a manifest mental phenomenon, and approaching specific mental aspects through quantification and assessment, which is provided by psychometrics. As the concrete result of a complex engineering endeavor in the field of psychology, e.g. the psychometric system MindMi™ combines sensitive aspects of recent theories on personality and behavior analyzed from a biological model perspective, using the benefits of an inventive implementation based on the electrodermal response technique, solving the inferential equation all the way with experimentally confirmed results.

2. EDA PHENOMENOLOGY IN THEORIES OF PERSONALITY AND BEHAVIOR

The Autonomic Nervous System is part of the Peripherical Nervous System and serves primarily as a regulatory function, helping the body to adapt to internal and environmental requirements, thereby maintaining homeostasis. There are a variety of measurements that can be used to assess changes in the activity of the Autonomic Nervous System. Electrodermal activity (EDA) is a method frequently used to evaluate the activity of the autonomic nervous system, with a long history in psychological research. Different personality traits were investigated using psychophysiological measurements (Cacioppo & Tassinary, 1990), such as electrodermal activity. the electrodermal response is seen as a peripheral manifestation of neural activation (Crider, 2008), driven by requirements of cognitive capacity (Murray & Kochanski, 2002).

The measurement of the electrodermal response takes place on the eccrine sweat glands, which are scattered over a large area of the body, but concentrated mainly on the palms and soles. The sympathetic branch of the autonomic nervous system innervates these sweat glands, where, unlike in most responses of the autonomic nervous system, the main neurotransmitter involved in changes is acetylcholine and not epinephrine (Mendes, 2009 in HarmonJones & Beer, 2009). Placing electrodes on the skin, especially in the palmar surface of the hands, is an ideal way to monitor the autonomic nervous system (Öhman, Hamm, & Hugdahl, 2000) through the sweat glands, controlled by the sympathetic nervous activity. In this case, neurosignals are collected in direct current (DC), using two electrodes subjected to a very small electrical potential difference, a measurable electric current is set between them, and the defined sizes are the phasic and tonic conductance. SCL (Skin Conductance Level) represents the tonic or basal skin conductance, a conductance level that is manifest in the absence of any external stimulus. SCL is expressed in microSiemens and falls generally in the range of 10-50 microSiemens. Phasic conductance or SCR (Skin Conductance Response) arises in the presence of an external stimulus (visual, auditory, tactile, etc.) and represents an increase in skin conductance, which can last up to 10-20 seconds, followed by a return to SCL. In the literature (Edelberg, 1968), it is mentioned that these SCR responses can occur spontaneously, without any external stimulus, with a frequency of 1-3/min, considering that there are so called electrodermally labile persons, who have a high frequency of SCR and a slow adaptation to simple stimuli repetition, and electrodermally stable persons, with rare spontaneous reactions and fast habituation. These differences are considered to be related with a number of psychophysiological variables, epidermal lability and stability representing fundamental differences in the characteristics of individuals.

Using peripheral measurements in the context of emotion, motivation and attention has revealed important empirical evidence for social and personality psychology (Pennebaker, Hughes, & O'Heeron 1987; Wegner, Broome, & Blumberg, 1997; Murphy, Steele, & Gross, 2007; Olsson et al., 2005). Changes in skin conductance can index emotional responses even before awareness of the emotion. An example of the fact that physiology can provide information on emotional and motivational responses before their awareness is provided by Bechara and colleagues (Bechara et al., 1997, apud. Mendes, 2009).

According to Crider (2008), electrodermal activity increases when the behavioral inhibition system is activated. Also, studies show an inverse relationship between electrodermal lability and expression of emotional and antagonistic impulses.

An increased EDR lability is associated with an undemonstrative and agreeable disposition, while high EDR stability is associated with an expressive and antagonistic disposition (Crider, 2008; Fowles, 1980). This is consistent with Block's distinction between undercontrolled and overcontrolled personality types (Block, 2002), with overcontrolled people being described as emotionally undemonstrative, shy and agreeable, and undercontrolled people being described as expressive and antagonistic (Robins et al., 1996).

The distinction between undemonstrative and agreeable EDR labiles versus expressive and antagonistic EDR stabiles contradicts the general expectation of a positive relationship between behavioral intensity and sympathetic nervous system activation. Jones (1950) proposed a distinction between an internalized, versus externalized model of emotional expression. Specifically, when behavioral expression is blocked due to social pressure or other reasons, emotional impulses could be expressed by a high sympathetic activation. Therefore, electrodermal lability may be interpreted as an internalized way of emotional expression when the externalized expression is inhibited. Electrodermal lability can act as a psychophysiological marker for individual differences in the effortful control of emotional expression and antagonistic behavior (Crider, 2008). According to the effortful control hypothesis, people with high EDR lability invest greater cognitive effort to inhibit their expression (Crider, 2008; Carver, 2005; Nigg, 2003).

The effortful control differs from the behavioral inhibition, which is a more automated and less reflective kind of inhibition and which is triggered by the approach-avoidance motivation (Fowles, 2000; Gray & McNaughton, 2000). Murray and Kochanska (2002) have defined effortful control as an ability to inhibit a dominant response and to initiate a subdominant response which is consistent with situational requirements. The effortful control hypothesis derives from Öhman's information processing approach to the EDR component of the orienting response. In Öhman's analysis, specific EDR is seen as a peripheral manifestation of neural activation, driven by demands on cognitive capacity (Crider, 2008; Murray & Kochanski, 2002). Specific EDR seems to reflect a requirement for resources when the current capacity is insufficient to meet the needs for immediate processing. Studies show that phasic electrodermal activity is sensitive to demanding tasks, electrodermally labiles showing less capacity available in the face of cognitive tasks. The demand for resources that is signaled by EDR activity may not be satisfied if a limited cognitive capacity is currently allocated to competitive and cognitively demanding tasks. Therefore, the relationship between EDR activity and processing efficiency varies according to the degree of concurrent competition for a limited processing capacity (Crider, 2008; Öhman, 1979; Öhman et al., 2000).

3. ELECTRODERMAL POTENTIAL IN ALTERNATING CURRENT (AC)

According to Edelberg's exocrine model, one of the most widely accepted theoretical models of skin conductance, the phasic changes of skin conductance occur when the skin glands fill, and the skin conductance returns to baseline when this moisture is reabsorbed in the glands. In this model, in fact, the exocrine glands are seen as resistors. The conductance increases (the resistance decreases) when these glands are filled. The amplitude of conductance modification derives from the amount of solution contained in the glands, but also from the number of exocrine glands that are simultaneously activated. The activation of exocrine glands is neurally regulated, being controlled by the brainstem. This is part of the phenomenology of exodermal manifestations of the brain, the electrodermal activity being a projection of the activity of reticular formation of the brainstem, the hypothalamus, the limbic system and the motor cortex (Bloch et al., 2006).

It is also known that the electrical activity of the skin is linked with the blood flow in the peripheral areas, depending directly on the heart rate.

It is known, however, that in the case of conductive media, the charge carriers can be electrons (in metals) or free ions in suspension (in solution), in the case of biological tissues. When a DC passes through an ionized solution, the phenomenon of polarization occurs, which can cause tissue heating or, in extreme cases, tissue destruction. Gildemeister (1920) was among the first to overcome this drawback by using an alternating current (AC) and measuring the total opposition to its passage through a tissue (Lawler, Davis, & Griffith, 1960). In his research on brain electrical activity between the years 1955-1960, A. L. Thomasset used AC instead of DC, considering that the body is an ionic and inhomogenous conductor (Thomasset, 1962, 2002). In this case, the manifest characteristic that is connected to the physiological activity of the tissue being subjected to an AC is the impedance. The measurement of impedance (Z) on a biological tissue involves both the 7 electrical resistance of the tissue (R) and its capacitive reactance (Xc), according to the formula $Z^2 = R^2 + Xc^2$. Physically, the resistance is the opposition of a conductor to an AC, being essentially the same in biological tissues as in nonbiological conductive materials (Kay, Bothwell, & Foltz, 1954; Nyboer, 1959), while the capacitive reactance of a biological tissue is caused by the additional oposition to an AC through the capacitive (storing) effect of bilipid cell membranes, of tissue interfaces and of structural characteristics (Baker, 1989; Barnett & Bagno, 1936; Schwan & Kay, 1956, apud. Chumlea & Guo, 1997). The membranes act as a dielectric or insulator that separates the extracellular and intracellular fluid, behaving like valves of the biological capacitor. Even in the case of AC, epidermal humidity is a determinant factor for penetration into the body. It is worth noting that low frequencies below 5.000 Hz are conveyed only through the connective tissue of the body (Ivorra & Aguiló, 2001; Ivorra & Rubinsky, 2007), while higher frequencies penetrate the outer layers of the cell (in referring to sinusoidal signals, using rectangular signals creates higher frequency harmonics that can enter the cell, even if the base frequency is low).

Authors like Boucsein, Schaefer, and Neijenhuis (1989) argue that exosomatic electrodermal recording techniques primarily focus on the tonic measurement, rather than phasic measurement. However, the measuring methods for phasic AC are the most useful in testing electric models of electrodermal response. For this, concepts of appropriate measurement are being developed for continuous recording of the impedance and phase angle (the second measurement that characterizes physiological parameters, besides impedance) (Chumlea & Guo, 1997; Baumgartner, Chumlea, & Roche, 1988; Lukaski & Bolonchuk, 1987; Subramanyan et al., 1980). The phase angle is expressed in degrees, as the arctangent of the ratio Xc/R, depending on the frequency of the current used.

In addition, the literature records the existence of two different types of "human electrical impedance" (Sutherland, Dorr, & Gomatom, 2005), namely an impedance of the surface (of the skin), and an internal impedance (of the whole body), which is basically resistive. The epidermal surface layer, that contains dead cells deposited on a living, heterogeneous and non-isotropic layer, shows both resistance and capacitance (Sălceanu, Iacobescu, & Anghel, 2013). The capacitive impedance decreases with frequency at higher resistances. According to some authors (Fowles et al., 1981), a drawback of using AC in electrodermal measurements is that capacitive properties of the skin are added to conductance values, resulting in too high conductance values. Since, as we previously mentioned, the skin capacitance is directly proportional to the frequency of measurement, by using a low frequency, below 40 Hz, with a phasic-sensitive correction, the skin capacitance may become negligible.

The cited authors have experimentally demonstrated that the electrodermal potential is a stronger parameter than conductance, being much less dependent on the constancy of skin contact area with the electrode, which causes the artifacts to be more pronounced in skin conductance curves than in potential curves. The method that Fowles used in 1981 requires a DC and cannot separate conductance and electrodermal potential waveforms. In order to study the electrodermal generating mechanisms, the electrodermal potential must be measured without the DC and compared with the conductance results in AC. This is possible by phasic-sensitive correction, by real time signal processing and by variable conversion (Grimnes, Jabbari, Martinsen, & Tronstad, 2011).

The advantages of using the DC conductance are supported by the simple fact that there is no skin capacitance there, and by a large number of references that exist in the literature. The disadvantages may include: the limit of 50mA/cm2, the intervention by changing the electromotive force that is generated in the circuit on the electrodes and in the skin (electro-osmosis, the filling of the sweat channels, the membrane potentials, the electrolysis of the skin and the irritation), the use of bipolar electrodes, that involves data coming from two different places of the skin, with unequal measurement areas, which is why conductance in DC is not suitable for physiological research (Grimnes et al., 2011). Although the measurement system in AC is far more complicated, requiring a greater number of parameters to follow, AC conductance however, enables measurement of electrodermal potentials, simultaneously, in the same place on the skin. Also, the absence of DC power leads to less stringent requirements for the electrode technique, so the monitoring of their potential error or polarization during use becomes unnecessary. Lastly, the sensors do not irritate the skin as in DC, and AC conductance is not affected by changes of electromotive force. Therefore, the electrodermal potential becomes a valuable indicator of autonomous and somatomotor aspects of cognitive functioning, of emotion, motivation and attention. It is manifest in the absence of DC, with the possibility of collecting (by using unipolar sensors) these following two aspects: the skin potential level (SPL) and the skin potential response (SPR).

4. NEUROSTIMULATION OF PHASIC RESPONSE OF THE ELECTRODERMAL POTENTIAL IN AC

The studies performed with the phasic neurostimulation system (Grigore D., patent RO127615 published in BOPI no. 11/ 29.11.2013), confirms the assumption that the simultaneous stimulation of the phasic stage of epidermis with a step signal and an alternative voltage signal shows with high accuracy the level of epidermal lability and stability, but also the electrodermal potential response in alternative voltage, a response loaded with information of psychological significance in the normality or pathology area.

The stimulation of the phasic stage of the epidermis consists in maintaining it under excitation for a calibrated time range on the phase conductance base. Due to this manner of stimulation, self-adjustability by reverse connection installed between the system outputs and the sensitive input area, the response in phase conductance perceived through the epidermis will be in a projective correspondence with the bioelectric events taking place in the body, generated in the self-adjustment processes whereby the psychophysiological functions are manifested.

The opening of a neurostimulating channel will align the measurement area with the targeted mental-physiological function, and the neurosignals collected from the sensors will contain the information on the response pattern for the applied stimulus.

The neurostimulation process will be tackled in terms of the assembly of applied signals: the *excitation* step signal, the response step signal and the *bearing*, sinusoidal signal.

The *excitation* signal is a step signal (Fig. 1), of which form can be written as follows:

$$u_1(t) = \sum_{k=1}^{N} A_k \left[\sigma(t - kT) - \sigma(t - (k+1)T)\right] \quad (1)$$

Where $\sigma(x - x_0) = 1$; $x \geq x_0$; $\sigma(x - x_0) = 0$; $x \leq x_0$ is the Heaviside function;

A - is the amplitude of the step signal;

T - is the duration of the step signal;

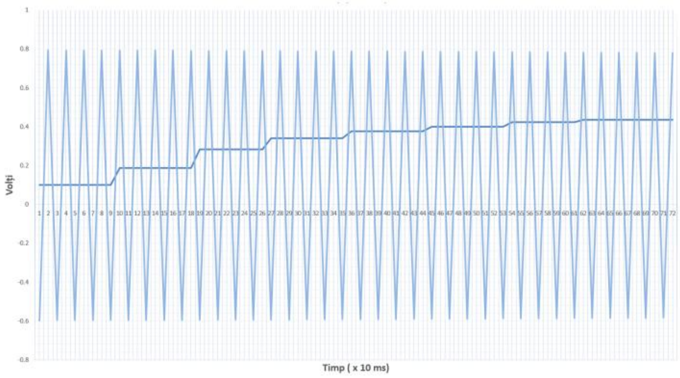

FIG. 1 Excitation signal

The *bearing* signal can also be written as follows:

$$u_2(t) = A_S \cos\left(\frac{2\pi t}{T_0}\right) \quad (2)$$

where A_S is the signal amplitude and T_0 is its duration.

The response signal. Fig. 2 shows all the three signals involved in the phase neurostimulation of the epidermis.

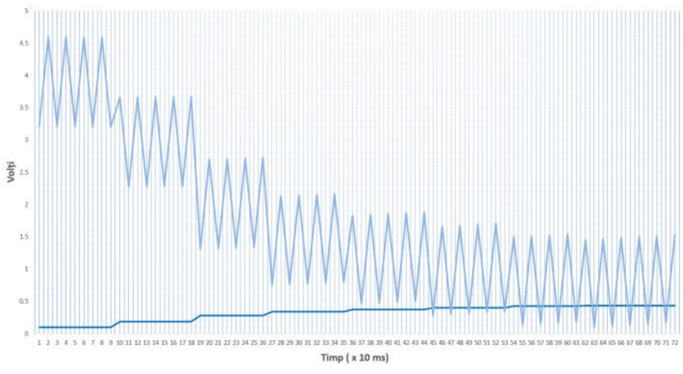

FIG. 2 Diagram of the signals involved in phase neurostimulation on a single step impulse

By composing the step excitation signal and the alternative voltage signal on the epidermis surface, the following signal results:

$$u_{Total}(t) = A_S \cos\left(\frac{2\pi t}{T_0}\right) + A_t \sum_{k=1}^{N} k\left[\sigma(t - 3kT) - \sigma(t - 3(k+1)T)\right] \quad (3)$$

which will be correlated with the phasic response of the electrodermal potential in alternative current. The envelope (marked in red) contains essential information about the psychophysiological processes on which we intend to apply an inference.

The third variable is the function □□□□□as an expression in time of electrodermal lability and its size will be an input parameter in the frequency and adjustment loop of the amplitude of the alternative excitation signal. Its evolution in time depends on the intensity of the SPR responses recorded in the measurement cycle, hence representing, on a high densit, a high level of lability, while on a low density, a low level thereof.

GSR patterns

By extending the diagram form at the level of *i* pulses for a stimulation cycle, we obtain:

$$u_1(t) = A_{S_1} \cos\left(\frac{2\pi t}{T_0}\right) + A_{t_1} \sum_{k=1}^{N} k\left[\sigma(t-3kT) - \sigma(t-3(k+1)T)\right]$$

$$u_2(t) = A_{S_2} \cos\left(\frac{2\pi t}{T_0}\right) + A_{t_2} \sum_{k=1}^{N} k\left[\sigma(t-3kT) - \sigma(t-3(k+1)T)\right] \qquad (4)$$

.

$$u_i(t) = A_{S_i} \cos\left(\frac{2\pi t}{T_0}\right) + A_{t_i} \sum_{k=1}^{N} k\left[\sigma(t-3kT) - \sigma(t-3(k+1)T)\right]$$

5. THE INFERENTIAL MODEL

In approaching the mathematic form of expression of the electrodermal potential stimulated in alternative current, Fig. 3 represents the transition of the function *u(t)* from point A, where it acquires the value of the *electrodermal potential level (SPL)* to point B, where it acquires the value of the *electrodermal potential response (SPR).*

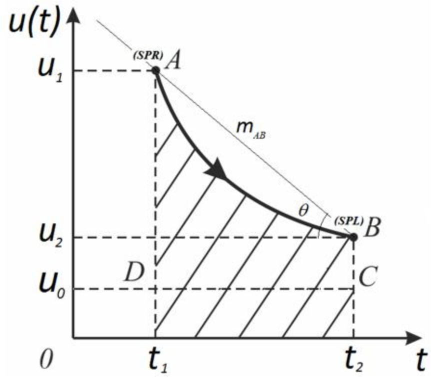

FIG. 3: The electrodermal potential stimulated under AC

a. Allocated energy

The neurostimulation of the phasic base of epidermis under alternative current is made for the same person for several channels simultaneously. The effect that the transition of the electrodermal potential may cause will be assessed under power. For each stimulated channel *i*, the form of the allocated power is:

$$P_i(t) = I_i \cdot u_i(t) \qquad (5)$$

where I_i is considered constant (a facility ensured by the construction of the neurostimulation hardware) so that the energy consumed in transition can be represented by the area from under the curve. This area can be determined by integrating the ratio (5):

$$S_i(t) = I_i \int_{t_1}^{t_2} u_i(t)dt \qquad (6)$$

S_i having the significance of *allocated energy* on the channel i in the neurostimulation process. For the entire process, on i channels of stimulation i, $(\forall) i = \overline{1,n}$ the allocated energy is represented as a matrix:

$$S = \begin{pmatrix} S_1(t) \\ S_2(t) \\ \cdot \\ \cdot \\ S_i(t) \end{pmatrix} \qquad (7)$$

b. The inference level

According to the theory of psychophysiological inference (Cacioppo & Tassinary, 1990), it is established that every source of neurostimulation related to a channel i achieves a specific inference for a band *j*, $(\forall) j = \overline{1,n}$. In other words, one will seek by which manner the allocated energy *Si* manifeφsts in a physiologicaγl potential will *p*roduce the inference o*n* a channel *i* of measurement and a band *j* of inference. The relationship between φ and γ is:

$$\gamma = \beta \cdot \varphi \qquad (8)$$

where β is a scale factor under the form □/(u_{max}-u_0), u_{max} is the maximum potential on the used scale and u_0 is a minimum value of the response potential to which a psychophysiological inference can be intercepted.

The indicator characterizing the transition through neurostimulation of the electrodermal potential under alternative current is the parameter m_{AB}, defined as the slope of the line containing the segment AB (Fig. 3). The form of m_{AB} for a channel i of neurostimulation can be written as follows:

$$m_{ABi} = \frac{u_{1i} - u_{2i}}{|t_1 - t_2|} \qquad (9)$$

The significance of the slope m_{AB_i} pertains to the level of electrodermal response (SPR), its position being a function directly proportional with the psychophysiological *inference level*. The variation of the parameter m_{AB_i} can be monitored $u_{1i} = u_{2i}$, in which case $m_{AB_{MIN}} = 0$, or for $u_{2i} = u_0$, in which case $m_{AB_{MAX}} = \frac{u_{1i} - u_0}{|t_1 - t_2|}$.

Considering that every transition from a channel i produces a specific inference on a band j, the form of the slope m_{ABj} related to a band j for a minimum value u_0 of the potential is written:

$$m_{AB\,j} = \frac{u_{1j} - u_0}{|t_1 - t_2|} \qquad (10)$$

It is defined the physiological component Φ_{ij} from the inferential relationship between channel i and band j as a product between the SPL potential measured on the stimulation channel and the ratio between the slope related to the *stimulation channel* and the slope of the *inference band*. The form of this *potential* will be:

$$\phi_{ij}(u) = u_{1i}\frac{m_{AB_j}}{m_{AB_i}} \tag{11}$$

a ratio by means of which (8) becomes:

$$\gamma_{ij} = \frac{\tau u_{1i}\left(u_{1j} - u_0\right)}{\left(u_{\max} - u_0\right)\left(u_{1i} - u_{2i}\right)} \tag{12}$$

c. The psychological indicator

To establish the form of the psychological indicator Ψ_{ij} we will consider the transition of the electrodermal potential for a channel i, the way that it causes inferences and the average response of the electrodermal potential at the level of all the i channels of neurostimulation. The output of the neurostimulation process on a channel i is defined as the ratio between the energy allocated to that channel and the average of the energies allocated on all the channels.

By means of the ratio (6) it is established the form of the average energy allocated on all the i channels of neurostimulation:

$$\overline{S} = \frac{I}{i}\int_{t_1}^{t_2}\left(u_1(t) + u_2(t) + \cdots + u_i(t)\right)dt \tag{13}$$

considering that $I_1 = I_2 = \cdots = I_i = I$, a condition ensured by the construction of the neurostimulation hardware.

Hence, from (6) and (15) we deduce the output for every i channel:

$$\rho_i = \frac{I\int_{t_1}^{t_2} u_i(t)dt}{\frac{I}{i}\int_{t_1}^{t_2}\left(u_1(t) + u_2(t) + \cdots + u_i(t)\right)dt} = i\frac{\int_{t_1}^{t_2} u_i(t)dt}{\int_{t_1}^{t_2}\left(u_1(t) + u_2(t) + \cdots + u_i(t)\right)dt} \tag{14}$$

On the other hand, considering that the psychophysiological inference ratio assumes an inferential reproduction of the entire panel of psychological indicators Ψ_{ij}, it is established that, in order to make it, the inferential relationship between elements will be as follows:

$$\psi_{ij} = \rho_i \gamma_{ij} \tag{15}$$

with the significance of psychological indicators, components by means of which, considering (13), we can write the final form of the psychophysiological tensor Ψ_{ij}:

$$\Psi_{ij} = \frac{\tau}{u_{\max} - u_0}\begin{pmatrix} \rho_1 u_{11}\frac{u_{11} - u_0}{u_{11} - u_{21}} & \rho_1 u_{11}\frac{u_{12} - u_0}{u_{11} - u_{21}} & \cdot & \cdot & \rho_1 u_{11}\frac{u_{1j} - u_0}{u_{11} - u_{21}} \\ \rho_2 u_{12}\frac{u_{11} - u_0}{u_{12} - u_{22}} & \rho_2 u_{12}\frac{u_{12} - u_0}{u_{12} - u_{22}} & \cdot & \cdot & \rho_2 u_{12}\frac{u_{1j} - u_0}{u_{12} - u_{22}} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \rho_i u_{1i}\frac{u_{11} - u_0}{u_{1i} - u_{2i}} & \rho_i u_{1i}\frac{u_{12} - u_0}{u_{1i} - u_{2i}} & \cdot & \cdot & \rho_i u_{1i}\frac{u_{1j} - u_0}{u_{1i} - u_{2i}} \end{pmatrix} \tag{16}$$

where we identify and re-written the form of a psychological indicator ψ_{ij} :

$$\psi_{ij} = \frac{u_{1i}\tau i}{u_{\max} - u_0} \frac{u_{1j} - u_0}{u_{1i} - u_{2i}} \frac{\int_{t_1}^{t_2} u_i(t)dt}{\int_{t_1}^{t_2} \left(u_1(t) + u_2(t) + \cdots + u_i(t)\right)dt} \tag{17}$$

d. The behavioural function

The matters of concern in diagnosis are those regarding the way that the psychological indicators reflect in behaviour. The entire panel of psychological indicators will reflect in the personality profile through a set of *behavioural functions*, of which form is as follows:

$$c = \alpha \cdot \psi \tag{18}$$

where □□is a share, as a measure of the manifestation level in the behavioural function of the psychological indicator. The tensor of the behavioural functions will be made of the product between the matrix of the shares and the matrix of psychological indicators:

$$C_{ij} = \begin{pmatrix} \alpha_{11} & \alpha_{12} & \cdot & \cdot & \alpha_{1i} \\ \alpha_{21} & \alpha_{12} & \cdot & \cdot & \alpha_{2i} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \alpha_{k1} & \alpha_{k2} & \cdot & \cdot & \alpha_{ki} \end{pmatrix} \cdot \begin{pmatrix} \psi_{11} & \psi_{12} & \cdot & \cdot & \psi_{1j} \\ \psi_{21} & \psi_{12} & \cdot & \cdot & \psi_{2j} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \psi_{i1} & \psi_{i2} & \cdot & \cdot & \psi_{ij} \end{pmatrix} \tag{19}$$

which becomes:

$$C_{ij} = \sum_{i-1}^{n} \alpha_{ki}\psi_{ij}, (\forall)k = \overline{1,n}; (\forall)j = \overline{1,n} \tag{20}$$

e. The behavioural style, the personality typology

To identify the personality typologies, the elements of the matrix C_{ij} will be grouped based on a number m of polarity criteria, in pairs, hence obtaining a set of *behavioural styles* under the form:

$$S_{pq} = \left| \left(\sum_{i-1}^{n} \alpha_{ki}\psi_{ij} \right)_p \left(\sum_{i-1}^{n} \alpha_{ki}\psi_{ij} \right)_q \right|, (\forall)p = \overline{1,m}; (\forall)q = \overline{1,m} \tag{21}$$

The combination of the behavioural styles leads to identifying a number t = $m(m$-1) personality typologies under the form:

$$V_{xy} = \left(S_{pq}\right)_x + \left(S_{pq}\right)_y, (\forall)x = \overline{1,t}; (\forall)y = \overline{1,t} \tag{22}$$

which on their turn will be grouped in the *m criteria classes.*The selection of the s The selection of the share of the highest value of the sum (22) leads to obtaining the *personality typology*.

6. MINDMI™ - THE SYSTEM THAT IMPLEMENTS NEUROSTIMULATION OF EDA PHASIC RESPONSE PRINCIPLE

Performing the cybernetic modeling of personality traits, temperament types, and propensities to regulate goaloriented actions, and approaching the input variables related to electrodermal activity, the MindMi™ System (Fig. 4), identified emotional and cognitive measurable dimensions that can be determined by behavioral inhibition or activation, depending on the electrodermal response and its lability.

Thus, according to the theories presented above, we considered the association of EDR lability (through $\lambda(t)$ function, which is perfectly determinable by direct measurement, as the density of the skin potential response to a stimulation cycle) with the regulatory function of AC excitation (by controlling the frequency and amplitude of the signal), in order to determine the level of psychophysiological activity, by linking skin potential response with the degree of inference of this activity in each area of measurement.

FIG. 4. MindMi^{TM} System (https://www.mindmisystem.com)

To complete the algorithm that implements the new cibernetic model, the following aspects were considered, which were previously described:

- the electrodermal activity increases when the behavioral inhibition system is activated;

- an increased EDR lability is associated with an undemonstrative and agreeable disposition; a high EDR stability is associated with an expressive and antagonistic disposition (Crider, 2008; Fowles, 1980);

- overcontrolled people are described as emotionally undemonstrative, shy and agreeable, while undercontrolled people are described as expressive and antagonistic (Robins et al., 1996);

- when behavioral expression is blocked due to social pressure or other reasons, emotional impulses can be expressed by a high sympathetic activation (Jones, 1950); electrodermal lability can be interpreted as an internalized way of emotional expression when the externalized expression is inhibited;

- the electrodermal lability can act as a psychophysiological marker for individual differences in the effortful control of emotional expression and antagonistic behavior (Crider, 2008). Corelating this with the skin potential response in AC (limited evaluative context) proves specificity and generality, transforming this marker from a concomitance into an invariant, which meets the condition for a strong inference (Cacioppo & Tassinary, 1990); - according to the effortful control hypothesis, people with high EDR lability invest greater cognitive effort to inhibit their expression (Crider, 2008; Carver, 2005; Nigg, 2003). - the effortful control hypothesis derives from Öhman's information processing approach to the EDR component of the orienting response: specific EDR is seen as a peripheral manifestation of neural activation, driven by demands on cognitive capacity (Crider, 2008; Murray & Kochanski, 2002);

- specific EDR seems to reflect a requirement for resources when the current capacity is insufficient to meet the needs for immediate processing;

- electrodermally labile people are showing less capacity available in the face of cognitive tasks;
- the relationship between EDR activity and processing efficiency varies according to the degree of concurrent competition for a limited processing capacity (Öhman, 1979; Öhman et al., 2000);
- empirical associations between personality and behavior can be derived from individual differences in brain functioning parameters (Matthews & Gilliland, 1999);
- the level of arousal (physiological activation) can be related to a scale of introversion - extraversion (Eysenck) in order to describe individual personality types and their corresponding behavioral patterns;
- extraversion has been empirically associated with motivational reactivity to rewards (Depue & Collins, 1999);
- neuroticism has been empirically associated with strong reactivity to punishments (Gray, 1987; Watson & Clark, 1984), and conscientiousness with the regulation of these two reactive trends (Rothbart, Ahadi, & Evans, 2000);
- the behavioral inhibition system (Gray, 1982, 1985a,b) has its neural bases in the septal area of the limbic system and in the hippocampus (the septo-hippocampal system and its interconnected structures);
- the behavioral inhibition system is a neuropsychological system related to sensitivity to punishment and aversive (avoidance-related) motivation, which inhibits motor behavior (Fowles, 1980);
- the behavioral activation system corresponds to sensitivity to rewards and appetitive (approach-related) motivation, being related to the individual's disposition of pursuing and achieving his goals;
- multiple interactions have been found between main personality traits, as a response to internal and external stimuli (inputs), such as stressors or feedback (Bogg & Vo, 2014; Van Egeren, 2009);
- the cybernetic theory (Wiener, 1948) describes how a mechanism exerts control over its own functioning, as a response to inputs, in order to achieve its self-regulation goals. The central idea of cybernetic models is that the unmet part of the goals (e.g. the remaining part of the way to the point X) is the engine of all self-regulated actions (Wiener, 1948);
- a cybernetic model, correlated with an adaptation system of personality, can describe independent and interdependent functioning of trait groups in order to facilitate goal-oriented actions;
- from a cybernetic perspective, the purpose of the adaptive response in a system of personality (whether it is independent or interdependent) is to support the carrying out of goal-oriented actions;
- from an interdependent perspective, different levels of traits, as well as different levels of different combinations of traits may correspond to different levels of the same responses, or even divergent responses (Bogg & Vo, 2014);
- the cybernetic feedback control theory (Powers, 1973a,b; Wiener, 1948) specifies the minimal set of commands that self-regulatory systems (e.g. a space heating system) require to meet a preset goal, providing a useful metaphor for how personality traits exert control over behavior;
- human beings differ greatly in how they control their actions (some impulsively, others prudently etc.). The way they do this gives each individual distinct characteristics that can be composed into an integrating theory of personality;

- according to Van Egeren's hypothesis (2009), human beings mentally incorporate control propensities of actions in global personality traits, these traits being responsible for encoding all major types of control necessary to achieve a goal;

- the descriptive terms that compose a trait and its functioning pattern can indicate, by themselves, specific self-regulatory operations that function through that trait;

- from a temperamental view (the temperament theory) any adaptation of an organism to its environment, its very survival, depends on the way it approaches rewards and avoids punishments (Schneirla, 1959);

- the theory of human agency (Bandura, 2006) assumes that human responsiveness to external stimuli has an active component, according to personal needs and goals, that are followed actively and proactively rather than reactively (Carver & Scheier, 1990; Emmons, 1995; Little, 1989; Pervin, 1983);

- personality traits are associated with self-regulatory controls that underlie behavioral patterns, rather than manifest behavioral patterns themselves (Van Egeren, 2009);

- there is a set of four functions, named here "behavioral functions", which regard the understanding, organization (in terms of control of actions), decision and networking. These have antagonistic nominal values and by combining them, a number of behavioral types can be linearly identified (Grigore et al., 2013).

According to the effortful control hypothesis, people with high EDR lability invest greater cognitive effort to inhibit their expression (Crider, 2008; Carver, 2005; Nigg, 2003). The effortful control hypothesis derives from Öhman's information processing approach to the EDR component of the orienting response: specific EDR is seen as a peripheral manifestation of neural activation, driven by demands on cognitive capacity (Crider, 2008; Murray & Kochanski, 2002).

The algorithm developed based on the above mentioned criteria subjects the acquisition data (collected from the palm surface of the hands) to a sequence of preliminary processing, in order to identify the neurophysiological activity level (Cx) in each area of measurement. This is associated with the skin potential response (SPR) obtained by neurostimulation AC, and with the level of inference8 (Fy) of the neurophysiological activity in psychological aspects, which corresponds to each area of measurement correlated with the degree of electrodermal stability. The value of several indicators (Ipxy) with psychological significance is further calculated. These reflect the neurophysiological activity and the corresponding inference in each area of measurement, expressing the activity level of cognitive, affective or volitional functions they projectively represent. Using these indicators of psychological significance, a programmable platform is provided, where the user can customize, in a user-interface, any other psychological construct, in addition to the predetermined ones.

7. CONCLUSIONS AND IMPLICATIONS

After a continuous process of modelling, developing and refinement of the MindMi™ patented system, which we partially described in this material, a number of psychological traits and indicators have become measurable through a non-invasive hand scanning device, using the Inference is the degree to which a neurophysiological activity can express one or more psychological aspects active principle of sweat gland activity as a peripheral manifestation of neural activation.

The device measures biopotentials from the skin surface (skin potential response and skin potential level) through a dual hand scanner with monopolar electrodes that gather all the necessary data in 5 minutes. After the scan, the system uses the collected data to acquire psychological information through an innovative algorithmic procedure.

The algorithm combines multiple variables of key relevance for their corresponding personality traits (e.g. the amplitude, the lability of the electrodermal response, the level of cortical arousal, and others). This core set of variables goes through a cybernetic modelling process, resulting in a numerous set of psychological indicators that reflect cognitive, emotional and social abilities, but also specific aptitudes and tendencies. The psychological indicators obtained are further used to create extensive psychological reports that comprise information about an examinee's personality, cognitive intelligence, emotional intelligence, cognitive pattern, and interpersonal or group compatibility.

These results can be used as an extensive source of information, having a key relevance for psychological assessment processes. The reports provided by the MindMi™ System, along with results from other assessment tools, thus become pieces of a puzzle that a specialist is assembling on behalf of the examinee.

MindMi™ facilitates more comprehensive data gathering and it can act as a decision support technology. It is important to note that MindMi™ reports do not treat or diagnose, but the information obtained with the system can be successfully integrated with other sources (e.g. interview, other psychological tests, practical activities or assessment centers).

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