Specijalna edukacija i rehabilitacija (Beograd), Vol. 14, br. 4. 441-458, 2015.

UDK: 616.89-008.43-073-053.2
612.81-053.2
Originalni naučni rad
doi: 10.5937/specedreh14-8622

THE CHANGES IN RELATION OF AUDITORY AND VISUAL INPUT ACTIVITY BETWEEN HEMISPHERES ANALIZED IN CARTOGRAPHIC EEG IN A CHILD WITH HYPERACTIVITY SYNDROME[1]

Zoran RADIČEVIĆ[*,**], Ljiljana JELIČIĆ[*,**]
Ivana BOGAVAC[*,**,2], Miodrag STOKIĆ[*,**]
Mirjana SOVILJ[*,**], Miško SUBOTIĆ[**]
[*]*Institute for Experimental Phonetic and Speech Pathology, Belgrade*
[**]*Life Activities Advancement Center, Belgrade*

The paper discusses the changes in relations of visual and auditory inputs between the hemispheres in a child with hyperactive syndrome and its effects which may lead to better attention engagement in auditory and visual information analysis. The method included the use of cartographic EEG and clinical procedure in a 10-year-old boy with hyperactive syndrome and attention deficit disorder, who has theta dysfunction manifested in standard EEG. Cartographic EEG patterns was performed on NihonKohden Corporation, EEG – 1200K Neurofax apparatus in longitudinal bipolar electrode assembly schedule by utilizing10/20 International electrode positioning. Impedance was maintained below 5 kΩ, with not more than 1 kΩ differences between the electrodes. Lower filter was set at 0.53 Hz and higher filter at 35 Hz. Recording was performed in a quiet period and during stimulation procedures that include speech and language basis.

1 This paper is the result of the projects Interdisciplinary research on verbal communication quality and E- Speech Therapist, OI178027 and TR32032, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

2 E-mail: ivbogavac@gmail.com

Standard EEG and Neurofeedback (NFB) treatment indicated higher theta load, alpha 2 and beta 1 activity measured in the cartographic EEG which was done after the relative failure of NFB treatment. After this, the NFB treatment was applied which lasted for six months, in a way that when the boy was reading, the visual input was enhanced to the left hemisphere and auditory input was reduced to the right hemisphere. Repeated EEG mapping analysis showed that there was a significant improvement, both in EEG findings as well as in attention, behavioural and learning disorders. The paper discusses some aspects of learning, attention and behaviour in relation to changes in the standard EEG, especially in cartographic EEG and NFB findings.

Key words: *cartographic EEG, attention disorder, auditory and visual information processing, Neurofeedback treatment*

INTRODUCTION

Speech and language system, which is distributed on wide brain regions, starting from regions of mind activity, through transferring network to executive speech organs, activates despite this long journey which is the connection of different structures that are engaged in reception and execution. Many scientific disciplines, as quantum physics and, contemporary cognitive psychology, are engaged in the examination of speech-language functioning (Nenadović et al., 2014; Radičević & Dobrijević, 2009a). We tried to investigate which part of the materialised thought lies in word origin and presents the source of information by examining the brain rhythms which are biological markers in brain tissue during initial information processing. We considered that this approach in speech-language processing examination may have huge theoretical, practical, diagnostics and therapeutic importance.

EEG is accepted as an operative technique with a few possibilities of examination (powers mapping, amplitudes, coherence, comodulation etc.) (Martinović, 2009; Nuwer, 1999). That is why we decided to use it in examination of speech and language processing in children during developmental period, and in children with speech-language disorders. We were aware

of the fact that our researches go on without clear signposts, so we entered into this field step by step. We upgraded our recent researches about brain rhythms during speech-language information processing by cognizing the structure of functional systems in a few aspects of their EEG representations, which proved we were going the right way (Radičević et al., 2008a; Radičević et al., 2008b; Radičević et al., 2009b; Radičević et al., 2009c, Stokić et al., 2015; Stokić et al., 2011).

Neurofeedback (NFB) procedures have already been in use for more than two decades. NFB can be defined as an operant conditioning procedure in which participants learn to achieve self-control over EEG patterns (Heinrich et al., 2007). This is achieved by converting those electrophysiological data (EEG) into acoustic or/and visual stimuli which are then continuously present on the computer screen providing feedback to the participant. Changes that are made in the desired direction are reinforced. NFB is usually run as a computer game and that is why it is generally attractive for children.

Many psychiatric disorders are associated with malfunctioning of the brain measured by EEG powers and coherence (connectivity) (Huster et al., 2014). Consequently, a procedure targeting the self-regularized normalization of brain function is beneficial as complementary to pharmaceutical treatment. Some of the studies try to examine the efficacy of NFB trainings as additional tool for the treatment of epilepsy (Sterman & Egner, 2006), substance use disorder (Sokhadze et al., 2008), affective disorders (Hammond, 2005), tinnitus (Dohrmann et al., 2007), or pain (Jensen et al., 2008). However, most of the studies explored NFB trainings in persons with ADHD. Arns et al. (2009) conducted a meta-analysis of 15 studies and concluded that EEG NFB for ADHD can be considered "efficacious and specific". These authors found medium to large effect of NFB training in assessment results regarding measures of impulsivity, hyperactivity, and attention deficits. It is increasingly studied as a treatment option in children with ADHD with promising results in some studies (Gevensleben et al., 2009; Strehl et al., 2006; Drechsler et al., 2007). Lofthouse

et al. (2012) also obtained medium to large treatment effects. The authors recommended that specificity of effects should be rigorously controlled using double-blind studies.

It is important to note that the application of NFB for basic experimental research on cognition is not extensively documented in the literature reviewed. Neurofeedback procedures have been successfully used to alter participants' alpha or gamma activity and thereby increase cognitive capabilities in mental rotation and memory (Hanslmayr et al., 2005; Keizer et al., 2010; Zoefel et al., 2011) or visual detection (Salari et al., 2012). It has also been shown that these learning mechanisms can induce long lasting changes in EEG activity (Gani et al., 2008) as well as network connectivity (Ros et al., 2013).

Our recent work in treatment of the behaviour disorders and learning disorders using Neurofeedback (NFB – a self-regulation method by normalizing brain rhythms amplitude and distribution over cortical regions using visual and auditory feedback) with previous cartographic EEG mapping assessment showed that early school children with Theta dysfunction in standard and cartographic EEG mapping have lower results in NFB treatment and in clinical manifestations when compared to the children with the same disorder but without Theta dysfunction (they have only Theta load mostly over frontal cortical regions which is unusual for children of that age). That is why, during NFB treatment as well as during learning at home, we applied redirecting of visual and auditory information in children with Theta dysfunction who also have dyslateralisation of hand, ear, and eye (not the same lateralisation of those functions). Redirection of auditory and visual information processing was applied by enhancement or inhibition of auditory and visual input of the information in specific brain hemisphere (left or right, contra lateral to the eye or ear – auditory and visual information processing is done in contra lateral brain hemisphere when compared to the eye or ear that is receiving the information).

Method

The aim of this study was to examine the effects of visual and auditory information redirection in a right-handed child with a preference for receiving visual information in the right eye and the auditory information in the left ear. In this sense, we have shown that longer treatment with the use of redirection of visual information in the left hemisphere, while reducing the reception of auditory information in the right hemisphere, leads to a significant improvement in the progression in NFB treatment, as well as the findings of EEG mapping (in a situation without the use of the redirection, and even more with its use).

In this study, we estimated the new experimental protocol based on visual and auditory information redirecting in NFB treatment applied on a child with *Attention-Deficit/Hyperactivity Disorder (ADHD)*. Neurofeedback treatment has been widely used in children with ADHD, but it should be noticed that this study does not examine the effects of NFB treatment or EEG correlations in these children. The study shows the relevant effects of new method used as experimental protocol in a boy with ADHD. The method itself is the novelty and is applied in one child with ADHD who was an adequate representative of children with this diagnosis, in order to determine whether information redirection has any influence on the success of NFB treatment. In this way, the obtained results may be the basis for further research in the field of visual and auditory information redirection on a larger sample of children with ADHD, with the aim to improve the effects of NFB treatment.

A boy aged 10 was undergoing the NFB treatment in the period from 2011 to mid-2013, because of Attention-Deficit/Hyperactivity Disorder (ADHD). The boy was diagnosed with ADHD by a mental health professional – psychiatrist, according to DSM-IV. He has average cognitive capacity (assessed using WB scale). The lateralization was assessed using The Edinburgh inventory (Oldfield, 1971). The

estimation of lateralization has shown that the examined boy is right-handed with a predominance of the right eye and the left ear. During the one-year period (2011-2012) the boy did not show significant improvement in terms of parameter estimated using NFB (useful average time theta / beta (T / B), theta / beta ratio, average theta power, average SMR, beta, alpha 1, alpha 2, and total alpha expressed in microvolt). NFB treatment is performed on the device Thought Technology ProComp, while the EEG mapping was performed on the device Neurofax NihonKohden with standard electrode arrangement using 10/20 International electrode positioning in the bipolar longitudinal montage. The EEG signal recording was performed at resting state and during stimulation procedures which included listening to fables, retelling of the fable itself, viewing picture story and retelling the picture story silently, silent reading of the story and retelling the story silently. This research was conducted in comfortable conditions in a sitting position and without parental presence.

EEG indicated the existence of theta dysfunction which was maximally expressed over central and frontal regions, and partly in parietal region, with the morphological change of theta waves during the recording of resting state with eyes closed emerging in doublets, triplets or short bursts, which were also present during the recording of EEG with eyes open, making significant dysrhythmic form of the raw EEG trace. The slow alpha activity increased in amplitude and sharpened, and was the dominant activity.

NFB treatment consisted of 2 to 3 treatments per week which lasted for 1 hour, when NFB programs were applied for: 1) reducing high theta activity predominantly in the C3-F3 region or Cz-C3 region, 2) occasionally increasing low alpha activity (8-10 Hz) or raising high alpha activity (10-12 Hz) over the same left hemisphere regions, 3) and in certain situations (as control), raising the sensory-motor rhythm (SMR) (13-15 Hz) of the right (Cz, C4) regions.

After one-year treatment, EEG mapping was performed with a control test because of absent significant advancement in NFB treatment, which was done in order to reduce the theta rhythm amplitude, regulate normal relations of the low and high alpha and beta ratio as well as the SMR rhythm.

After one-year, the treatment was continued over the next 8 months in the following year (2013) and was performed with and without the use of auditory and visual information redirection. Redirecting visual information to the left hemisphere of the child was done by blanking the right lateral half of the field glasses for the right eye and the nasal half of the left eye glasses, while the lateral half of the left eye glasses and nasal half of the right remained illuminated, both during the NFB sessions and at home during the reading. In reading and listening, during the NFB treatment and at home, as well as in normal conversation at home, a partial blockage of auditory input was done by rubber ear-plug in the left ear. This means that the child used a system for redirecting visual and auditory information on NFB sessions and daily at home with school materials while reading aloud, discussion and writing for 8 months (2-3 times per a week).

Samples of EEG trace in the duration of 10 seconds without artefacts were taken from the middle part of resting state and activation procedures, for obtaining cartographic maps in the delta (2-4 Hz), theta (4-8 Hz), alpha 1 (8-10 Hz), alpha 2 (10-12 Hz), beta 1 (15-20) and beta 2 (20-34 Hz) rhythm expressed in microvolt.

EEG recording was done in the years 2012 and 2013 in the same laboratory, on the same apparatus, with the same team of researchers, and without parental presence.

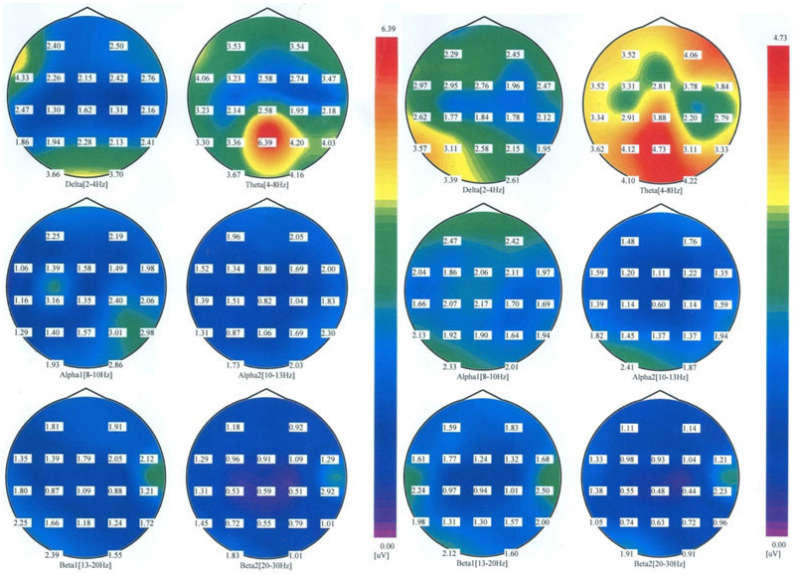
The study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki. The participant's parents gave their written consent prior to the experimental procedure.

RESULTS

Comparison of the findings of the standard EEG (2012/2013) showed slight to moderate decrease of the dysmorphic theta activity localized mainly in the central and central-frontal, and less in the parietal regions, while recording with the eyes closed, and a noticeable reduction of dysfunction when recording with the eyes open. EEG mapping (analysis of the brain rhythms amplitude over brain regions) done for the first time system for information redirection had not previously been used after the application of NFB treatment, showed the high value of theta rhythm amplitude in the central and central-parietal and frontal regions, with the right-hemisphere predominance, both during resting state and stimulation procedures. Also, there was a significant increase in low alpha activity in the left central regions during listening, as well as during resting state, while high alpha activity was significantly reduced not only at rest but also during all these procedures. Beta 1 activity was significantly present in reading (Picture 1) and viewing images (Picture 2) in the left frontal regions.

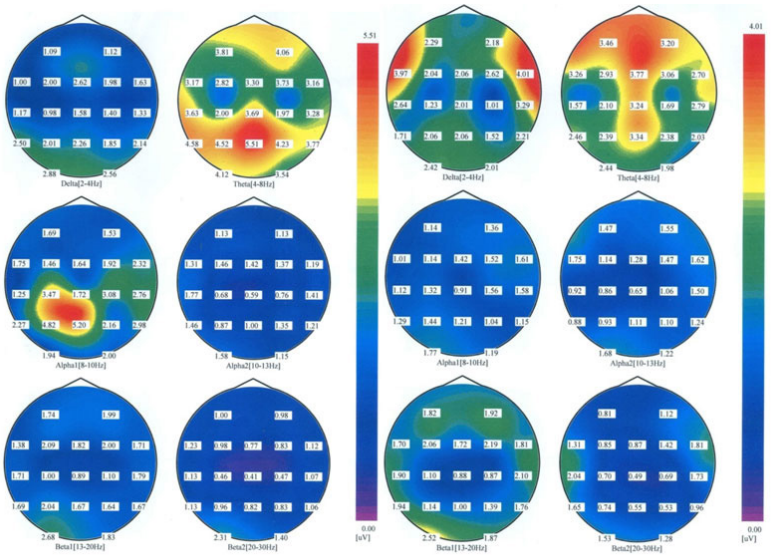
After one-year treatment, the EEG signal was recorded and it included: 1) cartographic representation of EEG recording without using the information redirection, and 2) EEG recording with the information redirection.

Analysis of the EEG signal without information redirection showed that the information redirection on the NFB treatment and in home conditions for a period of 8 months, has led to important changes: reducing the maximum average values of theta activity in the resting state and during stimulation procedures by about 27%.



Picture 1 – Silent reading without (left) and with visual information redirection input (right)

More significantly, there was an absolute suppression of the maximum values of theta activity in the posterior parietal-central regions, while the central and frontal regions were without increased theta load. With the reduction of theta activity, a slight increase in alpha 1 activity was registered as well as the first appearance of alpha 2 activities, particularly in reading (Picture 1) and listening (Picture 3). Beta 1 activity showed signs of maintenance in the frontal regions, as was the case in previous recordings.

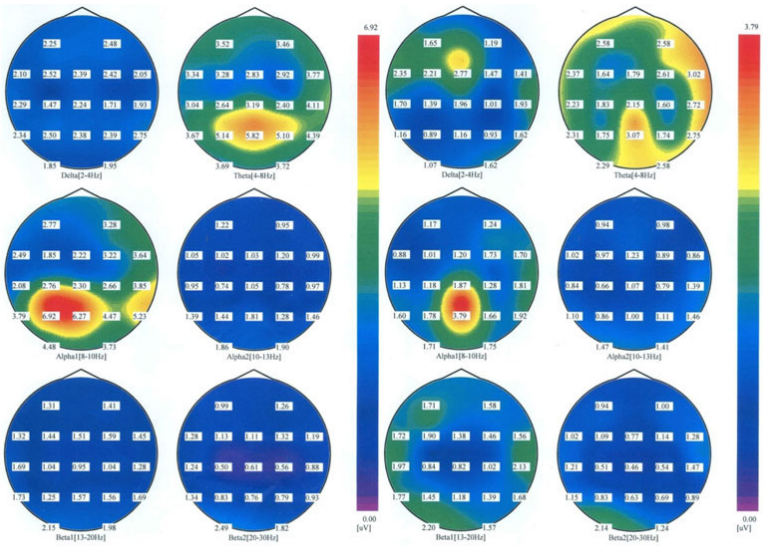


Picture 2 – Watching a picture story without (left) and with visual information redirection input (right)

Analysis of the EEG recording, during which visual information was redirected while watching a picture story (Picture 2), showed a markedly reduced theta activity in relation to the recording without redirection, as well as an increased high alpha activity localized dextral, and more significantly activated beta 1 activity in the frontal and left front, middle and posterior temporal regions.

When listening (Picture 3) with the use of the "ototip" – an ear-plug (redirecting auditory information) the reduction of theta activity is even more present, which was moved almost exclusively to the right hemisphere, with expressed alpha 2 activities and especially beta 1 activity in the left hemisphere. In silent reading with glasses and reading aloud with glasses, decreased theta activity is markedly suppressed in the parietal-occipital region, alpha 2 activity is present predominantly in the left regions (frontal, not just temporal-occipital) and beta 1 activity in both left and right temporal regions.

Results of the NFB treatment before applying redirection of auditory and visual information compared with the results after applying the information redirection, showed that progress was been made in all analyzed parameters: a) the average useful time, theta / beta ratio from 35.40% to 47.80%, b) average theta / beta ratio (from 5:15 to 4.65 μV), c) the average theta power (from 19.70 to 14.60μV), d) average SMR (from 5.90 to 6.28 μV), e) average beta (from 4.82 to 5:15 μV), f), the average alpha 1 (from 11:12 to 8.80 μV), g) and alpha 2 (from 6:20 to 6:28 μV), and h) the total alpha activity (from 11:20 to 10:54 μV).



Picture 3 – Listening to a story without (left) and with auditory information redirection input (right)

DISCUSSION

In the appropriate literature (Sauseng et al., 2005; Thatcher et al., 2007; Thompson, 2003; Weiss, 2003), we could find no experimental nor clinical approach or theoretical consideration regarding redirecting auditory and visual information input and how it reflects the state and the relations of brain rhythms

which are important for directing attention and the procedural – conscious memory. This memory is important for the information processing and decision-making, it is one of the key aspects of learning, and it is decreased in children with the syndrome of attention deficit and hyperactivity (Nenadović et al., 2011; Sauseng et al., 2005).

Application of the "ototip" for partial blocking of auditory input to the right hemisphere (left ear preference in our patient) was, in our opinion, based on theoretical and practical evidence (Radičević et al., 2009a) that the right hemisphere is the most common cause of excessive interest in new stimuli and that it is excitable during the rapid transition from one stimulus to another, hindering the development of information processing and memory more than the left hemisphere does. This disturbance of the right hemisphere is the reason for the difficulty in learning and development of the central motor inhibition – establishing the necessary resting state of the whole motor system when receiving and processing information.

The visual information redirection is also dictated not only because of the right eye preference in our patient, but also because of the fact that reading difficulties often arise from interference of information in the secondary visual regions of the left hemisphere.

From this point of view, given that the standard NFB treatment, despite the duration of approximately one year, did not improve the NFB results and the results of the clinical examination of the child, we were free to conduct such an experiment with information redirection. We believe that we have opened the way for further improvement in the use of not only the NFB, but also learning the curriculum at home. The redirection system is not applied in a child at school because of a possible unpleasant social response in other children when using the glasses and "ototip" – ear plug.

The increase in alpha 1 activity in using the information redirection goes along with the emergence of alpha 2 activity, which certainly reduces the effect. However, the NFB results in the training of 8 minutes show that the effect on the total alpha activity is beneficial because it typically reduces total alpha amplitude during intense stimulation of watching, listening and speaking.

The increase in beta rhythm of 15-20 Hz, which implies reasoning, analysis, and decision making (especially when it is in the left hemisphere and localized in the frontal, and not only in the temporal and visual regions) confirms our assumption that leads us to prove the purpose of the study.

The increase in alpha 2 activity indicates an increase in the open state of consciousness in which the child is not only consciously present during stimuli processing but also during memorisation, with simultaneously processing the space and time, which is of particular importance for the regulation of the attention deficit and hyperactivity syndrome.

Our experiment, which is a pilot study, showed that in children with attention deficit and hyperactivity, such treatment even though long-lasting, can lead to an improvement in behaviour, reducing hyperactivity and improving the development of conscious processing during learning. Reduction of hyperactivity, absence of standing up and walking around the room, not disturbing others in class, faster copying assignments from the board, and pronouncedly less need for assistance in the preparation of assignments at home were present in the boy who participated in our study.

CONCLUSION

Redirecting or blocking the information input on a specific hemisphere in children with hyperactive syndrome, and in children who have theta dysfunction in the standard EEG, opens the way for better engagement of focused attention and learning, as well as better use of the NFB training program.

REFERENCES

Arns, M., de Ridder, S., Strehl, U., Breteler, M., & Coenen, A. (2009). Efficacy of neurofeedback treatment in ADHD: the effects on inattention, impulsivity and hyperactivity: a meta-analysis. *Clinical EEG and Neuroscience*, *40*, 180-189.

Dohrmann, K., Weisz, N., Schlee, W., Hartmann, T., & Elbert, T. (2007). Neurofeedback for treating tinnitus. *Progress in Brain Research, 166*, 473-485.

Drechsler, R., Straub, M., Doehnert, M., Heinrich, H., Steinhausen, H. C., & Brandeis, D. (2007). Controlled evaluation of a neurofeedback training of slow cortical potentials in children with Attention Deficit/Hyperactivity Disorder (ADHD). *Behavioral Brain Function*, *3*, 35.

Gani, C., Birbaumer, N., & Strehl, U. (2008). Long term effects after feedback of slow cortical potentials and of theta–beta-amplitudes in children with attention deficit/hyperactivity disorder (ADHD). *International Journal of Bioelectromagnetism*, *10*, 209-232.

Gevensleben, H., Holl, B., Albrecht, B., Schlamp, D., Kratz, O., Studer, P., et al (2009). Distinct EEG effects related to neurofeedback training in children with ADHD: A randomized controlled trial. *International Journal of Psychophysiology*, *74*, 149-157.

Hammond, D. C. (2005). Neurofeedback with anxiety and affective disorders. *Child and adolescent psychiatric clinics of North America*, *14*, 105-123.

Hanslmayr, S., Sauseng, P., Doppelmayr, M., Schabus, M., & Klimesch, W. (2005). Increasing individual upper alpha power by neurofeedback improves cognitive performance in human subjects. *Applied Psychophysiology and Biofeedback*, 30, 1-10.

Heinrich, H., Gevensleben, H., & Strehl, U. (2007). Annotation: neurofeedback — train your brain to train behavior. *Journal of Child Psychology and Psychiatry*, *48*, 3-16.

Huster, R. J., Mokom, Z. N., Enriquez-Geppert, S. & Herrmann, C. S. (2014). Brain–computer interfaces for EEG neurofeedback: Peculiarities and solutions, *International Journal of Psychophysiology*, *91*, 36-45.

Jensen, M. P., Hakimian, S., Sherlin, L.H., & Fregni, F. (2008). New insights into neuromodulatory approaches for the treatment of pain. *Journal of Pain*, *9*, 193-199.

Keizer, A. W., Verment, R. S., & Hommel, B. (2010). Enhancing cognitive control through neurofeedback: a role of gamma-band activity in managing episodic retrieval. *NeuroImage*, *49*, 3404-3413.

Lofthouse, N., Arnold, L. E., & Hurt, E. (2012). Current status of neurofeedback for attention deficit/hyperactivity disorder. *Current Psychiatry Report*, *14*, 536-542.

Martinović, Ž. (2009). *Klinička elektroencefalografija*. Beograd: Naučna KMD.

Nenadović, V., Đoković, S., & Pečenica, D. (2011). Developmental changes in auditory attention. *Specijalna edukacija i rehabilitacija*, *10*(1), 77-92.

Nenadović, V., Stokić, M., Vuković, M., Đoković, S., & Subotić, M. (2014). Cognitive and electrophysiological characteristics of children with specific language impairment and subclinical epileptic form electroencephalogram. *Journal of Clinical and Experimental Neuropsychology*, *36*(9), 981-991.

Nuwer, M. R., Lehmann, D., da Silva, F. L., Matsuoka, S., Sutherling, W., & Vibet, J. F. (1999). IFCN guidelines for topographic and frequency analysis of EEGs and EPs. In: G. Deuschl & A. Eisen (Eds.) *Recommendations for the Practice of Clinical Neurophysiology: Guidelines of the International Federation of Clinical Physiology, (EEG Suppl. 52),* (pp. 15-20). Vancouver: International Federation of Clinical Neurophysiology.

Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia*, *9*, 97-113.

Radičević, Z., Jeličić, Lj., & Vujović, M. (2008a). Different profiles of mapping intensity of electrical activity at children with speech disorders in perceptive-lingual-vocal tasks. In: M. Sovilj & M. Skanavis (Eds.) *Verbal Communication Disorders – prevention, detection, treatment*. (pp. 62-68) Patra – Belgrade: PALO – IEPSP.

Radičević, Z., Vujović, M., Jeličić, Lj., & Sovilj, M. (2008b). Comparative findings of voice and speech: language processing at an early

ontogenetic age in quantitative EEG mapping. *Experimental Brain Research*, *184*, 529-532.

Radičević, Z., & Dobrijević, Lj. (2009a). Functional dynamical systems in processing speech-language in formation in quantiative EEG. In: S.Jovičić & M. Sovilj (Eds.) *Speech and language*. (pp. 31-46). Belgrade: LAAC & IEPSP.

Radičević, Z., Jeličić, Lj., Sovilj, M., & Barlov, I. (2009b). Comparison of mapping quantitative theta encephalograms during directed and required visual–verbal activity and passive period in children with different disorders of speech–language functioning. *Experimental Brain Research*, *195(4)*, 569-574.

Radičević, Z., Dobrijević, Lj., Sovilj, M., & Vujović, M. (2009c). Processing speech and language information in children with different speech language disorders in theta, alpha and beta1 rhythm of quantitative encephalogram (EEG). In: M. Sovilj & S. Jovičić (Eds.) *Proceedings on 3rd International Conference on Fundamental and applied Aspects of Speech and Language*, (pp. 67-72), Belgrade: IEPSP.

Ros, T., Théberge, J., Frewen, P. A., Kluetsch, R., Densmore, M., Calhoun, V. D., Lanius, R. A. (2013). Mind over chatter: plastic up-regulation of the fMRI salience network directly after EEG neurofeedback. *NeuroImage, 65*, 324-335.

Salari, N., Büchel, C., & Rose, M. (2012). Functional dissociation of ongoing oscillatory brainstates. *PLoS One*, *7*, e38090.

Sauseng, P., Klimesch, W., Schabus, M., & Doppelmayr, M. (2005). Fronto-parietal EEG coherence in theta and upper alpha reflect central executive functions of working memory. *International Journal of Psychophysiology*, *57*, 97-103.

Sokhadze, T. M., Cannon, R. L., & Trudeau, D. L. (2008). EEG biofeedback as a treatment for substance use disorders: review, rating of efficacy, and recommendations for further research. *Applied Psychophysiology and Biofeedback*, *33*, 1-28.

Sterman, M. B., & Egner, T. (2006). Foundation and practice of neurofeedback for the treatment of epilepsy. *Applied Psychophysiology and Biofeedback*, *31*, 21-35.

Stokić, M., Milosavljević, Z., & Maksimović, S. (2011). Oscilatory brain dynamics during lexical processing. *Specijalna edukacija i rehabilitacija*, *10* (1), 141-152.

Stokić, M., Milovanović, D., Ljubisavljević, M., Nenadović, V., & Čukić, M. (2015). Memory load effect in auditory-verbal short-term memory task: EEG fractal and spectral analysis. *Experimental Brain Research*, *233*(10), 3023-3038.

Strehl, U., Leins, U., Goth, G., Klinger, C., Hinterberger, T., & Birbaumer, N. (2006). Self-regulation of slow cortical potentials: a new treatment for children with attention deficit/ hyperactivity disorder. *Pediatrics*, *118*, e1530- e1540.

Thatcher, W., Biver, C. J., & North, D. (2007). Spatial-temporal current source correlations and cortical connectivity. *Clinical EEG and Neuroscience, 38*, 35-48.

Thompson, M., & Thompson, L. (2003). *The Neurofeedback Book*. Colorado, Wheat Ridge: The association for applied Psychophysiology and Biofeedback.

Weiss, S., & Mueller, H. M. (2003). The contribution of EEG coherence to the investigation of language, *Brain and Language*, *85*, 325-343.

Zoefel, B., Huster, R. J., & Herrmann, C. S. (2011). Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. *NeuroImage*, *54*, 1427-1431.

Specijalna edukacija i rehabilitacija (Beograd), Vol. 14, br. 4. 441-458, 2015.

PROMENE PRI PREUSMERAVANJU AUDITIVNE I VIZUELNE INFORMACIJE IZMEĐU HEMISFERA ANALIZIRANE KARTOGRAFSKIM EEG-OM KOD DETETA SA SINDROMOM HIPERAKTIVNOSTI

Zoran Radičević[*,**], Ljiljana Jeličić[*,**], Ivana Bogavac[*,**], Miodrag Stokić[*,**], Mirjana Sovilj[*,**], Miško Subotić[**]

[*]*Institut za eksperimentalnu fonetiku i patologiju govora, Beograd*
[**]*Centar za unapređenje životnih aktivnosti, Beograd*

Sažetak

U radu se analiziraju promene pri preusmeravanju vizuelne i auditivne informacije između hemisfera kod deteta sa sindromom hiperakrivnosti i njihovi efekti koji mogu dovesti do boljeg angažovanja pažnje pri analizi auditivne i vizuelne informacije. Metod je uključio upotrebu kartografskog EEG-a u toku kliničke procedure kod desetogodišnjeg dečaka sa poremećajem pažnje i sindromom hiperaktivnosti, koji je imao theta disfunkciju manifestovanu na standardnom EEG-u. Kvantitativni EEG profil je meren pomoću NihonKohden Corporation, EEG – 1200K Neurofaxaparata, koji obezbeđuje 19 EEG kanala. Elektrode su pozicionirane prema 10/20 Internacionalnom sistemu za pozicioniranje elektroda. Impendanca je bila održavana ispod 5κΩ, sa ne više od 1κΩ razlike između elektroda. Niži filter je bio postavljen na 0,53Hz i viši filter na 35Hz. Snimanje je vršeno tokom mirnog perioda kao i tokom stimulacije koja je uključivala osnove govora i jezika.

Standardni EEG i Neurofidbek (NFB) tretman su indikovali više theta opterećenje, alpha 2 i beta 1 aktivnost, merene kartografskim EEG-om, što je urađeno nakon relativnog neuspeha NFB tretmana. Nakon ovoga, primenjen je NBF tretman u trajanju od šest meseci, na način da kada dečak čita vizuelna informacija je prosleđivana levoj hemisferi, a auditivna informacija ograničena na desnu hemisferu. Ponovljene EEG mape su pokazale značajno poboljšanje na planu pažnje i na planu ponašanja i učenja. U radu se diskutuje o određenim aspektima učenja, pažnje i ponašanja u odnosu na promene na standardnom EEG-u, posebno kartografskom EEG-u i NFB saznanjima.

Ključne reči: kartografski EEG, poremećaj pažnje, analiza auditivne i vizuelne informacije, Neurofidbek tretman

Primljeno: 29.06.2015. *Prihvaćeno: 29.11.2015.*