Contemporary Engineering Sciences, Vol. 7, 2014, no. 23, 1207 - 1214
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ces.2014.49150

Visual Stimulation and Cerebral Activation

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Abstract

Korean society has seen a surge in the inflow of information, accompanied by colors and lights, with the emergence and technological advancement of devices such as TVs and smart phones. Human beings receive a significant proportion of their information visually. Among the five senses (visual, auditory, olfactory, gustatory, and tactile). Thus, human beings have a high reliance on the visual sense, which undoubtedly plays a crucial role in their lives. For that reason, research has been conducted in various fields to develop applications involving the visual sense. Particularly, it has been vigorously aiming to induce direct changes in physical conditions, such as the visual stimulus-induced physiological changes in the human body, emotional enrichment, concentration, attention, etc. However, the applications have yet to be developed, or have made very slow progress.

This study presents the analysis of the changes in cerebral activation induced by visual stimuli delivered through a combination of colors, and has derived significant results associated with the changes in relation to indices of concentration, psychology, etc., based on the variation of stimulation.

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Keywords: Brain wave activation, Color stimulation, Frequency analysis

1 Introduction

Lately, our society has witnessed a surge in glitzy advertisements and digital media with the advancement of smart phones and compact digital equipment, and visual stimulation by myriad colors and lights. Human beings receive this stumuli through the five senses: sight, hearing, smell, taste, and touch. The proportion of information acquired visually exceeds 80 % of the total through the five senses [1-5]. In addition, sight is an important sense to properly adapt to and cope with various environments.

Cerebral activation is defined as the increase in regional cerebral blood flow (rCBF) and glycometabolism in a specific part of the brain during the performance of specific tasks under normal conditions [4].

The methods for measuring cerebral activation include Positron Emission Tomography (PET), functional Magnetic Resonance Image (fMRI), and the electrocorticography (ECoG) apparatus. The fMRI measures the cerebral activation by using the blood oxygenation level dependent (BOLD) signal. BOLD has the advantage of having a strong signal and can measure the entire brain, but is also time consuming and costly [6-8]. Although the ECoG apparatus can measure only local regions of the brain, it can resolve the problem of time and cost and has been used increasingly, more for the advantage that it is harmless to the human body, and convenient.

Research has been conducted to analyze the state of human cerebral activation induced by exposure to colors and images. The visual stimuli used in this research include pictures with a variety of colors, designs flashing colored lights, etc. [9, 10]. However, there was concern that the method involving color stimuli was not systematic and dependent on the reaction alone. Therefore, in this study, we selected six colors: red, yellow, green, cyan, (often referred to as sky blue) blue, and purple, using the CMYK (cyan, magenta, yellow, and black) color code, and 20 color wheel designated by the Ministry of Education, in order to resolve such problems. Moreover, the visual images were produced by dividing the colors into background colors and character colors, to analyze the cerebral activation state of users.

2 Analysis of cerebral activation state based on the changes in visual stimuli

In this study, an experiment was conducted to investigate the cerebral activation state of the user for visual stimuli. The experiment was carried out by minimizing external factors such as light, and noise in a booth with a holding capacity of 1 person, to ensure stable extraction of brain waves from the subjects. 50 subjects in their 20s and 30s (comprised of 25 men and 25 women) were selected for this experiment, who were physically healthy, and without any neurological or mental illness, color-blindness or cognitive impairment.

2.1 Experiment Methodology

In this experiment, we selected the 6 color groups comprised of A. red, B. yellow, C. green, D. cyan, E. blue, and F. purple colors, using the educational 20 color wheel designated by the Ministry of Education and CMYK color code as the background color and character colors.

2.2 Color Stimulus Method

The colors were divided into groups comprised of 6 representative colors of A, B, C, D, E, and F designated in Fig. 1 and 2. If one of the main colors in characters is selected, the color wheel turns clockwise based on the color group where the given color belongs. By combining the color groups of the background in the order of A, B, C, D, E, and F, the color group consisting of 36 colors is selected. In case the character color and background color are the same, the intensity of the character color is lowered by one step, based on the CMYK color code for color group combinations.

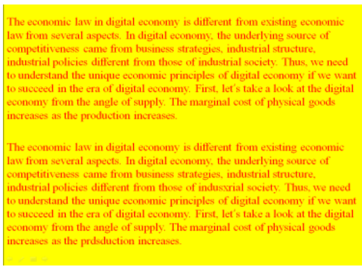

Fig.1. Example image type(sentence) used in the experiment

Fig 2. Example image type(words) used in the experiment

2.3. Electrode placement method to collect brain waves

Using the montage, a total of 10 positions were selected, including F7 and F8 (related to cognitive domains in brain structure), T3, T4, T5, and T6 (responsible for auditory and visual information), 8 points of O1 and O2 (responsible for visual area), earlobe A1, and A2-based electrode.

2.4. Process of Experiment

In the experiment, the subjects were made to watch videos, made up of 36 images, for 90 seconds. Each time one of the videos ended, a rest time of 30 seconds followed. The duration of the experiment was largely divided into the video watching time and resting time. The brain waves were measured to collect electroencephalographic data from the subjects in real time.

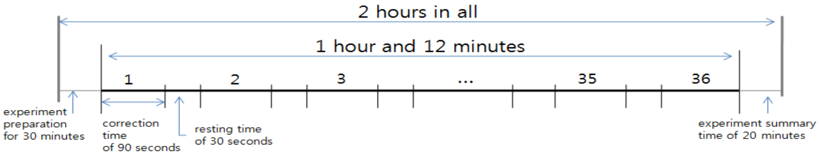

Fig. 3. Process of experiment

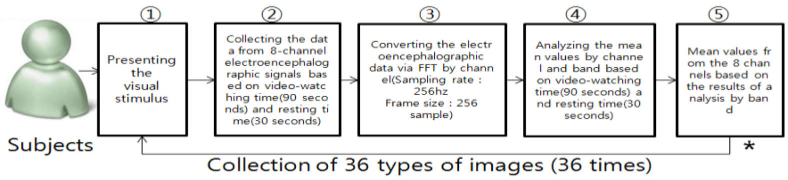

Fig 4. Mean values relative to the results of each video based on the data collection and conversion processes

In this study, the mean values of the collected electroencephalographic data were analyzed based on 5 stages according to the method presented in Fig. 3 and Fig. 4.

3 Results of Experiment

In this study, changes in cerebral activation states were analyzed after presenting the videos consisting of 36 types of images as stimuli to the subjects in an experiment. In order to compare the top 10 images that caused the greatest visual stimulus induced changes in cerebral activation states based on specific band, 3 analytical methods were employed in accordance with the method presented in Fig. 5.

First, the analysis based on the mean values applied the quantitative electroencephalographic (brain wave) values of men and women responding to the visual stimuli from individual images within the group of 36 images. The 8 channel brain wave mean values for the group of 25 men and 25 women were analyzed by gender separately, and jointly, and classified in descending order, followed by the selection of the top 10 stimulating methods found to have the greatest impact.

Second, an insignificant difference was observed in the mean values of high impact images and low impact images among the 36 images when the analysis applied the mean values. To ensure significant differentiation of means values by image, quantitative values were used based on the rank of impact of the results. For that, the * values in Fig. 5 were classified in descending order, followed by the rank analysis of the 8 channel mean values by image. After the rank analysis, the quantification method was used on the basis of the rank presented in Formula (1) to apply the weighted value. After applying the weighted value, the 8 channel mean values were analyzed by gender separately, and jointly, and classified in descending order. Following that, the top 10 stimulating methods which had high quantitative values were selected.

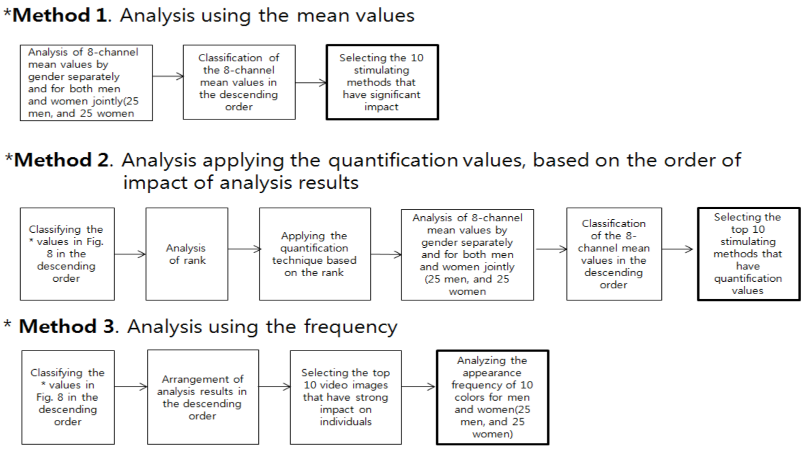

Fig. 5. Analytical methods used in this study

Quantitative value based on rank = (36 (total number of visual stimulation videos) - rank)/36 (total number of visual stimulation videos) (1)

Third, the video images with the greatest frequency could be determined based on the results of the analysis using the frequency. Regarding the method of analysis, the * values in Fig. 5 were classified, followed by the arrangement of analysis results in descending order. After this arrangement, the top 10 images were selected which had the greatest impact on individuals. Then, the frequency of the top 10 colors for men and women was analyzed.

3.1. Analysis of the changes in cerebral activation state by band

The combination of colors, which cause visual stimulus-induced changes in cerebral activation state by band, was presented in Fig, 6 through Fig. 11, indicating the mean values for both genders based on quantification values and video-watching time/resting time, analysis based on frequency. The Table 1 summarizes the results of analysis presented in Fig. 6 through 11.

Table1. Combination of colors inducing the changes in cerebral activation state by band

Band	Video-watching time Color group combining the top-ranking colors inducing the changes in cerebral activation state during the video-watching	Resting time, Color group combining the top-ranking colors inducing the changes in cerebral activation state after the video-watching
Delta	Color combination that includes the green, cyan, blue, and purple colors	Color combination that includes the green, cyan, and blue colors
Theta	Combination of colors that include the warm colors, such as yellow and red colors, and cold colors such as blue and purple colors	Combination of cold colors that include the green, blue colors, cyan, and purple colors
Alpha	Combination of cold colors that include the green, blue, and purple colors	Combination of warm color and cold color, such as the combination of red and blue colors
Beta	Combination of colors of same group, such as the combination of red color and red color and combination of green color and cyan color	Combination of colors of same group in the same way as the video-watching time
Gamma	Combination of colors that include the red color, such as the red color and red color, red color and purple color	Combination of colors that include the red color in the same way as the video-watching time
SMR	Combination of colors with excellent clarity, such as the combination of red and purple colors and combination of green and red colors	Combination of colors with excellent clarity in the same way as the video-watching time

4 Conclusion

This study presented an experiment investigating the visual stimulus-induced cerebral activation state of the user to analyze changes in the cerebral activation state of humans responding to color stimuli. By applying such results, the development of various application services can be expected. For example, cerebral activation in the delta band of certain users might be considered necessary to achieve specific functional goals. If a user watches video images, the functional goal may be achieved by the exposure to stimulus delivered through a combination of colors including cold colors such as green, cyan, blue, and purple. If this particular user is taking a rest without being exposed to the stimulus of video images, the colors combinations of green, cyan, and blue, which were used prior to the resting time, can be presented to reinforce the cerebral activation state in the delta band of the user.

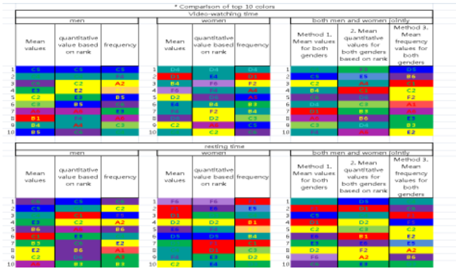

Fig. 6.Comparison of top 10 colors based on the changes in color stimulation (delta band)

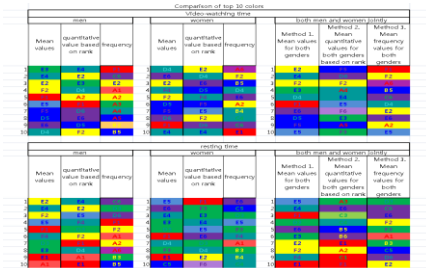

Fig. 7.Comparison of top 10 colors based on the changes in color stimulation (theta band)

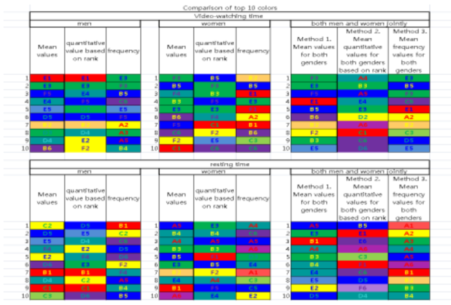

Fig. 8.Comparison of top 10 colors based on the changes in color stimulation (alpha band)

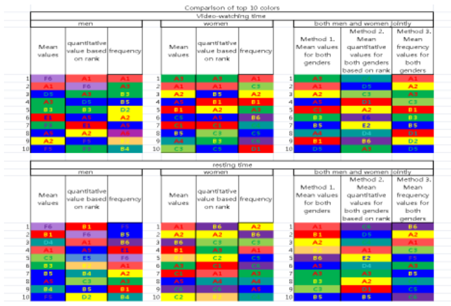

Fig. 9.Comparison of top 10 colors based on the changes in color stimulation (beta band)

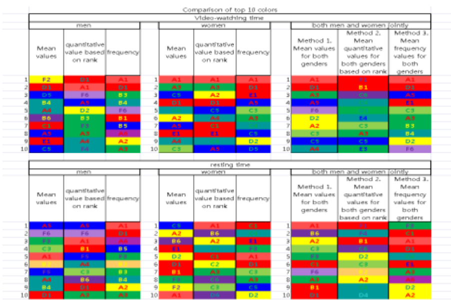

Fig. 10. Comparison of top 10 colors based on the changes in color stimulation (gamma band)

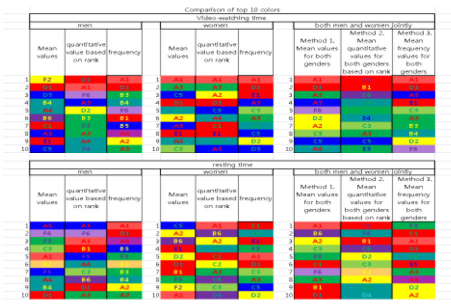

Fig. 11. Comparison of top 10 colors based on the changes in color stimulation (SMR band)

Acknowledgements. This work was supported by the DGIST R&D Program of the Ministry of Science, ICT and Future Planning of Korea (14-BD-01). And this work was supported by NRF-2012R1A1A4A01011858

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Received: August 1, 2014