International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 9 (2017) pp. 2022-2026

Relative SMR Wave Power Spectra Analysis of Visual Arts Majors and Non-majors

Kwang-Ju Kim and Doo-Hyun Choi*

School of Electronics Engineering, Kyungpook National University, Daegu, 41566, South Korea.
**Corresponding author*

ORCID : 0000-0002-4950-8863

Abstract

The change of SMR (sensorimotor rhythm) power spectrum of human's EEG for visual stimuli is analyzed in this paper. The subjects are consists of two groups of twenties' university students, one is majoring in visual arts and the other is non-majors. Two opposite visual stimuli of abstract paintings (Mondrian's and Kandinsky's) are provided to the two groups. EEG (Electroencephalogram) is measured using a standard equipment manufactured by Laxtha Inc. for 6 positions of the frontal and occipital lobes. The power spectrum of SMR wave for each position is analyzed and it is used to compare between the two groups. It is found that there are obvious difference in brain activity in the viewpoint of SMR power spectrum between the two groups. Major group shows higher brain activity at the frontal lobe for the artistic visual stimuli compared to non-major group and it can be thought as the result of their higher brain activity by analyzing the intention of the artists.

Keywords: EEG, SMR (Sensorimotor rhythm) wave, Artistic visual stimulus, Brain activity

INTRODUCTION

The human body has five senses: visual, auditory, olfactory, taste, and tactile senses. These five sensors transfer external and internal physical stimuli to the brain using electrical signals that can activate neurons. Information acquisition rate by the five senses is different and the arrival speed from a stimuli to the brain is also different. Vision is the highest information gathering sensor and by the reason there are many researches relating human visual sensing. By the way, the electrical signal related to brain activity can be measured by various invasive and noninvasive real-time technologies. The most common approach is EEG (electroencephalogram). EEG is a way to observe the functional state of the brain and allows analysis of the brain state according to human behavior through the analysis of the predominant wave from the EEG signal. So, research on relating to the external stimuli and/or mental activity using EEG is performed from the past [1-4]. Ueda et al. [5] reported that cold colored lights such as blue activated the stable brain wave that is, the alpha wave, and the warm colors such as red and white affected the activation of the agitated brainwave, the beta wave. Hong et al. [6] analyzed the influence of color therapy and stress changes in brain waves. They found that the groups under higher stress experienced a higher level of relaxation when exposed to green or blue colors because their alpha wave increased and high beta waves decreased. Also, Kuller [7], Noguchi and Sakaguchi [8] and Katsuura et al. [9] found that color have psychophysiological influences by analyzing brain waves under the influence of different colors. However, most of the studies use simple visual stimulation such as single color lighting or several colors separately.

In this study, visual art pieces which induce a higher level of m ental activity are used as visual stimuli and the level of brain wa ve activity in the viewpoint of SMR (sensorimotor rhythm) wave for different visual stimuli is analyzed to see the changes in brai n activity. Two abstract paintings with contrasting properties are used as visual stimuli. One is a cold abstract painting by Mondri an (geometric abstract painting) and the other is a hot one by Ka ndinsky (lyric abstract painting). Similar research can be found i n [10] and in this paper we focus on the relative power of SMR wave of the two groups: one is visual art majors having artistic e ducational background and the other is non-majors not having an y artistic background.

EEG & SMR [10]

The brain wave(EEG) is the electric signal measured noninvasively using electrodes attached to the surface of the scalp to sense the activities in the cortex membrane. The brain wave signals may be changed in accordance with the activities of the brain, the conditions at the time of the measurement, and the functions of the brain in terms of the time and the space. Brain waves are usually divided into the δ(delta) wave (0-3 Hz), the θ(theta) wave (4-7 Hz), the α(alpha) wave (8-13 Hz), the β(beta) wave (14-30 Hz), and the γ(gamma) wave (31-50 Hz) by ascending order from the lowest frequency to the highest frequency. In a healthy subject, the alpha wave is apparently activated when one is relaxed, passively responding to the outside, and has one's eyes shut [11-16]. That is, the alpha wave is a stable wave dominant in a state of relaxation, meditation, or

other mentally stable condition [17, 18]. Healthy people who have a high tendency to generate the alpha wave are not dominated by stress [19]. A deficiency in the alpha wave may result in anxiety, stress, brain damage, or disease. The SMR wave (12-15Hz), which is in the middle of the α-wave band and the low β-wave band, manifested when concentrating in a stable state. In other words, it appears in a state of concentration without stress. This paper focuses on this SMR wave difference between visual art major and non-major groups. It can be used for analyzing background educational experience of subjects and current students' attitude.

EXPERIMENTS

The EEG data acquired by [10] is used in this research. A total of 16 male and female college students of 19-25 years old who had no auditory or visual disease are enlisted as the subjects. Six of them are visual arts majors and 10 are not. The visual arts majors are third and fourth year students of the Department of Visual Arts, who are enlisted in consideration of their level of experience in visual arts studies. The non-visual-arts-majors ("non-majors") had various majors unrelated to art and did not have any artistic educational background.

The EEG data measured by PolyG-A (Laxtha, Inc.) is used in this study. To reduce external disturbance, the experiment was performed one by one in a large concert hall and visual stimuli are presented to the subjects using a high quality beam projector. The EEG was measured from six locations (Fp1, Fp2, F3, F4, O1, and O2) of frontal and occipital lobes on the scalp based on international 10-20 system [20] using the monopolar method. The GND (grounding electrode) was attached to the left earlobe (A1), whereas the reference electrode (Ref) was attached to the right earlobe (A2). The visual stimulations used in this study were selected from among geometric abstract (cold abstract) paintings and lyric abstract (hot abstract) paintings that clearly contrasted with each other in terms of the mode of their visual expression. The geometric abstract painting was Composition with red, blue and yellow (1930) (Figure 1a) by Mondrian. The painting was based solely on reason and expressed through the proportions of the segments and colors. For the lyric abstract painting, Composition VIII (1923) (Figure 1b) by Kandinsky was selected. It was based on internal procession in the artist's intuitive use of colors and forms.

(a) (b)

Figure 1. Visual stimulus. (a) Composition with red, blue and yellow (1930). (b) Composition VIII (1923)

The experimental sequence is given in Figure 2. At first, every subjects are required to relax during three minutes to get a reference EEG signal for the subjects. After relaxation each subject get two minute break time. First artistic stimulus is given for three minutes after the break. Another two minute break is given after the stimulus and the other stimulus is followed for three minutes. To minimize the influence of the previous stimulus, a two-minute break is followed after the first visual stimulus and the orders were randomly altered for each subject to eliminate the influence of the stimulation order. It took a total of 13 minutes for a subject to go through the entire process.

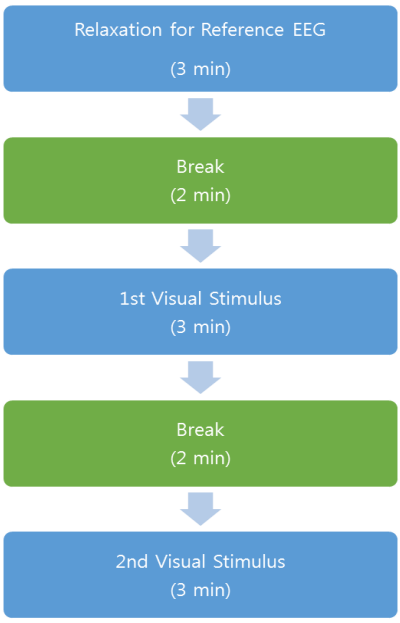


Figure 2. Experimental sequence

RESULT & DISCUSSION

The Telescan data collection and analysis tool and the SPSS 12.0 statistical verification software are used to analyze the EEG signal. The components at each frequency band of EEG and the relative power spectra are analyzed through a power spectrum analysis. For the analysis, the δ wave is excluded because it is prone to noise from cardiac functioning, body movement, blinking of the eyes, etc. The paired t-test is used to analyze the significant differences and 0.05 of the significance probability ($p < 0.05$) is used.

With the two groups of subjects, the statistical values of the paired t-tests of the SMR waves are calculated before and after the contrasting visual stimuli. Table 1 and 2 show the statistical values of the paired t-tests of the SMR waves before and after the ten non-majors were exposed to the geometric and lyric abstract paintings. The non-majors showed a significantly higher SMR wave power spectra at O1 and O2, the occipital lobe of the cerebrum, when the geometric abstract painting was presented to them, based on $p < 0.05$. On the other hand, their SMR wave did not increase significantly after the lyric abstract painting was presented to them. Therefore, it could be said that ordered,

geometric abstract stimulus may induce a more stable and concentration status than irregular, lyric abstraction, wherein the emotions of the artist are manifested freely.

Table 1. Paired t-tests of SMR wave of the non-major group exposed to the geometric abstract painting

Position of electrode	Before		After		P
	Mean	Standard deviation	Mean	Standard deviation	
Fp1	0.0251	0.0169	0.0220	0.0097	0.4068
Fp2	0.0202	0.0125	0.0228	0.0116	0.2928
F3	0.0505	0.0241	0.0555	0.0263	0.3590
F4	0.0496	0.0243	0.0542	0.0287	0.0703
O1	0.0842	0.0337	0.1073	0.0471	0.0171
O2	0.0811	0.0308	0.1116	0.0558	0.0257

Table 2. Paired t-tests of SMR wave of the non-major group exposed to the lyric abstract painting

Position of electrode	Before		After		P
	Mean	Standard deviation	Mean	Standard deviation	
Fp1	0.0251	0.0169	0.0225	0.0096	0.4351
Fp2	0.0202	0.0125	0.0213	0.0094	0.5936
F3	0.0505	0.0241	0.0509	0.0244	0.9346
F4	0.0496	0.0243	0.0484	0.0245	0.7275
O1	0.0842	0.0337	0.0939	0.0387	0.3415
O2	0.0811	0.0308	0.1018	0.0439	0.0885

Next, with the six visual arts majors, the statistical values of the paired t-tests of the SMR waves are calculated before and after the contrasting visual stimuli. Table 3 and 4 show the statistical values of the paired t-tests of the SMR waves before and after the six visual arts majors were exposed to geometric and lyric abstract paintings. The visual arts majors, who were trained in visual arts more than 5 years, showed a significantly higher SMR waves at Fp1, Fp2 and F3, the frontal lobe of the cerebrum when the geometric abstract stimulus was presented to them, based on $p < 0.05$. On the other hand, their SMR wave did not increase significantly after the lyric abstract painting was presented to them. It could be said that the group trained in visual arts focused on analyzing and understanding for geometric abstract painting. On the other hand, it could also be said that the lyric abstract painting drew out the emotions of the artists in an irregular and unrestricted manner, which made it difficult even for them to stay focused.

Figure 3 shows relative power spectra of SMR waves of major and non-major groups for each position according to three stimuli including reference state. Figure 3a shows a plot of the relative power spectrum of non-major group before and after the subjects were exposed to opposite stimuli. Figure 3b shows a plot of the relative power spectra of major group before and after the subjects were exposed to contrasting stimuli. It is found that the occipital lobe of the non-major group shows higher response to the geometric abstract painting than the lyric abstract painting. On the contrary, the frontal lobe of the major group shows higher response to the geometric abstract painting. It implies that the majors try to do higher brain activity and it may be thought as the result of their educational background on visual arts. Figure 4 and 5 show the brain maps of the non-major and major groups for different stimuli respectively. There are obvious difference between the two groups and need to more analysis to clarify the reason.

Table 3. Paired t-tests of SMR wave of the major group exposed to the geometric abstract painting

Position of electrode	Before		After		P
	Mean	Standard deviation	Mean	Standard deviation	
Fp1	0.0168	0.0053	0.0231	0.0067	0.0382
Fp2	0.0145	0.0049	0.0213	0.0066	0.0136
F3	0.0351	0.0100	0.0592	0.0177	0.0494
F4	0.0363	0.0134	0.0561	0.0195	0.1172
O1	0.0876	0.0270	0.0925	0.0304	0.7746
O2	0.0870	0.0107	0.1066	0.0337	0.2366

Table 4. Paired t-tests of SMR wave of the major group exposed to the lyric abstract painting

Position of electrode	Before		After		P
	Mean	Standard deviation	Mean	Standard deviation	
Fp1	0.0168	0.0053	0.0212	0.0091	0.4163
Fp2	0.0145	0.0049	0.0220	0.0120	0.2578
F3	0.0351	0.0100	0.0457	0.0110	0.1793
F4	0.0363	0.0134	0.0464	0.0107	0.2065
O1	0.0876	0.0270	0.0900	0.0272	0.8790
O2	0.0870	0.0107	0.0868	0.0076	0.9802

CONCLUSION

The relative power spectra of visual art major and non-major groups are analyzed in this paper. Two contrasting visual stimuli is used in this study. One is a Mondrian's geometric abstract painting and the other a Kandinsky's lyric abstract painting. EEG signals of Fp1, Fp2, F3, F4, O1, and O2 along the visual cortex are used to analyze the difference of brain activity of the two groups. Both groups show higher concentration on the geometric abstract painting than the lyric abstract painting. But the tendency is a little different. Non-major group shows more attention on the sensing, that is, higher response on the occipital lobe than the frontal lobe. On the contrary, the major group shows more activity at the frontal lobe instead of the occipital lobe. The difference can be found through the brain map also. It can be thought that the difference is caused by their educational background but we have to need more research on this hypothesis using more measurement data from more subjects.

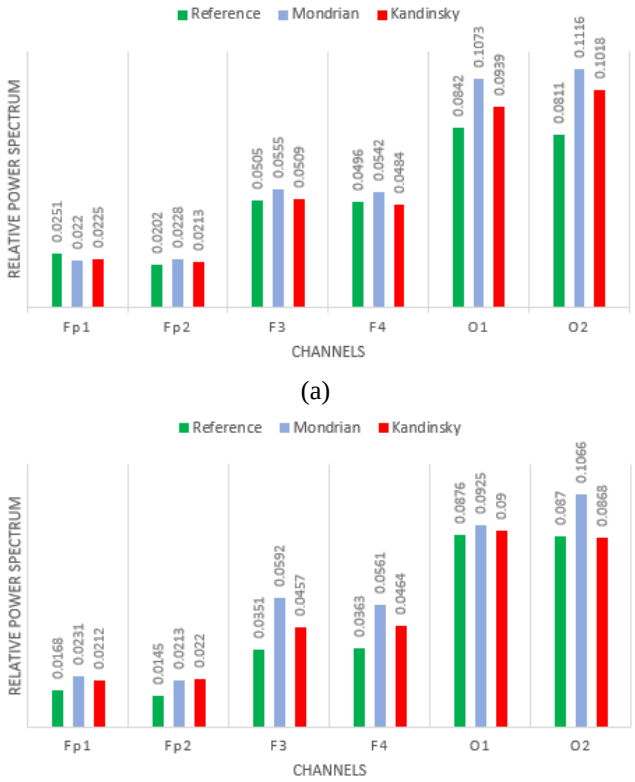
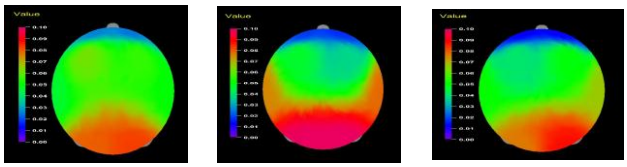
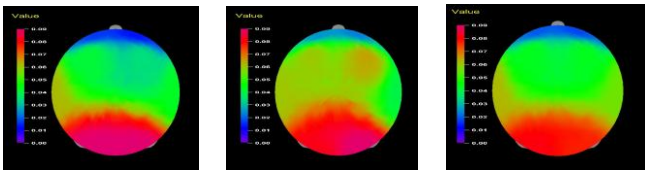


Figure 3. Relative power spectrum of SMR wave in response to contrasting visual stimuli (a) non-major group, (b) major group



(a) (b) (c)

Figure 4. Brain map about relative power spectrum of SMR wave of t he non-major group for contrasting visual stimuli (a) reference, (b) Mo ndrian, and (c) Kandinsky



(a) (b) (c)

Figure 5. Brain map about relative power spectrum of SMR wave of t he major group for contrasting visual stimuli (a) reference, (b) Mondria n, and (c) Kandinsky

REFERENCES

[1] Vogel, W., Broverman, D. M., Klaiber, E. L., 1968, "EEG and Mental Abilities," Electroencephalography and Clinical Neurophysiology, 24, pp. 166-175.

[2] Lutzenberger, W., Elbert, T., and Rockstroh, B., 1987, "A Brief Tutorial on the Implications of Volume Conduction for the Interpretation of the EEG," Journal of Psychophysiology, 7, pp. 81- 89.

[3] Brown, B. B., 1970, "Recognition of Aspects of Consciousness Through Association with EEG Alpha Activity Represented by a Light Signal," Psychophysiology, 6, pp. 442-452.

[4] Yoto, A., Katsuura, T., Iwanaga, K., and Shimomura, Y., 2007, "Effects of Object Colour Stimuli on Human Brain Activities in Perception and Attention Referred to EEG Alpha Band Response," Journal of Physiological Anthropology, 26, pp. 373–379.

[5] Ueda , Y., Hayashi, K., Kuroiwa, K., Miyoshi, N., Kashiba, H., and Takeda, D., 2004, "Consciousness and Recognition of Five Colors—Using Functional-MRI and Brain Wave Measurements," Journal of International Soc Life Info Science, 22, pp. 366–371.

[6] Hong, G. J., Kim, S. M., Lee, B. C., Yi, D. H., and An, S. K., 2009, "The Effect of Color Therapy on Stress and Electroencephalogram Variation," The Korean Society for Aesthetics and Cosmetology, 7(1), pp. 51-59.

[7] Kuller, R., 1986, "Physiological and Psychological Effects of Illumination and Colour in the Interior Environment," Journal of Light and the Visual Environment, 10(2), pp. 33-37.

[8] Noguchi, H., and Sakaguchi, T., 1999, "Effect of Illuminance and Color Temperature on Lowering of Physiological Activity," Journal of Physiological Anthropology and Applied Human Science, 18(4), pp. 117-123.

[9] Katsuura, T, Jin, X., Yasushi, B., Yoshihiro, S., and Koichi, I., 2005, "Effects of Color Temperature of Illumination on Physiological Functions," Journal of Physiological Anthropology and Applied Human Science, 24(4), pp. 321-325.

[10] Kim, K. J., Choi, Y., Lee, K., Lee, N., Son, C. S., and C hoi, D. H., 2015, "EEG Alpha Wave Analysis of Visual Arts Major and Non-major Groups for Contrasting Visu al Stimulations," International Journal of Applied Engin eering Research (ISSN: 0973-4562), 10(20), pp. 41254-41258.

[11] Jang, J. K., and Kim, H., 2011, "EEG Analysis of Learning Attitude Change of Female College Student on E-learning," Journal of the Korea Contents Association, 11(4), pp. 42-50.

[12] Knyazev, G. G., Savostyanov, A. N., and Levin, E. A., 2005, "Uncertainty, Anxiety, and Brain Oscillations," Neuroscience Letters, 387(3), pp. 121-125.

[13] Knyazev, G. G., and Slobodskaya, H. R., 2003, "Personality Trait of Behavioral Inhibition is Associated with Oscillatory Systems Reciprocal Relationship," International Journal of Psychophysiology, 48(3), pp. 247-261.

[14] Knyazev, G. G., Savostyanov, A. N., and Levin, E. A., 2004, "Alpha Oscillations as a Correlate of Trait Anxiety," International Journal of Psychophysiology, 53(2), pp. 147-160.

[15] Olga, B., 2012, "Comments for Current Interpretation EEG Alpha Activity: A Review and Analysis," Journal of Behavioral and Brain Science, 2, pp. 239-248.

[16] Barry, R. J., Clarke, A. R., Johnstone, S. J., and Brown, C. R., 2009, "EEG Differences in Children between Eyes-closed and Eyes-open Resting Conditions," Clinical Neurophysiology, 120, pp. 1806-1811.

[17] Jeong, S. Y., Lee, H. S., Lee, N. S., and Choi, D. H., 2013, "Comparative Study using EEG between Music Major Group and Non-major Group," Journal of the Ergonomics Society of Korea, 32(5), pp. 421-427.

[18] Kim, G. H., and Kim, B. J., 2014, "Reducing the Student's Stress from Studying by Personalized Brain Music Training," International Journal of Multimedia and Ubiquitous Engineering, 9(5), pp. 83-92.

[19] Jeong, C. S., Kim, J. S., and Kim, C. Y., 2014, "Brain-Waves Analysis according to Ego-state and OK-gram of Transactional Analysis Theory," The Journal of the Korea Contents Association, 14(11), pp. 858-863.

[20] Jasper, H. H., 1958, "The Ten-twenty Electrode System of the International Federation," Electroencephalography and Clinical Neurophysiology, 10, pp. 371-375.