PSYCHOLOGICAL DIAGNOSIS AND QUANTITATIVE ELECTROENCEPHALOGRAPHY ANALYSIS IN COGNITIVE REHABILITATION FOR PEOPLE WITH DOWN SYNDROME

ELŻBIETA LUBIŃSKA-KOŚCIÓŁEK[1], JOLANTA ZIELIŃSKA[2], KRZYSZTOF WOŁOSZCZUK[3]

[1]Institute of Special Needs Education, Pedagogical University of Cracow,
contact: elzbieta.lubinska-kosciolek@up.krakow.pl

[2]Pedagogical University of Cracow, Institute of Special Needs Education, Pedagogical University of Cracow

[3]Special School for Children with Intellectual Disabilities in Nowy Sącz

Primljeno: 06.04.2018.
Prihvaćeno: 12.11.2018.

Original scientific paper
UDK 159.9+616.8056.36
159.91-056.36
https://doi.org/10.31299/hrri.54.2.4

Abstract: *We present the possibility of the application of quantitative electroencephalography (QEEG) in diagnoses of people with Down Syndrome, complemented by psychological tests. We utilised the Mitsar EEG 202 and SON-R (2.5-7) test. Twenty people with Down Syndrome participated in this test run. The test results of an 18-year-old man were analysed in detail. Over-expression, specifically in theta waves (4-6 Hz), was observed in the frontal and parietal lobes. Data collected during the psychological diagnosis test confirmed the same indications (the QEEG findings) of the patient. We also propose neurofeedback training and types of tasks that should be applied in cognitive rehabilitation.*

Keywords: *Down Syndrome, QEEG, Psychological Diagnosis, Cognitive Rehabilitation*

INTRODUCTION

Down syndrome occurs in about 1 per 1000 live births in European countries and, according to the European Concerted Action on Congenital Anomalies and Twins (EUROCAT, 2015), it is the most common autosomal chromosome aberration. The presence of 21 chromosomes (or their long arms) in a karyotype results in characteristic dysmorphic features, delays in somatic development, and significant organ and system defects, including structural and functional abnormalities of the central nervous system (Carr, 1995; Delebar, 2007). Haydar and Reeve (2012) found that abnormalities in brain structure concern three areas in particular: the prefrontal cortex, cerebellum and hippocampus.

In 1939, for the first time, data about the electrical brain activity of people with Down Syndrome were shown. Kreezer tracked an alpha rhythm in 50 patients aged 16 to 56 years and reported a correlation between the mental ages of tested people and the amplitude of the alpha rhythm. Further studies of people with Down Syndrome led to the identification of specific regularities in bioelectrical brain activity in tested people: lowering of frequency in the alpha band (Gammerson, 1945; Schlack, Szmidt – Schultz, 1977; Szmid, 1978), presence of sharp waves and spikes in the electroencephalogram (EEG) in patients with Down Syndrome who had not been diagnosed as epileptic (Gibbs, 1965), considerable decrease in alpha wave activity between 2 and 5 years of age and an increase in subdelta, delta and theta activity in parietal-occipital and fronto-central areas for individuals aged 4-5 years (Szmid, 1985, 1992) (as cited in: Vogel, 2000, pp. 197- 199).

The development of EEG techniques, high resolution and neuroimaging has enabled more precise diagnostics of electrical brain activity of people with intellectual disabilities, which serves as a basis for planning neurofeedback-based therapy and evaluating the effectiveness of therapeutic interventions.

Research in this field is currently ongoing in various research centres in the world, including Poland (Zielińska, 2015), and interesting data have emerged from work by, *inter alia,* T. Surmeli and A. Etrem (2007, 2010). These authors evaluated electrical brain activity in eight children with Down Syndrome using QEEG, and reported an increase in delta and theta wave activity and increasing or insufficient activity of beta waves on all tests. At the same time, they showed the effectiveness of intensive neurofeedback training. Twenty-two respondents who participated in neurofeedback training showed clinical improvements based on the Developmental Behaviour Checklist (DBC-P)[1] and QEEG. Nineteen respondents achieved better scores on the WISC-R test and the test of variable attention (Surmeli, Etrem, 2010).

OBJECTIVES AND HYPOTHESES

The study presented in this article, which contributes to the exploration of possible neurotechnology in the diagnosis and therapy of people with intellectual disabilities, aimed at (1) determining bioelectrical function patterns in the brain of a male respondent with Down syndrome; (2) making a quantitative and qualitative diagnosis of a studied person's intellectual abilities; and (3) using the results from these studies to highlight indications for carrying out neurotherapy and educational rehabilitation.

Based on data in scientific publications, we hypothesised that the bioelectrical activity of the respondent's brain would show characteristic over-expression of slow theta and delta waves, and that the highest activity would be recorded in the frontocentral band. The results from the QEEG study would be complementary to results of the measurement of intelligence and would allow formulation of guidelines fundamental for effective and individualised interactions in the field of rehabilitation.

METHOD

Pilot studies

The pilot study involved 20 people with Down syndrome (10 male, 10 female) aged 18-22 years with moderate intellectual disabilities. We carried out a diagnosis of the intellectual abilities of the respondents and a measurement of bioelectrical activity of the brain. Preliminary analysis showed us a huge diversity of results. The hypothesis of over-expression of slow waves (theta and delta) was supported, but the over-expression was recorded in different areas of the cortex. Similarly, in the study of the intelligence tests, although the mental age of all respondents did not exceed 6 years of age, the distribution of the results for the individual subtests pointed to significant individual differences.

Therefore, we decided that the therapeutic process should be planned for every respondent individually. For further analysis and presentation, we chose the empirical material that we obtained during the study of a man with Down Syndrome.

Participant

An 18-year-old male, a pupil of a special school, took part in the study. Based on an analysis of the psychological – pedagogical documentation, we established that the intellectual development of the respondent was located within the limits of moderate intellectual disability. The man communicated verbally; however, he had a limited active dictionary and knowledge of notions. His statements were short and his distorted articulation made him difficult to understand. These difficulties were compensated by non-verbal messages.

When examined, he performed mental operations mainly on specific and visual material, presenting the inability of decentration which is characteristic of the preoperative period (Cockcroft, 2009). He could not pay attention to multiple aspects of a situation. The process of categorisation was limited to the recognition of significant differences and commonalities. The task consisted in classifying objects according to several features. The respondent had to choose the right element belonging to the category from others. Difficulties appeared when he had to select from a larger number of objects or extract a category requiring the recognition of several features of the objects.

The respondent demonstrated reduced ability in rule-based problem-solving, and required sup-

1 The parent/carer version of the DBC-P is a part of the Developmental Behaviour Checklist. It is an instrument used for the assessment of behavioural and emotional problems in people aged 4-18 years with developmental and intellectual disabilities.

port in the form of the presentation of an example. Difficulties also appeared in contextual thinking. In terms of visual perception, he coped better with thematic material than with athematic (symbolic) material. The respondent could synthesise and analyse known images consisting of several parts. Substantial difficulties appeared when working on symbolic material, especially in trials requiring the ability to reproduce a specific arrangement through manipulation of available elements.

The subject showed a decline in direct remembering, with clearly strong long-term memory. He encoded visual information more quickly and accurately than aural information. He could master content and behaviours through systematic repetition, but the learning process proceeded slowly, and the skills gained required constant strengthening.

The subject showed reduced efficiency of motor activity. He moved independently but showed difficulties in free movement and in overcoming obstacles (e.g. the stairs).

The subject showed a general understanding of the rules of society and was fully independent in terms of elementary self-service activities. He was able to adapt to the many new situations. He also showed a low level of anxiety and easily established positive relationships with both peers and adults, including strangers. He showed willingness to cooperate in a group, cheerful mood and a positive attitude toward the people around him. The respondent was perceived as a creative person by teachers and therapists.

Measurement of intelligence

This measurement was carried out using the Snijders-Oomen Non-verbaler Intelligenztest 2 ½ - 7 (SON-R), which is an alternative to general intelligence tests to measure learning potential and assess the cognitive functioning of various groups of people with different problems. It is used in psychological practice for the assessment of intellectual abilities, for determining not only the intelligence quotient but also the developmental age of the examined person. It can be administered without having to use written or spoken language. This research tool has been verified in studies of people with intellectual disabilities by Wijnads (1997) (as cited in: Tellegen, Winkel, Winberg-Williams, & Laros, 1998, p. 126).

The scale consists of six subtests: Mosaics, Categories, Puzzles, Analogies, Situations, and Patterns. The subtests Categories, Analogies and Situations feature material with a symbolic or thematic character, and the scale assesses reasoning. The subtests Mosaics, Puzzles, and Patterns assess performance. Moreover, tasks of the subtests provide data regarding right and left hemispheric preferences of the respondent (Tellegen et al., 1998).

The SON-R can be distinguished from traditional intelligence tests in two main aspects. The procedure allows the giving of feedback to the subject, who has the opportunity to change his or her strategy for solving problems, and instructions can be adjusted if they are misunderstood. In addition, the testing procedure is adaptive: test duration and items can be selected according to participants' abilities.

Examining the bioelectrical activity of the brain

QEEG allows us to quantify the electrical activity of the brain. It is an efficient and relatively inexpensive method for the study of developmental changes in brain-behaviour relations.

For the examination, we used the Mitsar-EEG-202 amplifier with WinEEG software, which enables quantitative and qualitative analysis of various aspects of the EEG signal (Rowan, & Tolunsky, 2003). Such a solution is essential for the planning of neurofeedback therapy because it reveals the distribution and amplitude of individual frequency bands of the brain waves in the area of the cortex. It also allows us to see abnormalities, which in the case of people with disorders and difficulties, are subject to training (Thompson, &Thompson, 2003). The collected data were compared to a normative data base, *The Human Brain Index,* built into the WinEEG software. The database includes the results of processing more than 3000 EEG recordings collected from more than 1000 healthy subjects aged 7 to 89 years (divided into 20 age groups). EEGs were recorded under different conditions (eyes open, eyes closed, during tasks to analyse event-related potentials). The results of the comparison based on age are presented as maps of deviations from normality. Similarly to previous authors (Surmeli, Etrem; 2010), we used a normative database to describe abnormalities in the

EEG of the subject and determine individual differences related to cognitive functioning. Comparison of the obtained results with the database facilitated the planning of neurofeedback training.

The EEG signal was recorded using a 19-electrode system, arranged according to the international system of 10 – 20. All leads were referenced to linked earlobes. At the impedance less than 5 kΩ and sampling rates of 250 Hz, an EEG signal was filtered in the period 0.53 Hz - 50 Hz.

We carried out three measurements of the bioelectrical activity of the brain of an 18-year-old man with Down syndrome. The first two measurements took place over two consecutive days, and the third one after six days. We recorded for four minutes in the resting state with opened eyes and with closed eyes. Independent component analysis was used to remove artefacts associated with the movement of the eyeballs.

Persons who carried out the test trials were well known to the respondent. The respondent's positive attitude to participate in the meetings was the result, *inter alia,* of his earlier experiences associated with participation in several neurofeedback sessions. His parents were informed about the test procedure and gave their written permission to make the measurements. We also obtained the permission of the Bioethics Committee to carry out the studies.

RESULTS

Assessment of intellectual abilities

Based on a quantitative analysis of the empirical material, we identified the mental age of the respondent as 5 years and 10 months. Due to the fact that the biological age of the respondent (18 years) was significantly higher than his mental age, we could not use the standard table of included norms in the textbook for calculating the quotient. Therefore, evaluation of the intellect was dropped at this stage. Moreover, we established the developmental age for the scale of reasoning at 5.5 years, and the scale of performing at 6 years.

The respondent achieved the best results in tasks of the subtests Puzzles (score 6.3) and Patterns (score 6.9) related to the performance scale, and the lowest results in the subtests Mosaics (5.2) and Analogies (5.4). The results (mental age) achieved by the respondent in the other individual subtests were Categories (5.8) and Situations (5.6).

Qualitative analysis of the way that the subject performed individual subtests revealed his competencies and difficulties. Performing the tasks included in the subtest Mosaics, the subject was able to lay blocks in a presented arrangement, but only if the elements that formed the example pattern were separated by clear lines. Under these conditions, the respondent could see their position in relation to each other. Difficulties were caused by a mosaic composed of two-colour blocks, as well as the need to recognise the pattern as a whole. Starting from left to right was not observed. When categorising thematic material, the subject correctly identified the sets when the comprising elements were the same or slightly different from each other, and the differences between categories were distinct. Problems appeared when the categorisation required finding the classification criterion within the wider group. Regarding the subtest Puzzles, the respondent performed well in merging parts of the image of a well-known subject, provided that the individual elements had a fixed position. The subject was not able to perform a task if it required the missing elements, and the location of the missing part was not obvious. In tasks requiring thinking by analogy, the respondent correctly separated the elements according to the given rule. After the presentation of the example, the respondent was able to select the elements and correctly change the criterion according to the new demonstration. Mistakes made at this stage resulted from inattention and omission of details. The respondent did not solve tasks according to one scheme learnt at the beginning of the subtest. Problems appeared during the performance of tasks according to given guidelines, which required choosing the right element among many. In the tasks related to the category Situations, the respondent correctly chose the fragments of the picture based on context when there were few possible solutions and the possible choices suggested the right solution. It proved too difficult for the respondent to select one of many possibilities or to build a logical whole from a few elements. Proper performance of the tasks relying on a reconstruction of the graphic pattern was dependent on the degree of their complexity (the number of elements in the pattern) and their physical placement.

Bioelectrical activity in the respondent's brain

We subjected the results of two measurements to quantitative analysis, because the third one contained a large number of artefacts, making it impossible to choose an appropriate fragment of the EEG signal for further calculations in the samples with eyes opened and closed. Analysis of the raw EEG data led to the identification of respondent artefacts, which came primarily from the movement of the tongue. Making the spectral analysis using Fourier transformation, we observed the distribution of individual frequencies of brain waves in the following bands and the heights of their amplitudes: Delta, 1.5-4 Hz; Theta, 4-8 Hz; Alpha, 8-12 Hz; SMR, 12-15 Hz; Beta 1, 15-18 Hz; and Beta 2, 18 – 25Hz.

With the topographies above, a distribution of the power spectrum of the EEG signal was generated from the first measurement with eyes open (Figure 1). The power spectrum analysis in the eyes-open state was presented in 2-Hz intervals, because it makes more visible the activities in the intervals of 2-4 Hz and 4-6 Hz, concentrated in the frontal lobe (Fz, the 10/20 system), as well as the activity in the interval of 6-8 Hz in the occipital lobe (P3, P4).

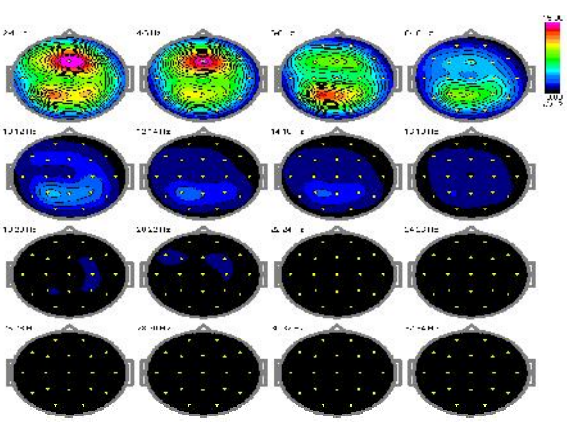

Figure 1. *Power spectral analysis in the eyes-open state in 2-Hz intervals (measurement 1).*

Analysis of the data obtained during the second measurement also indicated the highest value in the range of delta and theta bands at the electrode Fz and at the electrode Pz-P3 (in the frequency interval of 6-8 Hz).

The results of tests with eyes closed are shown below. In both cases there was a significant increase in the amplitude of the alpha band in the occipital part (see figure 2).

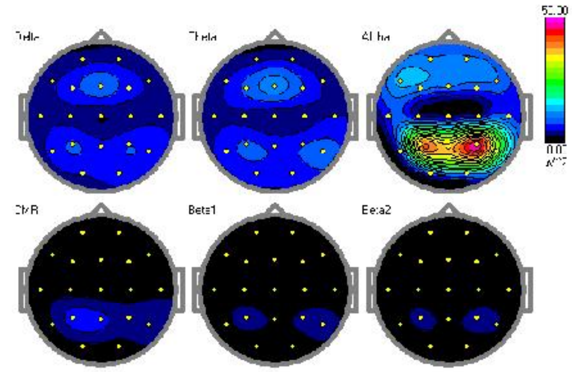

Figure 2. *Power spectral analysis in the eyes-closed state in 2-Hz intervals (measurement 1).*

The data from the recording with open eyes in measurement 1 were compared with the Human Brain Index database according to the age of the respondent. The frequencies showing the greatest deviation from the database were presented on topographic maps (see Figures 3-4).

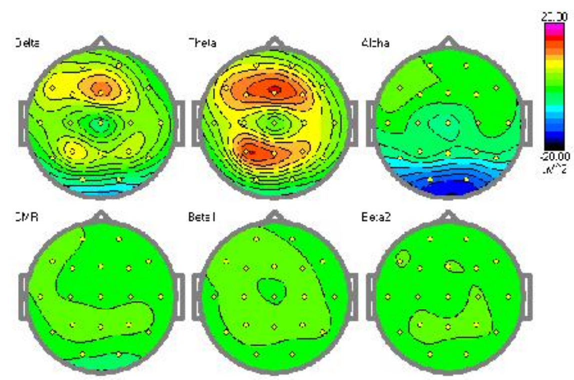

Figure 3. *Comparison of power spectra of individual band frequencies against the Human Brain Index database.*

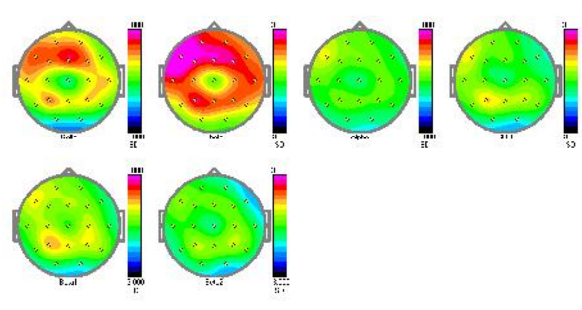

Figure 4. *Comparison of power spectra in terms of the standard deviation*

These comparative analyses indicate incompatibility with the normative base, mainly in the theta band, where anomalies reach 3 SD in the frontal area.

DISCUSSION

The recording of the EEG signal with closed eyes showed an increase in the activity in the alpha range and its decline when the eyes were opened. This phenomenon is associated with normal reactivity of the brain (Kropotov, 2011).

The distribution of the power spectrum of the EEG signal from both measurements with open eyes shows that the highest values were visible in the delta and theta waves in the central line at electrode Fz and Pz and in electrode P3.

It is assumed that the theta waves (3-7 Hz, 4-7 Hz, or 4-8 Hz) are generated primarily by the thalamus and in the limbic system (Hasselmo, Bodelón, & Wyble, 2002). Another likely source of this rhythm may be the hippocampus, as confirmed in research on animals and by the recent recording of theta waves from the hippocampus in humans (Winson, 1974; Bland & Oddie, 2001; Buzsáki, 1986; 2002). In adults, the majority of theta waves in the state of consciousness can be associated with sleepiness and exclusion of consciousness (Thompson, & Thompson, 2003). Theta waves are associated with the recalling of information from the memory and with the attention process (Klimesch et al., 2001; Nyhus, & Curran, 2010; Budzynski, Budzynski, Evans, & Abarbanel; 2009; Kropotov, 2011).

Delta activity is slow (0.5 - 3 Hz). Delta waves are probably formed in layer V of the cerebral cortex, and they are the dominant waves in infants (Volpe, 2008). They also occur during sleep in people of all ages (Zeitlhofer et al., 1993). Delta prominence is associated with slowed cognitive processing and learning difficulties/disabilities (Gasser, Rousson, & Schreiteer Gasser, 2003; Fonseca, Tedrus, Chiodi, Cerqueira, & Tonelotto, 2006; Budzynski et al., 2009) as well as brain damage (Swingle, 2008). According to Knyazev (2012), it may be assumed that the delta rhythm is also associated with the processes of motivation and attention, and especially the ability to discover and decode important stimuli from the environment. The excess of delta waves can therefore lower readiness to receive and process incoming information. Over-expression of theta and delta waves, which we observed during the study of bioelectrical activity of a brain of an adult with Down syndrome, confirms the results reported by other authors (Śmigielska-Kuzia et al., 2005; Surmeli, Etrem, 2010).

We recorded increased signal strength in delta and theta bands in the area of the central and medial frontals, as well as in the parietal area of the respondent brain.

The observed bioelectrical activity of the brain was related to the type of problems that appeared during the cognitive tests. During the psychological diagnosis we found, *inter alia,* that the respondent had a problem with selecting and organising perceptual stimuli and also with maintaining attention at an effective level for a long period of time. He made mistakes, even though he knew the solution to the problem. He experienced particular difficulties when the task required him to make some mental operations or to involve direct memory or recognise spatial relations. The present results converge with resent results on cognitive function in individuals with Down syndrome (Visu-Petra, Benga, & Miclea, 2007; Lanfranchi, Baddeley, Gathercole & Vianello, 2012; Lanfranchi, Carretti, Spano & Cornoldi; 2009).

SUMMARY AND CONCLUSIONS

The results obtained from the respondent indicated over-expression of slow waves, especially theta (4 - 6 Hz), which were recorded in the frontal and parietal regions. This over-expression may be associated with deficits of attention and memory. Analysis of the empirical material obtained during the traditional psychological diagnostic test of the respondent confirmed his difficulties in this area. In light of these data, it appears advisable to run further tests using QEEG during the performing of cognitive tasks by the respondent.

The qualitative psychological diagnosis, which reveals the weaknesses of a respondent with Down syndrome, as well as assessment of competencies within the limits of the Zone of Proximal

Development (Wertsch, 1998) should be the basis for the planning of further education that takes into account the individual's developmental potential.

Given the complexity of deficits and abnormalities in the cognitive functioning of people with intellectual disabilities, the introduction of diagnostic QEEG analysis seems to be reasonable due to the possibility of obtaining quantitative data. These data show the specificity of brain bioelectrical activity of the particular patient and they are especially important in the context of individualised therapy.

IMPLICATIONS FOR PRACTICE

Based on the presented analysis, we propose the following points for the process of a person's cognitive rehabilitation:

1. The initial stage of therapy, EEG - biofeedback, in our opinion, should be oriented on the deterioration in terms of theta, in particular at the frequency of 4-6 Hz, where the excess occurs around the middle frontal area, possibly causing problems with concentration of attention and memory, that were confirmed during the psychological diagnosis, and maintain the value in area of bands of beta and beta 2, as indicated in the normative database. Due to the fact that the therapy is based on a slow process of learning, we propose 40 sessions, twice a week. After this period, QEEG should be performed and its results compared with the current diagnosis.

2. The profile of the respondent's intellectual abilities and task performance indicate the need to take into account the following types of tasks in a process of rehabilitation:

Tasks developing the ability of object categorisation. It is known that the ability to categorise affects our interaction with the environment (Smith, 1989; Mandler, 1998; Goldstone & Kersten, 2003). Within these cognitive tasks, there should be exercises in the field of categorisation based on several features as well as exercises in extracting the common characteristics within the presented categories, and exercises in extracting the features that are typical of the most distinctive examples for the category and their verbal description.

Tasks that are associated with analogical thinking on thematic and athematic (symbolic) material create an opportunity for the respondent to gather experiences related to making analysis, find the relationships between objects and phenomena, and discover rules (Goswami, 1992, Chen, Sanchez, & Campbell; 1997; Richland, Morrison & Holyoa, 2006). Considering the creativity of the respondent, the evaluator can use a fantasy analogy that engages the imagination rather than a simple analogy (Gordon, 1961).

Tasks improving spatial ability (spatial orientation, visuospatial memory, targeting, spatial visualisation, flexibility of closure/field independence, and spatial perception) (Kimura, 1999) should be carried out on material enabling the subject to create spatial constructions, manipulate and multiply transform objects and verbally describe performed changes and the position of objects in space (far, close, from the right, on the top, beside, etc.).

Tasks involving working memory are needed because an increase in working memory capacity is important for development of cognitive skills, including logical thinking (Engle, Kane, & Tuholski, 1999; Fry & Hale, 1996; Hulme & Roodenrys, 1995). Exercises should support more precise memorising of a particular material and organising (structuring) of memorised information.

LITERATURE

Bland, B. H. & Oddie, S. D. (2001): Theta bend oscillation and synchrony in the hippocamal formation and associated structures: the case for its role in sensorimotor integration. Behav. Brain Res. Vol. 127, 119 – 136.

Buzsáki, G. (1986): Laminar distribution of hippocampal rhythmic slow activity (RSA) in the behaving rat: Current – source density analysis: effect of urethane and atropine. Brain Research. Vol. 365, 125-137.

Buzsáki, G. (2002): Theta oscillations in the hippocampus. Neuron. Vol. 33, 325–340.

Carr, J. (1995): Down's syndrome: Children growing up. Cambridge: Cambridge University Press.

Carretti, S., Spano, B,.G., & Cornoldi, C. (2009): A specific deficit in visuospatial simultaneous working memory in Down syndrome. Journal of Intellectual Disability Research, 53(5), 474-483.

Chen, Z., Sanchez, R., & Campbell, T. (1997): From beyond to within their grasp: Analogical problem solving in 10- and 13-month-olds. Developmental Psychology, 33, 790–801.

Cockcroft, K., (2009): Piaget's constructivist theory of cognitive development. In J. Watts, K. Cockcroft & N. Duncan (Eds.), Developmental Psychology (pp. 324–344). Cape Town: UCT Press.

Debelar, J-M. (2007): Perspectives on Gene-based Therapies. In J-A. Rondal & A. Rasore-Quartino (Eds.), Therapies and rehabilitation in Down Syndrome (pp. 1-17). Chichester: John Wiley & Sons Ltd.

Engle, W. R., Kane, J. M., & Tuholski, S. W. (1999): Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Myake & P. Shah (Eds.), Models of working memory (pp. 102- 134). Cambridge: Cambridge University Press

European Surveillance of Congenital Anomalies. (June, 2015). Prevalence Data Tables

Retrieved from: http://www.eurocat-network.eu

Fonseca, L. C.,Tedrus, G. M. A.S., Chiodi, M. G.; Cerqueira, J. N., & Tonelotto J. M. F. (2006): Quantitative EEG in children with learning disabilities: analysis of band power. Arq. Neuro-Psiquiatr.Vol.64(2b).

Gasser, T., Rousson, V., Schreiteer Gasser, U. (2003). EEG power and coherence in children with educational problems. Journal of Clinical Neurophysiology. Vol. 20, 273-282. Abstract Retrieved from: http://europepmc.org/abstract/MED/14530741

Goldstone, R. L., Kersten A. (2003). Concepts and Categorization. In I. B. Weiner, A.F., Healy, R. W., Proctor (Eds.), Handbook of Psychology, Experimental Psychology, Volume 4, (pp. 599 -622). New Jersey, Hoboken: John Wiley & Sons Inc.

Gordon, W. J. J. (1961): Synectицts: The Development of Creative Capacity. New York: Harper & Row.

Goswami, U. (1992). Analogical reasoning in children. Hillsdale: NJ: Lawrence Erlbaum.

Hasselmo, M.,E, Bodelón, C., Wyble, B.,P. (2002): A proposed function for hippocampal theta rhythm: Separate phases of encoding and retrieval enhance reversal of prior learning. Neural Comput. Vol. 14,793–817. Retrieved from: https://pdfs.semanticscholar.org/a90f/17a9b8dd293af0efe77c5a5248d378834472.pdf

Haydar, T. F., & Reeve, R. H. (2012): Trisomy 21 and early brain development. Trends in Neurosciences, Vol. 35(2), 81-91.

Hulme, C. & Roodenrys, S. (1995): Practitioners review: Verbal working memory development and its disorders. Journal of Child Psychology and Psychiatry, 36, 373- 398.

Kesslak, J.P., Nagata, S.F., Lott, I. & Nalcioglu, O. (1994): Magnetic resonance imaging analysis of age-related changes in the brains of individuals with Down's syndrome. Neurology, Vol. 4, 1039–1045.

Abstract retrieved from: http://www.neurology.org/content/44/6/1039

Kimura, D. (1999) Sex and cognition. Cambridge MA: MIT Press/Bradford Books.

Klimesch, W., Doppelmayr, M.; Yonelinas, A.; Kroll, Lazzara, N.,E.,A., Röhm M., D. (2001). Theta synchronization during episodic retrieval: neural correlates of conscious awareness. Cognitive Brain Researches. Vol. 12(1), 33–38. doi 10.1016/S0926-6410(01)00024-6

Knyazev, G. (2012): EEG delta oscillations as a correlate of basic homeostatic and motivational processes. Neurosci. Biobehav. Rev. Vol. 36, 677–695.

Kropotov, J., D. (2011): Quantitative EEG, Event-Related Potentials and Neurotherapy. Amsterdam, Boston, Heidelberg, London. New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokio: Elsevier Inc.

Lanfranchi, S., Baddeley, A., Gathercole, S., & Vianello, R. (2012): Working memory in Down syndrome: Is there a dual task deficit? Journal of Intellectual Disability Research. Vol. 56(2), 157-166. Abstract retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2788.2011.01444.x/abstract

Mandler J. M. (1998): Representation. In D. Kuhn & R. Siegler (Eds.), Handbook of child psychology, Volume 2, Cognition, perception, and language (5th ed.) (pp. 255–308). New York: Wiley

Nyhus, E., Curran, T. (2010). Functional role of gamma and theta oscillations in episodic memory. Neurosci Biobehav Rev. Vol. 34, 1023-1035.

O'Neil, J. M., & Egan, J. (1992): Men's and women's gender role journeys: A metaphor for healing, transition, and transformation. In B. R. Wainrib (Ed.), Gender issues across the life cycle (pp. 107-123). New York, NY: Springer.

Piaget, J., Inhelder, B. (1969): The psychology of the child. New York: Basic Books.

Raz, N., Torres, I.J., Briggs, S.D., Spencer, W.D., Thornton, A.E., Loken, W.J., Gunning, F.M., McQuain, J.D., Driesen, N.R. and Acker, J.D. (1995). Selective neuroanatomic abnormalities in Down's syndrome and their cognitive correlates: evidence from MRI morphometry. Neurology. vol. 45, 356–366.

Richland, L.. E., Morrison, R., Holyoak, K. J. (2006). Children's development of analogical reasoning: Insights from scene analogy problems. Journal of Experimental Child Psychology. Vol. 94, 249–273. doi:10.1016/j.jecp.2006.02.002

Rowan, A., J., Tolunsky, E. (2003). Primer EEG With a Mini Atlas. Philadelphia: Butterworth, Heinemann

Smith, L. B. (1989). A model of perceptual classification in children and adults. Psychological Review. Vol. 96, 125–144. from: http://www.iub.edu/~cogdev/labwork/smith89model.pdf

Surmeli, T., & Ertem, A. (2010): Post WISC-R and TOVA improvement with QEEG guided neurofeedback training in mentally retarded: A clinical case series of behavioral problems. Clinical EEG & Neuroscience Journal. vol. 41(1),32–41.

Sürmeli, T., Ertem, A. (2007): EEG Neurofeedback Treatment of Patients with Down Syndrome. Journal of Neurotherapy. Vol. 11(1), 63–68.

Swingle, P., G. (2008). Biofeedback for the Brain: How Neurotheraphy Effectively Treats Depression, ADHD, Autism, and More. New Brunswick, and London: Rutgers University Press

Śmigielska-Kuzia, W. Sobaniec, W. Kułak, Boćkowski, L. and Sołowiej, E. (2009), Quantitative EEG Analysis of REM Sleep in Children with Down syndrome. Annales Academiae Medicae Bialostocensi Journal., Vol. 50

Tellegen, P.,J., Winkel B., M.; Wijnberg-Williams, B.,J.; Laros J.,A. (1998): Snijders-Oomen Nonverbal Intelligence Test: SON-R 21/2-7: Manual and Research Raport. Göttingen: HOGREFE.

Thompson, M.; Thompson, L. (2003): The Neurofeedback Book: An Introduction to Basic Concepts in Applied Psychophysiology. Wheat Ridge, CO: Association for Applied Psychophysiology and Biofeedback.

Visu-Petra, L., Benga, O., & Miclea, M. (2007): Visual-spatial processing in children and adolescents with Down's syndrome: A computerized assessment of memory skills. Journal of Intellectual Disability Research, 51(12), 942-952.

Vogel, F. (2000): Genetics and the Electroencephalogram. Berlin-Heidelberg: Springer – Verlag

Volpe, J. J.(2008): Neurology of the Newborn. Philadelphia: Saunders Elsevier.

Wertsch, J. V. (1998): The zone of proximal development: some contceptual inssue. In P. Lloyd & Ch. Ferynyhough (Eds.), Lev Vygotsky: Critical Assessments (pp. 61-87). London: Routledge.

Winson J., (1974): Patterns of hipocamppal theta rhythm of the freely moving rat. Electroencephalography and Clinical Neurophysiology. 36: 291-301.

Zeitlhofer, J., Anderer, P., Obergottsberger, S., Schimicek, P., Lurger, S., Marschnigg, E., Saletu, B., Deecke, L. (1993): Topographic mapping of EEG during sleep. Brain Topogr. Vol. 6(2), pp123-129.

Zielińska, J. (2015): Supporting education of children with disabilities through application modern technology. In. L. Varkoly, R. Szczebiot, & M. Zabowsky (Ed.) Present day trends of innovations (pp. 54-61), Łomża: Printing House of Łomża State University of Applied Sciences.

PSIHOLOŠKA DIJAGNOZA I ANALIZA QEEG U KOGNITIVNOJ REHABILITACIJI OSOBA S DOWNOVIM SINDROMOM

Sažetak: *U radu se predstavlja mogućnost primjene QEEG-a u psihološkoj obradi osoba s Downovim sindromom. Primijenjeni su testovi Mitsar EEG 202 i SON-R (2.5-7). U ispitivanju je sudjelovalo dvadeset ispitanika s Downovim sindromom. Detaljno su analizirani rezultati osamnaestogodišnje muške osobe. Rezultati su uputili na prenaglašenu ekspresivnost, posebice theta-valova (4-6 Hz) registriranih u čeonom i tjemenom režnju. Podaci prikupljeni tijekom psihološke obrade potvrđuju iste rezultate QEEG-a kod pacijenta. Također iznose se pretpostavke neurofeedback-treninga i tipova zadataka koji bi se trebali upotrebljavati u kognitivnoj rehabilitaciji.*

Ključne riječi: *Downov sindrom, QEEG, psihološka procjena, kognitivna rehabilitacija*