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EEG Analysis of Brain Activity Changes Depending on Illuminance Level and Video Type

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Abstract

The purpose of this study was to analyze the difference in brain activity depending on the nature video type and illuminance level. When the "Only" and "Mix" nature videos were watched and the difference in brain activity was analyzed, the parts of the parietal lobes exhibited statistically significant differences, depending on the video type. Brain activity was analyzed also while the videos were watched in the illuminance "On" and "Off" conditions. Most parts of the brain exhibited higher brain activity in the "On" condition than in the "Off" condition. The results of this study showed that the scenery visual stimulation felt by the subjects varied depending on the video type, and that the illuminance level when the videos were watched also had an influence. Based on this result, it is expected that the videos used in this study will be utilized in the future for screen therapy by the scenery video stimulation, such as induction of brain activation to increase the cognitive function and parietal lobe activation reaction to increase the learning function.

Keywords: illuminance, brain activity, EEG, ECG, brain map, screen therapy, video, contents type

I. INTRODUCTION

South Korea has the highest suicide rate among the Organization for Economic Cooperation and Development (OECD) members. Additionally, cancer ranks first among the major causes of death in the country. Cancer is defined as a typical stress-caused disease, in that it is a representative physical illness that occurs owing to stress-induced weakened immune function of the human body [1]. Keyes (2007) notes that an improvement in the mental health of the population is required to prevent and help treat stress-induced diseases [2]. According to the results of a survey conducted by the National Center for Mental Health on mental health perceptions and attitudes, approximately 64% of the respondents answered that "people with mental illness can also live a normal life," and approximately 70% responded that "depression is curable". More than 60% of the respondents agreed with the statement that "people with mental illness are more dangerous than those without".

In recent years, studies on mental health in the field of psychiatry have been conducted based on empirical and objective brain science rather than analytical psychological theories. Additionally, psychotherapy also utilizes art, music, plays, dance, and videos rather than verbal methods through dialog [3]. In the US, research on technologies to understand the brain functions and on mental illness, such as depression and traumatic brain injury, has been conducted at a national level through the brain initiative. Additionally, the nonprofit organization Screening for Mental Health (SMH) provides opportunities in the US for mental health checkups, as well as education for connecting suitable treatment systems for individuals, and improving mental health perceptions [4]. The US-based suicide prevention Jed Foundation provides a connection service between counselors and target individuals to prevent depression and improve mental health [5]. In Japan, the Mental Health Research Institute conducts research on policies for mental illness at the national level. It also establishes regional health management strategies and plans, and constructs and operates systems for the management of patients with mental illness.

II. RELATED WORK

Multiple efforts have been made to observe electrophysiological changes in the brain using the electroencephalogram (EEG). Brain dysfunctions make it difficult to adjust the electrical activity of the brain, which appears on EEG in real time [6]. The EEG can be used as the brain imaging techniques in studies on mental health. The EEG, along with magnetoencephalography (MEG), exhibits the highest temporal resolution among record the spontaneous electrical activity of the brain through multiple electrodes attached to the scalp, and reflect the sum of the electrical activities that simultaneously occur in tens of thousands of neurons [7]. Many of the previous studies conducted to observe changes in patients with depression using EEG showed that these patients exhibited a unique abnormal asymmetric activity pattern in the frontal lobe, due to the relatively low activity in the left frontal lobe and relatively high activity in the right frontal lobe [8][9][10][11]. The main parts that exhibit abnormal findings in functional brain imaging studies on depression are the tonsil, hippocampus, prefrontal lobe, anterior cingulate cortex, and orbitofrontal cortex. Among these parts, the part that most frequently exhibits dysfunction is the prefrontal lobe [12][13][14]. Studies have been actively conducted of late to monitor mental health or to predict the most effective treatment response though EEG analysis [15][16][17]. Additionally, there is a growing amount of evidence that the EEG-based electrophysiological changes of depression are useful in predicting responses to antidepressants and guiding therapeutic decisions in clinical practice [7].

Many attempts have been made in the field of psychiatry or clinical psychology, which deals with mental health, to develop various methods to effectively manage mental illnesses such as excessive stress, post-traumatic stress, and depression. In particular, in the “therapeutic recreation” area, studies have been actively conducted on music, art, and video therapy, and diagnostic manuals of therapeutic effects have been developed. For video therapy (screen therapy), in particular, many researchers have insisted that unstructured or structured therapeutic effects can be used regardless of the theoretical orientation of the therapist [18][19]. Laumanna et al. (2003) analyzed changes in selective attention and heart rate according to the stimulation of video data, and found that a group of test subjects that watched natural environment videos had a longer average heart rate interval [20]. Jiang et al. (2019) allowed adult groups to watch various natural landscape photographs and then analyzed changes in the physiological indices of EEG and blood pressure [21]. The results indicated that there were significant differences in EEG and blood pressure, depending on the types of natural landscape photographs. Vincent et al. (2010) examined whether stimulation using nature videos has the effect of alleviating stress responses, and reported that the blood pressure, heart rate, bad moods, and unpleasant emotional reactions were indeed alleviated [22]. In terms of psychotherapy, biological treatment with psychotropic medications may cause dependence or toxicity due to medication overdose. Furthermore, all medications have side effects, and their excessive long-term dose may cause a burden on various organs, such as liver and kidneys. Therefore, efforts have been actively made to relieve stress or address mental health problems using various methods other than medications. To use these methodologies, their effectiveness must be closely examined. Additionally, it is very important to present objective conditions together, because environmental conditions related to visual stimulation may also have an impact. Therefore, the purpose of this study is to investigate differences in brain activity responses depending on various nature video types and illuminance levels.

III. METHOD

III.I Test subjects

In this study, tests were conducted on adults with excellent mental and physical health. The selected subjects did not have any mental or physical disease for a year prior to the study. The total number of participants in the experiment was 24 (12 males and 12 females). The subjects ages ranged from 21 to 31, with an average age of 25.1 (SD 3.5). This study was conducted after being approved by the National Bioethics Committee (1041107-201902-HR-001-01). The subjects participated in the experiment after they were fully aware of precautions on no drinking within 24 hours, no caffeine and smoking within two hours, and no eating within one hour of the test.

III.II Apparatuses and data collection

The EEG was measured after selecting a total of 19 positions in the prefrontal lobe (Fp1, Fp2), frontal lobe (F7, F3, Fz, F4, F8), parietal lobe (P3, Pz, P4), temporal lobe (T3, T4, T5, T6), central lobe (C3, Cz, C4), and occipital lobe (O1, O2) of the left and right hemispheres (Fig. 1). The reference electrode A1 was attached to the back of the right earlobe and the ground electrode was attached to the forehead.

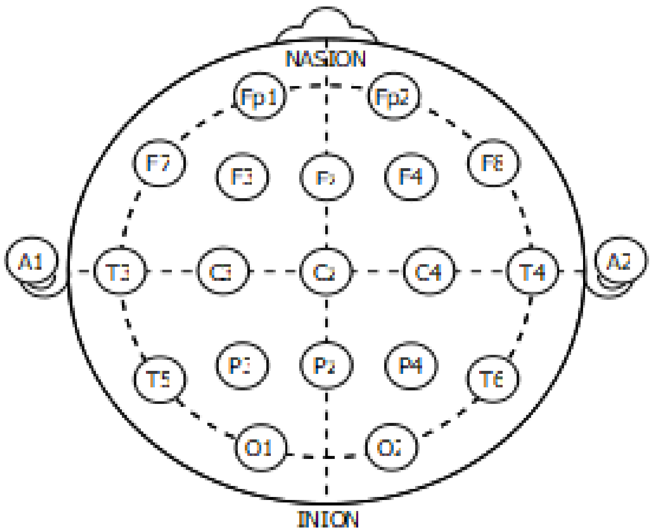

Fig. 1. EEG Electrode position

EEG and electrocardiogram (ECG) signals were measured using BIOS-24 (BioBrain Inc., Daejeon, Korea), a wired 24-channel polygraph system. The measured EEG analog signals

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were sampled at 250 Hz, converted into digital signals, and transmitted to a personal computer via USB. The transmitted digital EEG signals were filtered using BioScan (BioBrain Inc. Daejeon, Korea), an EEG analysis software program, and EEG rhythm data were created for each frequency domain. Spectral values that reflect the quantitative amounts of EEG rhythms were calculated. In this instance, EEG analysis indices followed the definitions of Kim (2016) (Table 1) [23].

Table 1. Abbreviation, full terminology, frequency range of EEG (Kim, 2016)[23]

Abbreviation	Full Terminology	Frequency Range (Hz)
AT	Absolute Theta Power Spectrum	4-8
AA	Absolute Alpha Power Spectrum	8-13
AB	Absolute Beta Power Spectrum	13-30
AG	Absolute Gamma Power Spectrum	30-50
AFA	Absolute Fast Alpha Power Spectrum	11-13
ASA	Absolute Slow Alpha Power Spectrum	8-11
ALB	Absolute Low Beta Power Spectrum	12-15
AMB	Absolute Mid Beta Power Spectrum	15-20
AHB	Absolute High Beta Power Spectrum	20-30
RT	Relative Theta Power Spectrum	4-8/4-50
RA	Relative Alpha Power Spectrum	8-13/4-50
RB	Relative Beta Power Spectrum	13-30/4-50
RG	Relative Gamma Power Spectrum	30-50/4-50
RFA	Relative Fast Alpha Power Spectrum	11-13/4-50
RSA	Relative Slow Alpha Power Spectrum	8-11/4-50
RLB	Relative Low Beta Power Spectrum	12-15/4-50
RMB	Relative Mid Beta Power Spectrum	15-20/4-50
RHB	Relative High Beta Power Spectrum	20-30/4-50
RST	Ratio of SMR to Theta	12-15/4-8
RMT	Ratio of Mid Beta to Theta	15-20/4-8
RSMT	Ratio of (SMR~Mid Beta) to Theta	12-20/4-8
RAHB	Ratio of Alpha to High Beta	8-13/20-30
SEF50	Spectral Edge Frequency 50% = Median Frequency	4-50
SEF90	Spectral Edge Frequency 90%	4-50
ASEF	Spectral Edge Frequency 50% of Alpha Spectrum Band	8-13

III.III Experimental setup and procedure

A 65-inch LG UHD TV was used as a video stimulation tool. The temperature of the laboratory ranged from 24℃ to 25℃, and humidity ranged from 30% to 45% (Hd). There were two illuminance levels, and tests were conducted in the either "On" or "Off" condition. The average illuminance was 245 lux in the illuminance "On" condition, and 12 lux in the illuminance "Off" condition, respectively. Although the 65-inch UHD TV was used in this study, the viewing distance in the experiment was applied based on HD, because the videos for stimulation were produced mainly using an HD (1080) camera. In this study, the subjects were seated at a viewing distance of 2.6 m, as recommended by the results of Poynton (1996)[24]. The optimal viewing distance can be calculated using equation (1). The viewing distance is closely related to scanning lines, and it decreases as the number of scanning lines increases.

$$\text{Optimal viewing distance} = \frac{3400}{\text{Scanning lines}} \times PH\ (Picture\ Height) \tag{1}$$

The decibel measurements (DB) of each video were as follows: the average value of video A was 52.25 DB and that of video B was slightly higher at 53.9 DB. The DB of each sub-video was examined. The average DB value of the three nature videos in video A was 51 DB, and that of the fourth video with natural scenes and people was 54.5 DB. The average DB value of the three nature videos in video B was 50.5 DB, and that of the fourth video with city scenes and people was 53 DB. In all instances, a slightly higher DB value was observed in videos with people or city scenes compared to the videos with only natural scenes.

Table 2 shows the experimental procedure. Before the subjects watched the first videos (ⓐ,Ⓐ; Video 1), a pre-test (Pre-test 1) that included the status of caffeine intake, drinking, and smoking, as well as demographic information was conducted, and devices were attached for the EEG measurement. The guide subtitles that inform the experimental procedure were then displayed for 20 seconds, and the subjects were instructed to close their eyes for 60 seconds while a black screen appeared. They opened their eyes and stared at a green screen for 20 seconds, and then watched the first videos (ⓐ,Ⓐ). A post-survey was then conducted (Post-test 1). After a ten-minute break, they again closed their eyes for 60 seconds, stared at a green screen for 30 seconds, and watched the second videos (ⓑ,Ⓑ; Video 2). All videos were displayed for 14 minutes. In two weeks, the subjects watched the third (ⓒ,Ⓒ; Video 3) and fourth (ⓓ,Ⓓ; Video 4) videos in the same procedure, after conducting a pre-test (Pre-test 2). All the procedures described above were conducted for each subject.

Table 2. Experimental procedure

Screen	Time required	Remark
Conducting a pre-survey	5 minutes	Checking the stress index
Black screen + CG	20 seconds	Guide subtitles (informing about experimental procedure)
Black screen	60 seconds	"Ding-dong" chime bell starts: closing the eyes; chime bell ends: opening the eyes
Green screen	20 seconds	Staring at a green screen
First exposure to videos	14 minutes	Watching the nature videos of the experiment
Conducting a post-survey on the first videos	6 minutes	Survey
Break	10 minutes	Taking a rest with the EEG monitor attached
Black screen	60 seconds	"Ding-dong" chime bell start: closing the eyes; chime bell ends: opening the eyes
Green screen	20 seconds	Staring at a green screen
Second exposure to videos	14 minutes	Watching the nature videos of the experiment
Conducting a post-survey on the second videos	6 minutes	Survey

III.IV Experimental design and statistical analysis

The independent variables of this study are the video type and illuminance level. The videos are mainly divided into two types: single landscape ("Only") and mixed landscapes ("Mix"). In the case of the single landscape (Only) group, three videos with a single natural landscape (ⓐ, ⓑ, ⓒ) and a video containing both a mixture of ⓐ, ⓑ, ⓒ, and people were watched through the UHD TV screen. In the case of the mixed landscape ("Mix") group, three videos with mixed natural landscapes (Ⓐ, Ⓑ, Ⓒ) and a video with a city view and people were watched. More specifically, the single landscape group watched the videos of ⓐ [mountain, field], ⓑ [sea, ocean], ⓒ [lake, river, valleys], and ⓓ [mountain and field/sea and ocean/lake, river, and valley + people]. The mixed landscape group watched Ⓐ [mountain, field + sea, ocean], Ⓑ [sea, ocean + lake, river], Ⓒ [mountain, field + lake, river, valley], and Ⓓ [city + people] (Table 3). As for the mixture of natural landscapes, their time proportions were not considered, and the videos were randomly arranged. There were two illuminance levels, specifically the "On' and "Off" conditions. The average illuminance of the "On" condition was set to 245 lux, and that of the 'Off" condition was set to 12 lux.)

The Mathematica software was used for statistical analysis. A non-parametric variance analysis (Kruskal-Wallis test), which does not consider descriptive statistics for each factor and the characteristics of the population, was conducted to analyze differences, depending on the video type (four "Only" videos and four "Mix" videos). The Mann-Whitney test was conducted to statistically verify the difference between the single landscape ("Only") and mixed landscape ("Mix") videos, and the difference between the two illuminance levels ("On" and "Off" conditions)

Table 3. Independent variable (video intervention)

Group	Type 1	Type 2	Type 3	Type 4
"Only"	ⓐ	ⓑ	ⓒ	ⓓ
				
"Mix"	Ⓐ	Ⓑ	Ⓒ	Ⓓ
				

IV. RESULT

IV.I Difference in brain activity depending on video type

IV.I.I Brain activity for the "Only" videos

Table 4 shows the Kruskal-Wallis test results. The parts and indices that exhibited statistically significant differences depending on the videos of ⓐ [mountain, field], ⓑ [sea, ocean] ⓒ [lake, river valley], and ⓓ [mountain, field/sea, ocean/lake, river, valley + people] were P4_AT, AB, AG, ALB, AMB, AHB, P3_AB, AG, and AMB. Table 5 shows the brain map (mean) for the indices that exhibited statistically significant differences.

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Table 4. Kruskal-Wallis test results of "Only" contents type (p<0.1)

Index	x2	P-value	Mean			
			ⓐ	ⓑ	ⓒ	ⓓ
P4_AT	6.19983	0.09817	13.70952	12.6852	16.26573	16.52533
P3_AB	7.234694	0.059217	13.06648	11.53916	14.92116	14.32099
P3_AG	7.327381	0.056536	9.108076	7.624461	11.27574	10.84514
P4_AG	6.361395	0.090852	9.757172	8.688031	12.99774	13.29097
P4_ALB	6.068878	0.094491	8.571081	7.699297	11.50258	11.5895
P3_AMB	6.706633	0.076851	8.654842	7.093939	10.43154	9.857275
P4_AMB	5.492347	0.096927	8.676342	7.710319	11.8382	11.95653
P4_AHB	5.915816	0.092345	9.505959	8.483591	12.76017	13.00023

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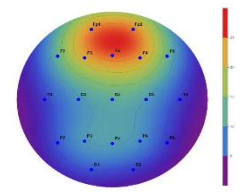
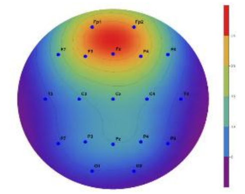
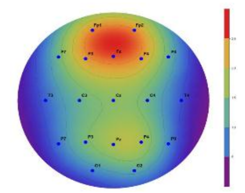
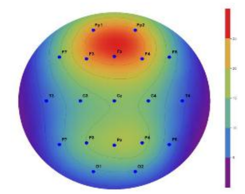
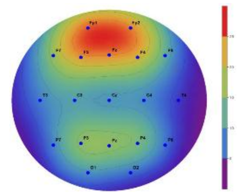
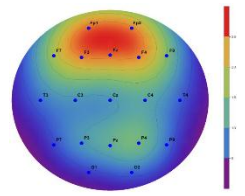
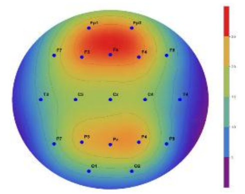
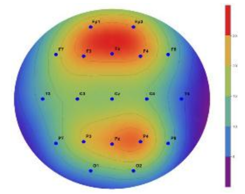
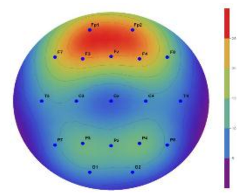
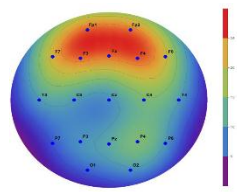
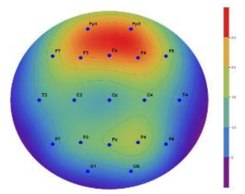
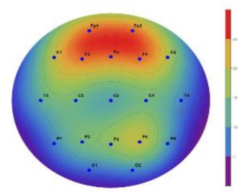
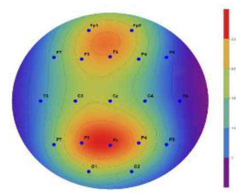
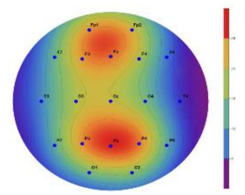
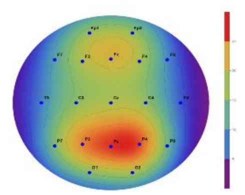
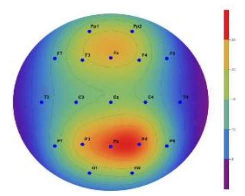
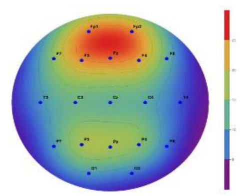
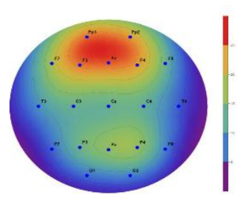
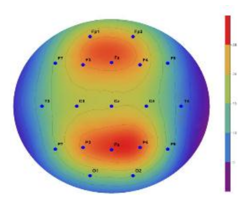
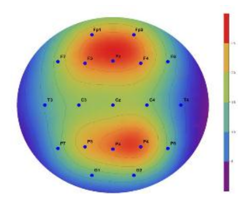
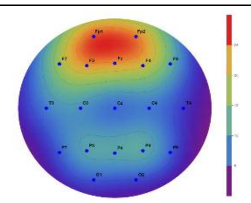
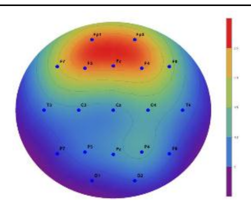
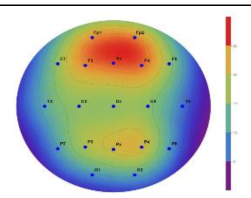
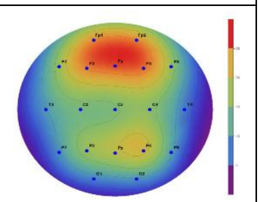
P3 and P4 are located in the parietal lobe. The parietal lobe exhibited higher brain activity when the videos of ⓒ [lake, river, valley] and ⓓ [mountain, field/sea, ocean/lake, river, valley + people] were watched, compared to when ⓐ [mountain, field] and ⓑ [sea, ocean] were watched (Table 5).

Table 5. Brain map by "Only" contents type

AT				
	ⓐ	ⓑ	ⓒ	ⓓ
AB				
	ⓐ	ⓑ	ⓒ	ⓓ
AG				
	ⓐ	ⓑ	ⓒ	ⓓ
ALB				
	ⓐ	ⓑ	ⓒ	ⓓ
AMB				
	ⓐ	ⓑ	ⓒ	ⓓ
AHB				
	ⓐ	ⓑ	ⓒ	ⓓ

IV.I.II Brain activity for the "Mix" videos

Table 6 shows the Kruskal-Wallis test results. When the "Mix" videos of Ⓐ [mountain/field + sea, ocean], Ⓑ [sea, ocean + lake, river], Ⓒ [mountain, field + lake, river, valley], and Ⓓ [city + people] were watched, P3_AT, AB, AG, AFA, ALB, AMB, RB, RMB, and RHB exhibited statistically significant differences. P4_AB, AFA, ALB, and AMB also

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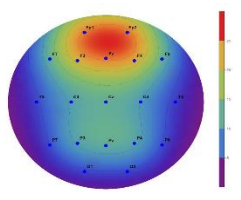
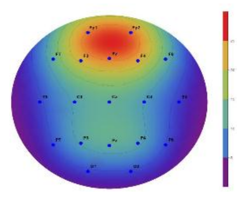
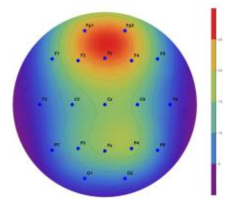
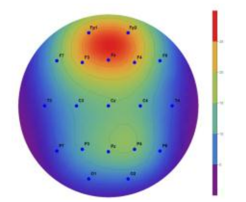
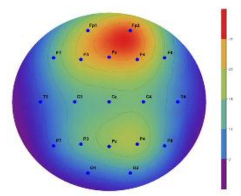
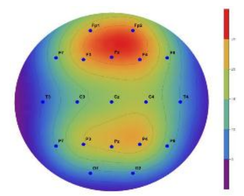
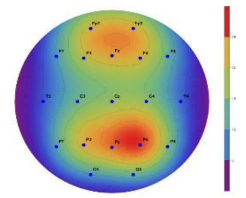
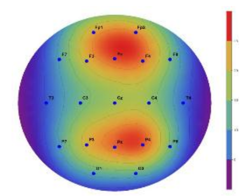
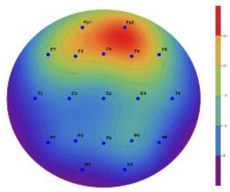
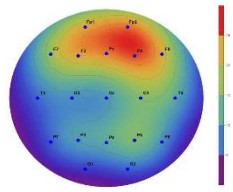
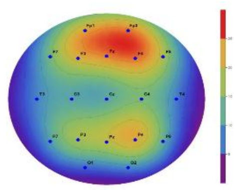
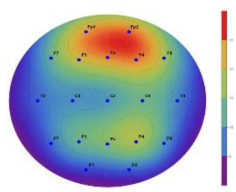
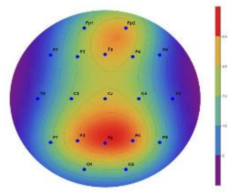
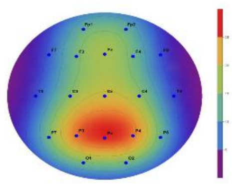
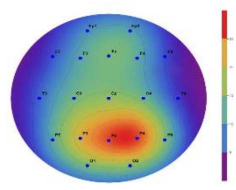
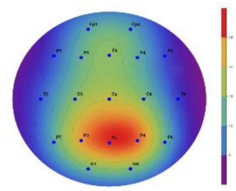
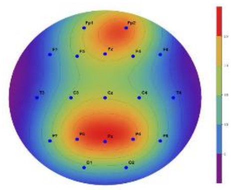
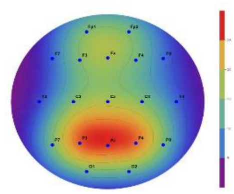
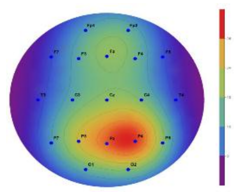
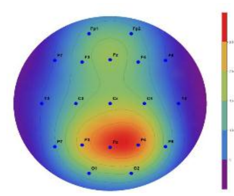
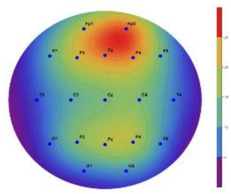
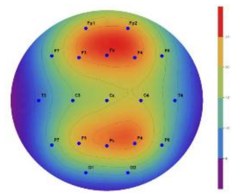
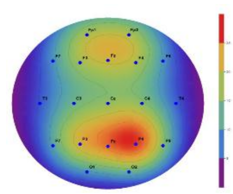
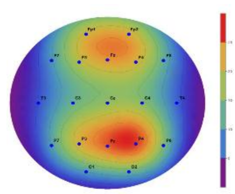
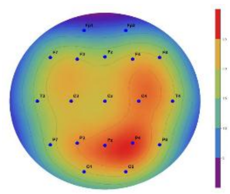
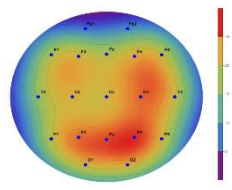
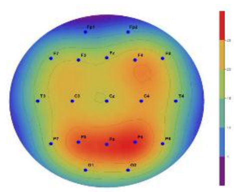
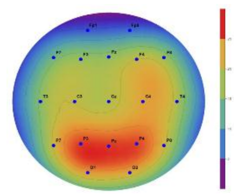
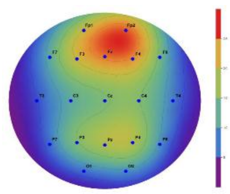
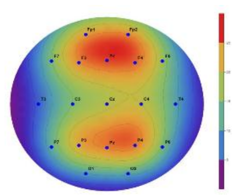
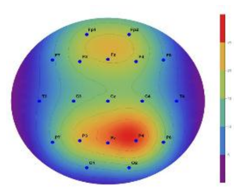
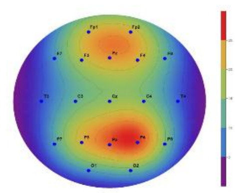
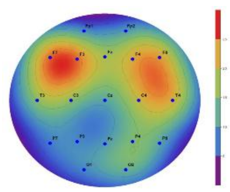
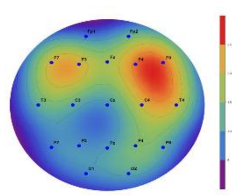
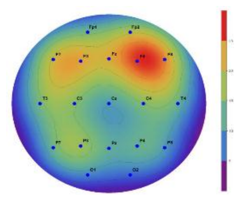
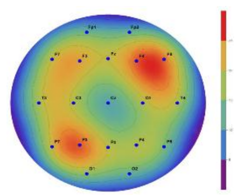
exhibited statistically significant differences. P3 and P4 exhibited the largest statistically significant differences when Ⓒ [mountain, field + lake, river, valley] was watched, followed by Ⓓ [city + people], Ⓑ[sea, ocean + lake, river], and Ⓐ [mountain, field + sea, ocean]. Table 7 shows the brain map (mean) for the indices that exhibited statistically significant differences.

Table 6. Kruskal-Wallis test results of “Mix” contents type ($p<0.1$)

Index	x2	P-value	Mean			
			Ⓐ	Ⓑ	Ⓒ	Ⓓ
P3_AT	8.745748	0.027244	14.99865	15.24743	16.25876	15.00579
P3_AB	15.44303	0.000503	13.58458	14.2941	16.26081	15.53177
P4_AB	5.463435	0.013877	14.75882	14.7678	19.11883	17.64436
P3_AG	16.91922	0.000182	8.345508	9.056937	11.86201	11.12143
P3_AFA	8.777211	0.026794	9.748225	10.36649	11.3334	10.41075
P4_AFA	6.380102	0.090037	10.27212	10.26652	14.48652	12.83767
P3_ALB	11.11565	0.00737	9.81465	10.42458	11.65947	10.83865
P4_ALB	6.283163	0.094331	10.50005	10.56054	14.98908	13.39398
P3_AMB	15.31633	0.000547	9.24369	9.879573	11.92146	11.15379
P4_AMB	5.181122	0.057963	10.42892	10.38578	14.79258	13.32154
P3_RB	8.306973	0.03429	0.237476	0.244822	0.291114	0.31139
P3_RMB	9.703231	0.016278	0.087329	0.08815	0.106426	0.113497
P3_RHB	11.21854	0.006946	0.092874	0.09455	0.126837	0.136146

Table 7. Brain map by “Mix” contents type

AT				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
AB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ

AG				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
AFA				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
ALB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
AMB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
RB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
RMB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
RHB				
	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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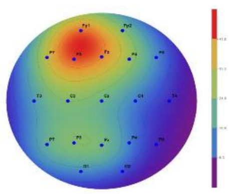
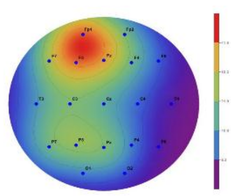
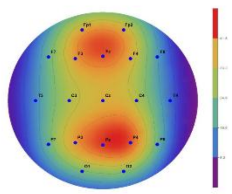
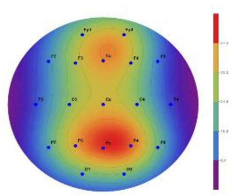
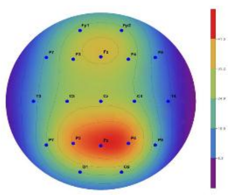
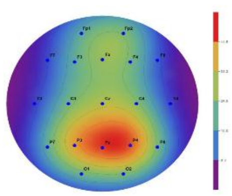
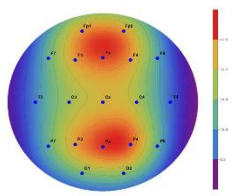
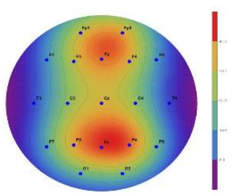
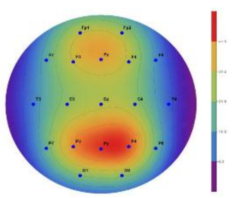
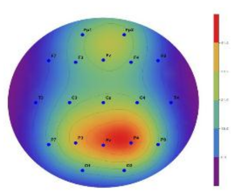
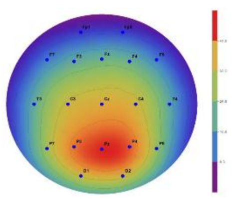
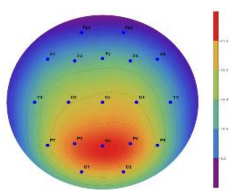
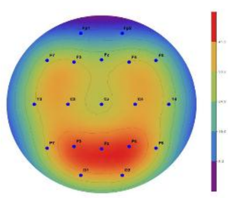
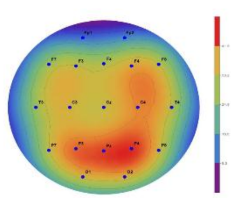
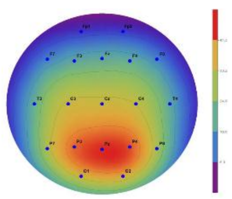
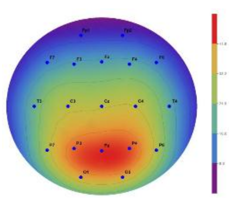
IV.I.III Difference in brain activity depending on “Only” Vs. “Mix”

When the difference in brain activity depending on the “Only” and “Mix” videos was analyzed through the Mann-Whitney test, statistically significant differences were observed at most of the 19 electrode attachment positions and for most of the EEG analysis indices. In particular, the AT, AA, AFA, ASA, ALB, RA, RB, RFA, RSA, and RAHB indices exhibited statistically significant differences at most of the electrode attachment positions. Table 8 shows the mean brain activity of the AT, AA, AFA, ASA, ALB, RA, RB, and RFA indices, which showed statistically significant differences at a number of electrode attachment positions. Brain activity was generally high when the “Mix” videos were watched.

Table 8. Brain map by “Only” and “Mix” contents type

AT		AA	
			
“Only”	“Mix”	“Only”	“Mix”
AFA		ASA	
			
“Only”	“Mix”	“Only”	“Mix”
ALB		RA	
			
“Only”	“Mix”	“Only”	“Mix”
RB		RFA	
			
“Only”	“Mix”	“Only”	“Mix”

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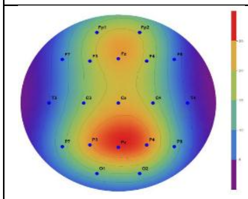
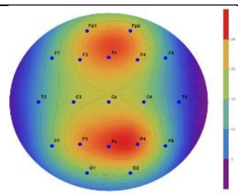
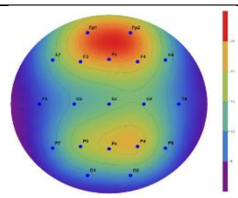
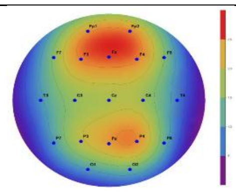
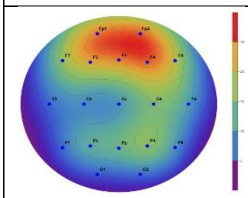
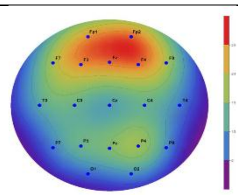
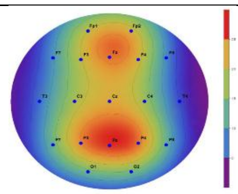
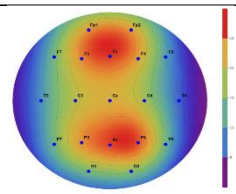
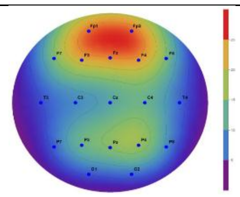
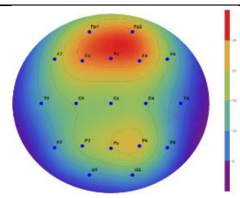
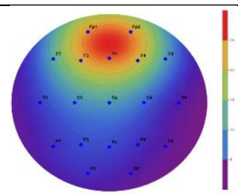
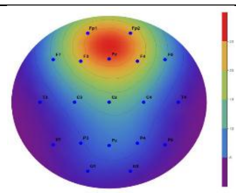
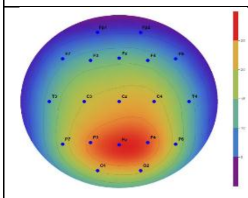
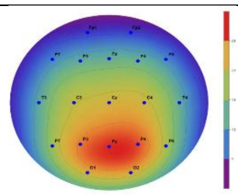
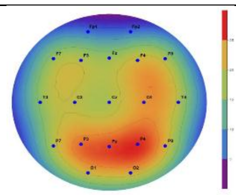
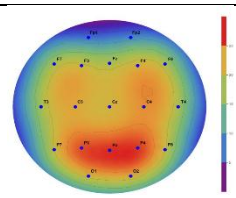
IV.II Difference in brain activity depending on illuminance level

When the Mann-Whitney test was conducted to analyze the difference depending on the two illuminance levels set in this study, the AA, AB, AG, ASA, AHB, RT, RA, and RB indices exhibited statistically significant differences at a number of electrode attachment positions. Although there were slight differences depending on the index and attachment position, brain activity was generally high when the videos were watched in the "On" condition (Table 9).

Table 9. Brain map by "On" and "Off" contents type

AA		AB	
			
Off	On	Off	On
AG		**ASA**	
			
Off	On	Off	On
AHB		**RT**	
			
Off	On	Off	On
RA		**RB**	
			
Off	On	Off	On

V. DISCUSSION

The purpose of this study was to analyze the difference in brain activity depending on the nature video type and illuminance level. When the "Only" nature videos of ⓐ [mountain, field], ⓑ [sea, ocean], ⓒ [lake, river, valley], and ⓓ [mountain, field/sea, ocean/lake, river, valley + human] were watched and the difference in brain activity was analyzed, the parts of P3 and P4 exhibited statistically significant differences, depending on the video type. These parts showed a difference in the Absolute Theta, Absolute Beta, Absolute Gamma, Absolute Low Beta, Absolute Mid Beta, and Absolute High Beta waves. In particular, P3 and P4 exhibited higher brain activity when the videos of ⓒ [lake, river, and valley] and ⓓ [mountain, filed/sea, ocean/lake, river, valley + people] were watched, compared to when other videos were watched, where P3 and P4 are the positions of the electrodes attached to the parietal lobe. The parietal lobe is the primary somatosensory cortex and processes tactile and kinesthetic receptors as well as incoming information first. It is also involved in primary somatosensory function, sensory integration, and spatial recognition, and plays an important role in interpreting visual and auditory information. In other words, there is a large amount of information to be processed when the videos of ⓒ [lake, river, valley] and ⓓ [mountain, field/sea, ocean/lake, river, valley + people] are watched, among the single landscape ("Only") videos.

When the "Mix" nature videos of Ⓐ [mountain, field + sea, ocean], Ⓑ [sea, ocean + lake, river], Ⓒ [mountain, field + lake, river, valley], and Ⓓ [city + people] were watched and the difference in brain activity was analyzed, the parts of P3 and P4 exhibited statistically significant differences, depending on the video type, in the same manner as the "Only" nature videos. As the mixed videos were watched, the Absolute Theta, Absolute Beta, Absolute Gamma, Absolute Fast Alpha, Absolute Low Beta, Absolute Mid Beta, Relative Beta, Relative mid Beta, and Relative High Beta waves increased in P3 and P4. In particular, P3 and P4 showed higher brain activity when the video of Ⓒ [mountain, field + lake, river, valley] was watched, compared to when other videos were watched. This indicates that the states of arousal, activity, attention, and vigilance are heightened when the video of Ⓒ [mountain, field + lake, river, valley] is watched than when other "Mix" nature videos are watched. When attention is paid to the spatial domain, alpha waves may increase or decrease in the occipito-parietal area [25]. Alpha waves are related to spatial attention [25], semantic memory [26], and visual identification [27]. In particular, there are evidences that the upper alpha (10–12 Hz) wave plays an important role in memory process [28], and it is considered essential in the long-term memory process [29]. In general, Beta waves are related to arousal, activity, cognitive action, attention, vigilance, and concentration. In other words, Beta waves appear as stimulation increases or discrimination becomes more difficult, indicating an increase in cognitive function. Mundy-Castle (1951) conducted a study on the EEG of general adults, and found that 12–30 Hz Beta waves increased when visual imagination was required, compared to when it was not [30]. The Beta state exhibits high activity in deep thought, imaginative activities, emotion control, vigilance, and concentration [31][32].

Many neuropsychological or functional magnetic resonance imaging (FMRI) studies have reported that the parietal lobe area is related to spatial recognition, rapid cognition, and attention [33][34]. In this experiment, the videos of ⓒ [lake, river, valley] and ⓓ [mountain, field/sea, ocean/lake, river, valley + people] activated Beta waves in the parietal lobe, compared to the videos of ⓐ [mountain, field] and ⓑ [sea, ocean], because the ⓒ and ⓓ videos required more attention or cognition. As for the characteristics of the videos, the ⓐ and ⓑ videos contained monotonous scenes, while the ⓒ and ⓓ videos contained dynamic scenes, such as sparkling waves, waterfalls, and falling water sound, and people swimming in a valley where water falls. Among the "Mix" videos, the video of Ⓒ [mountain, field + lake, river, valley] induced higher cognition or concentration than Ⓐ [mountain, field + sea, ocean], Ⓑ [sea, ocean + lake, river], and Ⓓ [city + people]. The Ⓒ video was dominated by dynamic scenes, such as sparkling waves, flowing water sound, waterfalls, and falling water sound, as in ⓒ, a single landscape ("Only") video.

When the difference between the single landscape ("Only") and mixed landscape ("Mix") videos was analyzed, alpha waves were higher in most parts of the brain when the "Mix" videos were watched. The contents of the "Mix" videos (Ⓐ [mountain, field + sea, ocean], Ⓑ [sea, ocean + lake, river], Ⓒ [mountain, field + lake, river, valley], and Ⓓ [city + people]) were more colorful and dynamic than the "Only" videos (ⓐ [mountain, field], ⓑ [sea, ocean], ⓒ [lake, river, valley], and ⓓ [mountain, field/sea, ocean/lake, river, valley + people]). Therefore, alpha waves were higher when the "Mix" videos were watched than when the "Only" videos were watched, indicating that the stimulation of more colorful natural landscapes further activates attention, mental concentration, and stress relief than nature videos with simple stimulation.

Brain activity was analyzed while the videos were watched in the illuminance "On" and "Off" conditions. Most parts of the brain exhibited higher brain activity in the "On" condition than in the "Off" condition. These results indicate that increasing the illuminance level will be able to increase the low brain activity for monotonous video stimulation in future video stimulation tests, and decreasing the illuminance level will be able to decrease excessively high brain activity for videos that lead to excessive arousal due to the necessity of complex cognition.

VI. CONCLUSION

In this study, the difference in brain activity depending on the video type and illuminance level was analyzed. The results of this study showed that the stimulation felt by the subjects varied depending on the video type, and that the illuminance level when the videos were watched also had an influence. In particular, there were significant differences in the fast alpha and Beta waves of the parietal lobe area, depending on the video in this study. Based on this result, it is expected that the videos used in this study will be utilized in the future for stimulation, such as induction of brain activation to increase the cognitive function and parietal lobe activation reaction to increase the learning function. This study, however, has limitations, because the number of subjects was somewhat small. Therefore, it is necessary to verify the results of this study in future research, with more subjects. Additionally, it is necessary to analyze the difference between the stress and non-stress groups in additional research, to prove that the presented videos have a stress reduction effect.

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