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Research Article

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Practical applications in neurofeedback

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ABSTRACT
This research provides, in its first part, a synthesis of some historical and theoretical elements regarding neurofeedback technologies. In the second part, four of the most well-known protocols, or intervention methods, in the field are described in a concise and simplified manner. In the third part, descriptions and data collected in training sessions conducted at the NLP Research Platform SRL office and on the Psihoexplorer.ro platform can be found.

Historical Aspects in Neurofeedback

The discovery of neurofeedback started, against all expectations, from an attempt to demonstrate the existence of telepathy. The numerous tests carried out by Hans Berger, over a period of over twenty years, proved to be a failure, which, among other things, seriously affected his medical career [1]. The only success was the identification of a single, weak and short-lived frequency emission. Affected by the initial failure, Berger became obsessively oriented towards understanding the collected data. Stubbornly and despite rejection from his colleagues, after another five years of effort, he published, in 1929, the first scientific paper in the field. The discovery of classical conditioning by Ivan Pavlov and operant conditioning by BF Skinner in the same period, together with the improvement of technical means, allowed the later confirmation of the discovery by Adrian and Matthews [2,3]. The Berger rhythm, as it was to be called, now represents the basic pattern of EEG rhythm.

Again, as an interesting and novel aspect, a first substantiation of the effects of NF is based on experiments on a few cats. Considering that animals cannot fake the results, Sterman et al. evaluated an initial protocol of relationship between operant conditioning and brain activity [4]. Cats trained to increase their frequencies, in the sensorimotor area, to approximately 12-15 Hz, proved to be more resistant to hydrazine, a compound that produces convulsive effects. Later tested on humans with convulsive disorders, this protocol, of sensorimotor rhythm (SMR), proved to be the first valid application of NF. Later, Lubar and Lubar used the SMR protocol in hyperkinetic children with ADHD [5]. By reducing excessive motor movements and increasing the level of attention, they demonstrated the usefulness of the method including for this category.

Theoretical Aspects in Neurofeedback

Neurofeedback (NF) represents the direct neurological addressing of the broader techniques in the Biofeedback (BF) segment. Starting from this role, NF allows the individual control of certain brain responses. Following an initial assessment, the therapist establishes the optimal protocol and work plan in accordance with the patient's impairment. The frequencies recorded by the sensors placed on the scalp are processed in real time and presented in the form of visual or auditory feedback. Through conscious and subconscious mechanisms of encouragement and reward, the person learns to control his or her various effects and cognitions Lubar and Lubar [5].

The usual course of NF procedures begins with the mounting of sensors and testing of connections, followed by a short period of client accommodation and then the actual implementation of the protocol. Depending on the software recordings and the observed reactions, the specialist will modify the response thresholds and frequency limits, so that the person achieves

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his goals. The different types of protocols are adapted, on the one hand, to the improvement of psychological conditions, and on the other hand, to the upgrading of specific skills. Among the defining elements regarding the success of Neurofeedback therapies, we find the selection of the type of intervention, the addressed region, and the frequency range. The more carefully selected and personalized these are, the faster the success of the therapy will be ensured [6].

Practical Aspects in Neurofeedback

Neurofeedback protocols include rules for applying interventions, specific to the objectives assumed in the therapeutic program. On the one hand, the different types of conditions to which they are addressed are indicated, and on the other hand, the locations of the electrodes and the targeted brain waves are specified. In the case of each type, different frequencies must be improved (increased) or limited (decreased) to fit within functional limits. The person's progress, the ability to fit within the landmarks, is rewarded through sounds, images, points. At the end of the interventions, or between training sets, reports are issued that highlight the favorable or unfavorable trend of the approach [7].

The optimal protocols are determined by therapists, through anamnesis, or classic assessment sessions. Another type of assessment is qEEG, or Brain Map, both of which offer certain advantages (simplicity, objectivity), but also some limitations (generality, lack of depth). Depending on the result of the assessment, specialists classify the person according to the condition that needs to be improved, or the progress that needs to be achieved in a certain area of life, for a certain type of protocol and a minimum number of sessions. During the sessions, it may be necessary for the programs to be modified according to the situations.

Among the most commonly used protocols in neurofeedback are: sensorimotor rhythm training (SMR), frontal stabilization, alpha training, and the Deep protocol. The electrode application locations are established according to the international 10-20 scalp mapping system.

Sensorimotor Rhythm Training (SMR)

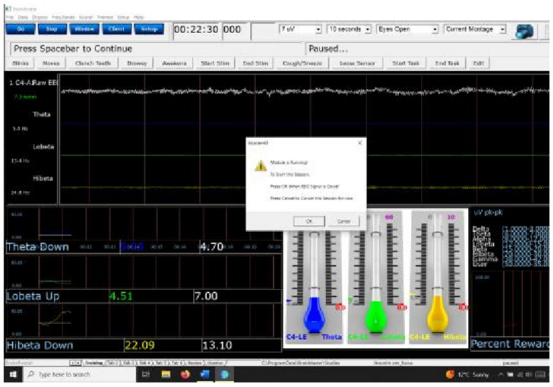
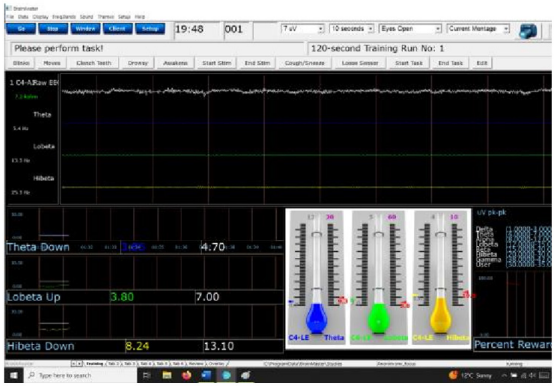
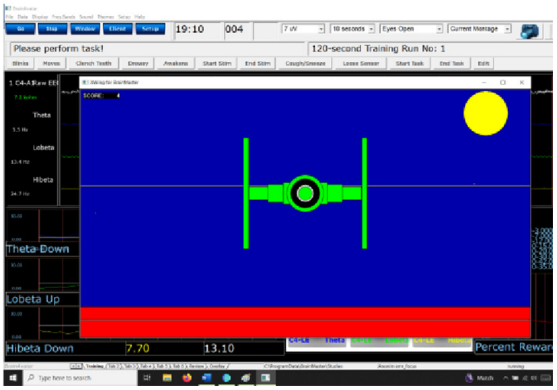
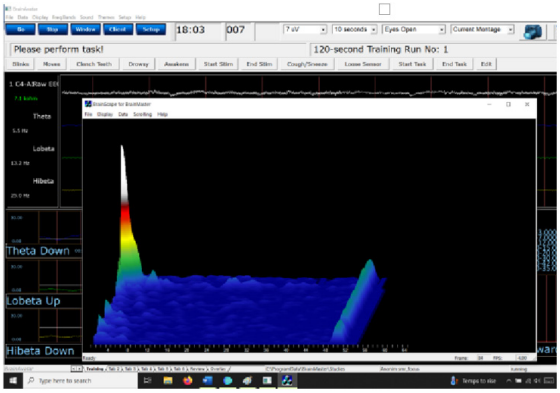
SMR training is recommended to improve attention and concentration. It is applied to clients who exhibit distraction, agitation, compulsive movement, disorganization. The SMR frequency band (12-15Hz), set as a target, is associated with a state of attention and control.

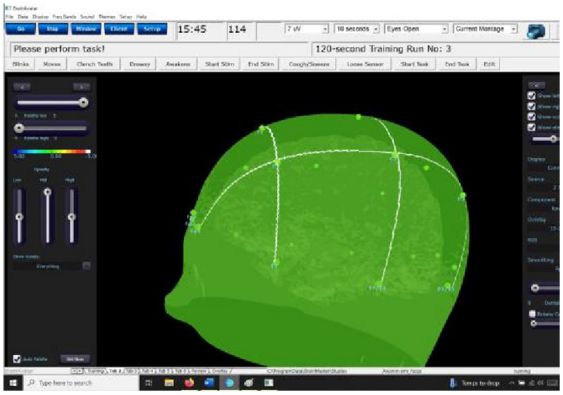
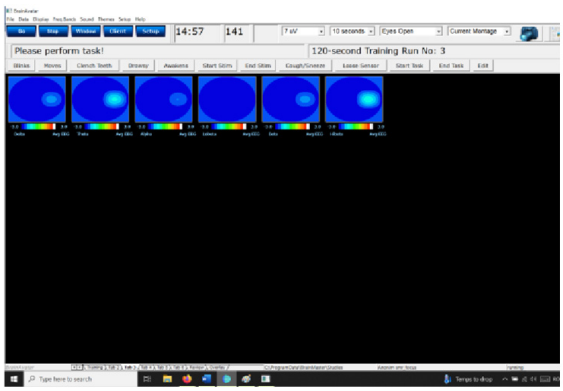
At the beginning of the program the client exhibits accentuations at the Theta and High Beta levels

- We aim on the one hand to: reduce Theta and High Beta
- And on the other hand, let's grow, rewarding: Lo-Beta (SMR)
- Default locations: Cz, or C4
- Applies: with eyes open
- Feedback type: visual and auditory

The SMR neurological circuit is a bottom-up, thalamo-cortical mechanism. It plays a role in reducing somatosensory interference. Motor activity can interfere with information processing, resulting in decreased cognitive performance [8].

Table 1: SMR training Implementation
Practical Aspects

Protocol initiation	Protocol deployment
	
Feedback type	Brain trends
	

Connectivity 3D Brain map	Flat Brain map
	

Frontal Stabilization Training

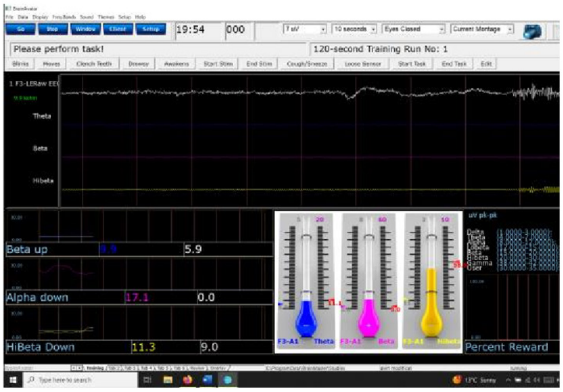
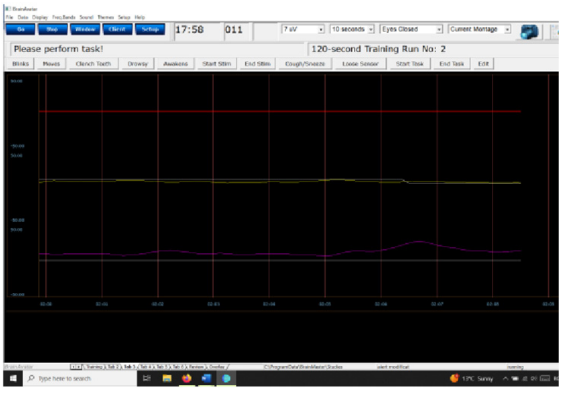
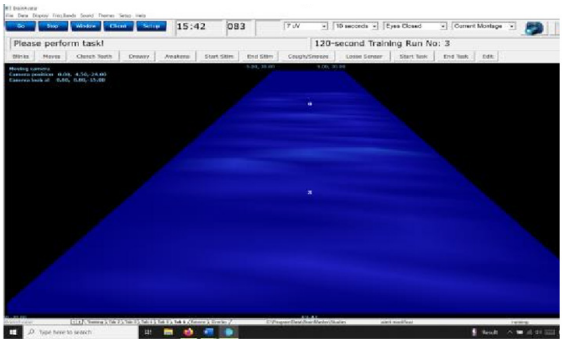
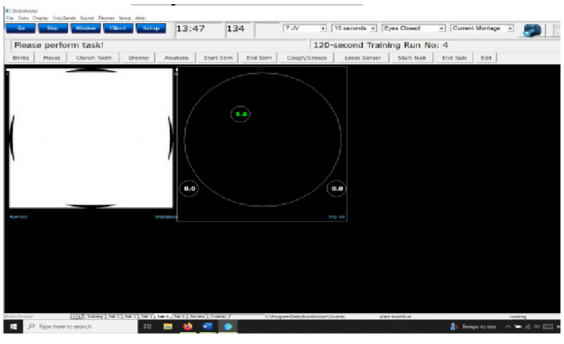
Frontal stabilization training is recommended to reduce anxiety and stabilize moods. It is applied to clients who manifest major depressive disorder, neuropsychiatric pathologies, tics. The Alpha frequency band (8-13), in these cases appears predominantly in the left prefrontal (rather than the right). The condition is also known as alpha asymmetry. We observe both the decrease in alpha frequencies and the stabilization of its values between the two prefrontal regions.

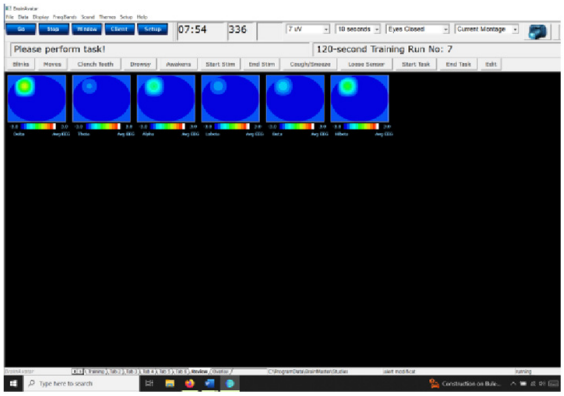
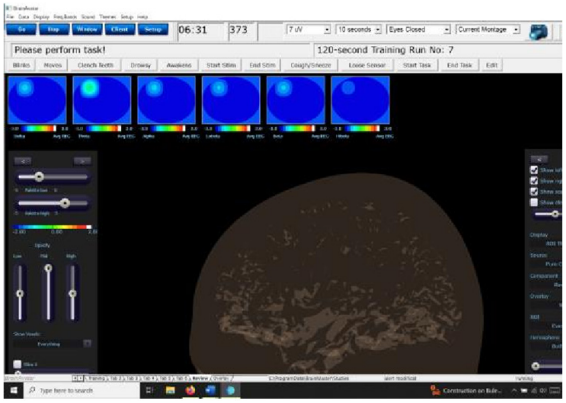
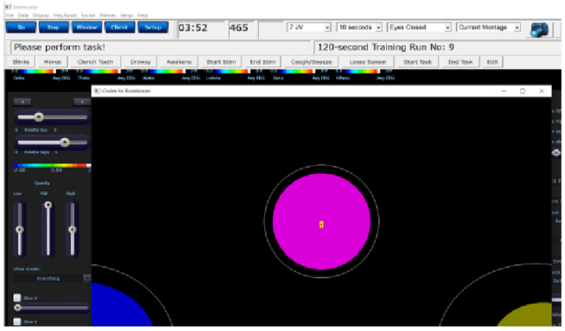
At the beginning of the program the client exhibits accentuations at the Alpha and High Beta levels

- We aim on the one hand to: reduce Alpha and High Beta
- And on the other hand, let's grow, rewarding: Mid-Beta
- Default locations: F3
- Applies: with eyes open
- Feedback type: visual and auditory

The neurological circuitry involved in frontal stabilization is the underlying one. The various components of the front striatal circuits (FSC), such as the thalamus, striatal nuclei, are involved in a variety of cognitive, affective, and motor functions. Similarly, the FSC underlies various pathologies and psychiatric disorders, including major depressive episodes (MDD), post-traumatic stress disorder (PTSD), obsessive-compulsive disorder (OCD), substance use, and schizophrenia. In addition, abnormalities in this circuit have been proposed to contribute to the pathophysiology of many primary movement disorders, such as Huntington's disease (HD), Parkinson's disease (PD), and tic disorders [9].

Table 2: Frontal Stabilization Training Sequence (customized)
Practical aspects

Protocol initiation – customization 3	View trends FREQUENCY
	
Camera using	**Impedance value**
	

Flat Brain map	3D Brain map
	
Feedback Circles	**Feedback Neurogames**
	

Alpha Training

Alpha training is recommended to improve sleep quality and relaxation. It is applied to clients who show excessive involvement, nervousness, stress; but also, to those who want to improve their performance. The alpha frequency band (8-13), which we are targeting, is associated with relaxation and calm.

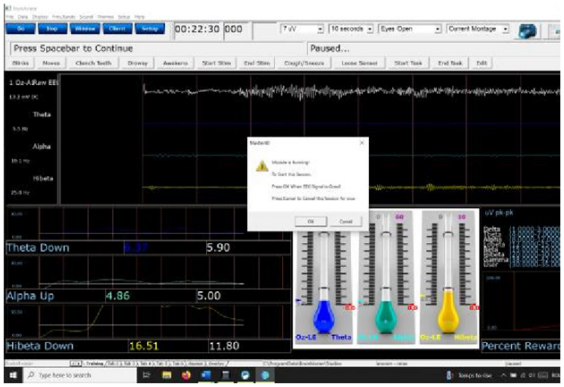
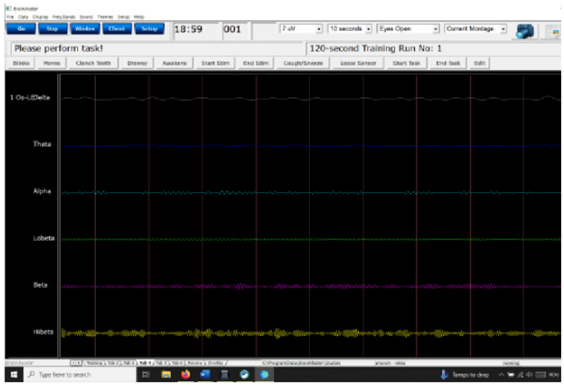
At the beginning of the program the client exhibits accentuations at the Theta and High Beta levels

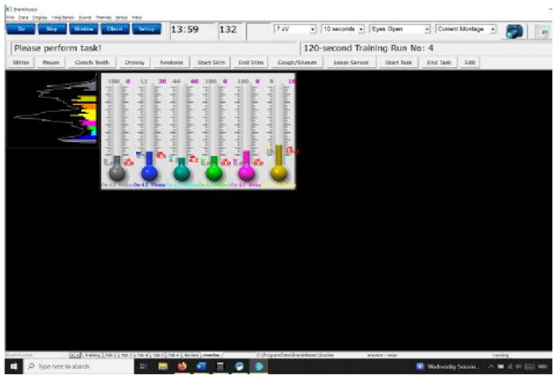
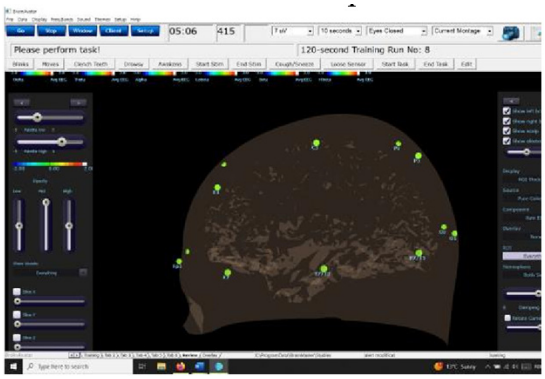
- We aim on the one hand to: reduce Theta and High Beta
- And on the other hand, let's grow, rewarding: Alpha
- Default locations: Pz
- Apply: with eyes closed
- Feedback type: auditory

The alpha neurological circuit involves the ascending mesocephalic-cortical arousal system and the limbic circuits. Both serve both cognitive and affective, or motivational, functions. One description refers to the coupling of the frontal and posterior cortex, working memory being combined with a meditative state. Cognitive activity occurs against a background of emotional calm [10].

Table 3: Alpha Training Schedule

Practical aspects

Training waveforms	protocol initiation
	

Thermometers	Surface Brain map
	

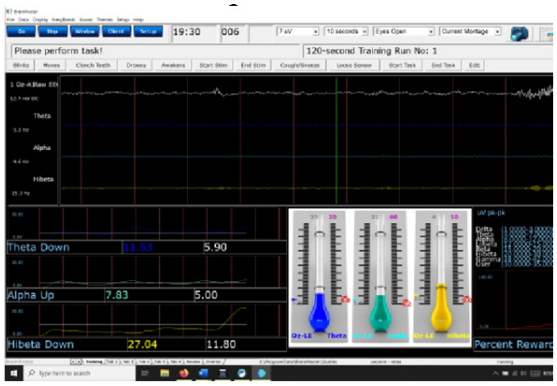
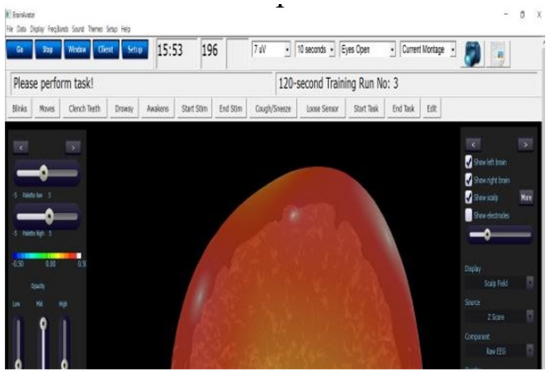
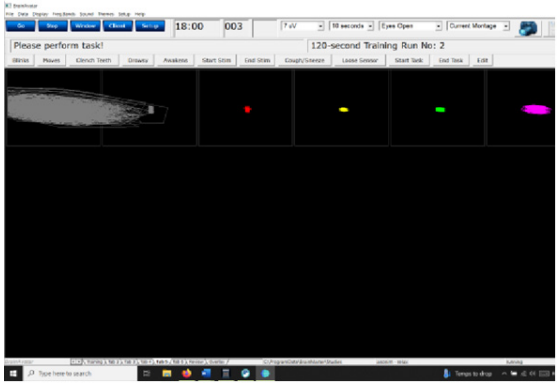
Deep Training - Deep Relaxation (Also Called Alpha -Theta)
Deep training is recommended to reduce stress, apathy, or pain levels. It is applied to clients who exhibit states of agitation, lack of vitality, sleep problems, permanent pain. The Theta frequency band (4-8), induces/is corresponding to states of deep relaxation, being related to hypnotism and REM sleep. It is found in practitioners of meditation techniques. Reaching an optimal level of detachment allows for the awareness of life events without subjectivity, the visualization of subconscious mental images (including about how to achieve future plans) and the emergence of cognitive flows without constraints.

At the beginning of the program the client exhibits accentuations at the High Beta level

- We aim on the one hand to: reduce High Beta
- And on the other hand, let's grow, rewarding: Theta and Alpha
- Default locations: Pz or Oz
- Apply: with eyes closed
- Feedback type: auditory

The Deep neurological circuit involves the parietal-occipital region (especially the Pz and Oz positions, but also O1 and P3), being linked to reduced levels of arousal, those of stimulus reception and a better flow of sleep stages. Also, the Theta band prominent in the frontal midline region (fmh), is associated with attributes such as concentration and creativity. Regarding the synchronization of the two rhythms, numerous studies have established a positive relationship between the synchronization of the Theta band (increased artistic performances) and Alpha (increased cognitive performances, such as working memory, episodic memory and encoding of new information) [11].

Table 4: Deep Training Deployment
Aspects of practice

Initiate protocol	3D head map
	
Phace space	**Wide trends**
	

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