Proceeding

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# Electrical activity of the brain during graphomotor activities: Case study

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**ABSTRACT**

This paper shows findings resulting from a research on bioelectrical activity of the brain while performing graphomotor activity in a seven-year-old boy subject. Measurements of brain potential was carried out by the method of electroencephalography and the obtained data underwent the spectrum analyses in the band of alpha, beta and mu waves. The implemented case analyses confirmed and increase of the beta rhythm while performing graphomotor activities. The obtained results imply a complexity of the process of visual-motor integration and the importance of functional integration of the central nervous system as a precondition for generating a movement and motor control. **Keywords**: EEG; Child; Fine motor skills; Alpha rhythm; Beta rhythm; Mu rhythm.

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## INTRODUCTION

A research in the field of motor learning represents an extremely important and propulsive segment in the field of kinesiology. Much research was directed toward studying motor learning in the field of kinesiology whilst motor development of a man in certain phases of development is dominantly described (Gallahue & Ozmun, 2006, Gallahue & Donnelly, 2007; Payne & Isaacs, 2002).

Kinesiology recognises ontogenetic research as extremely important ones. Dominantly it refers to studying development of different motor skills on the manifest level that is on the level of observational quality of performance (Appache, 2005; McKenzie, Alcaraz, Sallis & Faucette, 1998). Besides, the research also includes influence of different styles and strategies of teaching on success of the process of formation of motor skills (Gardner, 2006; Kolb, 2005; Gregorc, 2006). Besides the mentioned, problems of influence of disturbing factors such as fatigue, fear and lack of motivation on efficiency of motor learning are also studied in the field of kinesiology (Coker, 2009).

Research of brain activity during different motor and kinesiological activities represents a newer phase of studying human movement. Researchers study different motor activities such as operational knowledge manipulation (D'Anna et al., 2016), biotic and general motor knowledge (Beurskens, Steinberg, Antoniewicz, Wolff, & Granacher, 2016; Chen et al, 2014; Naito & Hirose, 2014) and sports motor skills (Parka, Fairweatherb & Donaldson, 2015). Research includes studying the brain activity during the performance of motor activities.

A particularly important segment of research regarding development of a child represents a significant area of visual-motor integration (Bavčević, 2015). Visual-motor integration represents a process of neuromuscular coordination or coordination of information from visual receptors and muscular effectors within the aim of performing precise motor activities (Teo Bavčević, Tonči Bavčević & D. Bavčević, 2016). Graphomotor activities represent one of the most important manifestations of the described process since they involve integration of visual receptors and fine motor skills of the fist. Graphomotor activities are particularly important in the period of primary education because they represent one of dominant researches in preparation of a child for acquiring the writing skill.

In order to understand better the process of visual-motor integration as a whole as well as the development of graphomotor skills, it is necessary to analyse neurobiological processes responsible for their integration and manifestation. Firstly, it refers to studying brain activities related to the described processes.

The aim of this research was to analyse electrical activity of the brain during performance of graphomotor activities of in the seven-year-old male subject.

## MATERIALS AND METHODS

The research was conducted in the form of a case study of a seven-year-old male subject. The subject was a completely healthy right-handed boy without any noted aberrant characteristics.

The procedure of evaluating electrical activity of the brain included electroencephalographic recording of the subject during graphomotor activities. According to the previously stated, the Test of Visual-Motor Integration (VMI) was applied to evaluate visual-motor integration of graphomotor type (T. Bavčević & D. Bavčević, 2015). The VMI test is an instrument of paper-pen type and it consisted of two parallel lines on A4 paper with the distance of 1,5 cm between them, forming a 178,5 cm long path. Task of the subject was to connect the dots from the beginning to the end of the path by drawing a line with a pencil and without any interruption or touching borders of the path as quickly as possible. The line is drawn with the dominant hand with a B-2B pencil on a paper. The evaluator measures time required for solving the test in seconds and after completing the test a number of errors is determined for each interruption of the line drawn and for touching the borders of the path. The final result of the VMI test represents a sum of time required for solving the task and all errors multiplied by two.

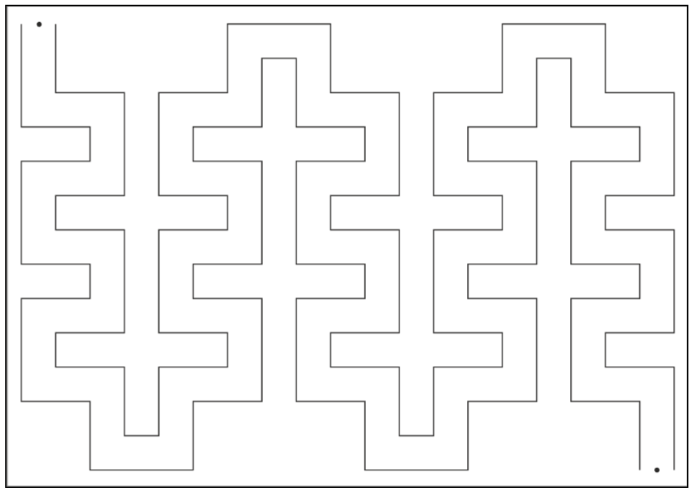

Figure 1. Graphic representation of the VMI test (T. Bavčević & D. Bavčević, 2015).

Recording electrical activities of the brain was performed by the use of a 14-channel EEG device EMOTIV Epoc. EEG electrodes were placed according to the 10-20 system with position AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4 and reference points in the CMS/DRL noise cancellation configuration P3/P4 locations. Recording was followed by a sampling rate of 128 SPS and recording resolution of 14 bits (1 LSB = 0.51μV) in the bandwidth of 0.2 – 43Hz.

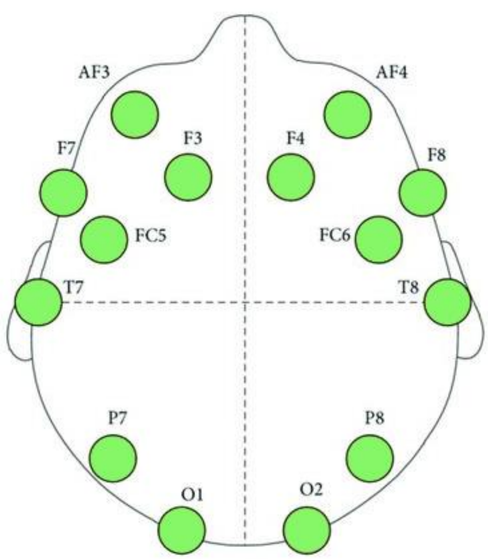


Figure 2. Electrodes placed according to the 10-20 system.

 

Measuring electrical activities of the brain was implemented on controlled setting and according to a well determined measuring procedure. During the process of recording the subject is sitting and the evaluator is giving instructions. Before the beginning of recording the subject is prepared for measurement and a recording of an EEG signal is tested in the 5 minutes period in order to calm the subject entirely and to establish the quality of signal.

The measuring procedure consisted of three consecutive phases:

1st phase: recording electrical activity of the brain with eyes open – 1 minute.
2nd phase: recording electrical activity of the brain with eyes closed – 1 minute.
3rd phase: recording electrical activity of the brain while solving the VMI test.

Data obtained from the electroencephalographic recording were exported to a RAW format and further analyses was implemented by the use of EEGLAB software.

Prior to the further analyses the signal was filtered by the use of a high-pass filter on 1Hz level and of a low-pass filter on 40Hz level.

The research also included spectral analyses of electrical activities of the brain in particular brain regions that is extrapolation of specific brain rhythm. This way the patterns of bioelectrical activity of the brain which appears during graphomotor activities were analysed.

Analyses in each phase of measurements referred to topological spectral representations of alpha rhythm in the bandwidth of 8Hz to 13 Hz and of beta rhythm in the bandwidth of 14 Hz to 29 Hz.

Presented results are a part of the research conducted in 2017 in Skalice Primary School, Split, the Republic of Croatia. The research was conducted with prior approval from the School Board, the headmistress and the parents of the children included in the project.

**RESULTS AND DISCUSSION**

Spectral analyses in the domain of alpha waves included the bandwidth of 8 Hz to 13 Hz. The results of the analyses are shown in Figures 3, 4, and 5.

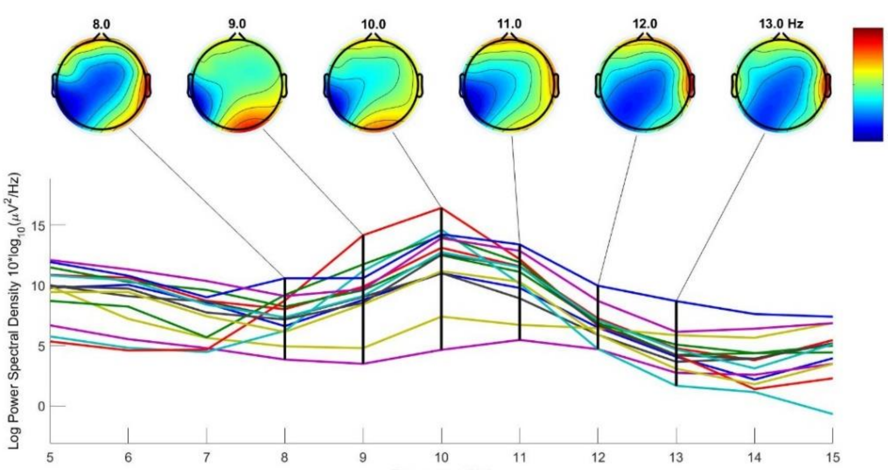


Figure 3. Alpha waves spectrum – 1st phase (eyes open).

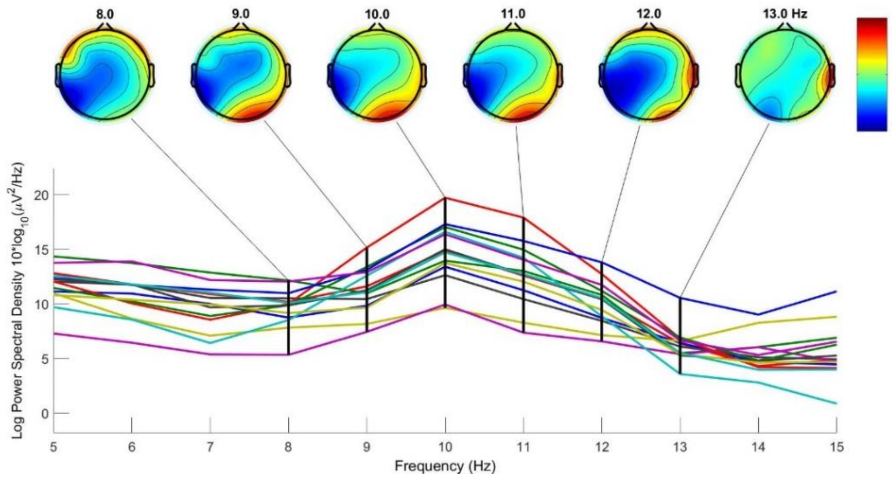


Figure 4. Alpha waves spectrum – 2nd phase (eyes closed).

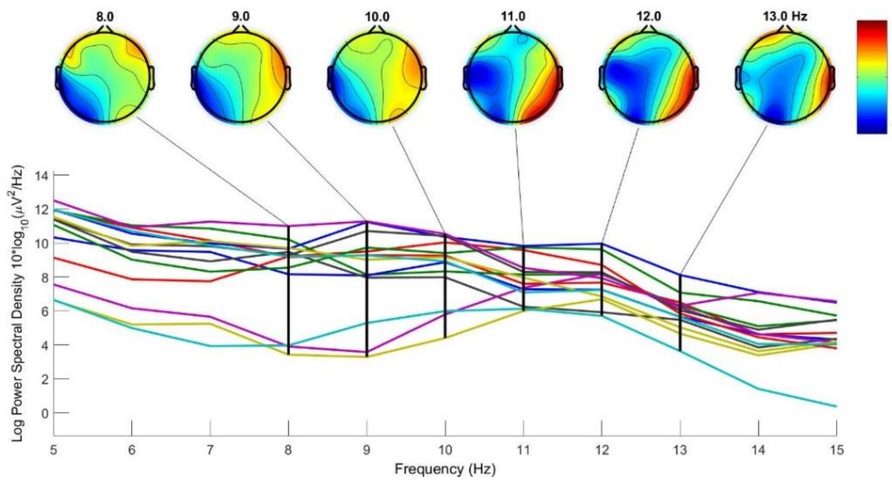


Figure 5. Alpha waves spectrum – 3rd phase (VMI test).

The spectral analyses in the domain of alpha waves with eyes open resulted in alpha rhythm in the area of occipital lobe, somewhat more expressed on the dominant right side. The highest amplitudes were recorded in frequencies of 9 Hz, 10 Hz and 11 Hz. Somewhat lower amplitudes were recorded in the right temporal area in frequencies of 8 Hz, 12 Hz and 13 Hz. These findings are adequate to awaken relaxed state and they are expected considering the subject successfully passed the relaxation phase before recording.

In the second phase (eyes closed) we have noticed an obvious increase of alpha rhythm amplitude. The strongest alpha rhythm is manifested in the area of occipital lobe at frequencies 9 Hz, 10 Hz, 11 Hz and 12 Hz. The recorded rhythm is somewhat more expressed toward the right side. At frequencies 12 Hz and 13 Hz it can be noted that alpha rhythm is also in the right temporal lobe. The obtained results imply a typical increase of the alpha rhythm while resting with the eyes closed which is a consequence of synchronisation of bioelectrical activities of neurones of the same spatial orientation.

Comparing the results of the spectrum analyses in the first and second phase or with the eyes closed and opened, it is possible to observe a manifestation of the alpha rhythm in the temporal lobe. These findings imply the possibility of mu rhythm which in terms of frequency is adequate to alpha waves, but it is also present in the area of motor cortex. It can be assumed that mu rhythm appears as a consequence of synchronised activities of brain neurones. During observation or performance of motor activities the system of mirror neurones is activated whereas they interfere with the remaining neural system. A result of such desynchronization is suppression of the mu rhythm (Oberman et al., 2005).

EEG recording of the subject was carried on in the third phase while solving the VMI test. The subject solved the test in 43 seconds without an error which forms the final result of the VMI test on level 43. The achieved result is in coordination with the results recorded in the previous research which were for boys of average age 7 approximately 41.58 with standard deviation of 10.17 (Bavčević et al., 2015).

While the subject was solving the VMI test the alpha rhythm was recorded in the area of the right occipital lobe with irradiation toward the right parietal and the temporal lobe. The highest amplitudes were recorded at frequencies 11 Hz, 12 Hz and 13 Hz. Also, suppression of the alpha rhythm was noted at frequencies 8 Hz, 9 Hz and 10 Hz in relation to the first and the second phase. These findings are in accordance with expectations since motor involvement results exactly in reduction of the alpha rhythm. Decrease of the alpha rhythm also corresponds to the fact that the subject did not make an error while solving the VMI test which implies to the conclusion that the subject was task oriented while highly concentrated. These findings are in accordance with the conclusions of the previous research whereas the expressed alpha rhythm is connected to the lack of concentration or automatized task solving which results in errors. After making an error there is a suppression of the alpha rhythm which can be explained by an increase of concentration or cognitive control in order to avoid future errors (Mazaheri, Nieuwenhuis, van Dijk & Jensen, 2009).

Spectral analyses in the domain of beta waves included the bandwidth of 14 Hz to 29 Hz. The results of the analyses are shown in Figures 6, 7, and 8.

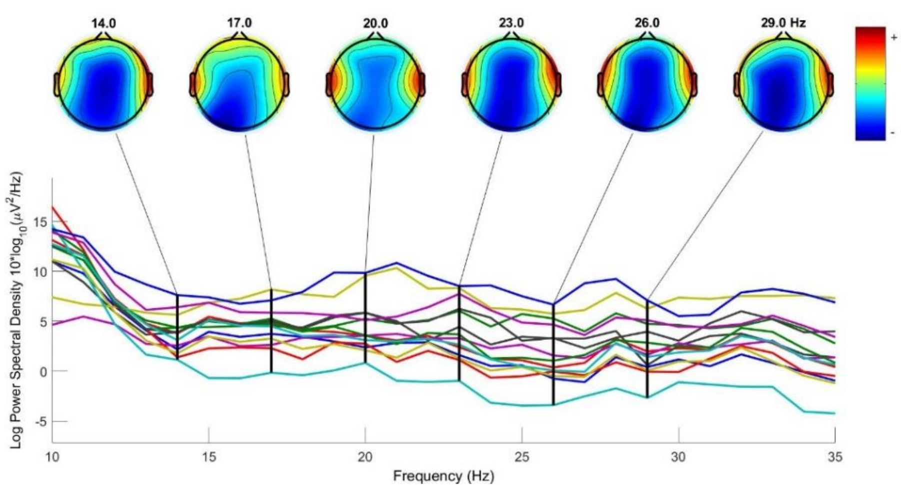


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Figure 6. Beta waves spectrum – 1st phase (eyes open).

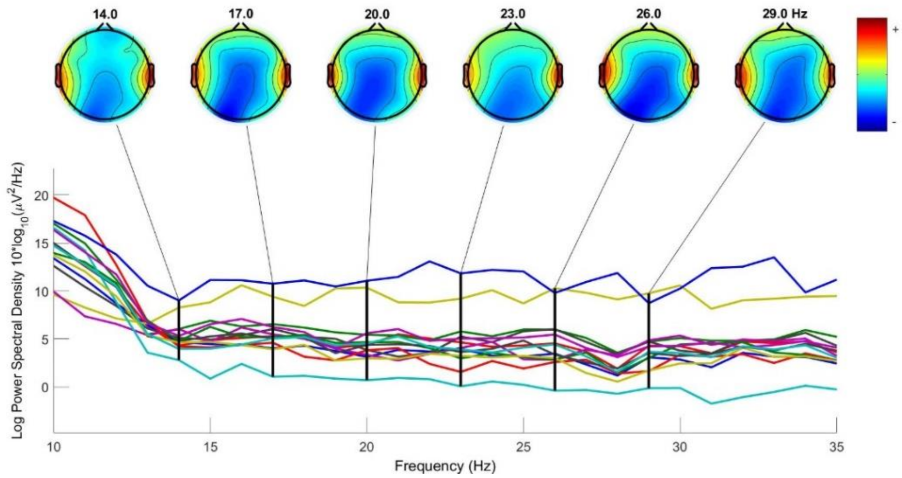


Figure 7. Beta waves spectrum – 2nd phase (eyes closed).

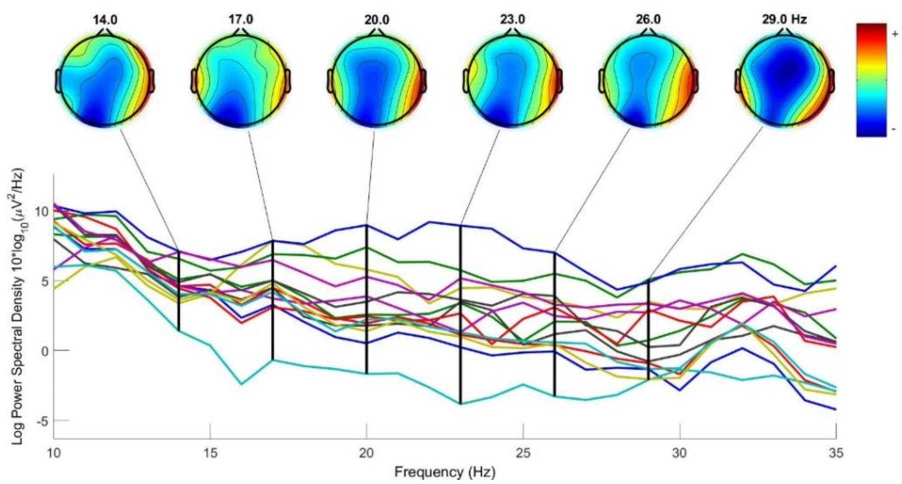


Figure 8. Beta waves spectrum – 3rd phase (VMI test).

In the first phase (eyes open) we have noticed an obvious beta rhythm of symmetrical topological orientation in the subject's left and right temporal lobe. The amplitudes are equally distributed within the observed frequency bandwidth. Slightly expressed amplitudes are noticed at frequencies 20 Hz, 23 Hz and 26 Hz. The obtained results are in accordance with the previous research and they are adequate to the state of active concentration in the subject (Baumeister, Barthel, Geiss & Weiss, 2008).

The spectrum analyses in the second phase (eyes closed) also noted topologically symmetrical beta rhythm predominantly positioned in the left and the right temporal lobe. The amplitudes are equally distributed along the bandwidth and somewhat less expressed in relation to the first phase (eyes open). It can be assumed that the subject in this phase was more relaxed which resulted in reduction of the beta rhythm.

Electroencephalographic recording in the third phase that is while solving the VMI test resulted in increase of the beta rhythm. The highest amplitudes were registered at frequencies 20 Hz, 23 Hz, 26 Hz and 29 Hz, predominantly in the area of the right occipital lobe with irradiation toward the right parietal and temporal lobe. Since solving the test required a high degree of concentration as well as cognitive and motor control from the subject, an increase of the beta rhythm was expected. The obtained results are in accordance with the previous research which imply to connection of the brain waves in the beta spectrum in somatosensory and motor cortex with movement performance and motor control (Baker, 2007; Lalo et al., 2007).

## CONCLUSIONS

Graphomotor skills result from visual-motor integration and the latter represents a complex ontogenetic process of coordinating information which a child receives through sight with muscle effectors responsible of fine motor skills (Bavčević, 2015). The mentioned processes require a functional integration directly dependant on development of the central nervous system.

Results of the implemented research confirmed an increased activity of the brain while performing graphomotor activities in the seven-year-old boy subject. The increased bioelectrical activity is dominant in the bandwidth of the beta rhythm, particularly in the upper part of spectrum of 20 Hz and higher in the band of beta 3 waves. The obtained results imply a conclusion that the activities of graphomotor type in children of the observed age require a high degree of concentration and of sensorimotor control.

Also, expressed brain activity indicates a high percentage of cognitive control while performing graphomotor activities. Based on the previously mentioned, it can be assumed that the process of visual-motor integration at this age is a process of strong development. From the aspect of the theory on motor learning it can be stated that the observed motor programme is still at its initial stage and its successful performance requires a conscious control of thinking.

If we compare the obtained results with the results from the previous research, it can be concluded that in ontogenetic sense the observed age is extremely important in the process of visual-motor integration (Bavčević et al., 2015). This is age of a strong development in processes of integration of neuromuscular system and the result of such changes is a significant improvement of graphomotor skills. Since graphomotor skills directly determine skills such as writing, child's success at school significantly depends on them. Therefore, at this age it is rather important to use a possibility of positive influence on developmental processes, and to make preconditions in both content and programme related sense for the process of visual-motor integration.

Further research in the area of fine motor skills should be oriented toward studying neurological basis of isolated micromotor movements as well as detection of precise brain regions responsible for movement generation and control.

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