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Case Report

Application of Heg Neurofeedback in a Child with Developmental Dysphasia - A Clinical Case

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Abstract

Developmental dysphasia is a serious problem that affects the child's overall neuropsychological development and has serious consequences for his socialization. The problem is complicated by the fact that the mechanisms by which the dissociation occurs between the delay in the appearance and development of speech in a child with such a pathology and the relative preservation of the remaining mental functions have not been specified. Because of this, there are also multiple theories and concepts that are equally credible. For this reason, the possible types of therapeutic interventions are numerous, based on individual theories. HEG neurofeedback training is a relatively new methodology of bio (neuro)feedback training, which has proven its effectiveness in many pathological conditions - ADHD, ASD, migraine, depression, etc. This case examines the application for the first time of a new methodology, using HEG neurofeedback training, in a child with developmental dysphasia and represents a clinical case description. Work to investigate the mechanism by which this condition is affected continues.

Abbreviations

HEG neurofeedback - Hemoencephalographic neurofeedback
ICD - International classification of the diseases
CNS - Central Neuros System
ADHD - Attention Deficit Hyperactivity Disorder
ASD - Autism Spectrum Disorder

Introduction

Developmental dysphasia represents a serious, but at the same time insufficiently well-explained problem in the child's mental development. This group of disorders includes disorders with difficulties in the understanding or production of speech sounds: rhythm disorders or a state of disturbance of the rhythmicity of speech, a disorder with a persistent deficit in the understanding, production or use of language (spoken or written). All of these disorders develop in early childhood and cause significant limitations in the child's communicative abilities.

There are many definitions of this disorder, but they can be summarized as: systemic underdevelopment of speech activity, which occurs with normal function of the sensory apparatus and relatively adequately developed intellectual abilities. This violation is expressed through language violations. It is mainly caused by organic damage or functional underdevelopment of the areas of the brain that regulate and organize speech activity, and the disorder manifests itself up to the stage of speech formation.

Some authors propose the term "systemic underdevelopment of speech", but this definition has a more symptomatological character.

The latest revision of ICD-11 changes the designation of developmental dysphasia as a disorder in the development of speech or language (section 6A01).

Prevalence of the disorder: There are still no precisely established data on the prevalence of this pathological condition worldwide. Unfortunately, there is no data for Bulgaria either. The disorder is believed to occur in 0.1% of the population. Some statistical studies show that the violation occurs in about 1% of children of preschool age, and in school-age children - on average in about 0.4%. It is emphasized that the disorder occurs more often in boys.

Causes of the disorder: As we indicated in the definition, the causes of this disorder can be organic or functional disorders of the Central Nervous System. Depending on the time of occurrence of the damage, it can appear in the prenatal, perinatal or postnatal period. At the same time, prenatal and perinatal injuries are mainly organic in nature, and functional injuries are mainly manifested in the postnatal period of development.

The mechanism of the disorder is perhaps the most debatable. As with other pathological conditions with unclear pathogenesis, several theories and concepts exist here. They can be conditionally divided into sensorimotor, psychological and linguistic.

Sensorimotor and language theories explain the occurrence of the disorder primarily with organic lesions in the central nervous system.

Psychological concepts are based on pathology in some of the mental functions and activity.

It is necessary to emphasize that in children with this disorder, motor and disorders along the entire cortico-bulbar tract, as well as myogenic diseases of the speech musculature, are not found.

Existing methods for correction of the disorder: Dysphasia of language-speech development is a complex medical-psychological-pedagogical problem. For this reason, the complex approach is aimed at establishing all functions of speech, taking into account the regularities in the development of the speech function in ontogenesis, as well as the regularities in the construction of the relevant language system.

The theoretical statements of the complex approach consist in the creation of a mechanism of speech activity, which includes the formation of a motive, an idea for the realization of this motive through a speech message, the construction of an internal program for speech production, the selection of grammatical means (words) and the structuring of sentence.

At the same time, standardization of the methods used for speech development cannot be allowed, due to the very specifics of speech underdevelopment, as well as the individual characteristics of the personality development of each child.

Materials and Methods

In the specific case for the application of HEG neurofeedback, a 4-year-old female child is considered, which falls into the category 6A01.21 Disorder in the development of language with a violation primarily of the expressive form.

Results

Given the fact that in ASD, HEG improved expressive speech in some of the children studied, it was decided to use this methodology also in a child with developmental dysphasia and disorder in the development of expressive speech.

The sessions were held twice a week, with the duration of each session being 30 min.

In this case under consideration, it is probably a special form of developmental dysphasia. This is observed in the violation of complex motives. Such a violation inevitably affects both the child's behavior and his speech activity.

Due to dysfunction of the prefrontal cortex, the child experiences difficulties in forming the reasons for the occurrence of the speech message. In this way, the impossibility to form an initial intention, as well as to activate a sustainable program to be transmitted for implementation from Broca's area, is established.

In sharp contrast to this, there is preservation of the operational side of speech. This explains the paradox that the child has all the lexical and grammatical possibilities, including to understand speech, but remains practically deprived of developed speech activity.

We should note that connections between the prefrontal cortex and Broca's area are preserved, according to neurofunctional studies.

With the child, the work began with the application of HEG neurofeedback training with a frequency of twice a week. Initially, the pIR sensor was used, and at the fourth month it was changed to nIR.

After 10-12 sessions, a gradual improvement in the child's emotional state began. He became calmer, came in willing to work and gradually reduced his dependence on contact with the mother.

Around the third month after the start of the training, a significant improvement was found in the child's motivation to establish contact with an adult, starting to better use short syllables and simpler words. Usually, the child's speech accompanied a specific action, and the word used corresponded to the action. By the end of the third month, the child began to use simple sentences, usually consisting of two words. Then the decision was made to replace the sensors and join a speech therapist for additional work on speech development.

Eight months after the start of training, the child showed sufficiently well-developed expressive speech, despite the fact that it continued to be agrammatic. The child uses a rich active vocabulary and actively communicates with peers and adults. The HEG neurofeedback training was discontinued and work continued only with a speech therapist.

Discussions

Neurofeedback is a method of changing the biological activity of the brain through positive or negative feedback. The standard neurofeedback methodology is based on the study of brain waves. Based on the property of neuroplasticity, the trainee seeks to manage changes in his bioelectrical activity by observing or listening to changes in the device and thus achieves conscious control over a function that was initially controlled at a subconscious level. Biofeedback technologies are increasingly entering the modern practice of psychologists, as well as specialists from other fields. They are used as an alternative method for therapeutically influencing many diseases and pathological conditions, mainly neurological, but also mental and psychosomatic.

The technologies of biofeedback, or biological feedback loop, are entering more and more nowadays and are used as an alternative method for therapeutically affecting many diseases and pathological conditions, mainly neurological, mental and psychosomatic [1-3].

E. Green and A. Green in the book "Biofeedback and Volition" give definitions about the basic principle and the first concept on which biofeedback training is based, namely "... Every change in the physiological state is accompanied by an appropriate change in the mental-emotional state, conscious or unconscious, and conversely, every change in the mental-emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state" [4].

The so-called "closed" principle enables the realization of the idea of psychosomatic self-regulation, but also by changing the will of the person or achieving conscious self-regulation.

The second concept embedded in the basic principles of biofeedback training is the concept of brain plasticity. Brain plasticity is a term that describes the ability of the brain, when in the absence of structural changes in its tissue, to pass into a relatively susceptible and adaptive state to external factors. This applies especially to its bioelectrical activity, but also to its physiological and metabolic activities. This concept is like a connecting link to the third, general, but characteristic not only for biofeedback training concept, that quantitative accumulations lead to qualitative changes.

Relying on Pavlov's principle of conditioned reflex activity, the application of systemic biofeedback sessions aims to move from subconscious regulation of action or function to conscious or volitional control. This is the fourth principle of biofeedback.

Based on the fact that the human brain is highly adaptable, and in a very specific way, by changing its functions, by different types and nature of stimuli from the environment, this feature of it can be triggered by the use of a brain-computer interface. By changing the stimuli and sensory modalities, the aim is to change the individual functions of the brain, as well as its ability to switch, block or unblock the activity of certain areas, and accordingly to change its functional and regulatory abilities, respectively movement, action, behavior and emotional states.

The modern development for monitoring brain activity is called hemoencephalography. This method allows to follow the changes in the biological activity of the brain in a different way.

When performing a certain activity, for example mental or movement control, certain brain areas are used directly and much more actively than others that are not directly associated with that type of activity. This suggests, and has been proven indisputably, that these activated areas will have a faster metabolism and, accordingly, a higher metabolic ratio than the rest of the cerebral cortex, which is not engaged in the performance of the activity.

The human brains, and correspondingly the cerebral cortex, have extremely high metabolic activity. Despite the fact that the weight of the brain is only 2% of the total weight of the individual concerned, the brain itself consumes about 20% of the body's total oxygen consumption and about 25% of the total glucose consumption. For this reason, the brain as an organ, and the cerebral cortex as a part of this organ, has an extremely rich network of blood flow in the activated brain areas.

In the normal operation of the blood vessel mechanism, the metabolic ratio or metabolic index can be measured and this can serve as a basis for creating a new biofeedback model.

At the heart of a change in the brain's metabolic activity is a phenomenon called neurovascular coupling. This phenomenon is inherent only to the brain, and its mechanism is a function of the correspondence of the metabolic requirements of the brain and cerebral cortex and changes in the volume of neurovascular coupling in the zones or areas with increased neuronal activity (for example, during mental activity, an increase in blood flow will be observed).

The consequence of this increased blood flow is the delivery of blood with a higher oxygen and glucose content to the activated areas in the cerebral cortex. This whole process and its regulation is carried out by astrocytes. Neurovascular coupling is known to be a process that is highly dependent on the factors that define and regulate its individual components. Such factors are e.g. physiological state of the cerebral cortex, resp. the neurons that make it up; the metabolic activity of these neurons; the state of the blood vessels in these brain areas; the excess or deficiency of neurotransmitters; the state of interneuronal connections, etc.

Characteristics of the methodology. HEG is a relatively new modality in neurofeedback techniques. So far, the technique is considered to have proven its effectiveness in relatively few pathological conditions: ADHD, depressive disorder and migraine [5-8]. In 2013-2016, the author conducted a study on the effect of HEG in children with ASD, which showed promising results [9], and an attempt was made to describe the psychophysiological and neuropsychological mechanism of action in such a disorder.

The prefrontal cortex produces signals that "tune" much of the rest of the cerebral cortex: these "commands" from the prefrontal cortex affect the processing not only of incoming visual and auditory inputs, but are also responsible for the planning, control, and execution of individual movements. Other signals from the prefrontal cortex assist in the retrieval and processing of memory traces, evaluation of emotions, etc. This is accomplished through direct and indirect anatomical connections in the form of interneuron pathways. The net effect of the action of these "tuning" signals is to direct the flow of neural activity from the prefrontal cortex to other areas of the cerebral cortex. As a final effect is the achievement of coordination between the incoming impulses, the internal state and the output signal, which is necessary to perform the specified action.

Through the theory of the integration of functions, the basic principle for the operation of HEG neurofeedback, which works successfully in many pathological conditions, can also be explained.

The final effect is an improvement in the work of the prefrontal cortex, the dysfunction of which underlies these pathological conditions.

The author in the book "Hemoecephalographic neurofeedback. Neuropsychological Mechanisms and Action "[9] attempts to determine the pattern of operation of this methodology in children with ASD. It can be summarized that "Multiple repetition of HEG neurotraining sessions should help build a cognitive map of how the child learns to manage (and voluntarily regulate) brain activity in its frontal lobes." The correct regulation of this activity should also lead to the correct course of a large part of the processes (physiological,

cognitive, and regulatory) that are characteristic of these brain lobes... In this way, direct and indirect stimulation of a large part of the brain is obtained cortex, while also supporting the strengthening of the broken connections between the frontal lobes and the other lobes of the cerebral cortex (temporal, occipital, insula) located further back.

Clinical Case Description

The child was born from a second, normal pregnancy. The birth was pathological, with a prolonged phase and the child was born with asphyxia. Active neonatal care improves the general somatic and neurological condition.

Mental development until the first year proceeds without significant deviations. By the end of the first year, the child begins to use a few relatively simple words.

According to the parents, after this age the child shows relatively large differences in the understanding and use of speech. By the age of three, parents report a good understanding of words in human speech, knows the names of most household objects, executes orders and even some complex instructions.

Expressive speech, however, remains at a relatively low level of development. Uses only simple syllables to denote an object or action. He helps himself often as he indicates the subject in which he shows interest.

Due to the existing difficulties in communication with peers and adults, emotional disorders are increasing in the child. Began to react with crying to every unsuccessful attempt to communicate, sometimes even with elements of aggression towards objects or self-aggression.

The initial psychological examination took place when the child was 4.5 years old. The child is very attached to his mother, it is difficult for him to perceive a new environment. At the slightest failure in communication with him, he reacts with violent crying and seeking contact with the mother. Impressive speech examination was hampered by emotional state, but nevertheless showed good knowledge of object names and comprehension of verbal instructions.

Examination of intelligence by means of a non-verbal test showed normal values for age. The examination of the neurological status shows normality, ophthalmological and ENT - examination-normal.

An EEG study and brain mapping were performed, which showed age-delayed maturation of the frontal lobes bilaterally without the presence of pathological dominants.

With the available data, the parents were offered to work with the child using HEG neurofeedback training, assuming that activation of the frontal lobes would improve the performance of the speech production mechanism.

Given the fact that in ASD, HEG improved expressive speech in some of the children studied, it was decided to use this methodology also in a child with developmental dysphasia and disorder in the development of expressive speech.

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Conclusions

The clinical case description does not claim to be exhaustive. Work continues to investigate the mechanism of action of HEG in such a pathology and to establish the effectiveness of its application.

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Conflicts of Interests

We declare that we have no conflicts of interest.

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